Exporters and the Environment

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Abstract

This paper documents a relationship between international trade and environmental performance at the plant level. Using a panel of establishment-level data from 1990-2006, I estimate the relationship between export orientation, import competition and pollution emissions. I find a robust relationship between international trade and pollution levels. Exporters emit 9-13% less after controlling for output, but there is significant heterogeneity across industries. Import competition is associated with the exit of the smallest, most pollution intensive plants. There is no evidence that this result is caused by polluting firms relocating to countries with low levels of environmental regulation and importing back into the U.S.

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1 Introduction

Deepening cross border links have brought increased attention to the impacts of international trade on the environment. There are significant economic literatures analyzing the effect of trade liberalization on pollution, the pollution haven hypothesis, the Environmental Kuznet's Curve and the impact of environmental regulation on trade. Despite all this attention, surprisingly little is known about international trade's effect on individual polluting establishments. This paper focuses on the relationship between international trade orientation and environmental performance at the plant level.

The theoretical literature has produced conflicting results on the influence of international trade on pollution levels. Copeland and Taylor (1995) find that trade liberalization can lead to an increase or decrease in pollution depending on how incomes differ across countries that liberalize. Cole and Elliott (2003) suggest that models which use differences in environmental policy to generate trade between countries find an increase in emissions after liberalization. Models that use differences in endowments to generate trade typically find a decrease in emissions post-liberalization. These conflicting results suggest the need for empirical studies of the impact of trade on pollution emissions.

Much of the empirical work analyzing the impact of globalization on the environment relies on cross-country variation in pollution levels and trade behavior. Antweiler et al. (2001) compare levels of openness to pollution concentrations and find that greater openness is associated with small but significant decreases in pollution. Frankel and Rose (2005) employ instruments to control for possible endogeneity in trade policy, environmental policy and income levels. They also find greater openness associated with decreases in pollution levels, though the results are not statistically significant for some pollutants. This literature has identified several macro channels through which trade and the environment are related, but provided few details on the micro foundations of those impacts.

A currently emerging literature seeks to introduce firm heterogeneity into the trade and environment debate. There is an extensive international trade literature examining firm-level heterogeneity's impact on international trade behavior. This research has found that firms that serve foreign markets through exports tend to differ substantially from firms that only enter domestic markets. Exporters tend to be larger, more productive and pay workers more than their competitors[1]. Introducing productivity differences into the trade and environment debate provides some evidence of how international trade exposure may impact firm-level emissions. Batrakova and Davies (2012) show that exporters use energy more efficiently than competitors for a panel of Irish firms. Cui et al. (2012) develops a model of firm productivity, pollution emissions and international trade decisions that predicts exporters will pollute less than non-exporters. Gutierrez and Teshima (2011) assess the impact of import competition on pollution from Mexican polluters.

In this paper I seek to empirically assess the relationship between international trade, environmental performance and productivity. The results provide a grounding for future theoretical work and context for existing country-level empirical analysis. I discover a strong relationship between productivity, international trade and environmental performance and establish several stylized facts using a unique dataset describing plant characteristics and pollution levels. The results show that exporters generate significantly less pollution emissions than non-exporters and that those emissions are less toxic than other establishments in the same industry. Import competition appears to drive less productive, more pollution-intensive establishments out of business. This could provide an important channel through which international trade liberalization can lead to reductions in overall emissions levels, as has been observed in the existing empirical literature.[2]

I also test several hypothesized channels through which productivity may impact environmental performance and trade behavior. I find some evidence that establishment age and management quality may play a role, but little evidence that liability concerns or size are driving establishment behavior. After controlling for the hypothesized channels, there is still a significant relationship between productivity, trade and pollution that remains unexplained. Although I cannot rule out the possibility that these statistical relationships are caused by other factors, the overall patterns appear generally robust. Finally, I develop a theoretical framework consistent with the stylized facts

[1]See Bernard and Jensen (2004) and Bernard et al. (2003) among many others for more details on the differences between exporters and non-exporters.

[2]Most notably, Antweiler et al. (2001) find a small, but statistically significant, negative relationship between international trade intensity, measured as exports plus imports divided by GDP, and ambient pollution concentration for the average country in their data set.

gleaned from the data that ties environmental performance and international trade orientation to underlying establishment productivity.

This paper proceeds as follows. Section 2 describes the establishment level dataset constructed from several different sources and section 3 lays a out a empirical framework consistent with the data. Section 4 analyzes exporters environmental performance relative to non-exporters in the same industry and section 5 seeks to establish the channels through which environmental performance, international trade orientation and productivity are related. Section 6 analyzes the impact of import competition on polluters in the United States, including searching for a pollution haven effect and section 7 concludes.

2 Data

This paper employs a unique dataset to test for relationships between international trade and environmental outcomes at the establishment level. The data are constructed by merging the National Establishment Time Series (NETS) with the EPA's Risk-Screening Environmental Indicators (RSEI). The NETS is compiled from Dunn and Bradstreet data on creditworthiness by Walls and Associates. Dunn and Bradstreet collect establishment level information that is used to generate credit scores. These scores are required to receive government contracts and are used to make decisions about accepting payment, leasing equipment or office space and setting financing terms. The data is collected by surveying establishments, tracking payment histories with other establishments and through research in trade publications and news archives.

Neumark et al. (2011) analyze the NETS data and compare it to data collected by the Current Population Survey (CPS) and the Current Employment Statistics (CES) Payroll Survey. They find that the NETS data on employment is of comparable quality the CPS and CES. They also use a media search to find reports of plant relocation. The NETS reflected around three-quarters of the moves that crossed a county or city line. That rate is similar to the rates found in Lexis-Nexis and Hoovers.com company location datasets.

The data is annual from 1990-2006 with observations on the number of employees, value of sales, an indicator variable if a plant exports, information on corporate parents, SIC codes at the

8-digit level and credit rating among many other variables. The NETS contains no information on capital making estimating productivity using a production function approach impossible. The data set acquired for this study contains about 35,000 unique manufacturing (SIC 20-39) establishments that have disposed of toxic chemicals during the study period.[3] The largest drawback of the NETS is that it includes no measure of capital expenditures or stocks. This makes estimation of establishment level productivity particularly difficult. For that reason I am forced on the export indicator as a proxy for high productivity establishments.

The RSEI is an establishment level record of toxic pollution emission collected by the EPA. Establishments that hold on-site more than a threshold level of any of the approximately five-hundred toxic chemicals listed by the EPA, have more than ten employees and are in specific "covered industries" must report how these chemicals are disposed. Specifically, establishments must report the quantity and disposal media (air, water, landfill, etc.) for each listed chemical. That information is used to build an annual report on emissions called the Toxic Release Inventory (TRI). Most existing empirical research on emissions rely on pounds of toxic emissions as reported in the Toxic Release Inventory available on the EPA website.

Pounds of emissions, however, are an imperfect measure of the environmental damage generated by pollution. The chemicals on the EPA list are extremely heterogenous with respect to toxicity and some establishments produce huge qualities of relatively benign waste while others produces very small quantities of extremely hazardous chemicals. To address this issue the Risk Screening Environmental Indicators weights emissions quantities reported in the TRI by toxicity level as measured in epidemiological studies. This generates a hazard score that encompasses both the quantity and toxicity of emissions and produces a clearer picture of the damages caused by pollution. The hazard score is then combined with reported disposal media and population characteristics (density and age structure) in the area around the establishment to create a measure of the risk of emissions to the nearby population. In the analysis that follows I will employ the hazard score as the primary measure of manufacturing establishments pollution emissions.

[3] Only establishments that are listed in the TRI and RSEI data are included this dataset so the results must be interpreted with caution. The decision to enter into TRI reporter status is not modeled here and results apply only to TRI reporters. The estimates here may not be representative of all manufacturing establishments.

RSEI and the TRI, which is the primary source for RSEI data, are not an ideal source of pollution data. Firms whose holding of toxic chemicals fall below reporting thresholds are not included. There is also evidence that establishments may be underreporting their pollution emissions (see Marchi and Hamilton (2006) and Koehler and Spengler (2007)). Both issues generate measurement error in the primary dependent variable employed in the empirical analysis. As long as this measurement error is uncorrelated with the explanatory variables it will bias the estimates towards zero. The existing literature provides no evidence that underreporting in a particular industry is a function of establishment size or international trade orientation.

The RSEI contains annual data on three measures of emissions (pounds, hazard and risk) for each establishment that exceeds the reporting threshold from 1988-2006. The data also contains a DUNS number field, which is the identifier used by Dunn and Bradstreet to index establishments, along with a variety of location information. I have used those fields to match NETS data to the emissions data in RSEI.[4]

The merged dataset is an unbalanced panel of between 12,000 and 14,000 annual establishment-level observations between 1990-2006. Approximately 7,500 of these establishments survive throughout the study period. To control for the price inflation the values of sales was divided by the manufacturing PPI deflator provided by the BLS.[5] The matched data set is summarized in Table 1. The full sample means are reported in column 1 with standard deviations in parentheses. Columns 2 and 3 report the non-exporter and exporter summary statistics respectively.

3 Empirical Framework

Cui et al. (2012) develops a simple framework that adds pollution emissions as a by-product of production to a heterogenous-firm monopolistic competition trade model similar to that developed in Melitz and Ottaviano (2008). In this model, a large group of potential entrepreneurs pay a fixed cost (f_e) and draw a productivity level (φ) from a common distribution $g(\varphi)$. Entrepreneurs who draw a sufficiently high productivity pay a fixed cost of production (f_d) and have the option to pay

[4]Walls & Associates, the data provider, assisted in the matching. See the appendix for more details on the merging procedures, matched and unmatched samples.

[5]See Levinson (2009) for a summary of the tradeoff between using industry specific and economy wide deflators.

a fixed cost (f) to install "clean" production technology. The firm production function is:

$$q_j = \varphi F_j(e, l), \tag{1}$$

where q is establishment output, e is pollution emissions and l is labor input. Each firm produces a unique variety and consumers' have Constant Elasticity of Substitution (CES) presences. The lack of capital data in the NETS forces me to assume that all producers in an industry employ the same technology and absorb that technology with industry level fixed effects.

The model can be solved for a set of cutoff productivities under some plausible assumptions on the magnitude of these fixed costs. It can be shown that $\varphi_d > \varphi_X > \varphi_c$. Entrepreneurs that draw a productivity below φ_d do not enter the market. Firms between φ_d and φ_x produce for the domestic market only. Firms above φ_x export and those with productivities above φ_c produce using the clean production technology. Firm emissions intensities are calculated from the production function:

$$\frac{e_{dh}}{q_{dh}} = (\frac{c_d s_d^e}{p_e})\frac{1}{\varphi} \tag{2}$$

These emissions intensities can then be used to solve for the difference between emissions levels in domestic-only firms and exporters. The difference can be decomposed into a market share effect, a technology effect and a productivity effect. The market share effect is an increase in emissions associated with higher production levels from the more productive firms. The technology effect is the reduction in emissions associated with adoption of the clean technology. The productivity effect is the reduction in emissions from a more efficient transformation of pollution (and labor) into output.

It is possible to use the Cui et al. (2012) framework to motivate the empirical approach employed here. In this framework plants differ in productivity, which is exogenously determined. Pollution emissions are a function of output and productivity. The model predicts that exporting firms will have lower emissions intensity than non-exporters. The empirical results suggest that the "market share" effect on emissions intensities must be smaller than the combined impact of the technology and productivity effects.

Expanding the Cui et al. (2012) model to consider the impact of import competition is straightforward. Imports reduce the domestic prices for all varieties, which shifts the cutoff productivities. Defining a new set of productivities $\varphi_d > \varphi'_d$, firms between these two productivity levels exit in response to import competition. These firms will be the least productive firms, with the highest emissions intensity in a given industry. Industries with high levels of import competition should see fewer high emissions intensity firms.

In this framework, productivity is exogenous and determines export orientation, environmental performance and response to import competition. While this is consistent with the results presented below, the direction of causality is uncertain. For example, establishments in jurisdictions with strong local environmental regulations may be forced to pollute less, but may also have higher productivity through a Porter hypothesis effect,[6] in which regulation induces cost saving innovations that reduce emissions and increase productivity. Another possible explanation is that exporters enjoy increased productivity through contacts with consumers in other markets.[7] This increased productivity could lead to improved environmental performance and generate the relationship observed in the data. Unfortunately the data is not rich enough to distinguish between these hypotheses. The channel through which international trade, pollution emissions and productivity are related remains an open question.

4 Exporters' Environmental Performance

This section describes the differences in environmental performance between exporters and non-exporters. Table 1 summarizes the differences between exporters and non-exporters across several establishment characteristics reported in the NETS. Column 4 reports differences between the sample means of non-exporters and exporters. Stars denote statistical significance of a t-test for difference in sample means. Exporters are larger as measured by both sales and employees. This result is consistent with the voluminous international trade literature on the importance of firm heterogeneity. This research has found that firms that serve foreign markets through exports tend

[6]See Porter and van der Linde (1995) for a full description of the Porter Hypothesis. It should be noted that empirical evidence of such an effect is decidedly mixed.

[7]See Biesebroeck (2005) for an empirical estimation of productivity increases from entering export markets.

to differ substantially from firms that enter only domestic markets. Exporters tend to be larger, more productive and pay workers more than other firms in the same industry.[8] Despite extensive documentation of the differences between exporters and non-exporters and the sources of these differences, the differences in environmental performance between exporters and non-exporters have not been widely analyzed.

Exporters hazards scores are over 220 points[9] higher than non-exporters a difference of around than 10%. Exporters are also significantly more likely to relocate and be foreign owned than non-exporting manufacturing facilities. Exporters hazard points per sale are much lower than non-exporters, but the due to the large standard deviations of both series these differences are not statistically significant.

Following the firm heterogeneity literature, I seek to analyze the difference in environmental performance between exporters and non-exporters within industries. I conduct a series of fixed-effect regressions to analyze the emissions conditional on establishment characteristics and industry. These regressions are based on pollution production functions as described in Cui et al. (2012). The estimation equation takes the form:

$$E_{ijt} = \alpha + \pi W_{ijt} + \beta Ex_{ijt} + \gamma_j + \delta_t + \epsilon_{ijt}, \tag{3}$$

where i references an establishment, j indicates an industry and t indexes years. The outcome variable, E_{ijt} is an establishment-level measure of hazard score from the RSEI.[10] γ_j is a set of industry fixed effects that control for the differing levels of emissions intensity across industries and δ_t are year fixed effects. ϵ_{ijt} is the stochastic error term. W is a vector of plant-level characteristics such as sales, employees and credit ratings. Ex_{ijt} is an indicator variable that equals 1 if the plant exported any amount of its production and β is the parameter of interest. It measures the difference in plant-level emissions between exporters and non-exporters conditional on all the

[8]See Bernard and Jensen (2004) and Bernard et al. (2003) among many others.

[9]Hazard scores are calculated by multiplying a toxicity score by the pounds of emissions and scaled by dividing by a million, so the units cannot be interpreted directly.

[10]As a robustness check I also perform the estimation using truncated regression where the sample is truncated to include only establishments that exceed the EPA's RSEI reporting requirements. The results presented here are not significantly different.

plant-level characteristics and indicator variables. The combination of fixed-effects means that β is identified from variation between exporters and non-exporters in the same industry during the same year. The NETS data reports only an indicator for whether the facility has exported in the most recent year so the model cannot include establishment fixed effects. Bernard and Jensen (2004) find reasonably high levels of persistence in exporting and to the extent establishments that have formerly exported are classed as non-exporters this will bias the estimated exporter coefficient towards zero.

The regression results are described in Table 2. They examine the relationship between exporting status and pollution emissions after controlling for industry type. Pollution emissions are measured in hazard scores as reported by the RSEI. Industry classifications are at the 6-digit SIC level as reported in the NETS and confirmed (at the four-digit level) in the RSEI. In regression 1, the impact of exporter status is measured without controlling for sales. The β coefficient is 0.063 suggesting that exporters generate around 6% more emissions (measured in hazard points) than their competitors in the same industry. Exporters tend to be larger than non-exporters so this difference could be attributable to establishment size or pollution-intensity. In regression 2, I control for establishment-level output to separate the impact of plant size and pollution intensity. The β coefficient shifts to negative and is significant at the 1% level. Exporters pollute more than 13% less than non-exporters after controlling for size differences.

Differences in environmental regulations over space and time may significantly impact establishments' environmental performance and be related to exporting status. For example, coastal states with relatively high per capita incomes might have stricter environmental regulations and may also be more likely to be home to exporters seeking access to foreign distribution channels. Similarly, environmental regulations have been strengthening over time, so if newer plants are more likely than average to be exporters, then this may bias the exporter coefficient downward. To address these issues I include state- and year-fixed effects in regression 3.[11] The β coefficient remains negative and significant, but drops in magnitude to 0.100.

In the fourth regression I include additional controls that may be related to export status and

[11]These regressions have also been estimated using county fixed effects and four-digit SIC fixed effects and the results were similar.

emissions. Including the number of employees as well as the reported level of sales controls for the NETS reported sales per worker of the establishment. Establishments that relocate often may be moving to take advantage of changes in environmental regulation and/or exporting infrastructure. To control for that possibility, the number of times a firm has changed location during the time period is included as a control in this regression. I also include a variety of controls reported in the NETS which may directly affect environmental performance or be correlated with attributes that do. The estimated environmental performance of exporters remains just over ten percent better than their non-exporting competitors. The additional controls reduce the output effect of sales on emissions slightly, again the β coefficient drops in magnitude, but remains significant at the 1% level.

Regressions 1-4 confirm that after controlling for output, exporters generated fewer emissions than non-exporters. The elasticity of emissions intensity is estimated to be between 0.40 and 0.81 depending on the specification. This could be due to significant fixed costs required for manufacturing production or economies of scale in emissions. Perhaps large establishments are more likely to invest in abatement technology to reduce emissions, or larger scale manufacturing allows for more efficient and less polluting production techniques. With the existing data it is difficult to pinpoint the determinants of this elasticity.

Table 3 summarizes the results of estimating equation 3 across industry definitions. The results highlight the significant heterogeneity in "environmental returns to scale" and exporters environmental performance across industries. Increases in output in the lumber and wood industry (SIC 24) are associated with decreases in hazard score.

In nine of the twenty two-digit SIC industries exporters are less pollution intensive, but that difference is only statistically significant in 7 of those industries. In the oil and gas industry (SIC 29) exporters have a 83% lower hazard score controlling for reported sales, while in the apparel and other textile industry (SIC 23) exporters are 160% more pollution intensive though the estimate is not statistically significantly different from zero.

The environmental performance of exporters appears to be correlated with the productivity advantage exporters have other firms in the same industry. I calculate the average sales per worker for each firm removing the industry and year means and calculate an exporter output per worker advantage for each two-digit SIC industry. The difference sales per worker between exporters and non-exporters is highly correlated with the environmental performance gap between exporters and non-exporters in a two digit SIC industry. Industries in which exporters have significantly higher sales per worker tend to be the industries where exporters environmental performance exceeds their non-exporter competitors.

Even, these estimates understate the level of variation in environmental performance across industries. Within a two digit SIC industry many of the four digit industries exhibit significant variation in both environmental returns to scale and exporter environmental performance. Similarly within a four digit industry there may be significant variation within the six digit industries.

Table 4 describes the environmental performance of exporters across a variety of different classes of pollutants. The Toxic Release Inventory includes indicators for a variety of pollutant classifications for each chemical reported.[12] Because not all facilities in the dataset report each of the chemicals I estimate a series of Heckman selection models in which the first stage is a probit which estimates the probability of emitting a specific class of chemicals, and the second stage is based on the baseline specification described in equation 3 controlling for selection into emitting a particular class of pollutants.[13]

Exporters environmental performance is typically better than their non-exporting competitors across pollutant classes. They emit significantly fewer metals and persistent bioaccumulative toxins (PBTs) and the exporter coefficients are negative, but imprecisely estimated for hazardous air pollutants regulated under the Clean Air Act and dioxin emissions. Emissions of carcinogens do not follow the pattern of other pollutant classes. Exporters emit around 6% more than non-exporters after controlling for selection conditional on observables. Increases in output are associated with reduced carcinogen releases. The chemical (SIC 28) and rubber (SIC 30) industries are the largest carcinogen emitters, but there is no obvious explanation for the differences in pollution patterns

[12] Classifications include carcinogens, metals, carcinogenic metals, dioxin, persistent bioaccumulative toxins (PBT) and Clean Air Act Chemicals. The CAA chemicals are chemicals listed as hazardous air pollutants such as arsenic, chromium and mercury, not the more well known criteria pollutants (sulfur dioxide, nitrous oxides).

[13] The results are qualitatively similar with identification from non-linearities in the inverse-Mills ratio and exclusion restrictions based detailed (8-digit SIC) industry fixed effects or exclusion restrictions of emissions of other TRI chemical classes. The results based on emissions of other TRI chemical classes are reported here.

for carcinogens relative to other classes of emissions.

It is important to note this result is estimated on a sample of establishments that report the TRI and may not be representative of the broader manufacturing industry. The lack of capital data in the NETS forces me assume that all establishments in a six-digit SIC industry employ the same technology. The exporter environmental performance advantage could be attributable to productivity advantages, as motivated here or different levels of capital, which is unobserved. The cross industry literature has generally found that more capital intensive industries tend to be more pollution intensive and exporting firms tend to be more capital intensive.[14] If that result holds within industry it suggests that the environmental performance differences observed here are not likely due to differences in capital. With the current dataset I cannot test that directly.

5 Relating productivity, trade and pollution

There are several hypothesized channels through which productivity may affect emissions. The correlation between environmental performance and export orientation could operate through firm size. Large firms have a high public profile and therefore may seek to limit pollution. It is also possible that productive firms are better incentivized to control the long-term liability of emitting pollution. Less productive firms may be more worried about the company's survival than minimizing a potential liability which may not appear for many years. Some authors have argued that the most productive firms locate in the regions with the strictest environmental regulations and are therefore compelled to pollute less. Exporters may be newer firms or have newer facilities which has been shown to be related to environmental performance. A final hypothesis suggests that the same management skills that generate frequent innovation and high productivity can be applied to preventing pollution emissions. While there has been research indicating that highly productive firms pollute less, there is no consensus on why this may be the case.

Arora and Cason (1996) argue that large firms have higher public profiles and therefore have a stronger incentive to reduce emissions than their smaller competitors. Larger firms may receive more attention from regulators, watchdog groups and environmentally conscious consumers. In this

[14] See Cole and Elliott (2003) and Bernard and Jensen (2004) for evidence on each of those claims respectively.

framework, exporters are larger than their competitors due to their productivity advantages. To test the impact of plant size on environmental performance I re-run the baseline estimation across 5 quintiles of establishment sales.[15] If firm size is the primary channel through which productivity impacts environmental performance, then export status (and the high productivity it signals) should not have a negative impact on emissions among the smallest firms. Table 5 lists the coefficients and t-statistics for the log sales coefficient and the export indicator variables for the baseline and each of the quintile regressions. In four of the five regressions the exporter coefficient is negative and statistically significant. There is considerable variation across quintiles in the environmental performance of exporters ranging from thirty percent cleaner in the second quintile to eight percent cleaner in the fourth. In the smallest quintile exporters pollute more than non-exporters, but this appears to be due the size distribution of exporters within the quintile. Running the regression for the second decile (11-20th percentile) exporters are significantly cleaner than non-exporters. Only in the smallest decile of establishments are exporters more polluting than non-exporters. It seems unlikely that firms in the second decile of manufacturing plant size (sales less than $4.2 million) are worried about the impact of their pollution emissions on their public profile.

The results are not consistent with the hypothesis that establishment size is the primary driver of environmental performance among exporting establishments. These results are consistent with the hypothesis that there are fixed costs in installing abatement technology. These fixed costs mean that only the largest, most productive establishments can afford to install abatement technology. Shadbegian and Gray (2005) show that abatement capital expenditures within industries vary within industry and do not increase measured productivity. Without detailed capital data at the establishment level, it is difficult to confirm this hypothesis.[16]

Konar and Cohen (1997) argue that more productive establishments may pollute less because they are more concerned with the long term liability that toxic emissions may generate. More productive firms have a larger incentive to reduce their long term liability, since they are more likely to survive to see claims made against them. Less productive firms are have a higher probability

[15]The results are robust to dividing the sample into quintiles by employees rather than sales as well estimating across deciles.

[16]I thank an anonymous referee for this suggesting this possible explanation.

of exiting and not facing the costs of higher long-term liability associated with current emissions. If this were the case we would expect the most productive firms to decrease their liability by attempting to minimize the risks associated with their emissions. This suggests exporters should have hazard and risk scores substantially lower than non-exporters. As a test of this hypothesis I employ two additional measures of emissions reported by the RSEI. The pounds of emissions is an un-weighted sum of establishment emissions with no control for toxicity and risk is a score that weights the toxicity of establishment emissions by the population characteristics of the area around the polluter. A liability minimizing polluter may reduce the toxicity of their emissions and the risk associated with that pollution.

Table 6 describes the environmental performance of exporters across the three different measures of pollution intensity. Column 1 reproduces the baseline regression for comparison. Column 2 reproduces the baseline regression with the log of pounds of toxic emissions as the dependent variable. Exporters pollute around four percent less than non-exporters within the same industry as measured by pounds of emissions. This suggests that the emissions of exporters are actually slightly less toxic than the emissions of non-exporters within the same industry conditional on the other covariates. Column 3 reports the baseline regression including with establishment risk score as the dependent variable. Here exporters environmental performance is very similar to non-exporters and imprecisely estimated. As the risk score is the best proxy for the ultimate liability of the establishment this is not consistent with liability concerns as the primary driver of high productivity establishment environmental performance.

Another hypothesized channel through which productivity, international trade orientation and environmental performance could be related is by management quality. The debate over the relationship between environmental performance. The baseline specification includes establishment credit rating calculated by Dunn & Bradstreet and reported in the NETS data.[17] The results are summarized in table 2. In the baseline (and robustness checks) a higher credit rating is associated with a small, but statistically significant improvement in establishment environmental performance. A one standard deviation improvement in credit rating (approximately 9.5 points on Dunn & Brad-

[17] Ashbaugh-Skaife et al. (2006) describe a strong positive correlation between measures of management quality and credit rating using information on German firms.

street's 1-99 scale) is associated with a three percent reduction in hazard score. This does not affect the general conclusion that exporters have better environmental performance.

A final channel to that merits exploration is establishment vintage. There is some evidence that the vintage of manufacturing establishments can affect their environmental performance. Gray and Shadbegian (2003) show a relationship between plant productivity, plant vintage and environmental performance in the pulp and paper industry. The primary channel is through technology choice which appears to vary with vintage. Heutel (2011) shows that grandfathering of environmental regulations, exempting existing establishments from environmental regulation, can affect the investment in existing dirty facilities and reduce the rate of new facility openings in the electric power sector. This represents another channel through which vintage could affect the environmental performance of establishments. If import competition affects the rate of new manufacturing plant formation or exit of existing plants those changes could have a significant impact on the environmental performance of the import competing industries.

Table 6 includes a series of regressions controlling for a linear trend in the year an establishment first appeared in the NETS flexibly through a set of fixed effects (regression 4), linearly (regression 5) and as a second-degree polynomial (regression 6).[18] The results suggest that establishment vintage plays a significant role in the environmental performance of manufacturing establishments. The general story that more productive establishments, as proxied by exporters, have better environmental performance than less productive establishments in the same industry remains unchanged. Comparing column 1 (the baseline) and column 4 which adds establishment vintage fixed effects into the regression leads to no statistically significant changes in environmental performance. In column 5 the vintage fixed effects are replaced by the year the plant first appeared in the DUNS. The coefficient is positive and statistically significant suggesting that newer establishments are actually dirtier than older establishments in the same industry conditional on covariates. Column 6

[18] This variable called "year start" in the documentation is an imperfect proxy for the age of the establishments. The data is truncated to 1990, the first year of the NETS, so all establishments that existed before the NETS list their first year as 1990 and only establishments opened after 1990 list an actual opening year. Limiting the dataset to only establishments opened after 1990 affects the magnitudes of the coefficients, but controlling for plant vintage in this limited sample has no affect on the exporter coefficient beyond the sample truncation. Many establishments report the year their company opened in addition to the year the establishment open and the results are essentially unchanged when company, rather establishment opening dates are used to proxy for vintage.

adds a plant opening year squared term to allow for non-linearities in the vintage effect. Here the linear term is negative, statistically significant and large in magnitude. The squared term is positive and statistically significant, but quite small. The vintage effect on establishment environmental performance is statistically significant and appears to operate orthogonally to the covariates in this analysis. The source of the vintage effect and its nonlinearities represent an interesting avenue for further study.

It is clear that exporters pollute less than non-exporters in the same industry after controlling for output. There are a variety of possible channels through which this relationship could operate. Several pathways appear to transmit the effect, but no single channel or combination of the channels explored here can fully explain the relationship. Unfortunately with this dataset no primary channel can be conclusively identified. The exact nature of the relationship among international trade orientation, environmental performance and productivity must remain something of a mystery.

6 Import Competition's Impact on Emissions

The previous empirical analysis has examined the relationship between export status and pollution. Import competition's impact on plant and industry pollution dynamics might also be important. Melitz and Ottaviano (2008) finds that import competition will force the least productive firms to exit in a given industry.[19] The empirical results above suggest a relationship between productivity and emissions. This section further analyzes that relationship by estimating the impact of import competition and the environmental performance of polluting establishments. Following Pavcnik (2002) I create a variable using the ratio of imports (m_{jt}) in a given industry and year to that industry's total output (y_{jt}) in that year:

$$MCT_{jt} = \begin{cases} 1 & \text{if } \frac{m_{jt}}{y_{jt}} > T, \\ 0 & \text{otherwise,} \end{cases} \tag{4}$$

[19]Melitz (2003) finds that trade liberalization leads to exit of the least productive establishments due to factor market competition from the expanding exporters. Melitz and Ottaviano (2008) relies on a different channel to produce the same effect. In that model import competition leads to reduced markups in domestic markets which leads to exit of the least productive firms. While both channels may be leading to this effect I will concentrate on the expansion of import competition making the latter model more appropriate.

where T is a threshold level of import competition that serves as an indicator for industries that face stiff import competition. Several different thresholds for exposure to import competition are tested. This variable is created using data from Peter Schott's collection of bilateral international trade data as described in Schott (2008).[20] Specifically, import competition variables are four digit SIC level dummies that indicate if more than X% of the sales in a particular industry come from imports. Import penetration variable measure the fraction of domestic demand served by imports. The trade and productivity data are reported annually at the four-digit SIC level for the years 1990-2005.

This effect is estimated using estimates of the form:

$$E_{ijt} = \alpha + \pi_W W_{ijt} + \lambda_1 \frac{m_{jt}}{y_{jt}} + \lambda_2 MCT_{jt} + \lambda_1 \frac{m_{jt}}{y_{jt}} * MCT_{jt} + \gamma_j + \delta_t + \epsilon_{ijt}, \tag{5}$$

where, as above, E_{ijt} is a plant-level measure of emissions, W_{ijt} is a vector of plant characteristics that serve as controls and δ_t is set of year fixed effects. MC_{jt} is an industry-level measure of import competition. This variable is calculated at the four-digit SIC industry level; for this reason γ is a set of industry fixed effects at the two-digit SIC level in this specification. The λ's are the parameters of interest, identified from differences in hazard scores between plants in the same two-digit industry in the same year, whose four digit industries differ in exposure to import competition.

The results of this specification are described in table 7. Regressions 1-5 test the various definitions of import competition on manufacturing plant environmental performance. Regression 1 employs import penetration ($\frac{m_{jt}}{y_{jt}}$) directly without the MCT_{jt} dummies. The results suggest that increased import penetration is associated with increases in pollution emissions in manufacturing facilities. Regressions 2 and 3 interact the level of import penetration with an indicator variable that is set equal to 1 if imports exceed 25 ($MC25_{jt}$=1) and 50% ($MC50_{jt}$=1) of domestic production respectively. Around 42% of industry year observations have import penetration levels

[20]The import penetration data is only available through 2005 cutting one year off the merged dataset and reducing the sample size for regressions including import competition data.

above 25% and 24% have import penetration levels above 50%. The results suggest that above a certain threshold increases in import competition are associated with decrease in hazard scores from manufacturing facilities. A one percent increase in import penetration beyond 25% or 50% is associated with a significantly better change in environmental performance than a a one percent increase below the threshold.

Figure 1 graphs the level of import competition on the horizontal axis against the log hazard score per dollar of output for each two digit SIC industry. Circles represent non-exporters and triangles represent exporters. Across industries there is significant variation in both the level and variance of hazard per dollar of output. Generally as the level of import competition increases the variation in hazard per dollar of output drops, driven almost entirely by reductions in the number of establishments with relatively high ratios of hazard per dollar of output. While not evidence of a causal link, these results are consistent with the hypothesis that there exists a relationship between productivity and environmental performance. High levels of import competition could lead to the exit of the least productive, most pollution intensive establishments.

The observed distribution of hazard per dollar of output does not appear to be consistent with the pollution haven hypothesis, but because of the policy import of the issue, I analyze the relationship between import competition and the the level of environmental regulation in the source country. If the pollution haven effect is driving this result then imports from countries with low levels of environmental regulation will be associated with the exit of pollution intensive manufacturers while imports from high regulation jurisdictions should have no effect. This can be tested by taking advantage of the bilateral trade data described above. The import source was matched with per capita GDP and measures of their environmental stringency from the Environmental Performance Index (EPI) compiled by Yale University. The EPI compares countries across more than 20 measures of environmental outcomes and policies. This data was used to create a weighted average of environmental measures and income for each industry's imports where the weights are the fraction of total imports from each source country. The higher the measure the better the environmental performance of the countries that import this sector's goods to the U.S. The measures of environmental performance and income embodied in U.S. imports are highly correlated, which reflects the strong relationship between environmental regulation and income.

Regressions 4 and 5 in table 7 summarize the impact of import competition controlling for the level of environmental regulation in the import source country and the level of income in the import source country respectively. In each case they are modifications of regression 3 run with an additional set of controls. The estimated impact of import penetration on environmental performance of manufacturing establishments is statistically indistinguishable after controlling for either the level of environmental protection or income embodied in an industry's import competition. The environmental and income competition interaction variables are both negative and statistically significant. That suggests that increases in import competition from low environmental regulation (or income) countries is associated with reduced hazard score even after controlling for the level of import competition and establishment characteristics.[21]

If import competition affects the rate of new manufacturing establishment formation or existing facility exit it could have an impact on the vintage of manufacturing facilities. The vintage of manufacturing facilities can in turn affect the environmental performance as described in section 5 above. To analyze the impact of import competition on polluting establishments I run a logit model on the probability of new manufacturing plant formation (births) or existing establishment exit (deaths). I estimate:

$$Logit[Prob(Birth/Death_{ijt} = 1)] = \alpha + \pi_W W_{ijt} + \lambda ImpComp_{jt} + \gamma_j + \delta_t, \qquad (6)$$

where the dependent variable is either Birth_{ijt}, which is a dummy variable equal to 1 if the establishment first appears in the NETS data that year, or Death_{ijt}, a dummy variable that equals to 1 if an establishment closes during that year. ImpComp_{jt} is a measure of import competition, either the fraction of domestic demand served by imports or a dummy for import competition levels above a certain level. I also interact the level of import competition with indicators for import competition above twenty-five and fifty percent to allow the marginal impact of import competition to vary across import competition levels. The λ coefficient(s) measure the impact of industry level

[21] Note that these results are not evidence that the pollution haven effect does not exist, but that the environmental performance differences noted described above are not caused by the pollution haven hypothesis. See Levinson and Taylor (2008) for a theory of the pollution haven hypothesis and an empirical assessment of its magnitude.

import competition on the probability of new manufacturing plant births or existing plant death. If import competition is causing the least productive (or least regulated) manufacturing plants to exit and those establishments also are more pollution intensive then increased import competition should be associated with increased probability of exit.

Table 8 summarizes the results of this estimation. Columns 1-3 evaluate the determinants of new manufacturing establishment births and columns 4-6 report the determinants of manufacturing facility deaths. New manufacturing establishments are somewhat smaller as measured by sales and significantly smaller as measured by employees. Exiting firms are not significantly larger or smaller than their competitors. New establishments are less likely to export, and exporters are less likely than other establishments in the same industry to exit.

The import competition variables are consistent with expectations. High levels of import competition are associated with a significant reduction in the probability of new establishment births. There is some weak evidence of an increase in establishment death at very high levels of import competition. The new establishment births results illustrate the non-linearity in the impact of import competition. In regression 1 the level of import penetration coefficient is positive though not statistically significant, suggesting increased competition is associated with increased manufacturing facility births. Regression 2 adds an indicator for import competition levels above twenty-five percent which is negative and statistically significant. Regression 3 replaces the import penetration above twenty-five percent indicator with an indicator for import competition levels above fifty percent. Again the indicator is negative and statistically significant. Taken together the results suggest that manufacturing facility births are relatively unaffected by low levels of import competition and then decreasing a higher levels of competition. The primary driver of manufacturing facility churn appears to be reductions in establishment births rather than increased exit of existing establishments.

The impact of import competition on polluters has implications for the trade and environment literature. The literature has separated the impact of trade liberalization on pollution emissions into three categories: the scale, technique and composition effects. These channels were first hypothesized by Grossman and Krueger (1993) and modeled explicitly by Copeland and Taylor

(1994). The scale effect is the increase in pollution due to increased economic activity generated by a trade liberalization. The technique effect is a reduction in pollution due to increased demand for environmental quality (a normal good) after a trade liberalization. The composition effect is the change in pollution due to the changes in the production (or consumption) bundle generated by a trade liberalization. This effect may generate either increases or decreases in pollution.

The technique effect is typically modeled as consumers demand for environmental quality encouraging government to increase pollution taxes to reduce emissions. This channel is certainly a possibility, but it requires government to act in response to citizens' preferences in a way that may or may not be realistic. The results of this section suggest a possible alternative channel through which trade liberalization may lead to a reduction in emissions. A trade liberalization may lead to increases in import competition which drives out the smallest, least productive and most pollution-intensive establishments. Empirical analysis comparing ambient pollution levels or aggregate emissions to trade volumes would identify this reduction in emissions, but it may be operating through industry dynamics instead of (or in addition to) the standard policy response modeled by papers in this literature.

7 Conclusion

Despite a considerable economic literature on the relationship between international trade and pollution there has been little or no research on how individual polluting establishments respond to international trade. The importance of firm heterogeneity in international trade behavior suggests that considering the environmental performance of individual establishments may provide additional insights. In fact, firm heterogeneity in environmental performance is significant and systematically related to international trade orientation. Exporters tend to pollute significantly less than non-exporters in the same industry. Further, import competition is associated with the exit of the most pollution-intensive establishments. This exit occurs regardless of the source of the imports suggesting that it is not an artifact of pollution-intensive plants relocating to areas with lower environmental regulation and importing back into the U.S.

The import competition result is particularly important in light of the empirical results on the relationship between international trade liberalization and pollution. Previous work has associated reductions in pollution levels after a trade liberalization with either increased environmental regulation (the technique effect) or trade induced changes in the relative size of different industries (the composition effect). If import competition leads to the exit of pollution-intensive establishments, it would be an additional channel through which trade liberalization could impact pollution. Comparing the relative importance of environmental regulation, changes in industry structure and within industry is left as an important but unresolved question.

I attempt to assess the channel that relates environmental performance to international trade and nominate establishment productivity as a likely causal factor. By analyzing several factors correlated with productivity, international trade orientation and environmental performance I am able to eliminate liability laws as an important channel, but establishment size, management quality, and plant vintage are important determinants of environmental performance. After controlling for these channels the majority of the productivity effect on emissions remains unexplained. The exact nature of this relationship remains an area for further study.

The results lead to several important questions about the impact of trade policy on pollution emissions. Many countries actively promote exports. To the extent that exporting increases productivity, this should lead to a reduction in firm level emissions per unit of output and likely a reduction in overall emissions. Import competition is more sensitive politically, but the results of this study suggest that improvements in productivity generated by import competition should reduce plant-level emissions in addition to broader economic efficiency gains. Any trade policy behavior that protects low productivity plants is likely to have negative environmental consequences.

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Table 1: Comparing Exporters and Non-exporters

	(1) All	(2) Non-Exporter	(3) Exporter	(4) Diff
Sales	38.9	38.4	39.8	1.4***
	(118.1)	(126.7)	(101.9)	
Emp.	286.1	276.7	302.0	25.2***
	(650.8)	(674.9)	(607.7)	
Relocation	0.12	0.10	0.15	0.05***
	(0.405)	(0.371)	(0.454)	
Female CEO	0.04	0.04	0.04	0.00
	(0.198)	(0.198)	(0.198)	
Credit Rating	67.6	67.6	67.6	0.00
	(9.5)	(9.7)	(9.1)	
Foreign Owned	0.03	0.02	0.04	0.02***
	(0.168)	(0.140)	(0.207)	
Hazard	21761	20936	23146	2215*
	(241707)	(256271)	(215028)	
Hazard/Sale	2227	3399	258	-3135
	(710399)	(897242)	(9652)	
N	185,024	115,980	69,044	

Note: Column 1 describes sample means and standard deviations (in parentheses) for the full data set, columns 2 and 3 summarize establishments listed as non-exporters and exporters respectively. Column 4 lists the difference in unconditional-means between exporters and non-exporters for selected variables. Sales are in millions of 1995 U.S. dollars and hazard scores provide a toxicity weighted measure of pounds of emissions in millions of hazard units. Stars indicate the statistical significance for a t-test for difference in group means. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level.

Table 2: Exporters' Environmental Performance

	(1) Log Hazard	(2) Log Hazard	(3) Log Hazard	(4) Log Hazard
Log Sales		0.813***	0.783***	0.405***
		(112.878)	(109.437)	(20.545)
Log Employees				0.438***
				(20.646)
Relocations				0.066***
				(3.070)
Foreign Owned				0.031
				(0.589)
Credit Rating				-0.003***
				(-2.743)
Female CEO				-0.181***
				(-4.139)
Export	0.063***	-0.134***	-0.100***	-0.103***
	(3.209)	(-7.087)	(-5.321)	(-5.467)
SIC6 FE	Y	Y	Y	Y
State FE	N	N	Y	Y
Year FE	N	N	Y	Y
R^2	0.301	0.344	0.364	0.371

Note: The dependent variable in each regression is the log of toxicity weighted pollution emissions (hazard score) for an establishment. Export is a dummy variable that takes the value of 1 if the establishment has reported exporting in the NETS. Sample size equals 185,024 for each regression. All standard errors are clustered at the establishment level. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level. Exporters pollute more than non-exporters within the same industry. Controlling for firm size by including firm output suggests that exporters have lower emissions intensities than non-exporters.

Table 3: Environmental Performance of Exporters Across Industries

SIC	(1) Sales Coeff.	(2) Export Coeff.	(3) Avg. Sales	(4) Avg. Hazard	(5) Frac. Exporter	(6) Industry Description
29	0.30***	-0.83***	87.8	2480	0.24	Petroleum & Coal
38	-0.02	-0.53***	63.5	666	0.49	Instruments & Related
31	0.14	-0.51**	21.6	1600	0.42	Leather & Leather
34	0.14***	-0.11***	17.2	1860	0.33	Fabricated Metal
39	0.18*	-0.09	20.4	898	0.49	Misc. Manufacturing
28	0.23***	-0.08**	30.5	1920	0.37	Chemical & Allied
37	-0.04	-0.08*	94.7	4520	0.35	Transportation
35	0.12**	-0.07*	43	2510	0.5	Industrial Machinery
20	-0.04	-0.05	58.9	87	0.23	Food & Kindred
30	-0.11**	0	20.6	315	0.41	Rubber & Misc. Plastic
32	0.21**	0.02	22.7	761	0.23	Stone, Clay, & Glass
36	0.32***	0.02	52.1	1820	0.4	Electronic & Other Electric
25	0.46***	0.11	27.7	1090	0.38	Furniture & Fixtures
26	-0.03	0.11	60.2	1740	0.37	Paper & Allied
24	-0.51***	0.16*	22.1	167	0.21	Lumber & Wood
33	0.29***	0.17***	33.9	7130	0.37	Primary Metal
27	0.44***	0.26**	32.7	31	0.29	Printing & Publishing
22	-0.02	0.36***	31.5	149	0.38	Textile Mill
21	0.33	0.47	155	40	0.19	Tobacco
23	0.7	1.6	25.7	69	0.25	Apparel & Other Textile

Note: Each row reports the results of an individual regression based on column 4 of table 2 above where the sample is restricted to the two-digit SIC industry reported in column 1. Column 2 reports the coefficient on log sales and column 3 reports the coefficient on exporters. Columns 3, 4 and 5 report the average sales, hazard scores and fraction exporters in the industry. Column 6 provides a brief description of the industry. Industry (SIC6), state and year fixed effects as well as coefficients for log employees, relocations, foreign owned indicator, credit rating and female CEO suppressed to conserve space. All standard errors are clustered at the establishment level. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level. There is significant variation in the environmental performance of exporters across industries.

Table 4: Exporters Environmental Performance Across Emissions Types

Dependent Var.	(1) Log(Carcinogens)	(2) Log(Metals)	(3) Log(CAA)	(4) Log(Dioxin)	(5) Log(PBT)
Log Sales	-0.243***	0.180***	0.065***	0.584**	0.162**
	(-9.670)	-6.875	-3.747	-2.338	(2.229)
Log Employees	0.480***	0.435***	0.562***	-0.447***	0.245***
	-17.697	-17.618	-30.56	(-2.923)	(4.201)
Relocations	-0.101***	-0.100***	-0.052**	-0.126	-0.152**
	(-3.416)	(-3.607)	(-2.523)	(-1.088)	(-2.498)
Foreign Owned	-0.075	0.125*	0.103**	-0.425*	0.359**
	(-1.074)	-1.94	-2.123	(-1.947)	(2.234)
Credit Rating	0.006***	-0.008***	0.002***	-0.017**	-0.009***
	-4.971	(-6.531)	-2.794	(-2.245)	(-2.997)
Female CEO	-0.308***	-0.174***	-0.243***	-0.288	0.321***
	(-5.004)	(-3.102)	(-5.745)	(-1.428)	(2.675)
Export	0.060**	-0.123***	-0.016	-0.195	-0.144***
	-2.318	(-5.353)	(-0.895)	(-1.523)	(-2.590)
SIC2 FE	Y	Y	Y	Y	Y
State FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y

Note: Each column reports the results of a Heckman Selection model with a different chemical classification reported in the Toxic Release Inventory as the dependent variable. Exclusion restrictions are emissions of other types of pollutants. Each regression includes 185,024 plant-year observations. All standard errors are clustered at the establishment level. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level. There is significant variation in the environmental performance of exporters across industries.

Table 5: Environmental Performance Across Firm Size Quintiles

Quintile	(1) Log Hazard All	(2) Log Hazard 1	(3) Log Hazard 2	(4) Log Hazard 3	(5) Log Hazard 4	(6) Log Hazard 5
Log Sales	0.41***	0.12***	0.53***	0.41***	0.19**	0.28***
	(20.54)	(2.87)	(6.18)	(3.85)	(1.99)	(6.45)
Export	-0.10***	0.10**	-0.27***	-0.14***	-0.08*	-0.20***
	(-5.47)	(2.14)	(-6.56)	(-3.21)	(-1.86)	(-4.86)
SIC6 FE	Y	Y	Y	Y	Y	Y
State FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
R^2	0.371	0.394	0.364	0.391	0.434	0.497
	185024	35314	38277	36446	37397	37661
% Exporters	36.0	24.2	36.1	40.0	40.8	39.3

Note: Dependent variable is log of hazard score for each regression. The first column reports the baseline specification from column 2 of Table 2 for comparison. Columns 2-6 report the results for equation 3 on a sample restricted by firm size quintile. All standard errors are clustered at the establishment level. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level. The results suggest that the environmental performance of exporters is not driven primarily by larger firms worried about higher levels of environmental regulation enforcement or their public profiles.

Table 6: Potential Channels of Environmental Performance

	(1) Log Hazard	(2) Log Pounds	(3) Log Risk	(4) Log Hazard	(5) Log Hazard	(6) Log Hazard
Log Sales	0.41***	0.12***	0.21***	0.41***	0.41***	0.41***
	(20.54)	(8.50)	(11.36)	(20.66)	(20.64)	(20.64)
Log Employees	0.44***	0.54***	0.42***	0.45***	0.45***	0.45***
	(20.65)	(35.62)	(21.33)	(20.95)	(21.02)	(20.99)
Relocations	0.07***	0.04***	0.01	0.08***	0.08***	0.08***
	(3.07)	(2.80)	(0.37)	(3.56)	(3.58)	(3.62)
Foreign Owned	0.03	0.17***	0.04	0.02	0.03	0.03
	(0.59)	(4.43)	(0.88)	(0.42)	(0.54)	(0.53)
Credit Rating	-0.00***	-0.00***	-0.00***	-0.00**	-0.00**	-0.00**
	(-2.74)	(-3.31)	(-4.96)	(-2.35)	(-2.31)	(-2.40)
Female CEO	-0.18***	-0.20***	-0.29***	-0.18***	-0.17***	-0.17***
	(-4.14)	(-6.36)	(-7.33)	(-4.02)	(-3.86)	(-3.98)
Export	-0.10***	-0.04***	0.02	-0.08***	-0.07***	-0.07***
	(-5.47)	(-3.06)	(1.12)	(-4.02)	(-3.70)	(-3.86)
Plant Open					0.04***	-17.69***
					(11.08)	(-4.70)
Plant Open^2						0.00***
						(4.71)
SIC6 FE	Y	Y	Y	Y	Y	Y
State FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Plant Open FE	N	N	N	Y	N	N
R^2	0.371	0.280	0.265	0.372	0.372	0.372
N	185024	185024	164216	185024	185024	185024

Note: Dependent variable is log of hazard score for each regression. The first column reports the baseline specification from column 2 of Table 2 for comparison. All standard errors are clustered at the establishment level. *** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level. The results suggest that the environmental performance of exporters is not driven primarily by larger firms worried about higher levels of environmental regulation enforcement or their public profiles.

Table 7: The Impact of Import Competition on Environmental Performance

	(1) Log Hazard	(2) Log Hazard	(3) Log Hazard	(4) Log Hazard	(5) Log Hazard
Log Sales	0.736***	0.744***	0.744***	0.672***	0.746***
	(13.354)	(13.489)	(13.532)	(10.471)	(13.555)
Log Employees	0.123**	0.111*	0.111*	0.199***	0.108*
	(2.070)	(1.861)	(1.881)	(2.851)	(1.818)
Export	-0.181***	-0.178***	-0.178***	-0.155**	-0.176***
	(-2.901)	(-2.870)	(-2.862)	(-2.078)	(-2.823)
Relocations	0.060	0.059	0.060	0.011	0.049
	(0.830)	(0.807)	(0.822)	(0.134)	(0.675)
Female CEO	-0.173	-0.179	-0.177	-0.045	-0.196
	(-1.146)	(-1.186)	(-1.170)	(-0.249)	(-1.296)
Credit Rating	-0.007***	-0.007***	-0.007***	-0.012***	-0.007***
	(-3.279)	(-3.132)	(-3.107)	(-4.369)	(-3.118)
Foreign Owned	-0.052	-0.098	-0.064	-0.173	-0.038
	(-0.306)	(-0.574)	(-0.376)	(-0.870)	(-0.221)
Import Comp. 25		0.724***			
		(8.372)			
Import Comp. 50			-0.182	0.079	0.480***
			(-1.320)	(0.470)	(3.007)
Import Penetration	0.265***	0.780***	1.081***	1.191***	1.104***
	(3.738)	(2.879)	(4.375)	(3.926)	(4.271)
Import Comp. 25 * Import Pen.		-1.029***			
		(-3.363)			
Import Comp. 50 * Import Pen.			-0.939***	-1.018***	-1.020***
			(-3.558)	(-3.206)	(-3.698)
Environmental Competition				0.000	
				(0.743)	
Import Comp. 50 * Enviro. Comp.				-0.000***	
				(-3.137)	
Income Competition					0.000
					(1.184)
Import Comp. 50 * Income Comp.					-0.000***
					(-7.350)
SIC2 FE	Y	Y	Y	Y	Y
State FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
R^2	0.225	0.227	0.226	0.239	0.225
N	148068	148068	148068	109389	145962

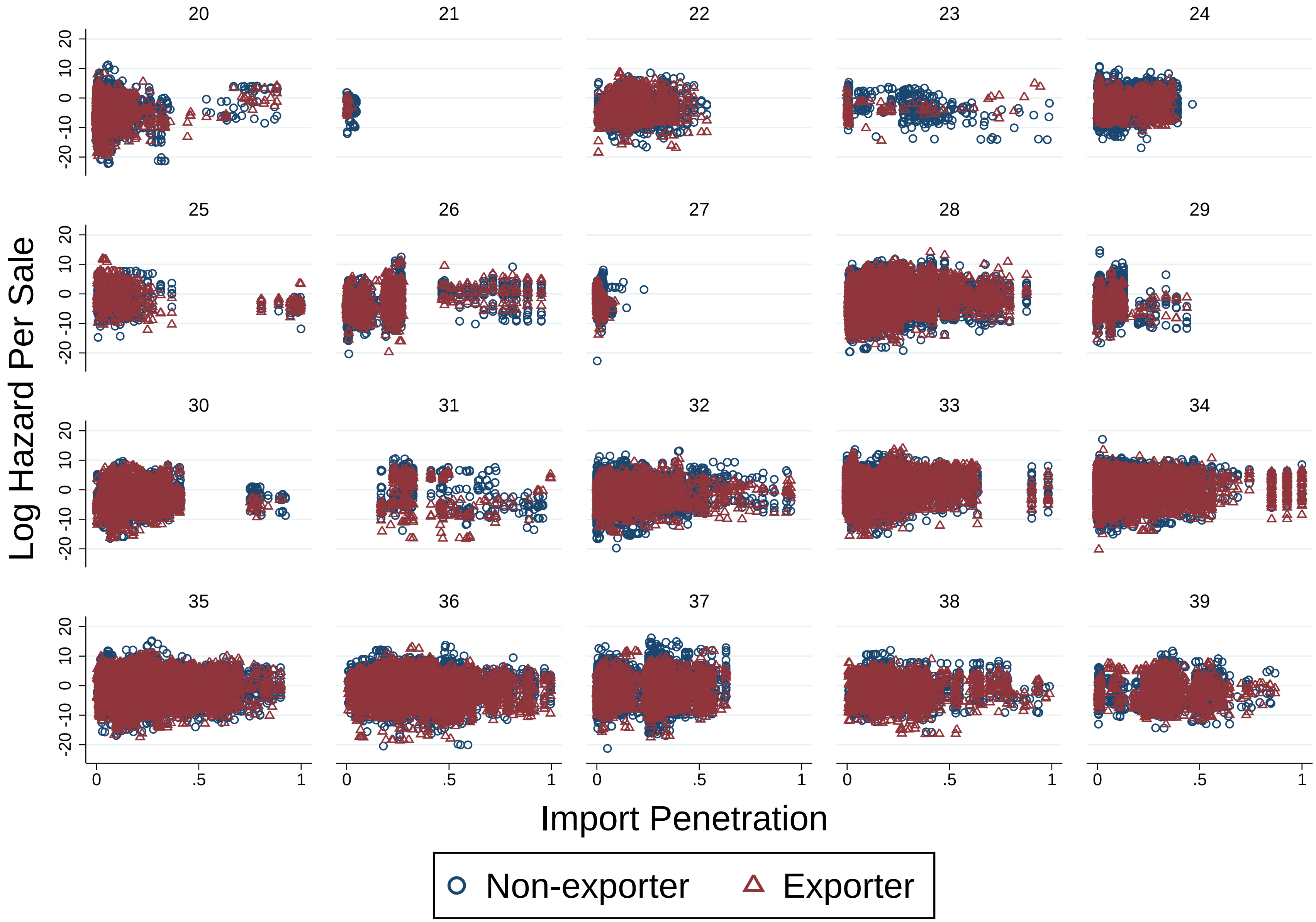
Note: Import Competition variables are four digit SIC level dummies that indicate if more than X% of the sales in a particular industry come from imports. Import penetration variable measure the fraction of domestic demand served by imports. Environmental and Income competition variables are created by weighting imports by the level of environmental protection or average per capita income in the source country respectively. Emp measured in hundreds employees. All standard errors are clustered at the establishment level. *** significant at the 1% level, ** significant at the 5% level, * significant at the 1% level. High levels of import competition are associated with lower emissions intensity even after controlling for export status.

Table 8: Import Competition and Manufacturing Plant Churn

Dependent Var.	(1) birth	(2) birth	(3) birth	(4) death	(5) death	(6) death
Log Sales	-0.035*	-0.024	-0.026	0.015	0.016	0.015
	(-1.839)	(-1.384)	(-1.496)	(0.736)	(0.773)	(0.725)
Log Employees	-0.058***	-0.065***	-0.064***	-0.032	-0.032	-0.031
	(-2.860)	(-3.508)	(-3.463)	(-1.437)	(-1.465)	(-1.422)
Export	-0.479***	-0.486***	-0.486***	-0.258***	-0.257***	-0.258***
	(-20.253)	(-21.939)	(-21.945)	(-11.223)	(-11.209)	(-11.232)
Relocations	-0.303***	-0.322***	-0.323***	-0.101***	-0.101***	-0.101***
	(-8.698)	(-9.748)	(-9.766)	(-3.410)	(-3.412)	(-3.415)
Female CEO	-0.194***	-0.197***	-0.197***	-0.249***	-0.249***	-0.249***
	(-3.491)	(-3.898)	(-3.899)	(-3.866)	(-3.865)	(-3.862)
Credit Rating	-0.001	-0.001	-0.001	-0.007***	-0.007***	-0.007***
	(-0.869)	(-1.122)	(-1.003)	(-6.823)	(-6.811)	(-6.854)
Foreign Owned	-0.071	-0.045	-0.051	0.004	0.005	0.004
	(-1.148)	(-0.791)	(-0.905)	(0.070)	(0.086)	(0.072)
Import Penetration	0.023			0.037		
	(0.794)			(1.406)		
Import Comp. 25		-0.099***			0.005	
		(-4.922)			(0.195)	
Import Comp. 50			-0.131***			0.069*
			(-5.258)			(1.691)
SIC2 FE	Y	Y	Y	Y	Y	Y
State FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
N	138808	138808	138808	147940	147940	147940

Note: Table reports the marginal impacts estimated from a series of probit estimations on the determinants of manufacturing facility churn. Birth is a binary indicator set to 1 in the year a facility opens and death is a binary indicator set to 1 in the year an establishment closes. Only births and deaths between 1990-2005 are observed in this data. Import Competition variables defined as above. Emp measured in hundreds of employees. All standard errors are clustered at the establishment level. *** significant at the 1% level, ** significant at the 5% level, * significant at the 1% level. The impact of import penetration on plant polluting behavior is unchanged after controlling for environmental regulation and worker income in the import-source countries.

Fig1: Hazard per dollar of sales at different levels of import competition by industry



Note: Vertical axis graphs the log hazard score per dollar of output for an establishment and horizontal axis graphs the level of import penetration measured at the four digit SIC industry level. Each panel represents a different two-digit SIC industry. Increases in import competition are weakly associated with lower variance in log hazard per sale driven by a reduction in the number of pollution intensive manufacturing facilities.