Offshoring Production or Offshoring Pollution?*

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Abstract: We combine firm-level trade data from the U.S. Census Bureau with plant-level Toxics Release Inventory data from the Environmental Protection Agency to investigate the impact of firms' imports on toxic emissions by their plants in the US. We find that goods imported from low-wage countries (LWCs) are more pollution-intensive than goods imported from the rest of the world. In addition, firms that import more from LWCs release less toxic emissions and spend less on pollution abatement in the US. According to our estimates, a ten-percentage-point increase in a parent firm's share of imports from LWCs is associated with a 5.8% decrease in its U.S. plants' toxic emissions. These effects are stronger for plants located in dirtier U.S. counties where benefits from pollution reduction are expected to be the largest. These results provide the first large-sample empirical evidence that U.S. firms offshore both production and pollution to the developing world.

Keywords: pollution haven, import, low-wage countries, environment

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I. INTRODUCTION

Between 1992 and 2009, real U.S. manufacturing output has grown significantly, whereas emissions of major air pollutants by U.S. manufacturers, including carbon monoxide and sulfur dioxide, have more than halved (Figure I). Much of the pollution reduction has been attributed to strict environment regulations (Chay and Greenston 2005; Shapiro and Walker 2014), but the regulations have also been blamed for drops in manufacturing productivity (Greenstone, List, and Syverson 2012), plant closures (Henderson 1996; Becker and Henderson 2000), losses of American jobs (Greenstone 2002), and lowered worker earnings (Walker 2013).

Environmental regulations can reduce pollution through technological innovation in production or abatement processes (Porter and Linde 1995), or through changes in the compositions of goods manufactured across countries (Copeland and Taylor 1994); the latter is facilitated by international trade. According to the Pollution Haven Hypothesis (hereafter PHH), “liberalized trade in goods will lead to the relocation of pollution intensive production from high income and stringent environmental regulation countries to low income and lax environmental regulation countries” (Taylor 2005, p.2). A corollary of the PHH which predicts that pollution rises in poor countries and falls in rich countries is under close scrutiny. For example, several studies relate the increases in imports to pollution reduction in U.S. manufacturing sector (Ederington, Levinson, and Minier 2008; Levinson 2009). Recently, Lin et al. (2014) find that 17–36% of four major anthropogenic air pollutants (SO2, NOx, CO, and black carbon) emitted in China are associated with production of goods for export; about 21% of each of these export-related emissions are attributable to China-to-U.S. exports.

However, how much of the pollution reduction can be attributed to emission substitution—between pollution emissions in high income and stringent environmental regulation countries and low income and lax environmental regulation countries—at the micro level has not yet been studied. In order to fill this void, we link firm-level imports to plant-level toxic emissions by combining U.S. Census Bureau's plant-level microdata, Longitudinal Firm Trade Transaction Database (LFTTD), and the Environmental Protection Agency's (EPA's) plant-level Toxics Release Inventory (TRI) database. The Census microdata provide plant-level operating information; LFTTD describes every international trade transaction between 1992 and 2009;[1] TRI database discloses toxic emissions by all manufacturing plants with over 10 full-time employees that either use or produce more than threshold amounts of listed toxic substances. We use the combined datasets to estimate the impact of imports by U.S. manufacturing firms on the amount of toxic materials emitted by their domestic plants.

We distinguish between imports from poor or low-wage countries (LWCs) and imports from the rest of the world. We also distinguish between imports from the most polluting countries—where environmental regulations are expected to be lax—and imports from the rest of the world.[2] (I want to add the Lucas, Wheeler, and Hettige study here as a footnote. But there is a large literature on Environmental Kurznet Curve on income and pollution) While imports from LWCs historically have been small, they have increased substantially over the recent years as trade barriers are removed. Between 1992 and 2009, real value of total U.S. imports has more than doubled, whereas real imports from LWCs have grown more than sevenfold. Consequently, the share of real imports from LWCs rose from 7% to about 23% (Figure II). While much has been found about how trade with LWCs has caused disruptions to manufacturing industries (Bernard, Jensen, and Schott 2006), workers and occupations (Ebenstein, et al. 2013), and local

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[1] Please refer to Bernard, et al. (2009) for a detailed description of this database.

labor market (Autor, Dorn, and Hanson 2013), little attention has been paid to the environmental consequences of trading with LWCs.

Anecdotal evidence suggests that LWCs like China and India have been exporting to the U.S. some pollution-intensive products formerly produced in the U.S. At the national level, the increasing share of imports from LWCs in Figure II corresponds to the decreasing air pollution in Figure I. At the industry level, Figure III shows that between 1992 and 2009 the greater the increase in the share of imports from LWCs, the more is the air pollution reduction, also suggesting a potential substitution effect between LWC imports and domestic emissions. Graphic presentation of changes in imports from the most polluting countries (based on CO_2 emission per dollar of Gross Domestic Product (GDP)) and changes in toxic air emission shows similar patterns to those in Figure III.

Our firm- and plant-level regressions lend support to the industry-level graphic patterns. Moreover, they shed light on the relocation and substitution effects predicted by PHH. First, goods imported by U.S. firms from LWCs are more "pollution-intensive" than those imported from the rest of the world. We measure a good's pollution intensity based on its industry's emission per dollar of output in the U.S. Our results imply that goods imported from LWCs are potentially more polluting than goods imported from the rest of the world, assuming these goods were produced based on U.S. technology. Our estimation results suggest that a ten-percentage-point increase in a firm's share of imports from LWCs ("LWC Import Share") is associated with a 6.7% increase in the pollution intensity of the firm's imported goods.

Secondly, domestic plants pollute less on American soil as their parent firm imports more from LWCs or from the most polluting countries. At the firm level, a ten-percentage-point increase in a parent firm's LWC Import Share is associated with a 5.8% decrease in each of its

U.S. plants' toxic emissions, whereas a ten-percentage-point increase in a parent firm's import share from the most polluting countries is associated with a 3.6% decrease in each of its U.S. plants' toxic emissions. These results are robust to the inclusion of the firm's total imports, suggesting a significant impact of LWC import on top of the impact of general import. Over 2002-2009, the economy-wide share of import from LWCs has increased by 16 percentage points and the toxic emission has dropped by two thirds, our estimates imply that imports from LWCs can account for about 14% of overall drop in toxic emission levels.[3]

Thirdly, U.S. plants spend less on pollution abatement as their parent firms import more from LWCs or from the most polluting countries. Based on the Survey of Pollution Abatement Costs and Expenditures (PACE), the most comprehensive source of pollution abatement data in the U.S. manufacturing sector, we find that U.S. plants spend less on pollution abatement if their parent firms import more from LWCs or the most polluting countries. Both the emissions and abatement results are more significant if the plants are located in the dirtiest U.S. counties, where the benefit of relocating or substitution could be the largest.

Finally, we exploit differences between imports from related parties and imports from independent third parties. Imports are categorized in LFTTD database as from related parties if the importer owns, directly or indirectly, 6 percent or more of the exporter. We find some weak evidence that, as U.S. firms import more from their related parties (as opposed to independent parties) in LWCs, the pollution intensity of their imports increases even more and their U.S. plants pollute even less. However, total imports from related parties in LWCs account for less

[3] Levinson (2009) estimates that shifting polluting industries overseas has contributed around 10 percent of the overall cleanup of U.S. manufacturing, over 1987-2001.

than 1% of a typical firm's total imports. Our findings suggest that the environmental effects of importing from LWCs are primarily driven by imports from independent parties in LWCs.

We believe these results are the first micro empirical evidence supporting the argument that the U.S. enjoys a cleaner domestic environment partly by importing pollution intensive goods from poor countries. In other words, the "green shift" of U.S. manufacturing is accompanied by a corresponding "brown shift" of imports from poor countries. Previous research on the environmental impact of trade mostly relies on country/industry level information (see, e.g., Grossman and Krueger 1995; Antweiler, Copeland, and Taylor 2001; Gamper-Rabindran 2006a). We extend this literature by offering the first empirical evidence of "pollution offshoring" at the firm level. Global trade and investment allows firms to disperse pollution intensive activities in their value chain according to environmental regulations around the globe (Hanna 2010). However, owing principally to a lack of detailed firm-level trade and pollution data, there has been almost no empirical study investigating whether firms indeed offshore the most polluting production processes or source more "dirty" products from abroad. By linking firm-level trade with plant-level emissions/abatement costs data, our study fills an important gap in studies at the intersection between trade and environment. This paper also belongs to a burgeoning literature attempting to explain the reduction in pollution emissions. Our results are not inconsistent with the basic conclusion that trade in general does account for the majority of pollution reduction in the U.S. (Levinson, 2009; Shapiro and Walker 2014); we contribute to this literature and highlight the impact of trading with poor countries on firm's emission outcomes.

The issue of U.S. pollution reductions coming at the expense of environmental quality in other countries is at the heart of many recent anti-globalization protests. While pollution is assumed to be local in the original PHH model, it is becoming a global concern. Recent studies show that pollution from China contributes to a significant portion of sulfate concentrations over the western United States (Lin, et al. 2014). Our findings provide additional empirical support for the call by policy makers for more coordination between international trade agreements and domestic environmental regulations (Keller and Levinson 2002).

The rest of the article is organized as follows: The following section discusses the details of our data samples and variables. Sections III presents the research design and results. Sections IV concludes.

II. DATA and VARIABLES

We construct our samples, which extend from 1992 to 2009, from several sources. We start with plant-level microdata and firm-level international trade data from the U.S. Census Bureau. In addition, we use plant-level toxic emissions and abatement costs data published by the U.S. EPA. A plant – or "establishment" in Census Bureau terminology and "facility" in TRI terminology – is a physical location where economic activity takes place. A firm can own one or multiple plants. We link these datasets by using the existing bridge files maintained by the Census Bureau, and by manually matching plant name and address. We describe the main datasets, the samples, and the key variables below.

Micro Data from the Census Bureau

The Census micro-level datasets on manufacturing plants include the Census of Manufactures (CM), the Annual Survey of Manufactures (ASM), and the Longitudinal Business Database (LBD). The CM data are collected during the economic census, which takes place in years ending in 2 and 7, and covers approximately 350,000 manufacturing plants each time. The

ASM typically samples about 60,000 plants in non-census years. All plants with more than 250 employees and all plants of large firms are included by design. Some 40,000 other plants are selected with a probability proportional to a composite measure of their size. Once a plant is surveyed, ASM continues surveying this plant to form a 5-year panel. The LBD covers every U.S. private non-farm sector establishment that files payroll taxes. We construct several variables that may affect a plant's emissions, including capital expenditures, skill intensity (non-production worker salary as a percentage of total workforce salary), and the shipment value of output at the plant/firm-level.

Trade Data from Census Bureau

The Longitudinal Firm Trade Transaction Database (LFTTD) links individual U.S. trade transactions to U.S. firms for the years 1992–2009. The database covers all shipments of goods that crossed U.S. borders. For each transaction, the database contains a firm identifier and includes pertinent details of the shipment, such as the date and the destination (or origination) country, as well as a ten-digit Harmonized System (HS) classification code, and a (nominal) shipment value for each product.

To identify LWCs, we rely on the list provided by Bernard, Jensen, and Schott (2006), who classify a country as an LWC if its annual GDP per capita was less than 5% of the U.S. annual GDP per capita from 1972 to 1992 (Appendix, Table A1). China, India, and most African countries are on the list. We calculate a firm's LWC Import Share as the percentage of its imports from LWCs over its total imports. LWC Import Share has risen substantially: from 7% in 1992 to about 30% in 2009 based on our sample statistics.

To identify countries with lax environmental standards, we rank countries by their annual carbon dioxide (CO_2) emission (kilograms per inflation-adjusted GDP), one of the World Development Indicators (World Bank 2010). We choose the minimum level of CO_2 emissions by the top tercile countries, 1 kilogram per dollar GDP, as the threshold. A country is categorized as one of the most polluting countries if its 1992–2009 average CO_2 emissions exceeded 1 kilogram per GDP. A few countries from Eastern Europe and the Middle East (presumably fossil fuel burners) stand out as different from LWCs (Appendix, Table A2).

We match firm-level LFTTD with plant-level microdata in the CM and the ASM through firm-level bridge files provided by the Census Bureau.

Toxics Release Inventory (TRI)

The U.S. EPA's TRI program is the first large-scale initiative to track facility-level pollution emissions. Introduced by the Emergency Planning and Community Right to Know Act (EPCRA) in 1986, the TRI program requires manufacturing plants that emit more than a given threshold level for any of the 600+ designated toxic chemicals to report emissions data for use in a publicly available database. Evidence suggests that national emissions declined by 43% between 1988 and 1999, a period in which the TRI program garnered strong public support. The EPA claims that the TRI program provides (1) information to encourage community-based environmental decision making and (2) incentives for businesses to find their own ways of preventing pollution (Bui and Mayer 2003). For each year, the TRI database contains approximately 80,000 facility-chemical reports from more than 20,000 different facilities. A significant degree of quality control and verification is carried out before the data is released to the public.[4]

Since its launch, the TRI database has become one of the most widely accessed databases providing comparative data on environmental performance across facilities and over time. It has been used by environmental researchers for studies addressing a wide range of topics, including environmental regulation (Gamper-Rabindran 2006b; Hellanda and Whitford 2003; King and Lenox 2000), and the relationship between waste management and financial performance (King and Lenox 2002). Prior research shows that participation in the TRI program significantly reduces TRI emissions, even after controlling for self-selection (Khanna and Damon 1999; Potoski and Prakash 2005). In addition, both public media and the stock market respond negatively when a firm reports higher emissions in the TRI (Hamilton 1995), and firms that have experienced the deepest stock price declines in response to their TRI reports have subsequently reduced emissions more than their industry peers (Konar and Cohen 1997).

We use the TRI database to construct three variables. First, we use the TRI database to calculate the pollution intensity of a firm's imports. Two measures of industry-level pollution intensities are adopted here. We first use the World Bank's "Industrial Pollution Projection System" (IPPS). The IPPS reports the amount (pounds per million dollars of value added) of 14 pollutants emitted from each of the 459 four-digit Standard Industrial Classification (SIC) industries, based on the 1987 TRI dataset. The IPPS has been a standard source of industry-level pollution intensities, and is frequently used in assessing the pollution content of trade (Cole 2004; Ederington, Levinson, and Minier 2008; Levinson 2009). We then use the more comprehensive

[4]Each EPA region has a TRI enforcement program that conducts, on an annual basis, a limited number of data quality inspections (of reporting facilities) and non-reporting inspections (of facilities that are in TRI industries but did not report). Violations, whether stemming from late reporting, failure to report, or data quality issues, can lead to penalties of $25,000 per day, per chemical, per violation, and may be subject to criminal charges.

toxicity weighting model provided by the EPA, Risk-Screening Environmental Indicators (RSEI). We sum up the RSEI-based toxic emissions of all plants in each of the 459 four-digit SICs reported in the 1992 TRI, and scale the emissions by the 1992 industry-level shipment values reported in the NBER-CES Manufacturing Industry Database (Bartelsman and Gray 1996).[5] We sum up a firm's import value in each 4-digit SIC industry[6] weighted by the corresponding industry-level pollution intensity to derive a firm's overall pollution intensity of its import.

Secondly, we use the TRI database to gauge plant-level toxic emissions within the U.S. We match facilities in the TRI database to plants in the LBD, based on plant names and addresses. A TRI-LBD bridge file for the years 1987–1999 was maintained at the Census Bureau; we follow the same method by matching name and address and extend the match to 2009. On average, 75% of the facilities that appear in the TRI are matched to the LBD. When using the TRI, it is important to keep in mind that various pollutants have different health consequences (Chay and Greenstone 2003). Toffel and Marshall (2004) compare thirteen methods of aggregating chemical-specific release data to the plant level and recommend the RSEI model (Environmental Protection Agency 2012) as the most comprehensive model for estimating the impacts of toxic releases on human health. Therefore, we follow recent studies using the RSEI model (e.g., Gamper-Rabindran 2006b) to define toxic emissions from a plant as its all-media release of designated toxic chemicals, multiplied by the RSEI toxicity weight for each chemical; emissions to air are weighted using inhalation toxicity weights and emissions to other media are weighted using oral toxicity weights.

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[5] We choose year 1992 because it is the first year of our sample and because EPCRA changed some reporting requirements in 1989 and 1992 was the first Census year after that.

[6] We follow Pierce and Schott (2009) to link the ten-digit Harmonized System (HS) classifications to the 1987 version of four-digit SICs.

Finally, we use the TRI database to approximate the potential benefits from emission reduction and hence the expected environmental pressure on plants in each county. In addition to facility-level emissions, the annual TRI reports and other media sources typically rank counties by total emissions and highlight those most polluting counties. Plants located in “dirty” counties face much greater public pressure to reduce toxic releases than plants located in cleaner counties. For example, according to Powers (2013), after Calhoun County, Texas, was listed as having the highest level of toxic releases in the country, local communities organized various awareness programs to inform the public about local pollution. Under public pressure, Alcoa had to commit to aggressive pollution reduction initiatives at two local plants. Similarly, when Butler County, Pennsylvania, was identified among the dirtiest counties, local communities successfully pressured the state into restricting the nitrate emissions of a major steel plant before the plant was allowed to release waste into the Connoquenessing Creek. We rank counties by the total RSEI toxicity-weighted emissions from all plants located there, based on annual emissions data and 1992 emissions data, respectively. We then select the 100 “dirtiest” counties according to the ranking; selecting the 25 or 50 dirties counties generates similar results.

Pollution Abatement Costs and Expenditures

The Pollution Abatement Costs and Expenditures (PACE) survey is the only comprehensive survey of costs of environmental abatement activities in the U.S. The survey collects facility-level pollution abatement costs data for manufacturing, mining, and electric utility industries. The costs are mostly incurred in the process of compliance with local, state, and federal regulations, or for voluntary or market-driven pollution abatement activities. Such costs include pollution treatment (to reduce or eliminate pollution that has been generated during production processes), pollution prevention (to prevent creation of pollution in the first place), recycling, and disposal.

We use the PACE surveys for the years 1992–1994, 1999, and 2005.[7] We use total Pollution Abatement Operating Costs (PAOC), which comprise salaries and wages, parts and materials, fuel and electricity, capital depreciation, contract work, equipment leasing, and additional operating costs associated with abatement of air and water pollution as well as solid waste reduction or disposal. The PAOC index has long been used to measure plants' pollution reduction investments (Pashigian 1984; Jorgenson and Wilcoxen 1990; List and Co 2000). Following prior studies, we normalize a plant's PAOC by its number of employees, which reflects an implicit choice between environmental protection and jobs (Becker, Pasurka Jr., and Shadbegian 2013).[8]

We match PACE to the trade database LFTTD using Census' common firm identifiers. The match yields 50,318 plant-years over the five years for which PACE data are available.

Samples

We construct two main samples; the first sample includes firm-level data about all manufacturing firms importing in manufacturing industries, and the second sample includes plant-level data about all manufacturing plants who disclose toxic emissions to the EPA and whose parent firms import. We use the first sample to analyze the pollution intensity of imports. This sample includes 88,458 firms and 277,768 firm-year observations for years 1992–2009. Panel A in Table I provides summary statistics for this sample. As the panel shows, an average

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[7]The PACE survey was discontinued in other sample years (1995–1998, 2000–2004, 2006-2009).
[8] Normalizing using total value of shipment yields qualitatively similar results.

importing firm sources 16% of its manufacturing imports from LWCs, slightly higher than the national average of 15%.

We use the second sample to analyze toxic emissions by U.S. plants whose parent firms import. This sample contains 17,773 plants of 7,115 U.S. parent firms. Altogether, there are 136,574 plant-year observations between 1992 and 2009. Panel B in Table I provides summary statistics for this sample. The sample plants are relatively large: A typical plant has over 417 employees and manufactures a total value of $175 million of output. Their parent firms source 8% of their imports from LWCs. The skill intensity variable has a mean of 0.35, that is, non-production workers' salaries account for about 35% of an average plant's total salaries.

III. RESULTS

In this section, we investigate five questions about the environmental impact of firm imports: (A) Are imports from LWCs dirtier? (B) Do domestic plants pollute less in the U.S. when their parent firms import more from low-wage or the most polluting countries? (C) Are the effects in (B) stronger for plants located in dirtier U.S. counties where the benefits of "pollution offshoring" are expected to be the greatest? (D) Do domestic plants spend less on pollution abatement in the U.S. when their parent firms import more from low-wage or the most polluting countries? (E) Are the effects in (A) and (B) stronger when firms import more from related parties in LWCs?

A. Are imports from LWCs dirtier?

To estimate the relation between a firm's LWC Import Share and the pollution content and intensity of its imports, we use the following specification:

$$\text{Pollution Intensity of Imports}_{jt} = \alpha_j + \alpha_t + \beta \text{LWC Import Share}_{jt} + X_{jt} + \varepsilon_{jt} \quad (1),$$

where $\text{Pollution Intensity of Import}_{jt}$ is the overall pollution intensity of firm j's imports; it is the firm's pollute import (value of imports multiplied by industry-level pollution intensity) scaled by its total imports, as described above, in year *t*. We use the logarithm of a firm's pollute import as the measure of its pollution content of imports. The key variable of interest, $\text{LWC Import Share}_{jt}$ is also described above.[9] We control for firm j's size (total value of shipment) in addition to firm and year fixed effects and cluster the standard errors at the firm level.

Our results are presented in Table II. We calculate a firm's pollution content and intensity based on IPPS in columns (1) and (3), and we use toxicity information based on TRI in columns (2) and (4); results are very similar across these two intensity measures. Larger firms import more polluting products, although the effects are not statistically significant in columns (3) and (4) when we scale the pollution content by total imports. Our results show that both pollution content and intensity variables of a firm's imports are positively and significantly related to its LWC Import Share. The results reveal that the more a firm imports from LWCs, the greater the intensity of its imports. The economic significance of the point estimate is sizeable. Coefficients in columns (1) and (2) imply that a 10-percentage-point increase in a firm's LWC Import Share is associated with a 10-14% increase in the pollution content of its imports. Coefficients in columns (3) and (4) imply that a 10-percentage-point increase in a firm's LWC Import Share

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[9] In an alternative specification, we use the logarithm of LWC import value, results are qualitatively unchanged and are available upon request.

raises the pollution intensity of its imports by about 0.07, approximately 7% of the sample's median value of import intensity.

B. Do domestic plants pollute less when their parent firms import more from low-wage or the most polluting countries?

We proceed to estimate toxic emissions at the plant level using the following specifications:

$$\text{Toxic Emission}_{ijt} = \alpha_i + \alpha_t + \beta \text{LWC Import Share}_{jt} + X_{ijt} + \varepsilon_{ijt} \quad (2),$$

$$\text{Toxic Emission}_{ijt} = \alpha_i + \alpha_t + \beta \text{MPC Import Share}_{jt} + X_{ijt} + \varepsilon_{ijt} \quad (3),$$

where Toxic Emissions_{ijt} is either the logarithm of the total toxicity-weighted emissions of plant *i* of parent firm *j*, or plant *i*'s total toxicity-weighted emissions scaled by the shipment value of its output, in year *t*. MPC Import Share_{jt} is the share of imports from most polluting countries by firm *j*. We control for several plant characteristics, such as the shipment value of its output, the logarithm of its capital expenditures, skill intensity, and the logarithm of its parent firm's total imports. We control for both plant and year fixed effects and cluster the standard errors at the firm level.

We report the estimation results in Table III. Columns (1) and (3) report results using the logarithm of a plant's toxic emission as dependent variables whereas columns (2) and (4) use the logarithm of a plant's toxic emission scaled by its output. The two sets of outcome variables yield qualitatively similar results.

The estimates in columns (1) and (2) show that a firm's LWC Import Share has a significantly negative impact on its domestic plants' overall toxic emissions as well as toxic emissions per dollar of shipment. The economic effect of the point estimates is considerable. For instance, the coefficient of -0.583 in column (1) implies that a 10-percentage-point increase in a parent firm's LWC Import Share lowers its average plant's toxic emissions by about 5.83%. Our results imply that over the 18-year sample period during which the economy-wide share of import from LWCs has increased by 16 percentage points, a plant would reduce its toxic emission by about 9 percentage points, which constitutes about 14% of overall drop in toxic emission levels. Coefficients on other explanatory variables are consistent with our expectation. In general, larger plants, plants with larger capital expenditures, and plants with a larger proportion of production workers tend to produce higher levels of toxic emissions. Finally, total import does not have a statistically significant impact on toxic emissions, and its inclusion does not qualitatively change the coefficients to LWC Import Share.

The results columns (3) and (4) are qualitatively similar to those in columns (1) and (2): a firm's import share from the most polluting countries has a negative impact on its domestic plants' overall toxic emissions as well as toxic emissions per dollar of shipment, although the effect of on toxic emissions per dollar of shipment is statistically insignificant. The economic effect of the point estimate based on the coefficient of -0.364 in column (3) implies that a 10-percentage-point-increase in a firm's share of imports from the most polluting countries lowers the average plant's toxic emission by about 3.64%.

C. Is the negative effect of importing from low-wage (or the most polluting) countries on domestic toxic emissions stronger for plants located in dirty U.S. counties?

We next explore the heterogeneous impact of imports across U.S. plants located in different U.S. counties. Dirty U.S. counties could face more public and regulatory pressure to reduce pollution (Environmental Protection Agency 2003; Powers 2013), therefore the benefit of "pollution offshoring" is greater for both the dirty counties and the plants located in these counties. Accordingly, we estimate the following specifications:

$$\text{Toxic Emissions}_{ijt} = \alpha_i + \alpha_t + \beta_1 \text{LWC Import Share}_{jt} + \beta_2 \left(\text{LWC Import Share}_{jt} * \text{100 Dirtiest Counties}_{it}\right) + X_{ijt} + \varepsilon_{ijt} \quad (4),$$

$$\text{Toxic Emissions}_{ijt} = \alpha_i + \alpha_t + \beta_1 \text{MPC Import Share}_{jt} + \beta_2 \left(\text{MPC Import Share}_{jt} * \text{100 Dirtiest Counties}_{it}\right) + X_{ijt} + \varepsilon_{ijt} \quad (5),$$

where 100 Dirtiest Counties$_{it}$ is a dummy variable that represents whether plant *i* is located in any of the 100 dirtiest U.S. counties in year *t* (or in 1992, for an alternative specification) based on total toxic emissions.

Tables IV and V report regression results of Equation (4) and (5) based on imports from low-wage countries and the most polluting countries, respectively. The interaction terms are significantly negative, suggesting that the negative impact of imports from low-wage or the most polluting countries on domestic toxic emissions is stronger for plants in dirty U.S. counties. On average across specifications, the negative impact of imports from low-wage or the most polluting countries on domestic emissions is doubled for plants located in the 100 dirties counties, compared to plants located elsewhere. After controlling for these interaction terms, the main effects of LWC Import Share and MPC Import Share remain mostly significantly negative.

D.Do firms importing more from LWCs spend less on pollution abatement in the U.S?

In addition to toxic emissions, we also examine plants' effort to reduce emissions. Table VI estimates specifications similar to Equation (2) and (3), except that we replace the dependent variable of plant toxic emissions with plant expenditures on environmental pollution abatement. We also replace plant fixed effects with 4-digit SIC industry fixed effects to take into account of significant gaps in time coverage of PACE. Following the prior studies using PACE data, we use both the abatement costs and the abatement costs divided by a plant's total number of employees and obtain similar findings. Results from columns (1) and (2) show that domestic plants spend less on pollution abatement when their parent firms import more from LWCs. The coefficient of -0.151 implies that a 10-percentage-point increase in the parent firm's LWC Import Share reduces its average plant's pollution abatement costs by about 1.51%, and reduces its average plant's pollution abatement costs per worker by about 0.7%.

Columns (3) through (6) suggest that the effect identified above is much stronger for plants located in dirty U.S. counties, where the benefit of "pollution offshoring" is expected to be greater. The negative impact of a U.S. parent firm's LWC Import Share on the pollution abatement costs of its plants in dirty U.S. counties is four times greater than the impact on its plants located in cleaner counties.

E. Do firms importing more from related parties in LWCs import dirtier goods and pollute less on domestic soil?

Finally, we compare the impact of LWC imports through arm's length transactions vs. those from related parties. In Tables VII and VIII, we estimate specifications similar to Equations (1) and (2), respectively, except that we include an additional explanatory variable to measure the share of imports from related parties in LWCs. Table VII shows that adding LWC imports from related parties does not qualitatively change the impact of LWC Import Share on the pollution content or intensity of imports that is estimated in Table II. In addition, columns (1) and (2) suggest that imports from related parties in LWCs further increase the pollution content of the firm's imports. However, columns (3) and (4) suggest that these results do not extend to pollution intensity.

Table VIII shows that adding LWC imports from related parties does not qualitatively change the impact of LWC Import Share on plant-level toxic emissions estimated in Table III. In addition, column (1) suggests that LWC imports through related parties further lowers the toxic emissions of domestic plants. However, column (2) suggests that this result does not extend to pollution intensity. Imports from related parties in LWCs do not affect a plant's toxic emission per value of shipment in a significant fashion. On average, in our sample, the imports from related parties in LWCs account for less than 1% of a firm's total imports. Therefore, despite the significant point estimate, the economic significance of importing from related parties in LWCs remains small. In sum, our findings suggest that the environmental effects of importing from LWCs are primarily driven by imports from arm's length transactions with parties in LWCs.

IV. CONCLUSIONS

This paper investigates the relationship between international trade and U.S. firms' strategies in dealing with domestic environmental standards. Our analyses show that, (1) imports by U.S. firms from LWCs are dirtier, (2) U.S. plants pollute less as their parent firms import more from low-wage or the most polluting countries, and this effect is stronger for plants in dirtier U.S. counties, where potential benefits from pollution reduction are expected to be greater, (3) U.S. plants spend less on pollution abatement as their parent firms import more from low-wage or the most polluting countries, and this effect is stronger for plants in dirtier U.S. counties, and finally, (4) as U.S. firms import more from their related parties in LWCs, the pollution intensity of their imports increases, whereas the toxic emissions of their plants reduces.

We believe these results are the first empirical evidence supporting the argument that the U.S. enjoys a cleaner domestic environment partly by importing pollution intensive goods from poor countries. Furthermore, our results provide indirect support to prior findings that the economic costs of environmental regulations discourage investments in the U.S. while encouraging U.S. imports from abroad. Our paper also represents the first empirical evidence of "pollution offshoring" at the firm level. By linking firm-level trade and plant-level emissions and abatement costs data, our study fills an important gap in studies of trade and the environment.

Finally, our paper contributes to an emerging literature on the relationship between trade with LWCs and firm performance. While much has been discovered regarding the ways in which trade with LWCs has depressed wages and employment in the U.S, little attention has been paid to the impact of imports from LWCs on firms' environmental performance. Our paper fills this void and calls for more coordination between international trade agreements and domestic environmental regulations.

References

Antweiler, Werner, Brian R. Copeland, and M. Scott Taylor, "Is Free Trade Good for the Environment?" *American Economic Review*, 91 (2001), 877-908.

Autor, David H., David Dorn, and Gordon H. Hanson, "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," *American Economic Review*, 103 (2013), 2121-2168.

Bartelsman, Eric J., and Wayne Gray, "The NBER Manufacturing Productivity Database," NBER Technical Working Paper 205, (1996).

Becker, Randy A., and J. Vernon Henderson, "Effects of Air Quality Regulations on Polluting Industries," *Journal of Political Economy*, 108 (2000), 379-421.

Becker, Randy A., Carl Pasurka Jr., and Ronald J. Shadbegian, "Do Environmental Regulations Disproportionately Affect Small Businesses? Evidence from the Pollution Abatement Costs and Expenditures Survey," *Journal of Environmental Economics and Management*, 66 (2013), 523-538.

Bernard, Andrew B., J. Bradford Jensen, Stephen J. Redding, and Peter K. Schott., "The Margins of US Trade," *American Economic Review*, 99 (2009), 487-493.

Bernard, Andrew B., J. Bradford Jensen, and Peter K. Schott, "Survival of the Best Fit: Exposure to Low-wage Countries and the (uneven) Growth of U.S. Manufacturing Plants," *Journal of International Economics*, 68 (2006), 219-237.

Bloom, Nicholas, Mirko Draca, and John Van Reenen, "Trade Induced Technical Change? The Impact of Chinese Imports on Innovation, IT and Productivity," NBER Working Paper, (2012).

Bui, Linda T. M., and Christopher J. Mayer, "Regulation and Capitalization of Environmental Amenities: Evidence from the Toxic Release Inventory in Massachusetts," *Review of Economics and Statistics*, 85 (2003), 693-708.

Chay, Kenneth Y., and Michael Greenstone, "The Impact of Air Pollution on Infant Mortality: Evidence from Geographic Variation in Pollution Shocks Induced by a Recession," *Quarterly Journal of Economics*, 118 (2003), 1121-1167.

Cole, Matthew A., "US Environmental Load Displacement: Examining Consumption, Regulations and the Role of NAFTA," *Ecological Economics*, 48 (2004), 439-450.

Copeland, B.R., and Taylor M.S. (1994), "North-South Trade and the Environment," *Quarterly Journal of Economics*, 109 (1994), 755-787.

Ebenstein, Avraham, Ann Harrison, Margaret McMillan, and Shannon Phillips, "Why are American Workers getting Poorer? Estimating the Impact of Trade and Offshoring Using the CPS," NBER Working Paper, (2013).

Ederington, Josh, Arik Levinson, and Jenny Minier., "Trade Liberalization and Pollution Havens," *Advances in Economic Analysis and Policy*, 4 (2008), 1-22.

Environmental Protection Agency, "EPA's Risk-Screening Environmental Indicators (RSEI) Methodology," Environmental Protection Agency Working Paper, (2012).

Gamper-Rabindran, Shanti, "NAFTA and the Environment: What can the Data Tell Us?" *Economic Development and Cultural Change*, 54 (2006a), 605-633.

Gamper-Rabindran, Shanti, "Did the EPA's Voluntary Industrial Toxics Program Reduce Emissions? A GIS Analysis of Distributional Impacts and by-media Analysis of Substitution," *Journal of Enviromental Economics and Management*, 52 (2006b), 391-410.

Grant, Don, and Andrew W. Jones, "Are Subsidiaries More Prone to Pollute? New Evidence from the EPA's Toxics Release Inventory," *Social Science Quarterly*, 84 (2009), 162-173.

Greenstone, Michael, "The Impacts of Environmental Regulations on Industrial Activity: Evidence from the 1970 and 1977 Clean Air Act Amendments and the Census of Manufactures," *Journal of Political Economy*, 110 (2002), 1175-1219.

Greenstone, Michael, John A. List, and Chad Syverson, "The Effects of Environmental Regulation on the Competitiveness of U.S. Manufacturing," NBER Working Paper, (2012).

Grossman, G. M., and A. B. Krueger, "Economic Growth and the Environment," *Quarterly Journal of Economics*, 110 (1995), 353-377.

Hamilton, James T., "Pollution as News: Media and Stock Market Reactions to the Toxics Release Inventory Data," *Journal of Environmental Economics and Management*, 28 (1995), 98-113.

Hanna, Rema, "US Environmental Regulation and FDI: Evidence from a Panel of US-Based Multinational Firms," *American Economic Journal: Applied Economics*, 2 (2010), 158-189.

Hellanda, Eric, and Andrew B. Whitford, "Pollution Incidence and Political Jurisdiction: Evidence from TRI," *Journal of Environmental Economics and Management*, 46 (2003), 403-424.

Henderson, J Vernon, "Effects of Air Quality Regulation," *American Economic Review*, 86 (1996), 789-813.

Iacovone, Leonardo, Ferdinand Rauch, and L. Alan Winters, "Trade as an Engine of Creative Destruction: Mexican Experience with Chinese Competition," *Journal of International Economics*, 89 (2013), 379-392.

Jorgenson, Dale W., and Peter J. Wilcoxen, "Environmental Regulation and U.S. Economic Growth," *RAND Journal of Economics*, 21 (1990), 314-340.

Keller, Wolfgang, and Arik Levinson, "Pollution Abatement Costs and Foreign Direct Investment Inflows to U.S. States," *Review of Economics and Statistics*, 84 (2002), 691-703.

Khanna, Madhu, and Lisa A Damon, "EPA's Voluntary 33/50 Program: Impact on Toxic Releases and Economic Performance of Firms," *Journal of Environmental Economics and Management*, 37 (1999), 1-25.

King, Andrew A., and Michael J. Lenox, "Industry Self-Regulation Without Sanctions: The Chemical Industry's Responsible Care Program," *Academy of Management Journal*, 43 (2000), 698-716.

King, Andrew, and Michael Lenox, "Exploring the Locus of Profitable Pollution Reduction," *Management Science*, 48 (2002), 289-299.

Konar, Shameek, and Mark A. Cohen, "Information As Regulation: The Effect of Community Right to Know Laws on Toxic Emissions," *Journal of Environmental Economics and Management*, 32 (1997), 109-124.

Levinson, Arik, "Technology, International Trade, and Pollution from U.S. Manufacturing," *American Economic Review*, 99 (2009), 2177-2192.

Levinson, Arik, and M. Scott Taylor, "Unmasking the Pollution Haven Effect," *International Economic Review*, 49 (2008), 223-254.

Lin, Jintai, Da Pan, Steven J. Davis, Qiang Zhang, Kebin He, Can Wang, David G. Streets, Donald J. Wuebbles, and Dabo Guan, "China's International Trade and Air Pollution in the United States," *Proceedings of National Academy of Science*, 111 (2014), 1736-1741.

List, John A., and Catherine Y. Co, "The Effects of Environmental Regulations on Foreign Direct Investment," *Journal of Environmental Economics and Management*, 40 (2000), 1-20.

Lucas, Robert E.B., David Wheeler, and Hemamala Hettige, " Economic Development, Environmental Regulation, and the International Migration of Toxic Industrial Pollution," World Bank Policy Researh Working Paper, (1992).
Pashigian, B Peter, "The Effect of Environmental Regulation on Optimal Plant Size and Factor Shares," *Journal of Law and Economics*, 27 (1984), 1-28.
Pierce, Justin R., and Peter K. Schott, "A Concordance Between Ten-Digit U.S. Harmonized System Codes and SIC/NAICS Product Classes and Industries," US Census Bureau Center for Economic Studies Working Papers, (2009).
Porter, Michael E., and Claas van der Linde, "Toward a New Conception of the Environment-Competitiveness Relationship," *Journal of Economic Perspectives*, 9 (1995), 97-118.
Potoski, Matthew, and Aseem Prakash, "Green Clubs and Voluntary Governance: ISO 14001 and Firms' Regulatory Performance," *American Journal of Political Science*, 49 (2005), 235-248.
Powers, Nicholas, "Measuring the Impact of the Toxics Release Inventory: Evidence from Manufacturing Plant Births," US Census Bureau Center for Economic Studies Woking Paper, (2013).
Shapiro, Joseph, and Reed Walker, "Why is the United States' Air Quality Improving? The Roles of Trade, Regulation, Productivity, and Preferences," (2014) Working paper.
Taylor, M. Scott, "Unbundling the Pollution Haven Hypothesis," *Advances in Economic Analysis & Policy*, 3 (2005), 1-28.
Toffel, Michael W., and Julian D. Marshall, "Improving Environmental Performance Assessment: Comparative Analysis of Weighting Methods used to Evaluate Chemical Release Inventories," *Journal of Industrial Ecology*, 8 (2004), 143-172.
Walker, W. Reed, "The Transitional Costs of Sectoral Reallocation: Evidence From the Clean Air Act and the Workforce," *Quarterly Journal of Economics*, 128 (2013), 1787-1835.
World Bank, "World Development Report 2010: Development and Climate Change," (2010).

FIGURE I

POLLUTION EMISSION FROM US MANUFACTURING 1992-2009

This figure shows the air pollution from US manufacturing sector from 1992 to 2009, where we set the 1992 level as 100. Panel A shows the total release of fugitive and stack air from all manufacturing facilities in TRI. Panel B shows the total release of toxic content in fugitive and stack air from all manufacturing facilities in TRI. Panel C shows the emission of CO from industrial activities in National Emissions Inventory. Panel D shows the emission of SO2 from industrial activities in National Emissions Inventory.

FIGURE II

US IMPORTS AND IMPORTS FROM LWCs 1992-2009

This figure shows US import and import from LWCs from 1992 to 2009, where we set the 1992 level as 100. Panel A shows the real value of total import and import from LWCs. Panel B shows the share of import originating from LWCs.

FIGURE III

CHANGES IN IMPORTS FROM LWCS AND CHANGES IN TOXIC AIR EMISSION 1992-2009

This figure shows the changes in each industry's toxic air emission 1992 to 2009 (where we set the 1992 level as 100) against changes in the share of imports from LWCs. Panel A shows the relation based on pounds of emission. Panel B shows the relation based on toxic content of emission.

Appendix

Table A1
The list of low-wage countries

Afghanistan	China	India	Pakistan
Albania	Comoros	Kenya	Rwanda
Angola	Congo	Lao PDR	Samoa
Armenia	Equatorial Guinea	Lesotho	Sao Tome
Azerbaijan	Eritrea	Madagascar	Sierra Leone
Bangladesh	Ethiopia	Malawi	Somalia
Benin	Gambia	Maldives	Sri Lanka
Bhutan	Georgia	Mali	St. Vincent
Burkina Faso	Ghana	Mauritania	Sudan
Burundi	Guinea	Moldova	Togo
Cambodia	Guinea-Bissau	Mozambique	Uganda
Central African Rep	Guyana	Nepal	Vietnam
Chad	Haiti	Niger	Yemen

Table A2

The list of most-polluting countries

Trinidad and Tobago	Kyrgyzstan	Iraq	Malaysia
Venezuela	Moldova	Iran	Indonesia
Guyana	Tajikistan	Jordan	China
Suriname	Turkmenistan	Saudi Arabia	Mongolia
Bolivia	Uzbekistan	Qatar	Algeria
Czech Republic	Bosnia	Yemen	Libya
Estonia	Macedonia	Bahrain	Egypt
Russia	Serbia	India	Mauritania
Armenia	Romania	Pakistan	Liberia
Azerbaijan	Bulgaria	Thailand	South Africa
Georgia	Syria	Vietnam	Zimbabwe
Kazakhstan			

Table I

SUMMARY STATISTICS

Panel A: Firm level	N	Mean	SD
Firm's total shipment value of output (in thousand dollars)	277768	210690.7	3727718
Firm's total import (in thousand dollars)	277768	39700	630000
Share of import from LWCs	277768	0.162	0.318
Ln(Toxic content import)	277768	25.009	7.723
Ln(Pollute content import)	277768	11.863	5.288
Toxic content import/Firm's total import	277768	10.903	30.879
Pollute content import/Firm's total import	277768	6.455	20.144

Panel B: Planet Level	N	Mean	SD
Ln(Toxic emissions)	136574	12.978	6.09
Total number of employees	136574	417.583	802.24
Plant's total value of shipment (in thousand dollars)	136574	175201	586365
Skill intensity	136574	0.351	0.193
Total capital expenditures (in thousand dollars)	136574	6129.05	36024
Parent firm's share of imports from LWCs	136574	0.087	0.186
Dirtiest 100 counties	136574	0.222	0.416
Dirtiest 100 counties (in 1992)	136574	0.244	0.429

Table II

POLLUTION CONTENT AND INTENSITY OF FIRM IMPORTS

	(1) IPPS	(2) TRI	(3) IPPS	(4) TRI
	Ln(Pollute Import)		Pollute Import / Total Import	
LWC Import Share	0.986***	1.402***	0.722**	0.674**
	[0.068]	[0.103]	[0.288]	[0.295]
Ln(Firm Shipment)	0.558***	0.663***	0.038	0.107
	[0.019]	[0.028]	[0.072]	[0.116]
Adjusted R^2	0.699	0.615	0.650	0.609

N=277,768. This table reports regression estimates of the impact of LWCs import share on the pollution intensity of a firm's imports, from 1992 to 2009, based on equation (1). The sample includes all firms that import. We use industry-level pollution intensities based on the IPPS and the TRI and multiply by a firm's import value in each industry to calculate the pollution content and intensity of imports. All regressions include a constant and control for firm and year fixed effects. Standard errors are clustered at the firm level. ***, **, and * denotes statistical significance at 1%, 5%, and 10% level, respectively.

Table III

FIRMS' IMPORTS AND THEIR PLANTS' TOXIC EMISSION

	(1) Ln(Toxic Emission)	(2) $Ln(\frac{\text{Toxic Emission}}{\text{Plant Shipment}})$	(3) Ln(Toxic Emission)	(4) $Ln(\frac{\text{Toxic Emission}}{\text{Plant Shipment}})$
LWC Import Share	-0.583***	-0.117***		
	[0.143]	[0.044]		
MPC Import Share			-0.364***	-0.039
			[0.113]	[0.058]
Ln(Plant Shipment)	0.449***	-0.629***	0.450***	-0.063***
	[0.035]	[0.019]	[0.036]	[0.019]
Skill Intensity	-0.778***	-0.400***	-0.784***	-0.401***
	[0.154]	[0.055]	[0.105]	[0.055]
Ln(Capital Expenditures)	0.056***	0.015***	0.056***	0.015***
	[0.009]	[0.004]	[0.009]	[0.005]
Ln(Total Imports)	0.022**	-0.004	0.023**	-0.004
	[0.011]	[0.004]	[0.011]	[0.006]
Adjusted R^2	0.712	0.759	0.712	0.759

N=136,574. This table reports regression estimates of the impact of firms' imports from LWCs (or the top third of countries in terms of CO2 emission per GDP) on their plant-level toxic emissions in the US, from 1992 to 2009, based on equation (2). The sample includes all firms that import and are surveyed by the TRI. The dependent variable is a plant's toxic content from all-media pollutant emissions. All regressions include a constant and control for plant and year fixed effects. Standard errors are clustered at the firm level. ***, **, and * denotes statistical significance at 1%, 5%, and 10% level, respectively.

Table IV
FIRMS' IMPORTS FROM LWCs AND THEIR PLANTS' TOXIC EMISSION, BY LOCATION

	(1)	(2)	(3)	(4)
	Ln (Toxic Emission)		$Ln(\frac{\text{Toxic Emission}}{\text{Plant Shipment}})$	
LWC Import Share	-0.508***	-0.469***	-0.079*	-0.466
	[0.090]	[0.094]	[0.047]	[0.050]
100 Dirtiest Counties	0.567***		0.499***	
	[0.048]		[0.028]	
LWC Import Share * 100 Dirtiest Counties	-0.351**		-0.183*	
	[0.176]		[0.098]	
LWC Import Share * 100 Dirtiest Counties (1992 ranking)		-0.480***		-0.298***
		[0.183]		[0.098]
Ln(Plant Shipment)	0.446***	0.449***	-0.065***	-0.063***
	[0.026]	[0.026]	[0.019]	[0.019]
Skill Intensity	-0.779***	-0.778***	-0.400***	-0.400***
	[0.105]	[0.105]	[0.055]	[0.105]
Ln(Capital Expenditures)	0.055***	0.056***	0.014***	0.015***
	[0.007]	[0.007]	[0.004]	[0.004]
Ln(Total Imports)	0.020**	0.020**	-0.004	-0.004
	[0.007]	[0.007]	[0.004]	[0.007]
Adjusted R^2	0.713	0.712	0.760	0.759

N=136,574. This table reports regression estimates of the impact of firms' imports from LWCs on their plant-level toxic emissions in the US, from 1992 to 2009, based on equation (3). The sample includes all firms that import and are surveyed by the TRI. "100 Dirtiest Counties" refers to the top 100 counties in the US in terms of toxic emissions based on the TRI. All regressions include a constant and control for plant and year fixed effects. Standard errors are clustered at the firm level. ***, **, and * denotes statistical significance at 1%, 5%, and 10% level, respectively.

Table V
FIRMS' IMPORTS FROM MOST POLLUTING COUNTRIES AND THEIR PLANTS' TOXIC EMISSION, BY LOCATION

	(1)	(2)	(3)	(4)
	Ln (Toxic Emission)		$\text{Ln}(\frac{\text{Toxic Emission}}{\text{Plant Shipment}})$	
MPC Import Share	-0.309***	-0.276***	-0.002	-0.022
	[0.072]	[0.075]	[0.038]	[0.040]
100 Dirtiest Counties	0.578***		0.511***	
	[0.050]		[0.030]	
MPC Import Share *100 Dirtiest Counties	-0.272*		-0.190**	
	[0.141]		[0.082]	
MPC Import Share *100 Dirtiest Counties (1992 ranking)		-0.369**		-0.257***
		[0.153]		[0.086]
Ln(Plant Shipment)	0.448***	0.450***	-0.065***	-0.063***
	[0.026]	[0.026]	[0.019]	[0.019]
Skill Intensity	-0.785***	-0.785***	-0.402***	-0.402***
	[0.105]	[0.105]	[0.055]	[0.055]
Ln(Capital Expenditures)	0.056***	0.056***	0.014***	0.015***
	[0.007]	[0.007]	[0.004]	[0.004]
Ln(Total Imports)	0.023***	0.023***	-0.004	-0.004
	[0.007]	[0.007]	[0.004]	[0.004]
Adjusted R^2	0.713	0.712	0.760	0.759

N=136,574. This table reports regression estimates of the impact of US firms' imports from the most polluting countries on their plant-level toxic emissions in the US, from 1992 to 2009, based on equation (3). The sample includes all firms that import and are surveyed by the TRI. "100 Dirtiest Counties" refers to the top 100 counties in the US in terms of toxic emissions based on the TRI. All regressions include a constant and control for plant and year fixed effects. Standard errors are clustered at the firm level. ***, **, and * denotes statistical significance at 1%, 5%, and 10% level, respectively.

Table VI

FIRMS' IMPORTS FROM LWCs AND THEIR PLANTS' EXPENDITURES ON POLLUTION ABATEMENT

	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(PAOC)	$\text{Ln}\left(\frac{\text{PAOC}}{\text{Total Employment}}\right)$	Ln(PAOC)		$\text{Ln}\left(\frac{\text{PAOC}}{\text{Total Employment}}\right)$	
LWC Import Share	-0.151**	-0.066***	-0.062	-0.071	-0.044*	-0.049**
	[0.064]	[0.022]	[0.092]	[0.091]	[0.024]	[0.023]
100 Dirtiest Counties			-0.006		0.021***	
			[0.009]		[0.009]	
LWC Import Share *100 Dirtiest Counties (1992 ranking)			-0.391**		-0.094**	
			[0.153]		[0.153]	
100 Dirtiest Counties (1992 ranking)				-0.037		0.017**
				[0.028]		[0.009]
LWC Import Share *100 Dirtiest Counties (1992 ranking)				-0.353**		-0.075**
				[0.147]		[0.036]
Ln(Plant Shipment)	0.465***	0.020***	0.465***	0.465***	0.020***	0.020***
	[0.027]	[0.005]	[0.027]	[0.027]	[0.005]	[0.005]
Skill Intensity	-0.843***	-0.205***	-0.839***	-0.834***	-0.207***	- 0.208***
	[0.072]	[0.055]	[0.072]	[0.072]	[0.021]	[0.021]
Ln(Capital Expenditures)	0.379***	0.058***	0.378***	0.378***	0.058***	0.058***
	[0.025]	[0.004]	[0.025]	[0.025]	[0.005]	[0.005]
Ln(Total Imports)	0.060***	0.015***	0.060***	0.060***	0.015***	0.015***

	[0.006]	[0.002]	[0.006]	[0.006]	[0.002]	[0.002]
Adjusted R^2	0.498	0.559	0.498	0.498	0.559	0.559

N=50,318. This table reports regression estimates of the impact of firms' imports from LWCs on their plant-level pollution abatement costs in the US, in 1992, 1993, 1994, 1999 and 2005. The sample includes all firms that import and are surveyed by the PACE. All regressions include a constant and control for 4-digit SIC industry fixed effects and year fixed effects. Standard errors are clustered at the firm level. ***, **, and * denotes statistical significance at the 1%, 5%, and 10% level, respectively.

Table VII

POLLUTION CONTENT AND INTENSITY OF FIRM IMPORTS FROM RELATED PARTIES in LWCs

	(1) IPPS	(2) TRI	(3) IPPS	(4) TRI
	Ln(Pollute Import)		$\frac{\text{Pollute Import}}{\text{Total Import}}$	
LWC Import Share	0.968***	1.383***	0.722**	0.681**
	[0.068]	[0.103]	[0.288]	[0.296]
LWC Import Share from Related Parties	0.613***	0.605***	-0.011	-0.206
	[0.063]	[0.083]	[0.312]	[0.330]
Ln(Firm Shipment)	0.556***	0.663***	0.038	0.108
	[0.019]	[0.028]	[0.072]	[0.085]
Adjusted R^2	0.700	0.615	0.650	0.609

N=277,768. This table reports regression estimates of the impact of a firm's import from related parties in LWCs on its pollution intensity of imports, from 1992 to 2009. The sample includes all firms that import. We use industry-level pollution intensities based on the IPPS and the TRI and multiply by a firm's import value in each industry to calculate the pollution content and intensity of imports. All regressions include a constant and control for firm and year fixed effects. Standard errors are clustered at the firm level. ***, **, and * denotes statistical significance at 1%, 5%, and 10% level, respectively.

Table VIII

FIRMS' IMPORTS FROM RELATED PARTIES IN LWCs AND THEIR PLANTS' TOXIC EMISSION

	(1) Ln(Toxic Emission)	(2) $Ln(\frac{\text{Toxic Emission}}{\text{Plant Shipment}})$
LWC Import Share	-0.578***	-0.117***
	[0.143]	[0.044]
LWC Import Share from Related Parties	-0.104***	-0.037
	[0.049]	[0.043]
Ln(Plant Shipment)	0.449***	-0.629***
	[0.035]	[0.019]
Skill Intensity	-0.777***	-0.400***
	[0.105]	[0.055]
Ln(Capital Expenditures)	0.056***	0.015***
	[0.007]	[0.005]
Ln(Total Imports)	0.024**	-0.004
	[0.011]	[0.004]
Adjusted R^2	0.712	0.759

N=136,574. This table reports regression estimates of the impact of imports from related parties in LWCs on their plant-level toxic emission in the US, from 1992 to 2009. The sample includes all plants of parent firms that import and are surveyed by the TRI. All regressions include a constant and control for firm and year fixed effects. Standard errors are clustered at the firm level. ***, **, and * denotes statistical significance at 1%, 5%, and 10% level, respectively.