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Offshoring Production while Offshoring Pollution

Xiaoyang Li
Cheung Kong Graduate School of Business

Yue Maggie Zhou
Stephen M. Ross School of Business
University of Michigan

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ABSTRACT

This paper introduces a firm-strategy perspective to the global combat against environmental pollution. We find that U.S. plants release less toxic emissions when their parent firm imports more from low-wage countries (LWCs). Consistent with the Pollution Haven Hypothesis, goods imported by U.S. firms from LWCs are in more pollution-intensive industries; U.S. plants also shift production to less pollution-intensive industries and spend less on pollution abatement when their parent firm imports more from LWCs. The negative impact of LWC imports on toxic emissions is stronger for U.S. plants located in counties with more powerful institutions, but weaker for more-capable U.S. plants and firms. These results highlight the role of local institutions and firm capabilities in explaining firms' choice of offshoring and environmental strategy.

Keywords: environmental strategy, pollution haven, offshoring, institutions, globalization, supply chain sustainability

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Li: Cheung Kong Graduate School of Business, 2F, Tower E3, Oriental Plaza, 1 East Change An Avenue, Beijing 100738, P. R. China. xyli@ckgsb.edu.cn

Zhou: Stephen M. Ross School of Business, University of Michigan, 701 Tappan St, Ann Arbor, MI 48109, USA. ymz@umich.edu.

INTRODUCTION

The global effort to combat pollution has gained tremendous momentum in recent years. The United States and China, the two largest emitters of greenhouse gas, issued a joint announcement in 2014 to strengthen bilateral cooperation, including joint technological initiatives, research efforts, and economic policies, to tackle climate change (The White House, 2014). One hundred ninety-six countries attending the 2015 United Nations Climate Change Conference voted to adopt a joint agreement to curb global warming (NPR, 2015). India and France launched a global alliance to mobilize investments from rich countries to develop solar power around the world, especially in sun-rich but cash-poor tropical countries (Financial Times, 2015). Participation in these global initiatives is not always welcomed at home, however. Only recently have politicians, the media, and large businesses in the United States started to openly accept climate change and global warming concerns (Leiserowitz *et al.*, 2013). Other critics are content with the empirical evidence that strict environmental regulations and informal institutional pressure in the United States have already significantly improved its environment (Chay & Greenstone, 2003; Levinson, 2009; Shapiro & Walker, 2014). Significant portions of Americans still think their government should not take responsibility for other countries' environmental problems.

We challenge these critical views by proposing that the United States' strict regulations and institutional pressure for environmental performance might come at the expense of the environment in other countries. 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). For example, a recent study in China using atmospheric modeling found that 17%–36% of four major anthropogenic air pollutants (SO2, NOx, CO, and black carbon) emitted in that country are associated with the production of goods for export, and that about 21% of export-related emissions are attributable to goods destined for the United States (Lin *et al.*, 2014). Unfortunately, most prior research on PHH has relied on aggregate country-, state-, or industry-level information (Antweiler, Copeland, & Taylor, 2001; Ederington, Levinson, & Minier, 2004; Grossman & Krueger, 1995; Hanna, 2010; Levinson, 2010, 2009), which partly explains some contradictory results in this research. To our knowledge, no one has studied the issue at the level of the firm, where production-pollution decisions are made.

To fill this gap, this paper brings a firm-strategy analysis to the policy debate. In response to institutional pressure, such as that for environmental performance, firms can acquiesce (e.g., comply), compromise, avoid, defy, or manipulate (Oliver, 1991). While compliance by a firm "elevates its legitimacy and protects it from public criticism and the financial penalties of noncompliance" (Oliver, 1991: 153), strict legal and institutional requirements impose significant compliance costs on firms (Blass *et al.*, 2014). In order to lower compliance costs, firms can compromise by innovating products and processes (King & Lenox, 2001; Porter & Van der Linde, 1995) or manipulate (e.g., by greenwashing, Kim & Lyon, 2015). These strategies, however, are constrained by societal scrutiny (Marquis & Toffel, 2014) or firm capabilities (Barnett & Salomon, 2012; Berchicci, Dowell, & King, 2012). We conjecture that firms may also lower the compliance costs by arbitraging between varying institutional constraints, effectively putting "sovereignty at bay" (Kobrin, 2001; Vernon, 1971). For example, firms can redesign their supply chain, shifting their domestic production to cleaner segments and import from poor or low-wage countries (LWCs) products that are more polluting to produce, thereby achieving compliance and avoidance at the same time. Even though the comparative advantage of LWCs should attract more labor-intensive industries rather than the more polluting capital-intensive industries (Cole & Elliott, 2005), LWCs also have lax environmental standards and poor environmental regulatory quality (Esty & Porter, 2002), which attract foreign businesses based on environmental rather than pure labor-cost considerations.

To test these ideas, we linked firm-level imports and plant-level production statistics maintained by the U.S. Census Bureau (Census) to plant-level toxics emissions information from the Environmental Protection Agency's (EPA's) Toxics Release Inventory (TRI) database. We found that domestic plants pollute less on American soil as their parent firm imports more from LWCs: When a plant's parent firm increases its share of imports from LWCs by 10 percentage points, the plant's toxic emissions on American soil fall by 4%–6%. We then explored a few micro-mechanisms and uncovered evidence consistent with the PHH and a "pollution-offshoring" strategy. In particular, we found that goods imported by U.S. firms from LWCs are in more pollution-intensive industries than goods imported from the rest of the world, and U.S. plants shift production to less pollution-intensive industries and spend less on pollution abatement when their parent firm imports more from LWCs. Taking this evidence together suggests that at least some U.S. firms are offshoring more pollution-intensive production to LWCs.

Pollution offshoring is both costly and risky. We therefore investigated two sources of heterogeneity affecting firms' offshoring decisions. The first source of heterogeneity is the local institution. Plants located in communities that are less proactive in opposing pollution will pursue less pollution offshoring. In contrast, in places where local institutions proactively combat pollution, revealing that a plant pollutes can trigger aggressive responses from the media and local communities, followed by additional inspections and potential penalties from local governments. Drawing insights from the social activism and environmental justice literature (Hiatt, Grandy, & Lee, 2016; King, 2008; Mohai, Pellow, & Roberts, 2009; Pastor, Sadd, & Hipp, 2001), we conjecture that the negative impact of imports from LWCs on domestic pollution will be stronger for American plants located in counties where the local institutions are more powerful, such as counties with a more informed (educated) population, a higher voter turnout in presidential elections, or a stronger presence of environmental nongovernment organizations like the Sierra Club. The second source of heterogeneity we explore is firm capability. Based on the corporate social responsibility (CSR) literature (Berchicci *et al.*, 2012; Chin, Hambrick, & Treviño, 2013; Dowell, Hart, & Yeung, 2000), we hypothesize that more-capable firms, or firms with more productive plants, and firms with more intangible assets such as technological capability and brand equity, will have lower costs and more reputational incentive to comply with, rather than avoid, strict environmental requirements in the United States. Therefore, the negative impact of imports from LWCs on domestic pollution will be weaker for more-capable plants and plants with more-capable parent firms. Our empirical results support these conjectures.

This paper's main contribution is to introduce a firm-strategy perspective to the policy debate about global coordination to combat environmental problems. It provides the first micro-level empirical evidence that the "green shift" of U.S. manufacturing corresponds with a "brown shift" of imports from poor countries. It advances the PHH by pointing out an important mechanism of intensive-margin/strategic adjustments (e.g., product portfolio reconfiguration) at the firm level, which has not been previously distinguished from extensive-margin adjustments (e.g., firm entry and exit) at the industry or regional level. These findings imply that, with the globalization of production, adopting strict domestic environmental standards can relieve negative externalities in one location while amplifying them in another location. With the recent public debates around re- or near-shoring vs. offshoring, the impact of institutional constraints on the configuration of global production networks becomes increasingly salient. While conventional wisdom assumes that pollution is local, a recent study shows that pollution from China contributes to a significant portion of the sulfate concentrates found over the western United States (Lin *et al.*, 2014). Our empirical findings lend further credence to policy makers' assertions that there should be more coordination between international trade and environmental agreements (Keller & Levinson, 2002).

In addition, this paper highlights the role of local institutions and firm capability in explaining firm's choice of arbitraging in institutional differences. While the idea of institutional arbitrage is not new, existing studies have been limited to multinational corporations (MNCs) and institutional constraints with no clear CSR consequence. Our findings, based on the most comprehensive sample of manufacturing firms, suggest that firms could respond to institutional pressure by compliance at the local level but avoidance at the global level. Our goal is not to offer any moral endorsement for or against a "jurisdiction shopping" strategy (Ahuja & Yayavaram, 2011), but to demonstrate that such a strategy is conceptually possible and practically feasible. At the same time, we point out that a firm's capability influences the costs and benefits of embracing CSR initiatives in its home country, and therefore influences its decision about offshoring and environmental strategy.

THEORY DEVELOPMENT

Institutions are humanly devised constraints that structure human interactions; they include formal rules as well as informal norms of behavior and conventions (North, 1990). Institutions can be both supportive and detrimental to organizations. On the one hand, institutions provide (1) information, which enables better monitoring and measuring of effort and performance, and (2) clarity of property rights and "rules of the game," which facilitate enforcement (Alchian & Demsetz, 1972; Coase, 1937; Demsetz, 1967). Accordingly, strong institutions promote economic growth (North 1990). On the other hand, institutions can be developed independent of efficiency and diffused through coercive, mimetic, and normative processes (DiMaggio & Powell, 1983; Meyer & Rowan, 1977). Because organizations require legitimacy to survive and thrive (Weber, 1924), institutions exert powerful pressure on firms to conform (Orru, Biggart, & Hamilton, 1991).

Institutions vary not only by their strength and benefits/costs to organizations, but also by time and space. This variation creates an opportunity for organizations to arbitrage across institutional boundaries. In a closed social system, firms must comply with institutional demands despite the high cost of compliance. Globalization relaxes this local constraint and allows firms to arbitrage between varying local institutions. For example, firms can circumvent trade barriers through foreign direct investment (Caves, 1996) or evade tax liability by relocating operations to low-tax countries (Desai et al. 2004).

Arbitraging between environmental standards

Pollution is a negative externality. By partially privatizing its social costs, strict environmental standards raise firms production costs, which should in turn discourage pollution-intensive production. However, the impact of strict environmental standards on U.S. firms has been controversial in policy and academic debates. Many argue that strict environmental standards in the United States weaken American firms' competitiveness in international markets, causing declining manufacturing productivity (Greenstone, List, & Syverson, 2012), plant closures (Becker & Henderson, 2000; Henderson, 1996), losses of American jobs (Greenstone, 2002), and falling wages for U.S. workers (Walker, 2013).

While the literature often separately studies the two main responses to environmental standards—compliance or avoidance—we argue that firms can achieve compliance *and* avoidance by arbitraging between different institutional requirements. For example, it has been found that, in response to the Clean Air Act Amendments (CAAA), firms use air pollution abatement techniques to remove pollutants from the air, but release these pollutants into water bodies, landfills, or the ground (Greenstone, 2003). In addition, firms operating multiple facilities across multiple jurisdictions in the United States generate more total waste (King & Shaver, 2001).

Globalization provides an additional dimension along which firms can arbitrage. Whereas the annual cost of complying with environmental standards in the Unites States amounts to hundreds of billions of dollars and more than two percent of GDP, most less developed countries spend only a fraction of one percent (Jaffe *et al.*, 1995) and have not been able to adopt strict environmental standards for fear of hurting economic growth (The Economist, 1998). Such differences create a unique arbitrage opportunity for firms from rich countries. For example, U.S.

firms invested more outside the United States when they expected their county to be subject to more stringent environmental regulations (Hanna, 2010). The concern over "job killing" environmental regulations in the United States is one major obstacle to trade agreements such as the North American Free Trade Agreement (NAFTA). Here we propose an intensive-margin adjustment mechanism within firms that is consistent with the PHH: adjusting production sites. More specifically, firms can redesign their supply chain to locate more-polluting production in LWCs to "avoid" U.S. pollution standards, while assigning their domestic plants to produce in cleaner segments to "comply" with the U.S. standards. Accordingly:

> *Hypothesis 1: A U.S. plant will emit less pollution as its parent firm imports more from LWCs relative to non-LWC countries.*

Local institutions and global response

Firms are subject to national regulations as well as local informal institutional pressures. Powerful local news media and activists can exert significant impact on firms (Hiatt *et al.*, 2016; King, 2008). They can mobilize voter turnout to influence regulatory changes that would impose an economic penalty on non-conforming firms (Tarrow, 2011). For example, when Butler County, Pennsylvania, was identified by the EPA as among the dirtiest counties, local residents successfully pressured the state to restrict nitrate emissions of a major steel plant before the plant was allowed to release waste into the Connoquenessing Creek (Powers, 2013). Local residents can also engage in protests, civil suits, and letter-writing campaigns to impose operational costs such as legal fees and public relations expenses, to distract managerial attention, or to threaten the firm's reputation amongst its customers, employees, and shareholders (Eesley & Lenox, 2006). After Calhoun County, Texas, was publicized by the EPA as one of the dirtiest counties in America, local residents 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 (Powers, 2013).

Some counties are more tolerant of noncompliance, or are less able to mobilize opposition to noncompliance than others. Noncomplying firms in these counties are therefore less likely to relocate elsewhere (including relocating out of the country). This dynamic contributes to environmental inequality, such as the discriminatory siting of toxic facilities in the United States

(Mohai *et al.*, 2009; Pastor *et al.*, 2001). Consistently, both anecdotal and empirical evidence has shown that U.S. counties with more informed (educated) population and with greater voter turnout in presidential elections have fewer toxic facilities located in them (Shapiro, 2005), and these counties are more likely to force firms to cut emissions or relocate production (Hoffman & Ocasio, 2001; Khanna, Quimio, & Bojilova, 1998; Maxwell, Lyon, & Hackett, 2000). Another important player is non-government social movement organizations such as the Sierra Club, which can engage their members to frame and influence individual values and stakeholder understandings, thereby affecting firm decisions (Hiatt, 2010).

Compared within increasingly powerful state and county stakeholders in the United States, communities in LWCs have less power against their governments due to both a lack of information and a lack of property rights. They might also have different incentives, as their basic economic needs have yet to be met. This results in more lenient environmental standards and lighter local institutional pressure for environmental performance in LWCs. Therefore, firms with their American plants located in counties that are expected to react more aggressively to toxic emissions will be more likely to offshore to LWCs.

Hypothesis 2: The negative impact of imports from LWCs on domestic pollution will be stronger for U.S. plants located in counties where the local institutions are more powerful.

Firm capability and offshoring

Despite the higher costs, fulfilling CSR objectives by complying with (rather than avoiding) institutional requirements brings potential benefits for some firms. Firms that adopt strong environmental management have been found to enjoy greater accounting returns (Hart & Ahuja, 1996; Nehrt, 1996; Russo & Fouts, 1997) or higher financial returns (Dowell *et al.*, 2000; Klassen & McLaughlin, 1996) or both (King & Lenox, 2002). This is because socially responsible firms can potentially deter stakeholder activism (Reinhardt, 1999), attract consumers (Casadesus-Masanell *et al.*, 2009; Elfenbein & McManus, 2010; Sen & Bhattacharya, 2001; Servaes & Tamayo, 2013) and motivate productive employees (Flammer, 2015; Greening & Turban, 2000; Prendergast, 2007; Tonin & Vlassopoulos, 2015), thereby enhancing shareholder value (Eccles, Ioannou, & Serafeim, 2014; Porter & Kramer, 2011).

Firms' incentive to arbitrage institutional differences depends on the costs and benefits of avoidance relative to those of compliance. These costs and benefits are partly driven by firm capability. Whereas less-capable firms often find it challenging to meet environmental standards, more-capable firms will find it relative easy to remain profitable while achieving or even outperforming these standards. For some capable firms, such as firms with more productive plants, the cost of compliance is lower. These firms are more likely to be at the technological frontier and will find it less costly to innovate their products and processes, thereby enjoying more "environmental capability" (Berchicci *et al.*, 2012). They are also more likely to have accumulated slack resources necessary to undertake CSR (Chin *et al.*, 2013).

For other capable firms, such as firms with a larger amount of intangible assets including technological capability and brand equity (Dowell *et al.*, 2000; Morck & Yeung, 1992), avoidance brings less benefit but more risk. These firms are likely to enjoy a greater "stakeholder influencing capacity" and send a more credible signal by engaging in CSR than firms with less brand equity, thereby profiting more from complying. In addition, because they are more likely to compete on product differentiation and brand reputation, they will be more cautious about the potential damage to their reputation in their home country by socially irresponsible activities abroad—the kind of reputational damage that Apple and Nike experienced in recent years (Wall Street Journal, 2013, 2014). Furthermore, these firms are less likely to compete based on production costs and therefore will be under less cost pressure when making offshoring and environmental decisions. We therefore expect more productive plants and firms with more intangible assets to engage in less pollution offshoring.

Hypothesis 3: The negative impact of imports from LWCs on domestic pollution will be weaker for more productive U.S. plants, U.S. plants of more productive parent firms, and U.S. plants of parent firms that own more intangible assets.

THE U.S. ENVIRONMENT AND IMPORTS FROM LWCS

The EPA's TRI program is the first large-scale initiative to track facility-level pollution emissions in the United States. Introduced by the Emergency Planning and Community Right to Know Act (EPCRA) in 1986, the TRI program intends to provide public environmental information and to affect firm behavior indirectly through consumer, public, or community pressure (Konar & Cohen, 1997).[1] The TRI database has also become one of the most widely accessed databases providing comparative data on environmental performance across facilities and over time. It has been used by a large body of stakeholders including the government, investors, potential employees, industry, media, and general public. Prior research shows that residential house prices in heavily polluted areas declined after the TRI database was published (Oberholzer-Gee & Mitsunari, 2006). Both public media and the stock market respond negatively when a firm reports higher emissions in the TRI (Hamilton, 1995). 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 & Cohen, 1997). In fact, plants that report to TRI dropped their total pollutant emissions by about 60% between 1988 and 2005, leading the EPA to conclude that the "national publication of the TRI data by the government, followed by analysis by citizens' groups and the news media, led to action by industry to reduce emissions" (EPA, 2000; Oberholzer-Gee & Mitsunari, 2006).

Based on TRI, we constructed an overview of the toxic emissions from U.S. manufacturing plants. Consistent with prior statistics (e.g., Levinson, 2009), Figure 1 shows that the emissions of major air pollutants by U.S. manufacturers fell by more than half between 1992 and 2009, despite the significant growth in real U.S. manufacturing output.

Insert Figure 1 about here

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[1] The EPA requires facilities that emit more than 25,000 pounds or handle more than 10,000 pounds of any of the 600+ designated toxic chemicals to self-report emissions data for use in a publicly available database. Although the TRI database is based on self-reported information, there are a few mechanisms to ensure its accuracy. First, each EPA region has a TRI enforcement program that conducts, on an annual basis, a 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, or per violation, and may be subject to criminal charges. Second, a complementary self-reporting program, EPA's Audit Policy program, launched in 1995, reduces or waives certain penalties for environmental violations that are voluntarily disclosed to the government by regulated entities. Such self-reports are found to help regulators identify self-policing firms and reallocate enforcement resources to firms that do not self-report (Toffel & Short, 2011). These enforcement mechanisms give firms incentive to self-report.

In comparison to Figure 1, we plotted the overall trends in imports in Figure 2 based on Census' aggregate trade statistics. Figure 2 shows that while imports from LWCs have been small historically, they have increased substantially in recent years as trade barriers have been removed. Between 1992 and 2009, when the real value of total U.S. imports more than doubled, the real value of imports from LWCs grew more than ten-fold. Consequently, the share of total U.S. imports from LWCs in this period rose from 7% to about 23%. The increasing share of imports from LWCs in Figure 2 corresponds to the decreasing air pollution in Figure 1.

Insert Figure 2 about here

Figure 3 shows that between 1992 and 2009, those industries that had a greater increase in the share of imports from LWCs also experienced a greater reduction in air pollutant emissions from U.S. plants. For example, industries that experienced the greatest increase in imports from LWCs were in the sectors of printing (SIC 278), apparel and textile (SICs 235 and 238), rubber and plastics (SIC302), and furniture (SICs 251, 254, and 259); all experienced some of the largest drops in air pollution emissions. In contrast, industries that had the least increase in imports from LWCs due to transportation costs or trade barriers, including industries in the sectors of food (SIC 208), stone, clay, and glass products (SIC 325), and tobacco products (SIC 214), experienced the least improvement in air pollution emissions. Together, figures 1 through 3 suggest a potential substitution effect between imports from LWCs and domestic emissions at the national and industry levels.

Insert Figure 3 about here

EMPIRICAL DESIGN

Our empirical tests combine firm-level trade, plant-level production, and plant-level pollution data, an approach that offers several benefits. First, it fills a gap in prior research about the impact of globalization on the environment, which is mostly at the country, state, and industry levels due to data limitation. Second, it allows us to control for multiple alternative explanations for environmental performance such as scale of production, capital intensity, skilled labor requirement, and pollution abatement at the plant level. Finally, it allows us to examine the impact of different local institutions and productivity on individual plants within the same firm.

Samples, data sources, and variables

We constructed our samples from several sources. Our first data source is the plant-level toxic emissions data published in the EPA's TRI database, which contains approximately 80,000 facility-chemical reports from more than 20,000 different plants. Toffel and Marshall (2004) compare 13 methods of aggregating chemical-specific release data to the plant level and recommend EPA's Risk-Screening Environmental Indicators (RSEI) model as the most comprehensive model for estimating the impacts of toxic releases on local residents' human health. The RSEI model estimates the toxicity weight for each chemical based on its toxicity, its fate and transport through the environment after its release, the route (inhalation and oral) and extent of human exposure, and its single most sensitive adverse effect (cancer and non-cancer) (EPA, 2012).

We used the TRI database and the RSEI model to construct several variables. The first variable, *toxic emissions*, gauges the total plant-level toxic emissions.[2] An alternative measure using the total toxicity-weighted emissions scaled by plant output generated similar results. The second group of variables is to measure the toxic content of a firm's imports. We summed the RSEI-based toxic emissions of all plants in each 4-digit SIC industry in 1992 and divided the sum by the total output from that industry in 1992, based on the NBER-CES Manufacturing Industry Database (Bartelsman & Gray, 1996), to derive a pollution intensity measure for that industry. We then summed a firm's import value in each industry, weighted by the industry's

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[2] We followed recent studies using the RSEI model 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 and emissions to other media are weighted using oral toxicity (Gamper-Rabindran, 2006).

pollution intensity, to derive the firm's *toxic imports*, which measures the toxic content of a firm's imports. We also scaled *toxic imports* using the firm's total imports to derive *(toxic imports/total imports),* which measures the pollution intensity of a firm's imports.[3] We constructed the third group of variables with a similar methodology: We summed a plant's output in each industry, weighted by the industry's pollution intensity, to derive the overall pollution content and intensity of a plant's output, *toxic output* and (*toxic output/plant shipment*), respectively. As a robustness check, we constructed alternative measures of *toxic imports* and *toxic output* using the World Bank's "Industrial Pollution Projection System" (IPPS); results were similar. Finally, we constructed three variables from TRI to capture plant-level operational efforts in reducing pollution. They include the number of *pollution prevention* (P2) practices such as operational and procedural changes and material, equipment and product changes (Harrington, Deltas, & Khanna, 2014), and total tonnage of *production waste*.

Our second data source is plant-level micro data from the U.S. Census. It is used (1) to control for other factors that might influence pollution emissions, such as plant size (*plant output*),[4] *capital expenditures,* and share of non-production workers over the entire workforce (*skill intensity*, which can also proxy for the plant's production technology), (2) to derive the overall pollution intensity of a plant's output, as mentioned in the previous paragraph, and (3) to calculate the cost of *fuel consumption* per unit of output as a measure of energy efficiency that could potentially explain the change in plant-level pollution emissions. The Census micro data on manufacturing plants include the Census of Manufactures (CM) and the Annual Survey of Manufactures (ASM). 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

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[3] This measure of pollution intensity is based on each industry's emission per dollar of output in the United States. Ideally, we should use pollution intensity in the exporting countries. However, information about industry-level pollution intensity in most countries does not exist. Using U.S. pollution intensity as a proxy for pollution intensity of imported goods is a common practice in the literature (Levinson, 2009). Such a measure assumes that the *ordering* of industries based on pollution intensity overseas is the same as in the US. For example, we are assuming the primary metal industry is more polluting per dollar of output than the food industry in both the US and LWCs because the underlying technology is similar.

[4] Using alternative measure of scale, such as employment, returns similar results.

selected with a probability proportional to a composite measure of their size. Once a plant is surveyed, the ASM continues surveying it to form a five-year panel. We linked the Census and TRI datasets using the existing bridge files maintained by the Census for 1992–99 and by manual matching using plant names and addresses for subsequent years.

Our third data source is the U.S. Census' Longitudinal Firm Trade Transaction Database (LFTTD). The database covers all transactions of goods that crossed U.S. borders. For each transaction, the database contains a firm identifier and pertinent details of the transaction, as well as a 10-digit Harmonized System (HS) classification code of the product category. We followed Pierce and Schott (2012) by linking the ten-digit Harmonized System (HS) classifications to the 1987 version of four-digit SICs. To identify imports from LWCs, we relied on a list provided by Bernard et al. (2006), who classify a country as an LWC if its average annual GDP per capita was less than 5% of the U.S. annual GDP per capita in 1972–92. A list of LWCs is provided in Table 1. China, India, and most African countries are on the list. We calculated a firm's *LWC import share* as the percentage of its total imports that originated from LWCs.

Insert Table 1 about here

Our fourth data source is the plant-level Pollution Abatement Costs and Expenditures (PACE) survey provided by U.S. Census, which is the most comprehensive survey of environmental abatement costs in the United States. *Abatement costs* include pollution prevention, pollution treatment (to reduce or eliminate pollution that has been generated during production processes), waste recycling, and disposal. We used the PACE surveys for the years when they are available in our sample period: 1992–1994, 1999, and 2005. We used total Pollution Abatement Operating Costs, which comprise salaries and wages, parts and materials, fuel and electricity, capital depreciation, contract work, equipment leasing, and additional operating costs associated with the abatement of air and water pollution as well as solid waste reduction or disposal.

Finally, we complemented our firm- and plant-level data with state-level *Sierra Club membership* information and county-level demographic information (*college education* and *voter turnout*) based on the U.S. Census' American Community Survey. We also matched parent firms that are publicly listed to the Compustat dataset in order to collect information about their *intangible assets* (i.e., technological capability measured using RND expenditure and brand equity measured using advertising expenditure, see Morck & Yeung, 1992).

Our main sample is the intersection of plants' pollution data from TRI, plants' operating information from ASM and CM, and firm's import importation from LFTTD. This sample contains about 18,000 plants of more than 8,000 U.S. parent firms for a total of 137,000 plant–year observations in 1992–2009. Table 2 provides summary statistics for this sample. An average importing firm sources 16% of its manufacturing imports from LWCs, slightly higher than the national average of 15% that we calculated based on Census' aggregate trade statistics. 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. The sample plants are relatively large: A typical plant has about 418 employees and manufactures a total value of $175 million of output. A separate calculation reveals that plants in our sample accounted for more than 80% of all U.S. manufacturing plants' total toxic emissions in the sample period.

Insert Table 2 about here

Table 3 reports the pairwise correlation among our key variables of interest. It shows that a plant's toxic emission is negatively correlated with its parent firm's share of imports from LWCs, but positively related to the plant's size, capital expenditures, and total volume of imports. These simple correlation statistics foreshadow our subsequent multivariate regression results.

Insert Table 3 about here

Specifications

We mainly used the following specification to estimate toxic emissions at the plant level:

$$\ln(\text{toxic emission})_{\text{ijt}} = \alpha_{\text{i}} + \alpha_{\text{t}} + \beta \text{LWC import share}_{\text{jt}} + \text{X}_{\text{ijt}} + \varepsilon_{\text{ijt}}, (1)$$

where $ln(toxic\ emissions)_{ijt}$, the logarithm of the total toxicity-weighted emissions of plant *i* of parent firm *j* in year *t*, and LWC import share_{jt}, the share of imports from LWCs for firm parent firm *j* in year *t*, are defined as before. X_{ijt} is a vector of control variables that include the logarithm of *plant output*, the logarithm of its *capital expenditures*, and the *skill intensity*. We also controlled for the parent firm's *total imports*. Standard errors are clustered at the firm level.

We then modified the specification in Equation 1 in two ways. First, we investigated alternative dependent variables. They include plants' toxic output, a number of measures of the plants' efforts to reduce pollution such as abatement costs and pollution prevention practices, etc. Second, we added local institutional pressure, plant/firm capability, and their interaction terms with LWC import share to explore the additional impact of local institutions and firm capability. We also ran a separate firm-level regression to estimate the pollution intensity of industries in which U.S. firms import goods from LWCs.

ANALYSES AND RESULTS

Imports from LWCs and domestic pollution

Table 4 reports our main results based on Equation 1. All columns include plant fixed effects. In addition, columns (1) and (6) include year fixed effects, and columns (2)–(5) include industry*year fixed effects to control for changes in industry-specific technology and reductions in trade costs over time.

Insert Table 4 about here

The results are qualitatively similar across all columns. They show that a firm's LWC import share was significantly and negatively correlated with its domestic plants' toxic emissions; results for toxic emissions per dollar of shipment are not shown due to space limit but were similar. The economic effect of the point estimates is considerable. For instance, the coefficient of –0.401 in column (2) implies that a 10% increase in a plant's parent firm's LWC import share is correlated with about 4% reduction in the plant's toxic emissions. Our results imply that, over the 18-year sample period, when the economy-wide share of imports from LWCs grew by 16 percentage points, a plant would reduce its toxic emission by about 6.4%, a reduction that accounts for around 10% of the total drop in U.S. toxic emissions in the period. 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 tended to produce greater toxic emissions. Finally, result show total imports did not have a statistically significant impact on toxic emissions and including it did not qualitatively change the coefficients of LWC import share. H1 is supported.

Robustness checks. One might wonder how much of the pollution-import effect is caused by imports from China. Results in column (3) suggest that imports from China indeed played a significant role, whereas imports from EU countries did not have a significant impact. That said, column (4) suggests that even after excluding China, LWC imports had a significant, albeit weaker, correlation with domestic pollution at the plant level. We also estimated column (2) on the two subsample periods before and after 2001, when China joined the WTO. Our main results held in both periods. We also ran a robustness check replacing imports from LWCs with imports from the "most polluting countries" based on countries' CO2 emission per GDP using the World Development Indicators; results are consistent.[5]

In column (5) we used an alternative measure of toxic emission following King and Lenox (2000). The alternative measure weights each chemical by its toxicity using the Reportable Quantities (RQ) provided by the EPA in the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). RQ serves as a threshold for reporting accidental spills, therefore the toxicity weight for each chemical is calculated as the inverse of its RQ. The coefficients in column (5) show that our main findings hold with this alternative measure of

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[5] In order to identify countries with lax environmental standards independent of economic development or wage level, we first constructed a list of "most polluting countries" (MPCs). We ranked countries by their annual carbon dioxide (CO2) emission (kilograms per inflation-adjusted GDP), one of the World Development Indicators (World-Bank, 2010) Such measures have been used in prior studies (Levinson, 2009) to proxy the strength of environmental regulation across countries. We chose the minimum level of CO2 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 CO2 emissions exceeded 1 kilogram per GDP. The list shows that a few countries from Eastern Europe and the Middle East (presumably fossil fuel burners) stand out as different from LWCs.

emissions. We also scaled the dependent variables by the plant output and lagged the independent variables; results are similar.

Endogeneity. Despite our efforts to control for determinants of pollution, there could be some unobservable variables that bias our estimates. Two obvious candidates for such unobservable factors are regulation and technology. Firms may be reducing pollution in the United States due to more strict environmental regulations or because they have developed new technologies to reduce pollution; at the same time, they may be increasing imports from LWCs due to increased U.S. demand for LWC products. These unobservable factors might affect a firm's decision to import and emit and thus induce a correlation between the right-hand-side variables and the error term.

To address the problem of omitted variables, we first used a longitudinal, rather than cross-sectional, analysis based on a panel of plant-level dataset. In addition, we included plant and industry-year fixed effects to account for unobservable time-invariant factors at the plant-level (such as plant innovativeness and technological capability) and industry-specific yearly events that would affect pollution (such as industry-specific regulatory change, technological progress, or tariff changes). Furthermore, we adopted an instrument-variable (IV) strategy.

We instrumented for the firm-level share of imports from LWCs using the industry-level contemporaneous Chinese exports to eight non-U.S. OECD countries, following the method suggested by Autor, Dorn, and Hanson (2013).[6] A significant proportion of the growth in LWC exports over our sample period was driven by Chinese exports. China's transition to a market-oriented economy, including lowering trade barriers, an abundant supply of labor released from urbanization, comprehensive policy reforms, and accession to the WTO, contributed to a substantial increase in China's manufacturing competitiveness. We therefore expected industries that experienced exports from China to non-U.S. OECD countries to have also experienced more imports from LWCs in the U.S. However, the increase in exports from China to non-U.S. OECD countries mainly reflects a "supply shock" driven by China's manufacturing competitiveness. It

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[6] These eight other developed countries are Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain, and Switzerland. Please refer to Autor, Dorn, and Hanson (2013) for a detailed description of this approach.

is therefore less likely to be correlated with demand-side shocks in the United States or U.S. regulation and technology.

We use data from the United Nation Comrade Database on imports to construct the IV as follows:

$$LWC\ Share_{it} = \sum j \frac{I_{ijt}}{I_{it}} \frac{\widetilde{LWC_{Jt}}}{I_{Jt}} \quad (2)$$

$$\frac{\widetilde{LWC_{Jt}}}{I_{Jt}} = \frac{I_{ocjt}}{I_{ojt}} \quad (3),$$

where I_{ijt} is the value of imports by firm *i* in industry *j* at year *t* and I_{it} is the value of imports by firm *i* at year *t*. I_{ocjt} is imports in the eight non-U.S. OECD countries from China in industry *j* and year *t*. I_{ojt} is total imports in the eight non-U.S. OECD countries from all countries in industry *j* and year *t*. We report the two-stage least square (2SLS) results using the IV in column (6) of Table 4. The coefficients are consistent with those in column (1).

Mechanisms. While Table 4 suggests that imports from LWCs reduced U.S. plants' pollution emissions, it does not prove a substitution effect between pollution in the United States and pollution in LWCs. A few mechanisms can be at play. We explore these mechanisms in the next few paragraphs.

First, it could be that as U.S. firms import cheaper products from LWCs, their costs decrease and profit increase. The increased profits would enable U.S. firms to finance more environmental projects. If this were the case, we should see U.S. plants spend more on pollution abatement as their parent firm imports more from LWCs. To test this mechanism, we estimated in the first two columns of Table 5 the correlation between imports from LWCs and U.S. plants' expenditures on pollution abatement. Because of the significant gaps in time coverage of PACE data, we had to use industry*year and plant fixed effects separately but not jointly. In addition to total abatement costs, we also estimated abatement costs divided by a plant's total output; results were similar: They refute the mechanism of cheap LWC production resulting in more U.S. investments in pollution abatement, thereby reducing plant-level pollution emissions. Instead, Columns (1)–(2) in Table 5 show that domestic plants spent *less* on pollution abatement when their parent firm imported more from LWCs. The coefficient of –0.314 implies that a 10-percentage-point increase in a plant's parent firm's LWC import share reduced a plant's pollution abatement costs by about 3.14%, or about 22,100 nominal dollars, relative to about $704,000 spent on abatement by an average plant in our sample.

Insert Table 5 about here

Following a similar logic, we investigated whether plants increased pollution prevention (P2) practices as their parent firm imported more from LWCs. Prior studies have shown that P2 practices reduce toxic emissions (Harrington *et al.*, 2014). Our results in Column (3) show that plants did not significantly step up their P2 practices as their parent firm imported more from LWCs. On the other hand, Column (4) shows that plants reduced their production waste. Column (5) shows that as a plant's parent imported more from LWCs, the plant consumed less fuel, controlling for total output. However, the reduction in production waste, as shown in Column (4), and in fuel consumption, as shown in Column (5), are consistent both with plants investing in pollution reduction (without offshoring pollution) and with plants adjusting their product portfolio (through offshoring).

Next, we tested an intensive-margin adjustment mechanism that is consistent with a PHH and a pollution-offshoring strategy at the firm level: firms moving high-emission production offshore to concentrate domestic production on less-polluting goods and processes. To test this mechanism, we first checked if imports from LWCs were more pollution intensive. The coefficients in Table 6 show that the pollution content of a firm's imports was positively and significantly related to its LWC import share. Coefficients in column (2) imply that a 10-percentage-point increase in a firm's LWC import share is associated with a 2.5% increase in the amount of its "toxic imports." Coefficients in columns (3) and (4) imply that a 10-percentage-point increase in a firm's LWC import share is associated with an increase in the pollution intensity of its imports of about 0.10, or approximately 20% of the sample's median value of pollution intensity of imports.

Insert Table 6 about here

We then investigated if plants increased their output in cleaner segments relative to their output in dirtier segments as their parent imported more from LWCs.[7] The coefficients in Table 7 imply that a 10-percentage-point increase in the share of imports from LWCs lowered the toxicity-weighted output of a U.S. plant by about 0.3%.

Insert Table 7 about here

Together, Tables 4–7 provide some evidence of "pollution offshoring" by U.S. firms. They imported products in more pollution-intensive industries from LWCs than from rich countries. Correspondingly, U.S. plants polluted less on U.S. soil, spent less on pollution abatement, and produced more in less-polluting industries.

Local institutions

Table 8 tests the impact of local institutions. We expanded Equation 1 by adding measures of local institutional power in the area where a plant is located and their interactions with LWC import share. Results suggest that the negative impact of imports from LWCs on U.S. plants' pollution emission was stronger for plants located in counties with a more educated population, counties with stronger voter turnout, and states with a greater membership in Sierra Club. In fact, a significant portion of the negative impact of imports from LWCs on domestic pollution seems to be driven by the power of local institutions. H2 is supported.

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[7] Pollution offshoring at the firm level means that either (1) firm changed their plant mix, establishing new plants in cleaner industries and closing down plants in dirtier industries, or (2) plants changed their product mix, increasing production in cleaner industries and reducing production in dirtier industries. We focused on (2) for two reasons. First, our supplementary analyses did not return strong support for (1), partly due to lack of information on exited plants. Second, plant closure and establishment would not have explained our plant-level finding in Table 4.

Insert Table 8 about here

Firm capability

Table 9 adds measures of plant and firm capability. In order to present the full model, all columns include one measure of local institutional pressure on environmental performance, Sierra Club membership, and its interaction with LWC import share. Coefficients to these variables are similar to those in Table 8, Column (1), albeit economically larger. Coefficients to the capability measures suggest that more productive plants and plants of parent firms with more intangible assets (RND and brand equity) pollute less. In addition, the negative impact of imports from LWCs on pollution is weaker for more productive plants, plants of more productive parent firms, and plants of parent firms that own more intangible assets. H3 is supported.

Insert Table 9 about here

In sum, results in Tables 4–9 suggest a potential substitution between pollution-intensive production in the United States and such production offshored to LWCs, and these effects are stronger for U.S. plants located in counties where local institutions are more powerful but weaker for more-capable U.S. firms.

DISCUSSION AND CONCLUSIONS

This paper investigated the relationship between U.S. firms' imports from low-wage countries and toxic emissions by their domestic plants. Our empirical results suggest that plants released fewer toxic emission on American soil when their parent firm imported more from LWCs. In addition, goods imported by U.S. firms from LWCs were in more pollution-intensive industries than goods imported from the rest of the world. U.S. plants also shifted production to less pollution-intensive industries and spent less on pollution abatement when their parent firm imported more from LWCs. The negative impact of imports from LWCs on domestic plants' toxic emissions was stronger for plants located in counties where the local institutions were more powerful, but weaker when the plants were more productive or when the parent firms possessed more intangible assets such as brand equity.

This paper's main contribution is to introduce a firm-strategy perspective into the policy debate about global coordination to combat environmental problems. It advances the PHH by pointing out an important mechanism of intensive-margin/strategic adjustments (e.g., product portfolio reconfiguration) at the firm level. It provides the first micro-level empirical evidence of "pollution offshoring" and calls for more coordination between international trade and environmental agreements. In addition, it highlights the role of local institutions and firm capabilities in explaining firms' choice of offshoring and environmental strategy.

One intriguing question our results raise is how firms "get away with" offshoring pollution. We therefore ran a few supplementary analyses to explore any further heterogeneity across firms that would influence the relationship between imports from LWCs and domestic pollution. First, Dowell, Hart, and Yeung (2000) find that U.S. MNCs adopting a single stringent global environmental standard enjoy higher market values in the U.S. stock market. We would expect these U.S. MNCs to pursue less pollution-offshoring. Unfortunately we do not have information about which U.S. MNCs adopted a single stringent global environmental standard during our sample period. As a supplementary analysis, we included an MNC dummy in our regression. We did not find a significant difference between MNCs and domestic firms. Our results may be different from those in Dowell et al. (2000) for a number of reasons in addition to the lack of comparable information about firms' internal environmental standards. First, we used different samples. Whereas Dowell et al.'s used a sample of large and public S&P 500 MNCs for 1994–97, we used a more comprehensive sample of more than 8,000 firms and 18,000 plants of all sizes and ownership for 1992–2009. Second, we used different econometric models. While Dowell et al. (2000) used both cross-sectional and random-effects models to allow for selection as part of their theory that countries with lax environmental regulations might attract poorer quality and less competitive firms, we used models with firm or plant fixed effects, industry-year effects, and an instrumental approach to alleviate endogeneity concerns, in order to test our theory. Whether U.S. firms adopting a single stringent global environmental standard pursue less pollution-offshoring can be an interesting subject for future research when data on more firms' international environmental standards become available.

Consumers may be less sensitive to environmental issues in upstream production than environmental issues in downstream production. In a second supplementary analysis we explored if firms in downstream (less pollution-intensive) industries might procure more upstream (more pollution-intensive) products from LWCs. We first checked the relationship between a country's level of development and the "upstreamness" of its industries. Antràs et al. (2012) constructed a measure of industry upstreamness (or average distance from final use) and showed that a country's per capita GDP is not statistically related to the upstreamness of its exports. We then performed an industry-level, cross-sectional regression and found that the industry upstreamness is not statistically correlated with our measure of pollution intensity. For example, both the automobile and footwear industries are among the five most downstream industries, but automobile manufacturing is very polluting while footwear manufacturing is much less so. Finally, we reran our regressions to account for imports in firms' main and upstream segments, respectively. The results indicate no significantly different effects between imports in the main and upstream segments.

In a third supplementary analysis, we examined if firms more visible to their customers might find it more difficult to engage in "pollution offshoring" without being caught, and will therefore have less incentive to do so. We investigated the impact of brand equity on pollution offshoring. We measured brand equity using advertising expenditure at both the industry and firm level. Our results are not presented here due to space limitations. They showed that for firms in industries with higher brand equity, and firms with higher brand equity themselves, imports from LWCs had a less negative impact on plants' toxic emissions. After controlling for brand equity, however, the negative impact of imports from LWCs on pollution is very similar to that in our main regressions.

It is worth emphasizing that we are not claiming nefarious activities by U.S. firms: They might just be optimizing and rebalancing their global sourcing network in response to increased costs for domestic environmental compliance.[8] When adopting a pollution offshoring strategy, U.S. firms have not broken any environmental laws in either the United States or their host country. LWCs often care too much about maintaining exports and foreign direct investment to drive their economic growth to enforce strict environment regulation. For example, until very recently India strongly objected to a global climate-change accord, claiming that "developing countries should not be asked to limit their economic growth as a way of fixing a problem that was largely created by the others." India has also been reluctant to transit from fossil fuel to cleaner forms of energy without significant financial commitment from the rich world (The New York Times, 2015). When U.S. firms are in compliance with both U.S. and foreign environmental regulations, it is not easy to detect that they follow less stringent environmental standards in the host country than in the United States. Besides, U.S. firms may adopt an internal practice for their overseas plants that is less strict than U.S. laws but stricter than the laws in the developing country, which may make the host-country residents less critical or even appreciative of U.S. firms' practices.

Still, to the extent that U.S. firms have a choice between the cheaper, pollution-intensive goods from LWCs and the more expensive goods produced by domestic suppliers under stringent environmental standards, they are making a strategic decision about the private costs of production vs. the public (and international) costs of pollution. Unfortunately, it is not always easy to correct environmental or labor malpractice by even the most famous MNCs in foreign countries. It took Nike almost a decade after the first report of its malpractices to announce that it would raise the minimum wage, significantly increase monitoring, adopt U.S. OSHA clean air standards in all factories, and create the NGO Fair Labor Association (FLA) (Business Insider, 2013). Almost twenty years after the first report, problems still persist (Wall Street Journal, 2014). Foxconn, the Apple supplier that "has faced a firestorm of international media attention over its labor practices in China" and "reportedly improved working conditions there," has diversified into other low-wage nations: Malaysia, Mexico, Brazil, Vietnam, Indonesia, where labor regulations are more lax (Christian Science Monitor, 2012). With global environment and

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[8] Alternatively, as more U.S. firms exit pollution-intensive industries, products in these industries might become more expensive, causing higher production costs for U.S. firms in the downstream industries. As a robustness check, we included the costs of the plant's material inputs in our regressions; results were similar.

labor issues still in hot debate at the policy level, it is hard to blame individual firms—a situation that begs for policy and regulatory change at a higher level.

This paper has a few limitations that suggest opportunities for future study. First, we do not directly test the net impact of globalization on the environment in LWCs. On the one hand, offshoring by U.S. firms in more pollution-intensive industries can increase the size of pollution-intensive production in LWCs, exacerbating the pollution problem. On the other hand, offshoring by U.S. firms might bring to LWCs more advanced environmental technologies relative to what LWCs would have used without globalization, thereby causing less pollution for the same magnitude of production. A more comprehensive analysis of the impact of globalization on the environment in LWCs can be pursued when such data becomes available.

In addition, our main analyses do not differentiate between in-house offshoring and global outsourcing. In fact more than 80% of jobs in labor-intensive industries such as textiles were outsourced, avoiding labor and environmental regulations and hence offering lower costs (Christian Science Monitor, 2012). Another example is Apple, which employs 60,000 staff but relies on an additional 700,000 people by subcontracting its production (New York Times, 2012). On the one hand, offshoring pollution-intensive production to firms' own subsidiaries in LWCs provides better control by the U.S. parent firm and enables the overseas subsidiaries to self-regulate in accordance with their internal standards (Christmann & Taylor, 2001; Dowell *et al.*, 2000). On the other hand, subcontracting pollution-intensive production to independent contractors helps insulate firms from the potential liabilities and reputational damage in cases where something goes wrong. In order to shed light on these opposing theoretical expectations, we explored differences between imports from related parties (foreign subsidiaries or affiliates of MNCs) and imports from independent third parties. Imports are categorized in the LFTTD database as being from related parties if the importer owns, controls, or holds voting power equivalent to at least 6% of the outstanding voting stock or shares of the exporter. Our results suggest that firms' imports from related parties in LWCs do not have a statistically different correlation with domestic emissions than firms' imports from independent parties in LWCs. On average, in our sample, the imports from related parties in LWCs accounted for less than 1% of a firm's total imports. Therefore, the economic significance of importing from related parties in LWCs remains small; the environmental effects of importing from LWCs are primarily driven by imports from arm's length transactions with unrelated parties.

In sum, this paper highlights the relationship between firms' offshoring strategy and their environmental performance in the United States. In addition to the theoretical contributions highlighted herein, the paper provides plant-level, empirical evidence of offshoring, pollution, abatement, and product-mix adjustments using a unique data set of a large sample of U.S. firms and plants. It will, we hope, encourage more empirical studies to complement both the extensive efforts in the literature on global manufacturing and environmental strategies and the heated policy debates on the sustainability of globalization.

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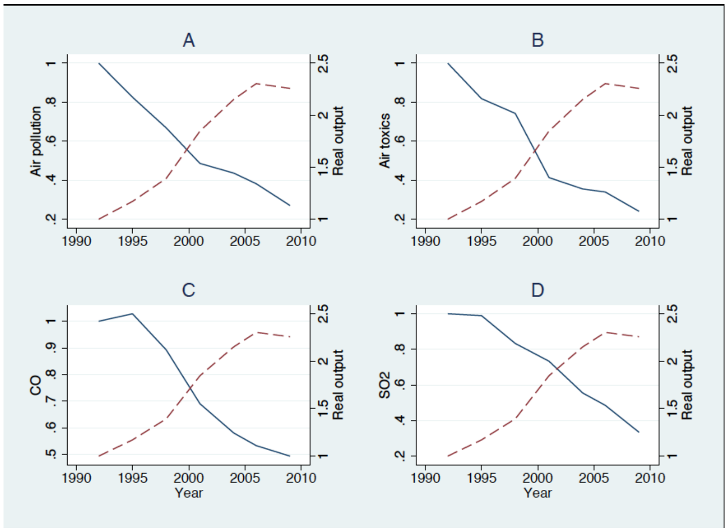

Figure 1. Pollution and output from U.S. manufacturing, 1992–2009.

Notes. This figure shows air pollution (solid line) and real output (dashed line) from the U.S. manufacturing sector in 1992–2009, where we normalized the 1992 value to be 1. (*A*) Total release of fugitive and stack air from all manufacturing facilities in TRI. (*B*) Total release of toxic content in fugitive and stack air from all manufacturing facilities in TRI. (*C*) Emission of CO from industrial activities in National Emissions Inventory. (*D*) Emission of SO2 from industrial activities in National Emissions Inventory.

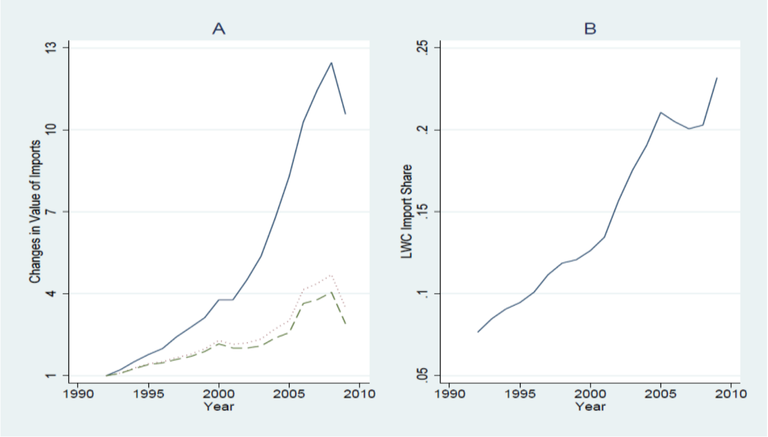

Figure 2. U.S. imports and imports from LWCs, 1992–2009.

Notes. Figure 2A shows total value of U.S. imports (dotted line), imports from non-LWCs (dashed line), and imports from LWCs (solid line) in 1992–2009, where we normalized the 1992 value of imports to be 1. Figure 2B plots the fraction of imports originating from LWCs (solid line, left y-axis) in 1992-2009.

Figure 3. Changes in imports from LWCs and changes in toxic air emissions, 1992–2009.

Notes. This figure shows the changes in each industry's toxic air emissions [toxicity-weighted release] in 1992–2009 against changes in the share of imports [expressed in decimal] from LWCs. The 1992 value for toxic air emissions is normalized to be 1. [A] Based on pounds of emissions. [B] Based on toxicity-weighted pounds of emissions.

Table 1. 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 Republic	Guyana	Nepal	Vietnam
Chad	Haiti	Niger	Yemen

Table 2. **Summary statistics for key variables (main sample)**

		Mean	SD
(1)	Ln(Toxic emissions)	12.98	6.09
(2)	LWC import share (Parent firm’s share of imports from LWCs)	0.16	0.19
(3)	Plant’s total value of shipment (in million dollars)	175	586
(4)	Skill intensity	0.35	0.19
(5)	Total capital expenditures (in million dollars)	6.13	36.0
(6)	Parent firm’s total imports (in million dollars)	711	3200

N=136K.

Table 3. **Correlation matrix**

		(1)	(2)	(3)	(4)	(5)	(6)	(8)
(1)	Ln(Toxic emissions)	1.00						
(2)	LWC import share	-0.07*	1.00					
(3)	Plant’s total value of shipment (in million dollars)	0.18*	-0.06*	1.00				
(4)	Skill intensity	-0.09*	0.01*	-0.10*	1.00			
(5)	Total capital expenditures (in million dollars)	0.18*	-0.08*	0.65*	-0.03*	1.00		
(6)	Parent firm’s total imports (in million dollars)	0.08*	-0.03*	0.34*	-0.03*	0.25*	1.00	

N=136K. *p<0.01.

Table 4. Firms' imports from LWCs and their U.S. plants' toxic emissions

	Ln(Toxic emission)		Ln(Toxic emission)		Ln(RQ emission)	Ln(Toxic emission)
	(1)	(2)	(3)	(4)	(5)	(6) 2SLS
LWC import share	-0.583	-0.401			-0.112^{f}	
	[0.143]	[0.130]			[0.063]	
Import share from China			-0.348 ^{c}			
			[0.146]			
Import share from EU			0.029^{d}			
			[0.075]			
LWC import share, excluding China				-0.548		
				[0.191]		
LWC import share, instrumented						-0.772^{h}
						[0.374]
Ln(Plant output)	0.449	0.451	0.451	0.452	0.238	0.450
	[0.035]	[0.035]	[0.035]	[0.025]	[0.015]	[0.035]
Skill intensity	-0.778	-0.703	-0.702	-0.708	-0.381	-0.786
	[0.154]	[0.150]	[0.150]	[0.104]	[0.060]	[0.155]
Ln(Capital expenditures)	0.056	0.047	0.047	0.047	0.023	0.056
	[0.009]	[0.009]	[0.009]	[0.007]	[0.004]	[0.009]
Ln(Total imports)	0.022^{a}	0.025^{b}	0.025^{e}	0.023	0.008^{g}	0.022^{i}
	[0.011]	[0.011]	[0.011]	[0.007]	[0.004]	[0.011]
Ln(Total imports/Plant output]						
Year FE	Yes	No	No	No	No	Yes
Industry*Year FE	No	Yes	Yes	Yes	Yes	No
Plant FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.712	0.715	0.715	0.715	0.790	0.712

This table reports regression estimates of the correlation between firms' imports from LWCs and their plant-level toxic emissions in the U.S. in 1992–2009, based on Equation 1. N=136K, including all plants that are surveyed by TRI and with parent firms that import. Standard errors clustered at the firm level are included in square brackets. *p*-values for all point estimates are less than 0.01 unless noted otherwise. ^{a} *p*-value=0.046. ^{b} *p*-value=0.023. ^{c} *p*-value=0.017. ^{d} *p*-value=0.699. ^{e} *p*-value=0.023. ^{f} *p*-value=0.075. ^{g} *p*-value=0.046. ^{h} *p*-value=0.039. ^{i} *p*-value=0.046.

Table 5. **Firms' imports from LWCs and their U.S. plants' pollution-reduction efforts**

	Abatement costs (1)	Abatement costs (2)	Pollution prevention (3)	Production waste (4)	Fuel consumption (5)
LWC import share	-0.314	-0.738	0.036[c]	-0.183[f]	-0.196
	[0.097]	[0.238]	[0.047]	[0.073]	[0.064]
Ln(Plant output)	0.423	0.086[a]	0.086	0.190	0.528
	[0.027]	[0.061]	[0.014]	[0.020]	[0.023]
Skill intensity	-1.504	-0.071[b]	-0.068[d]	-0.333	-0.095[h]
	[0.092]	[0.237]	[0.066]	[0.091]	[0.089]
Ln(Capital expenditures)	0.568	-0.440	0.026	0.025	0.038
	[0.023]	[0.063]	[0.005]	[0.006]	[0.006]
Ln(Total imports)	0.045	-0.050	0.001[e]	0.012[g]	-0.001[i]
	[0.007]	[0.018]	[0.004]	[0.006]	[0.005]
Industry*year FE	Yes	No	No	No	No
Plant FE	No	Yes	Yes	Yes	Yes
Adjusted R^2	0.407	0.600	0.501	0.452	0.671

N=50K for Columns [1] and [2], including all plants that are surveyed by both TRI and PACE and with parent firms that import. N=136K for Columns [3]-[6], including all plants that are surveyed by TRI and with parent firms that import. Standard errors are included in square brackets. *p*-values for all point estimates are less than 0.01 unless noted otherwise. [a] *p*-value=0.159. [b] *p*-value=0.764. [c] *p*-value=0.444. [d] *p*-value=0.303. [e] *p*-value=0.803. [f] *p*-value=0.012. [g] *p*-value=0.046. [h] *p*-value=0.286. [i] *p*-value=0.841.

Table 6. Firms' imports from LWCs and their pollution contents

	Ln(Toxic imports)		$\frac{\text{Toxic imports}}{\text{Total imports}}$	
	(1)	(2)	(3)	(4)
LWC import share	0.239	0.247	1.008	1.043
	[0.028]	[0.028]	[0.280]	[0.281]
Ln(Firm size)	0.028	0.026	-0.106[a]	-0.129[b]
	[0.007]	[0.007]	[0.073]	[0.073]
Ln(Total imports)	1.093	1.092	0.330	0.327
	[0.004]	[0.004]	[0.042]	[0.042]
Year FE	Yes	No	Yes	No
Industry*year FE	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.830	0.830	0.636	0.636

This table reports regression estimates of the correlation between firms' imports from LWCs and the pollution intensity of their imports, from 1992 to 2009, based on Eq. 2. N=278K, including all firms that import. Standard errors clustered at the firm level are included in square brackets. *p*-values for all point estimates are less than 0.01 unless noted otherwise. [a] *p*-value=0.146. [b] *p*-value=0.077.

Table 7. Firms' imports from LWCs and their U.S. plants' toxicity-weighted output

	Ln(Toxic output)		$\frac{\text{Toxic output}}{\text{Plant shipment}}$	
	(1)	(2)	(3)	(4)
LWC import share	-0.030[a]	-0.030[e]	-1.437[h]	-1.595[m]
	[0.013]	[0.012]	[0.681]	[0.682]
Ln(Plant output)	0.999	1.002	-1.502[i]	-1.312[n]
	[0.003]	[0.003]	[1.333]	[1.338]
Skill intensity	-0.030[b]	-0.034	3.295[j]	2.606[o]
	[0.013]	[0.013]	[1.302]	[1.299]
Ln(Capital expenditures)	0.001[c]	0.001[f]	0.112[k]	0.119[p]
	[0.001]	[0.001]	[0.162]	[0.161]
Ln(Total imports)	0.001[d]	0.0001[g]	0.148[l]	0.057[q]
	[0.002]	[0.002]	[0.064]	[0.064]
Year FE	Yes	No	Yes	No
Industry*year FE	No	Yes	No	Yes
Plant FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.936	0.937	0.423	0.428

This table reports regression estimates of the impact of firms' imports from LWCs on their plant-level toxicity-weighted output in the U.S. in 1992–2009. N=703K, including all plants with parent firms that import. Standard errors clustered at the firm level are included in square brackets. *p*-values for all point estimates are less than 0.01 unless noted otherwise. [a] *p*-value=0.021. [b] *p*-value=0.021. [c] *p*-value=0.317. [d] *p*-value=0.617. [e] *p*-value=0.124. [f] *p*-value=0.317. [g] *p*-value=0.960. [h] *p*-value=0.035. [i] *p*-value=0.260. [j] *p*-value=0.011. [k] *p*-value=0.489. [l] *p*-value=0.148. [m] *p*-value=0.019. [n] *p*-value=0.327. [o] *p*-value=0.045. [p] *p*-value=0.460. [q] *p*-value=0.373

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Table 8. Local institutional pressure and pollution offshoring

	Local institutional pressure		
DV= Ln(Toxic emissions)	College Education (1)	Voter Turnout (2)	Sierra Club Membership (3)
LWC import share	0.330[a]	0.890[c]	-2.352
	[0.214]	[0.644]	[0.567]
Local institutional pressure	-0.005[b]	0.530[d]	-0.144[g]
	[0.007]	[0.784]	[0.103]
LWC import share*Local institutional pressure	-0.031	-3.158[e]	-0.478
	[0.009]	[1.554]	[0.138]
Ln(Plant output)	0.451	0.454	0.453
	[0.025]	[0.035]	[0.026]
Skill intensity	-0.706	-0.721	-0.698
	[0.105]	[0.151]	[0.105]
Ln(Capital expenditures)	0.047	0.046	0.047
	[0.007]	[0.009]	[0.007]
Ln(Total imports)	0.025	0.025[f]	0.025
	[0.007]	[0.011]	[0.007]
Industry*year FE	Yes	Yes	Yes
Plant FE	Yes	Yes	Yes
Adjusted R^2	0.715	0.715	0.715

N=136K. The sample and control variables are the same as in Table 4. Standard errors are included in square brackets. *p*-values for all point estimates are less than 0.01 unless noted otherwise. [a] *p*-value=0.123. [b] *p*-value=0.475. [c] *p*-value=0.167. [d] *p*-value=0.499. [e] *p*-value=0.162. [f] *p*-value=0.023. [g] *p*-value=0.201.

Table 9. Capability and pollution offshoring

	Plant productivity	Firm productivity	Firm intangibles
DV= Ln(Toxic emissions)	(1)	(2)	(3)
LWC import share	-1.408	-0.271[b]	0.005[g]
	[0.495]	[0.175]	[0.174]
Capability	-0.666	0.036[c]	-0.014[h]
	[0.046]	[0.039]	[0.007]
LWC import share* Capability	0.240	0.272[d]	0.045[i]
	[0.083]	[0.120]	[0.019]
Local institutional pressure (Sierra Club membership)	-0.501[a]	-0.523[e]	-0.186[j]
	[0.428]	[0.433]	[0.546]
LWC import share*Local institutional pressure	-1.644	-1.396[f]	-1.518[k]
	[0.613]	[0.622]	[0.697]
Ln(Plant output)	0.833	0.452	0.522
	[0.038]	[0.026]	[0.036]
Skill intensity	-0.732	-0.678	-0.632
	[0.105]	[0.106]	[0.131]
Ln(Capital expenditures)	0.032	0.047	0.048
	[0.007]	[0.007]	[0.009]
Ln(Total imports)	0.023	0.023	0.025
	[0.007]	[0.007]	[0.009]
Industry*year FE	Yes	Yes	Yes
Plant FE	Yes	Yes	Yes
Adjusted R^2	0.715	0.715	0.730

N=136K for Columns (1) and (2), including the same plants as in Table 4. N=90K for Column (3), including all plants that are surveyed by TRI and with parent firms that both import and are publicly listed. Standard errors are included in square brackets. *p*-values for all point estimates are less than 0.01 unless noted otherwise. [a] *p*-value=0.242. [b] *p*-value=0.121. [c] *p*-value=0.356. [d] *p*-value=0.023. [e] *p*-value=0.227. [f] *p*-value=0.025. [g] *p*-value=0.977. [h] *p*-value=0.046. [i] *p*-value=0.018. [j] *p*-value=0.733. [k] *p*-value=0.029.