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ARE ALIENS GREEN? ASSESSING FOREIGN ESTABLISHMENTS' ENVIRONMENTAL CONDUCT IN THE UNITED STATES

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Previous research has found that foreign-owned establishments often lack specific capabilities needed to respond to local business conditions and are held to a higher standard by local stakeholders. These establishments compensate, however, by possessing offsetting capabilities such as technological excellence. In this article, we investigate how these conflicting forces shape the environmental conduct of foreign-owned facilities. Using data from the Environmental Protection Agency, we find that foreign-owned establishments generate more waste yet manage more waste than U.S.-owned establishments. We also find evidence that both domestic and foreign-owned firms generate more waste if they operate multiple facilities across multiple jurisdictions in the United States. Copyright © 2001 John Wiley & Sons, Ltd.

INTRODUCTION

Depending upon whom you believe, multinational firms are either catalysts for heightened environmental performance or purveyors of environmental destruction.[1] The debate is often emotional. If there is one thing more disturbing than the belief that businesses cause irreversible harm to the environment, it is that foreigners, who suffer minimal consequences, control the businesses that inflict the greatest harm.

Much of this debate has focused on the potential for firms to seek safe haven from environmental regulation by locating in nations with lax environmental standards (e.g., Birdsall and Wheeler, 1992; Eskeland and Harrison, 1997). As stringent environmental regulation becomes more international, the focus of the debate may switch to the environmental performance of foreign-owned firms in highly regulated states. In this paper, we empirically examine the environmental conduct of domestic versus foreign firms in the United States.[2]

The literature on foreign direct investment provides conflicting predictions for the environmental performance of foreign vs. indigenous firms. On the one hand, it suggests that foreign firms face difficulties in responding to local conditions. On the other hand, it suggests that foreign firms are held to a higher standard than their domestic counterparts and might have superior technological capabilities. These capabilities, the literature suggests, depend on the conditions and regulations in the foreign firm's home country. High factor prices or stringent regulation in home countries can encourage innovation and process improvement, thereby providing international advantage.

To investigate these arguments, we explore the relative level of waste generation, waste

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[1] Rondinelli and Vastag (1996) and Mander and Goldsmith (1996), respectively, provide examples of these arguments.

[2] Our goal is not to directly contribute to the growing literature that relates environmental behavior to financial performance (e.g., Dowell, Hart, and Yeung, 2000; Hart and Ahuja, 1996; Nehrt, 1996; Russo and Fouts, 1997; Waddock and Graves, 1997).

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processing, and waste release for foreign and U.S.-owned facilities in the U.S. chemical and petroleum sectors. We also evaluate the intensity in which foreign and domestically owned facilities are regulated under the Clean Water Act. Finally, we test for evidence of a 'home country effect' among the foreign-owned facilities.

We find that foreign firms lag their U.S. counterparts in preventing waste. We attribute this result to the difficulty that foreign firms face in managing complex and contingent improvement processes (like pollution prevention). We find mixed evidence that foreign-owned facilities face greater stakeholder pressure. Foreign-owned facilities process more waste than U.S.-owned facilities, but they do not have more federal Clean Water Act permits. Finally, we find no evidence that more stringent home country regulation leads to better environmental performance in the United States.

Additional analysis of factors that influence the environmental performance suggests that the difficulty faced by foreign firms is a manifestation of a more general effect. We find evidence that managing more establishments across more regulatory environments within the United States imposes difficulties for all firms—including domestic ones.

The paper proceeds in the following manner: the next section addresses the theoretical arguments that link foreign-owned establishments with differing environmental behavior; the third section describes the sample and defines the variables; the fourth section presents the methods used in the analysis; the fifth section interprets and discusses the empirical results; and sixth section concludes.

THEORY AND HYPOTHESES

Waste materials, like products, go through several stages before being emitted from a facility. At each stage, management decisions and operational capabilities influence the amount and nature of material passing to the next stage. We portray these stages, which we call the Pollution Chain, in Fig. 1. On the left-hand side of the figure we have the manufacturing process of a firm that produces byproducts. If these byproducts are used internally or sold to another firm, they are not classified as waste. However, if no internal or external user can be found, then these byproducts must be reported to federal authorities as waste. The firm can then process this material (through recycling, energy recovery, or treatment), or within regulatory bounds the firm can release it into the environment.

With this as background, the following subsections highlight how foreign ownership is related to the environmental conduct of firms.

Foreign-owned facilities face greater social demands

Theories of foreign direct investment argue that foreign firms are at a disadvantage in a local market vs. indigenous firms (e.g., Hymer, 1976;

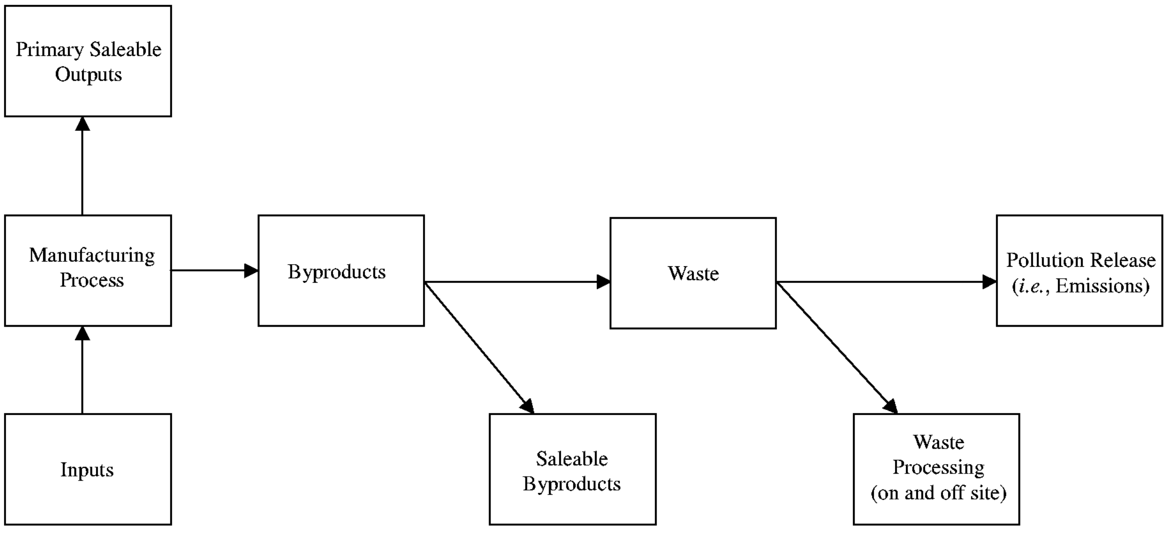

Figure 1. The pollution chain

Caves, 1971; Buckley and Casson, 1976; Dunning, 1977). One source of this disadvantage is that foreign firms often face discrimination by host-country consumers, governments, and suppliers (Hymer, 1976). As a result, foreign firms are more often investigated, audited, and prosecuted than their domestic counterparts (Vernon, 1998). For example, Mezias (1999) finds that foreign firms operating in the United States face more labor lawsuits than indigenous firms. With respect to environmental issues, regulators often single out 'deep pockets' and politically palatable targets for enforcement actions. In other cases, foreign firms receive extra attention not because of explicit discrimination, but because they look different from their domestic counterparts, and stakeholders use these differences as a proxy for unobserved performance (King and Baerwald, 1998). For instance, the Council on Economic Priorities listed Formosa Plastics as an environmental 'bad actor' partly because its foreign owners chose not to join the usual U.S. groups and associations (King and Baerwald, 1998).

It is possible to measure the actions of one group of stakeholders—regulators—directly. Although guidelines exist for administering environmental laws, substantial discretionary power often remains with the regulator. Previous research has demonstrated that regulatory policies differ substantially with region and with the company being regulated (Meyer, 1995). Facilities that are smaller, more focused, and more political powerful are likely to be less strictly regulated (Gray and Deily, 1996). Frequently, companies that become the target of stakeholder action also become the focus of increased regulatory scrutiny (King and Baerwald, 1998). If, as suggested by theory, stakeholders more closely scrutinize foreign-owned establishments, they will be more strictly regulated. This leads to the following hypothesis:

Hypothesis 1a: Foreign-owned establishments are more strictly regulated than domestically-owned establishments.

Other stakeholders may also exert pressure on foreign-owned establishments. For example, lawyers may expect that they are more likely to win suits against foreign establishments. Community action panels may be more willing to exert pressure on a foreign firm. Suppliers and buyers may require that foreign firms demonstrate a higher level of performance. Such pressure might affect pollution reduction throughout the Pollution Chain. All other things equal, foreign establishments should have lower emissions. Differences in stakeholder pressure should be most strongly apparent, however, in differences in waste processing. Research suggests that stakeholder pressures more strongly affect waste processing efforts than they do waste prevention efforts (Cebon, 1993). The first response to stakeholder pressure is usually 'end of pipe' management. The production process itself is not changed but pollution is ameliorated at the end of the line. Such end-of-pipe processing often requires capital equipment or visible transactions with third parties. Thus it provides relatively visible and tangible evidence of response to stakeholder concerns (OTA, 1994). It also allows managers to insulate the production process from unpredictable stakeholder demands (OTA, 1994; King, 1995; Klassen and Whybark, 1999). Therefore, because foreign-owned establishments face greater social demands, we expect that they will do more waste processing.

Hypothesis 1b: Foreign-owned establishments will do more waste processing than domestically-owned establishments.

Foreign-owned facilities lack the ability to effectively meet local regulation

Theories of foreign direct investment (FDI) argue that foreign-owned establishments not only face greater scrutiny but are disadvantaged by having less information about the local business environment and less expertise in responding to local business conditions (e.g., Hymer, 1976; Caves, 1971; Buckley and Casson, 1976; Dunning, 1977).

Evidence suggests that waste prevention requires highly tacit, conditional, and local skills. Studying the diffusion of pollution prevention efforts across a single large firm, Cebon (1993) finds that differences in local conditions prevent the transfer of successful practices. Moreover, he finds that attempts to standardize practices can disturb local programs and damage overall pollution prevention. Several authors argue that pollution prevention skills are so local and tacit that they cannot be transferred economically, and thus can provide a basis for sustained competitive advantage (Hart and Ahuja, 1996; Nehrt, 1996; Russo and Fouts, 1997). Perhaps because of this difficulty in managing waste reduction at a distance, Levy (1995) finds that Japanese facilities in the United States lag behind their U.S. counterparts in waste reduction. This is surprising because Japanese companies are the originators of several waste reduction techniques (Womack, Jones, and Roos, 1990). Levy argues that the difficulty of moving successful practices to new locations might explain this paradox. Because of their relative lack of experience with local conditions, and the difficulty of managing distant conditional and tacit skills, foreign-owned facilities should have greater difficulty managing waste prevention activities in their facilities.

Foreign-owned facilities may also face an additional difficulty in preventing waste. They may be less able to negotiate arrangements with other firms to turn waste into saleable byproducts. As we previously described, waste is a byproduct that has no buyer, and one way to reduce it is to find a buyer. Previous research has shown that information disadvantages restrict foreign firms from identifying new buyers and suppliers (e.g., Evans, Lane, and O'Grady, 1992). Identification of a potential user of industrial byproducts requires detailed contextual knowledge about diverse industrial applications. For example, if foreign-owned steel companies have less information about local conditions, they may not even recognize the possibility of selling their waste byproducts.

Selling waste chemicals also requires navigating a difficult contracting process. In the United States, for example, Superfund and other environmental legislation make waste contracting extremely complex and dangerous. Consider the difficulties apparent in the following online posting to a company seeking waste ferrous chloride or 'pickle liquor'.

> *arrange a LONG TERM ironclad contract with your local PL (pickle liquor) source for delivery at no cost to you. Your PL source is faced with trying to dispose of a listed hazardous material [and] must spend a lot of money to do this. You are offering them a 'free' disposal method, so use your bargaining power to get them to deliver it free to your tanks for a long, long time... Of course, check the metals very closely... The metal concentrations will vary sharply depending upon which grade and type of steel is being pickled... (Posted to the Water Environment Federation by Jim Joyce on March 20, 1999, at 12:12:51; emphasis in the original)*

The difficulties evident in this example could be magnified when the generator of the byproduct is foreign-owned. Foreign firms are likely to use unusual process technology and thus produce more unusual waste. The legal liability risks associated with the transfer, and a relative lack of knowledge about cultural and regulatory contexts may further impede foreign managers from forming contracts to sell waste byproducts (e.g., Gomes-Casseres, 1989; Morck and Yeung, 1991). Finally, foreign managers might be wary of contracting because foreign managers have more difficulty monitoring the handling of waste.

In summary, theory suggests that foreign-owned establishments will have less expertise and less information useful to meeting local environmental requirements. As a result, we argue that they will have greater difficulty (1) reducing their waste and (2) finding and negotiating with buyers for waste byproducts. This leads to the following hypothesis:

> *Hypothesis 2: Foreign-owned establishments will generate more waste than domestically owned establishments.*

Foreign-owned facilities have offsetting technological capabilities

Given the disadvantages that we just reviewed, it seems remarkable that a firm would ever choose to operate in a foreign country. Indeed, theories of foreign direct investment suggest that firms tend to own foreign operations only when the firm possesses some unique advantage whose value can only be fully captured through ownership of a foreign facility (e.g., Buckley and Casson, 1976; Caves, 1996; Dunning, 1977). Such advantages can stem from product and process technologies, management skills, and brand names or marketing prowess (e.g., Magee, 1977; Markussen, 1995). To the extent that foreign firms have superior technology and management, foreign-owned establishments might have more efficient production technologies compared to their indigenous counterparts. For example, oxygen lance furnaces in steel making, which greatly reduced waste in steel manufacture, and statistical methods for waste minimization, were first adopted and exploited by foreign firms (Utterback, 1995; Womack *et al.*, 1990).

Thus, we acknowledge that superior technological capabilities in foreign-owned establishments might counteract the forces that led us to Hypothesis 2. As a result, we are cognizant of this potential countervailing pressure when we interpret our results.

One way to help untangle the potentially conflicting effects of superior technology and local disadvantage is to focus on other stages in the Pollution Chain. Onsite waste processing requires technological sophistication but does not require extensive knowledge of local conditions or capabilities (King, 1995; OTA, 1994). Recycling, treatment, and even energy recovery operations require technological skill and operational finesse. However, these processes are often used to insulate the firm from differences in surrounding regulation. If the offsetting technological advantages of foreign-owned facilities are general, then they should reduce the cost of waste processing. In 1994, the Office of Technological Assessment reported that companies from Germany and Japan had superior waste-processing technology and were using this equipment in the United States. Porter and van der Linde (1995) argue that superior waste-processing technology may reduce entry barriers into highly regulated states. Thus, we should expect foreign firms operating in the United States to have superior waste processing technology. Due to the reduction in marginal cost provided by this technology, foreign-owned facilities should tend to process more of their waste onsite.

Hypothesis 3: Foreign-owned establishments will do more onsite waste processing than domestically-owned establishments.

Offsetting technological capabilities may depend on home country conditions

The above discussion addresses differences between U.S.-owned facilities and those facilities owned by firms from any other nation. Some scholars have also argued that firm advantages with respect to environmental practices might depend on home country conditions. Porter and van der Linde (1995) argue that regulation can encourage the development of better products and more efficient processes. For instance, by increasing the price of raw materials, regulation can cause managers to search for more efficient process technologies. These innovation offsets, Porter and van der Linde argue, may then allow the firm a competitive advantage relative to firms from other nations. For example, scarce resources in Japan caused innovations in process and products that then allowed Japanese companies to penetrate many foreign markets (Womack *et al.*, 1990). Scarcity in raw materials and the resulting high cost of work-in-process material led to the Toyota production system, which then spread to other Japanese companies. To fully benefit from their production advantages, many car companies built operations in the United States. Therefore, we hypothesize the following:

Hypothesis 4a: Establishments owned by companies from countries with high-priced energy will produce less waste than those from countries with low-priced energy.

Home country conditions other than factor prices can encourage important and beneficial innovation. Porter and van der Linde (1995) argue that superior waste-processing technology may allow firms to profitably enter foreign markets. Scholars have proposed several mechanisms through which this hypothesis might operate. The most straightforward proposes that home country conditions cause firms to develop skills that reduce the costs of meeting regulatory requirements in foreign countries. For example, the U.S. Clean Air Act caused U.S. firms to develop catalytic technology to reduce auto exhaust. As a result, U.S. companies were leaders in introducing low-emission vehicles abroad (OTA, 1994). Similarly, the threat of regulation caused German companies to develop special recycling and energy recovery technology. Now BMW and other German car companies have introduced advanced systems for auto recycling into the United States.

To be beneficial, home country conditions need not include intense command and control regulation. Most developed countries use a mix of voluntary and nonvoluntary systems (OECD, 2000). The development of a supportive infrastructure and culture is also important. As a result of these difficulties, we do not try to link regulatory attributes to firm behavior. Instead, we hypothesize that businesses from countries that do more waste processing will tend to have found better methods for such processing, and thus will choose to do more waste processing when operating abroad.

Hypothesis 4b: Establishments owned by companies from countries that do more waste processing will perform more onsite waste processing than those from countries that do less waste processing.

Hypotheses 4a and 4b argue that home country conditions influence the performance of firms operating abroad (Porter and van der Linde, 1995). However, other scholars argue that each different national milieu requires specific investments, and these investments do not transfer to other countries (Rugman and Verbeke; 1998).[3] For example, firms operating in the United States need to learn how to respond to the unusual but powerful Superfund legislation. The skills needed to do this may have limited value outside the United States.

If responding to environmental regulation at home or abroad entails specific investments, home country conditions may not positively affect the performance of companies operating abroad. Indeed, as we discussed in Hypothesis 1, the cost of responding to these unique and local conditions may cause foreign firms to underinvest in the development of these skills and thus underperform relative to indigenous firms.

SAMPLE AND VARIABLE DEFINITIONS

To test the hypotheses, we gathered data from the U.S. Government Environmental Protection Agency's Toxic Release Inventory (TRI) data base. The TRI data base provides plant-level information on waste generation, waste processing, and emissions into the air, water, and land. Reporting is mandated by law and the data base covers all establishments operating in the United States with 10 or more full-time employees and that manufacture or process 25,000 pounds or use more than 10,000 pounds of any listed chemical during a calendar year. By examining environmental performance in the United States, we enjoy the research design advantage of not introducing variation due to multiple host countries.

With respect to the accuracy of these data, the EPA reports that 93–95% of those facilities that needed to report did so in 1987 and 1996. Moreover, more detailed analyses by the EPA for three SIC codes found that in SIC 33 (i.e., primary metal), releases were under reported by 0.25%. In SICs 35 and 36 (i.e., industrial machinery and equipment and electronic and other electric equipment), companies over reported by 5% and 24% and most of these errors were caused by confusion about the reporting of onsite land disposal (EPA, 1998).

We restrict our analyses to chemical and petrochemical sectors (SICs 28 and 29) for the following reasons. First, these sectors produce about 40 percent of all chemical emissions, and our pollution measures best capture the environmental performance in these sectors. Second, by limiting the scope of our sample we avoid the need to compare very dissimilar industries like chemical production and food processing. Third, these two industry sectors have the highest levels of foreign direct investment when compared to all 2-digit manufacturing SICs in the United States. In 1992 13.6 percent and 16.9 percent of chemical and petroleum establishments, respectively, were foreign-owned whereas the average for all manufacturing industries was 3.3 percent (U.S. Department of Commerce, Bureau of Economic Analysis). Therefore, we are able to maximize variation in foreign vs. U.S. establishment ownership in these industries.

The TRI data base provides both a complete and detailed array of data on the generation and release of chemicals. Moreover, the TRI is based on the population of establishments that emit chemicals and is not restricted to firms choosing to respond to voluntary questionnaires. The TRI does not provide, however, much establishment information. Such data are important for our analyses because we must know the ultimate owner of an establishment, and we wish to control for establishment characteristics that influence generation and emission levels. TRI does report Dun and Bradstreet (D&B) numbers. Matching the D&B number with the Dun's data base, we were able to acquire data concerning the number of employees at each facility in 1996 and the ultimate owner of the facility.[4] Our D&B data only include the identities of

[3] Nehrt (1998) also argues that performance advantages from pollution prevention for first movers and followers is contingent on home country regulatory regime.

[4] Matching the two data sets proved more difficult than we originally hoped because respondents often reported their corporate D&B number rather than their facility D&B. In some cases, they dropped leading zeros or made slight mistakes in transposing the number. To fix these errors, we wrote a computer program to match facilities from the TRI data set to the D&B data set. This program used the zip code, SIC code, company

facilities in existence in 1996. If the ownership of facility had changed or the facility had closed prior to 1996, that facility (or that facility under previous ownership) could not be included in the sample.

U.S. regulation is among the strictest in the world, but foreign companies in our sample also tend to come from nations with extensive environmental regulation (Jaffe *et al.*, 1995; Kopp, Portney, and Dewitt, 1990). Ninety-eight percent (659) come from northern European nations, Canada, or Japan. The remainder include four facilities owned by Australian companies, three by Italian companies, two by Chinese (PRC) companies, two by Taiwanese companies, two by Israeli companies, one by an Indian company, and one by a Turkish company. Our results do not vary substantially if we remove these facilities from our sample.

Taking advantage of the yearly reporting requirement of the TRI, we constructed a panel data set that contains information on plant waste from 1991 to 1996. These cut-off dates were chosen because 1996 was the most recently released TRI data at the time we began this project and is also the year represented in our Dun's data. Previous to 1991, reporting differences make it difficult to compare waste processing. The D&B data provide information on the facility size (employees on site) in 1996. To fill in employee data for earlier years, we used the production index from the TRI data. Each year, companies are asked to provide percentage differences in production for each line of business relative to the previous year. We used these percentage changes to estimate the facility size prior to 1996. To insure that errors in production ratios did not cause expanding errors, each record was checked for reporting accuracy by comparison with other information in the TRI (e.g., plant closings). In most cases, facilities reported production ratios for several lines of production and these were turned into a facility production ratio based on the weighted average.

The resulting sample is an unbalanced panel of 20,605 establishment–year observations. The total number of establishments in the sample is 4078. On average, establishments are in the sample for 5.1 years (out of 6 possible years). However, some establishments are present for only 1 year.

Dependent variables

We developed an improved method to collapse information on the generation and processing of multiple chemicals into a single meaningful measure. To approximate and equalize the environmental effect of the hundreds of chemicals reported in the TRI, we weighted each chemical by its toxicity. To do this, we turned to the reportable quantities (RQ) measure from the CERCLA statute. This measure identifies the size of a spill, in pounds, that necessitates emergency reporting to the EPA. Chemicals are classified into one of the five RQ categories based on 'the intrinsic characteristics of each hazardous substance, such as the aquatic toxicity, acute and chronic toxicity, ignitability, reactivity, and potential carcinogenicity' (EPA, 1997). For example, a spill of greater than one pound of arsenic requires reporting to the EPA, whereas only spills greater than 5000 pounds of isopropyl alcohol require reporting. Table 1 reports the various RQ categories, the weights we assigned to those categories, and an example of the chemicals within each category. We create a value for waste generated at the facility level by summing the toxicity-weighted chemical waste generated by the facility in each year. We then took the natural log of this sum as represented by the following equation:

$$\text{Waste Gen}_{it} = \ln\left(\sum_{\forall c} \text{weight}_c * \text{waste generated}_{cit}\right) \quad (1)$$

where Waste Gen_{it} is aggregate waste generation for facility i in year t, weight_c is the toxicity weight for chemical c in year t, and waste generated_{it} is the pounds of generated chemical waste of chemical c for facility i in year t.[5]

Although we focus on the chemical and petroleum sectors, we still expect there to be differences between industries due to underlying differences in technology or enforcement. We therefore wish to

identification, and company name to match a facility. Only if there was a unique match between location, product, and company did we conclude that we had correctly identified a facility and could merge the data. Because the Dun's data are necessary to conduct our statistical analyses, we omitted nonmatched establishments from our sample. In this way, we matched 75% of the facilities in the TRI data set. For more information see King and Lenox (2000: 704).

[5] We examined alternative forms for the weighting and used alternative toxicity weights from the EPA and Purdue University. The results when using these alternative measures did not materially differ from those we present.

Table 1. Chemical toxicity weightings

Reportable quantity (RQ)[a]	Weighting	Examples of chemicals
1	1.0	Arsenic Mercury Silver Cyanide
10	0.1	Chlorine Phosgene
100	0.01	Formaldehyde Ammonia
1000	0.001	Styrene Zinc
5000	0.0002	Copper Isopropyl alcohol

[a]RQ's are based on the CERCLA statute (see EPA, 1997)

control for possible industry effects. Failing to control for industry might confound the interpretation of any differences we find between foreign and indigenous establishments because the level of foreign direct investment varies across industries.

Because waste generation is strongly influenced by the product being manufactured (i.e., the industry) and the size of the operation, we constructed a measure that compares the waste generation of the facility to other facilities in its industry and that corrects for size differences (RELATIVE WASTE GEN). To do this, we used OLS regression to estimate a 'waste production function' that relates the log of facility size to the log of aggregate toxic waste generation for each 4-digit SIC code within each year. The standardized residual, or deviation, between the observed and predicted waste generation given a facility's size and industry measures the relative generation of a facility. Thus, if a facility generates more than predicted given its size and SIC code, it will have a positive residual and a positive score.

$$\text{Relative Waste Gen}_{it} = \text{WG}_{it} - \text{WG}^*_{it}$$
$$\text{WG}^*_{it} = \beta_{jt} + \beta_{1jt} s_{it} + \beta_{2jt} {s_{it}}^2 \quad (2)$$

where WG^*_{it} is predicted waste generation for facility i in year t, s_{it} is facility size (all variables are log transformed), and β_{jt}, β_{1jt}, and β_{2jt} are the estimated coefficients for 4-digit SIC j in year t.

Our hypotheses predict that foreign-owned facilities may have different performance with respect to several aspects of their environmental conduct. To estimate the relative degree to which each facility releases toxic material or processes its waste, we used the technique described above to create three additional measures. RELATIVE EMISSIONS is the standardized residual between observed and predicted toxicity-weighted emissions for the facility. RELATIVE PROCESSING is the standardized residual between the observed and predicted amount of waste processed by the facility (log of sum of all toxicity-weighted pounds processed on and offsite). RELATIVE ONSITE PROCESSING is the standardized residual between the observed and predicted amount of waste processed onsite by the facility (log of the sum of all toxicity-weighted pounds burned, recycled, or otherwise treated).

To measure the degree to which the different facilities in our sample are regulated, we count the number of performance criteria with which each facility must comply (i.e., the number of permits issued to a facility). Under the Clean Water Act, regulators may impose limits on water flow, suspended solids, and so on. Although guidelines exist for administering the law, substantial discretionary power remains. We label this variable PERMITS. The minimum value of this variable is zero, the maximum value is 3, and the mean is 0.43.

Independent variables

Foreign ownership

The focal independent variable is whether or not an establishment is foreign owned. In order to make this assessment we used the D&B data to identify the ultimate parent of the establishment and the home nation of the ultimate parent. The D&B data, from which we draw, is the data source for D&B's publication *Who Owns Whom*. In some circumstances, the data base did not list a nationality. For these, we individually verified the nationality of the ultimate parent.

We code the variable FOREIGN to be one if the ultimate parent firm is foreign owned, zero if it is U.S. owned.[6] Seventeen percent of the

[6] The Dun and Bradstreet data list DuPont as American owned even though the Bureau of Economic Analysis considered the company Canadian owned at this time. This is an often discussed example regarding the classification of foreign ownership in that the Bronfman family of Toronto and New York owned approximately 20 percent of the company over our sample period. We classify DuPont as American owned because this is consistent with the Dun and Bradstreet data and because the firm has 'never been placed under the control of a foreign chemical

establishments in our sample are foreign owned. This is very consistent with the underlying level of foreign ownership in the population (13.6% in SIC 28 and 16.9% in SIC 29) and lends support to the representativeness of our sample.

To capture the differences in home nation that are central to Hypothesis 4, we use OECD Environmental Data from their annual compendium reports to measure relative oil prices. The price of oil should approximate the relative price of important environmental factors. Oil is an important input into many petrochemical operations either as a feedstock or as a source of energy. High oil prices also often result from government taxes on oil. Thus they often represent attempts to encourage resource conservation. For each year, we create a normalized deviation for each country's oil price relative to all other countries in the sample (RELATIVE OIL PRICE).

We measured the extent to which a country engages in waste processing in two ways. We again used OECD data to calculate the annual spending on all waste processing (public and private) as a percentage of GNP. We also calculated the percentage of glass and cardboard recycled in each country. The two measures are highly correlated ($R = 0.72$), but we have more complete data on recycling. Thus, we chose to report our results for this measure. Our results do not change in significance if we use either measure. We created a deviation measure relative to other countries in the sample (RELATIVE RECYCLING).

Control variables

It is possible that our measure of foreign ownership might measure the effect of multinational activity, not foreign ownership. To provide a U.S.-based comparison group, we created a dummy variable U.S. MULTINATIONAL that indicates if the firm was U.S.-owned and had foreign sales. We obtained data on the foreign sales of each firm from the Compustat data base. Thus, our U.S. MULTINATIONAL variable indicates a publicly traded firm with foreign sales.

Another possibility is that foreign-owned firms operate more facilities or more dispersed facilities in the United States. To control for these effects, we measure the total number of TRI-reporting facilities that the firm operates. We take the natural log of TRI-reporting establishments to create the variable LN(NUMBER OF PLANTS). We created a variable, labeled STATE DISPERSION, to measure the degree of dispersion of facilities in the United States while accounting for the number of establishments that a firm has. This variable is calculated in the following manner: (number of states in which the firm operates establishments−1)/total number of establishments. Companies that operate in only one state take the value zero. The variable takes values that approach 1 for companies that are dispersed, given the number of plants that they operate.

It is possible that foreign firms choose to operate in states with differing levels of regulation. To control for this effect, we used the regulatory stringency measure suggested by Meyer (1995). We measure REGULATORY STRINGENCY by calculating the inverse of the log of state toxic emissions divided by total employees in four main polluting industries: chemicals, petroleum, pulp and paper, and materials processing.

Finally, although we controlled for the effect of each facility's size (in each SIC code and year) in the creation of our dependent variables, it is possible that some effect still remains that operates across industry sectors. To create a relative size measure, we again created a deviation measure for facility size (in employees, in natural logarithms) relative to other facilities in the industry. We label this variable RELATIVE EMPLOYEES.

Table 2 reports descriptive statistics and correlation coefficients among the variables.

METHODS

To test our prediction that foreign-owned facilities will have more permits, we use an ordered logistic regression. We choose this approach because of the limited nature of this dependent variable. This approach predicts the probability that an establishment will have zero, one, two, or three criteria permits. Because the number of permits could change from year to year, we use the entire sample in our analyses. However, since such change is not common, we also examined the same specification using establishment averages over the sample years. We found similar results.

company' and 'the *de facto* nationality of its owners is arguable' (Graham and Krugman, 1991: 10). Our results are not sensitive to the classification of this company.

Table 2. Descriptive Statistics

	Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Relative waste gen.	0.01	0.99	1.00												
2	Relative waste proc.	0.01	1.00	0.79	1.00											
3	Relative onsite proc.	0.00	1.00	0.54	0.66	1.00										
4	Relative releases	0.03	0.98	0.79	0.48	0.34	1.00									
5	Permits	0.43	0.54	0.13	0.12	0.13	0.11	1.00								
6	Relative employees	0.07	0.98	−0.01	−0.01	−0.01	−0.07	0.22	1.00							
7	Relative employees^2	0.96	1.52	0.00	0.00	−0.01	0.04	0.07	0.27	1.00						
8	Foreign	0.17	0.37	0.06	0.08	0.06	0.03	0.05	0.09	0.03	1.00					
9	U.S. multinational	0.21	0.41	0.08	0.09	0.07	0.04	0.14	0.19	0.04	−0.23	1.00				
10	ln(number of plants)	2.01	1.53	0.13	0.13	0.12	0.08	0.21	0.29	0.08	0.26	0.45	1.00			
11	State dispersion	0.37	0.27	0.10	0.11	0.09	0.06	0.12	0.16	0.02	0.19	0.18	0.45	1.00		
12	Regulatory stringency	0.15	0.87	−0.09	−0.06	−0.10	−0.10	−0.13	−0.03	−0.04	0.02	−0.04	−0.08	−0.06	1.00	
13	Relative recycling[a]	0.51	0.74	−0.06	−0.03	−0.00	−0.09	−0.03	0.06	0.06	—	—	0.14	−0.21	0.01	1.00
14	Relative price of oil[a]	0.10	0.56	0.06	0.02	−0.04	0.08	0.00	0.02	−0.00	—	—	0.04	0.17	0.10	−0.55

$n = 20605$; [a] $n = 3413$ for foreign firms excluding those from China, India, Israel and Taiwan

For the analyses of waste generation, emissions, and waste processing, we take advantage of the panel data design and estimate a random-effects model with generalized least squares (GLS). The formulation of the random-effects model is: $Y_{it} = \alpha + X_{it}\beta + u_i + \varepsilon_{it}$. Y_{it} is the value of dependent variable for establishment i in year t. X_{it} is a vector of independent variables for establishment i in year t and α is the intercept. The term u_i is a random disturbance that characterizes the ith establishment. Finally, ε_{it} is an establishment–year specific random disturbance. By assumption, u_i and ε_{it} are distributed iid normal. A further description of random-effects models and their estimation can be found in Greene (1993: 469).

The advantage of the random-effects set-up is that by introducing the term u_i we recognize that there might exist unobserved heterogeneity across establishments that affects the value of the dependent variable. For example, the underlying technology that a plant employs might affect the level of waste generated. Because we have multiple observations per plant, should such an unobservable effect exist, the resulting OLS residuals would be correlated across observations. This violates an assumption of OLS; therefore, we favor the random-effects set-up.

Alternative ways of controlling for the possibility of correlated errors across years by establishment are averaging the variables over the period for each establishment and running OLS on the averages, running OLS on a year-by-year basis, or running establishment fixed-effects. We cannot estimate establishment fixed-effects because the variable of interest, FOREIGN, does not vary across time by establishment in our panel. Therefore, we cannot estimate its coefficient in a fixed-effects specification.[7] However, we examined OLS specifications using the variable averages and with the raw data on a year-by-year basis. The findings from these specifications provided similar results to those from the random-effects specification and are available from us on request. In part we choose to present the random-effects specification because they present the most conservative set of estimates.

Before presenting the results, we must note that some caution is required in interpreting the significance of the coefficient estimates due to the very large size of our sample. Because the standard errors of the coefficient estimates decrease as sample size increases, we want to ensure that the effects are both statistically significant and of magnitude such that they are meaningful. To aid in this we do the following. First, we follow Leamer's recommendation to adjust the threshold level for statistical significance (Leamer, 1978).[8] For most of our analyses, a t-value of 3.14 or higher satisfies this threshold. Second, we estimate the practical effect of our findings in terms of pounds of toxic material generated and processed. Such an assessment cannot be made by simply assessing the coefficient estimate. This is because our dependent variables of waste generation, waste processing, and releases have removed industry, year, and size effects. Therefore, we provide an assessment of the magnitude of these effects for the average-sized firm in the petroleum-refining industry (SIC 2911) in 1996. We choose this industry because it is a large understandable industry with many companies and many foreign-owned facilities.

RESULTS

Table 3 presents the results from our empirical analysis. We first focus on the hypothesized variables. Following this we discuss results with respect to some of the control variables.

Column 1 presents the ordered logistic regression analysis that assesses whether foreign-owned facilities have more regulatory permits than their U.S. counterparts. We find a non-significant effect for FOREIGN in the model in column 1 and thus we do not support Hypothesis 1a. Thus, we cannot demonstrate that regulators treat foreign and domestic establishments differently when enforcing the Clean Water Act, and therefore find no direct evidence of regulatory discrimination.

Column 2 examines the relative waste processing of foreign and domestic firms (Hypothesis 1b). Controlling for the level of waste generation, we find the coefficient estimate of FOREIGN

[7] Greene (1993: 475) notes how the random-effects specification is estimable when the specification contains regressors that do not vary by establishment.

[8] Leamer's formula for accepting significance is $F_{r,n-K} > [(n-K)/r]^*(n^{r/n} - 1)$, where r is the number of restrictions in the test, n is the sample size, and K is the number of coefficients that are estimated in the specification (including the intercept). For tests of the individual coefficient estimates, r equals 1. In order to calculate the t-value cut-off, we take advantage of the relationship that the square of the t distribution with x degrees of freedom equals the F distribution with $1,x$ degrees of freedom.

Table 3. Regression analyses (standard errors in parentheses)

Model Number	1.	2.	3.	4.	5.	6.	7.
Method used	Ordered Logit	GLS with establishment random-effects					
Dependent variable	Permits	Relative proc.	Relative waste gen.	Relative onsite proc.	Relative waste gen.	Relative onsite proc.	Relative releases
Foreign	0.02	0.09*	0.14*	0.04			0.08
	(0.04)	(0.02)	(0.04)	(0.03)			(0.04)
Relative recycling††					0.04	−0.03	
					(0.06)	(0.05)	
Relative price of oil					0.14	−0.14	
					(0.07)	(0.06)	
Relative waste generation	0.24*	0.71*		0.44		0.48	
	(0.02)	(0.00)		(0.02)		(0.02)	
Relative employees	0.39*	−0.04*	−0.17*	−0.06*	−0.14*	−0.06*	−0.18*
	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
Relative employees^2	0.00	−0.00	−0.04*	−0.01	−0.05*	−0.02*	0.00
	(0.01)	(0.00)	(0.00)	(0.00)	(0.01)	(0.01)	(0.00)
U.S. multinational	0.20*	0.04	0.02	0.02			0.01
	(0.04)	(0.01)	(0.02)	(0.02)			(0.02)
ln(number of plants)	0.17	0.02	0.09*	0.04*	0.02	0.07*	0.06*
	(0.13)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.01)
State dispersion	0.16	0.08	0.22*	0.06	0.14	0.10	0.12
	(0.06)	(0.04)	(0.06)	(0.06)	(0.17)	(0.15)	(0.05)
Regulatory stringency	−0.29*	−0.01	−0.07*	−0.04*	−0.07*	−0.03	−0.08*
	(0.02)	(0.01)	(0.01)	(0.01)	(0.03)	(0.03)	(0.01)
Constant		−0.09*	−0.28*	−0.10*	−0.05	−0.15	−0.06
		(0.02)	(0.03)	(0.02)	(0.13)	(0.11)	(0.04)
N	20605	20605	20605	20605	3413	3413	20605
Chi-square (d.f.)	2196.8	21505.3	644.94	5327.42	155.8	856	659.9
	(8)	(8)	(7)	(8)	(7)	(8)	(7)
Adj R^2	0.07†	0.62	0.02	0.29	0.01	0.29	0.02
Proportion of residual due to u_i		0.68	0.80	0.72	0.83	0.75	0.80

* t-value of estimate exceeds Leamer's suggested t-value (3.14 when $n = 20605$ and 2.85 when $n = 3413$)
[a] pseudo R^2
[b] No information available on China, India, Israel and Taiwan

to be positive and significant.[9] We further examined the robustness of this finding by investigating specifications with deviations in the *percentage* of waste processed at a facility as the dependent variable. We found results that were consistent with those that we report. The economic difference between foreign and domestic firms is also important. For example, in the context of petroleum refining, the coefficient represents about an additional 19,000 pounds of waste processing for a facility of mean size (170 employees) in 1996. Therefore, as predicted by Hypothesis 1b, our results indicate that foreign establishments perform more waste processing than U.S.-owned establishments.

[9] We recognize that our specification includes an endogenous variable (i.e., Relative Waste Generation is the dependent variable in column 3). The estimates of this specification will have desirable properties only if the errors (i.e., ε) in columns 2 and 3 are uncorrelated. Because we control for establishment random effects in both models, we expect that we have removed a primary potential driver of correlation among the error terms across equations (i.e., unobserved establishment characteristics). For a more complete discussion of endogeneity and estimating strategy performance see Shaver (1998). If we remove relative waste generation from this specification, the coefficient for FOREIGN becomes (0.18) and remains significant.

Column 3 presents the test of Hypothesis 2, which argues that foreign-owned firms generate more waste than their U.S. counterparts. Consistent with this hypothesis, the coefficient estimate for the variable FOREIGN is positive and significant. Although the coefficient is statistically significant, the adjusted R^2 of the model is quite small. This small R^2 is to be expected. In generating the dependent variable we have already removed most size and industry effects—two very important determinants of waste generation. In addition, more than three-quarters of the variance not explained by the independent variables can be attributed to the establishment random effect. Therefore, the idiosyncratic firm–year error component is relatively small. Turning to the economic importance of the effect, the coefficient represents about 140,000 pounds more waste generation for a petroleum refinery of mean size in 1996.

The combination of the stringent significance level and the large magnitude of the estimate lends support to the existence of an underlying effect. Thus, our results support Hypothesis 2 and do not support the counterargument that foreign firms possess more efficient technology and generate less waste. It appears that the difficulties of operating in the U.S. environment offset any advantage that foreign firms have with respect to waste prevention technology.

We now turn to Hypothesis 3, which makes a more refined comparison of the differences in firm technology by assessing if foreign-owned establishments perform more onsite waste processing. In Column 4, we find no evidence that foreign-owned facilities do more onsite waste processing because the coefficient estimate is not significantly different from zero.

To test Hypotheses 4a and 4b, we investigate if home country differences influence waste generation and onsite waste processing of foreign-owned facilities in the United States. In order to perform this analysis, we first restrict the sample to the foreign establishments. Due to data availability for recycling levels, we exclude establishments from China, India, Israel, and Taiwan (a total of seven establishments or less than 1% of the total number of foreign facilities). As shown in Columns 5 and 6, we do not find significant coefficient estimates for recycling or the price of oil in either column and thus find no support for Hypotheses 4a or 4b. Indeed, the effect of higher home country oil prices is nearly significant in the opposite direction to the one hypothesized. That is, higher oil prices in the home country seem to be associated with more waste generation and less onsite waste processing in the United States. One explanation for this would be that less efficient foreign firms move to the United States to take advantage of lower oil prices.

Finally, we wish to investigate the net effect of the hypothesized pressures on the amount of pollution released by foreign-owned facilities and answer the practical question: are aliens green? We show that foreign-owned facilities generate more waste, but we also show that they tend to process (treat, recycle, or burn) more waste. What is the net effect of these offsetting activities? In Table 3, Column 7 we use the variable at the end of the Pollution Chain, RELATIVE RELEASES, as the dependent variable. The estimate of FOREIGN in this specification is positive, but the t-value does not exceed the cut-off that we have adopted given our large sample size. It appears that foreign-owned facilities generate more waste and process more waste than their domestic counterparts, but these two tendencies counter each other enough so that one cannot conclude that they release more pollution.

In summary (see Table 4), we find support for theoretical predictions that foreign firms' unfamiliarity with local business conditions will constrain their waste reduction options and cause them to produce more waste. We find no evidence that any inherent technological superiority counteracts this tendency or causes them to conduct more onsite waste processing. Nor do we find that home country conditions influenced the U.S. performance of foreign-owned facilities. Our findings are more equivocal about whether or not foreign-owned facilities face increased stakeholder pressure. When we control for their level of waste generation, foreign firms process more of their waste. However, we find no direct evidence that they face discrimination from regulatory agencies, and foreign firms do not release less waste than their U.S. counterparts. This may suggest that the higher waste-processing levels simply represent a means of compensating for higher levels of waste generation.

We now turn to the results of the control variables. Interestingly, the pattern of results for two of these variables suggests that all firms have difficulty in operating across multiple jurisdictions. The sign and significance for STATE

Table 4. Summary of findings

Underlying arguments	Hypotheses	Findings
Foreign firms face heightened stakeholder pressure.	1a: Foreign-owned establishments will be more stringently regulated than their domestic counterparts.	Not supported
	1b: Foreign-owned establishments will do more waste processing than similar domestic establishments.	Supported
Foreign firms have difficulty operating in local environment.	2: Foreign-owned establishments will generate more waste than U.S.-owned establishments.	Supported
Foreign firms have superior production technology.	3: Foreign-owned establishments will do more onsite waste processing than U.S.-owned establishments.	Not supported
	Facilities owned by companies from countries with:	
Conditions in the home country affect the technological capabilities of foreign-owned facilities operating in the U.S.	4a: High-priced energy will produce less waste than those from countries with low priced energy.	Not supported
	4b: Greater waste processing will perform more onsite waste processing than those from countries with less waste processing.	Not supported

DISPERSION suggest that firms that operate in more states generate more waste. The difficulty of operating multiple establishments is highlighted by the significance of the coefficient of LN(NUMBER OF PLANTS). We find that the greater number of establishments that a company operates in the United States, the higher the level of relative waste generation, relative onsite processing, and relative releases (Columns 2, 4, and 7).[10]

Another control variable, REGULATORY STRINGENCY, takes a negative value across all columns and is significant in all columns except 2 and 6. Consistent with expectations, relative waste generation, relative releases, and relative onsite processing are all lower in states with more stringent regulations. Interestingly, permits are also lower in states with more stringent environmental regulations. This might reflect the fact that federal and state regulations are partial substitutes.

The coefficient estimates of MULTINATIONAL are not significant in the models where relative waste generation, relative releases, relative processing, and relative onsite processing are the dependent variables. Thus the empirical evidence does not suggest that the variable FOREIGN is capturing an effect of multinationality. Interestingly, U.S. MULTINATIONAL is positive and significant when PERMITS serve as the dependent variable.

With respect to the robustness of our findings, the random effects specification helps to reduce misinterpretation due to unobserved heterogeneity, but it does not rule out the possibility that unmeasured facility attributes have an impact. For example, foreign firms might also operate facilities that are older than domestic companies. This age difference, not foreign ownership, might cause our findings. To help rule out this rival hypothesis, we gathered data on establishment age for approximately 40% of our sample. When we include age and control for the effect of the change in sample, the coefficient magnitude and significance for FOREIGN remained stable. These results suggest that the variable FOREIGN is not capturing an age effect.[11]

[10] It is possible that we underestimate the number of facilities operated by foreign firms (those outside of the United States), and thus this inaccuracy accounts for some of the significance of the FOREIGN variable. However, the same tendency to underestimate the number of facilities should hold true for U.S. multinationals, and we do not see significance for this variable in the aforementioned columns.

[11] In further sensitivity analysis, we included the variable 'company age in the U.S.' to control for the possibility that company experience in dealing with U.S. regulations might vary by foreign and domestic companies. We found consistent results when we included this variable. Therefore, we have further evidence

Before concluding, it is important that we recognize that limitations to our analysis exist. Although we improve on some previous measures, our variables may not perfectly measure the constructs we seek to evaluate. Thus, it is important we not overinterpret our results and confuse lack of support for a hypothesis with disconfirmation. Moreover, other limitations of our analysis arise from its setting. We consider only the chemical and petroleum sectors in the United States. In addition, our empirical results focus on the environmental conduct of companies in one highly regulated nation. It is possible that the uniqueness of the U.S. regulatory environment makes the results nongeneralizable to other highly regulated states. For example, it is often said that the United States emphasizes 'command and control' regulation, while other countries emphasize more cooperative approaches. In the last ten years, however, the United States has implemented incentive-based mechanisms and voluntary initiatives between government and business (Lyon and Maxwell, 1999). Still, it is possible that the foreign-owned firms in another highly regulated state (e.g., Germany) might behave differently than those in our study.

CONCLUSION

So, are aliens green? Our results suggest not. Our research suggests that firms operating in unfamiliar business conditions have difficulty responding to environmental demands. As a result of these general difficulties, foreign-owned facilities in the United States generate more waste.

Our results suggest that the tendency for firms to seek pollution havens or avoid environmental responsibility is only part of the environmental story, particularly in highly regulated nations. We find that foreign firms are at a disadvantage when operating in a host country, and we conclude that this is because they are unfamiliar with its business, cultural, and legal environment (e.g., Hymer, 1976; Caves, 1971; Buckley and Casson, 1976; Dunning, 1977). We also find that foreign firms expend considerable effort to compensate for this disadvantage by ameliorating more of the waste that they generate.

that age does not spuriously drive our results. Nevertheless, we recognize that assessing the effect of experience on performance is often difficult (e.g., Shaver, Mitchell, and Yeung, 1997: 819).

Our analysis also begins to reveal that the difficulties faced by foreign firms in a host country reflect more general difficulties faced by all firms that operate facilities across multiple jurisdictions. Facilities owned by firms with more numerous and more dispersed operations generate more waste. Managing across numerous far-flung operations may require the creation of standard practices and procedures. These standards may then impede local ingenuity and local performance.

Our research also casts doubt on the generality of the 'Porter hypothesis' that home country regulation will influence the performance of firms when operating abroad. The sign of our measures for home country conditions is in opposition to the predicted direction, and the coefficient for the price of oil approaches statistical significance. This difference may be caused by our chosen dependent variable. Porter and van der Linde (1995) hypothesize that home country regulation will raise the financial performance of firms operating abroad, and we only consider environmental performance. However, it seems logical that home country regulation would *most* affect the environmental capabilities of the firm. One would expect that having experienced high factor prices or high regulation in the home country, the company would have developed lower-cost means for reducing waste or recovering the waste that they produce. Our analyses suggest no such effect. Thus, our analysis supports the contention of Rugman and Verbeke (1998) that responding to local conditions requires investments that provide little general benefit.

For policy-makers, our research provides new insight into the costs and benefits of harmonizing regulation across nations. Our research suggests that local regulation may provide a competitive advantage for local firms. Moreover, our evidence suggests that great harmony is likely to be needed to level the playing field. We find that within the United States differences in conditions across the 50 states may still impede waste prevention, thus suggesting that harmonization would have to be even greater than that obtained within the United States.

For firms, our research highlights the difficulty of managing multiple facilities across multiple divisions. We do not measure how firms govern their far-flung operations, but we infer that current governance techniques impede the ability of facilities to efficiently respond to local conditions. Indeed, news reports indicate that managers increasingly recognize the need for greater intrafirm flexibility, particularly with respect to environmental regulation. BP Amoco has replaced its global emissions policies with a tradable permit scheme (Houlder, 1998). Within this system local facilities can trade emissions, and managers hope that this flexibility will allow the firm to efficiently and effectively reduce pollution. Thus, at BP Amoco at least, managers recognize the difficulties caused by managing across numerous regulatory environments, and seek to find ways to overcome these difficulties. As more nations enact strict environmental regulation, such skills will become even more important.

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