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Exporting and Environmental Performance: Where You Export Matters[*]

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Abstract

Empirical analyses that rely on micro-level panel data have found that exporters generally pollute less than nonexporters. While alternative explanations have been proposed, firm-level data has not been used to examine the role of destination markets in the relationship between exports and pollution. In this paper, we argue that because consumers in high-income countries value clean environments more than consumers in developing countries, exporters targeting high-income countries are more likely to improve their environmental outcomes than exporters targeting destinations where the environment is not valued highly. Using a panel of firm-level data from Chile we find support for this hypothesis. A 10-percentage-point increase in the share of exports to high-income countries is associated with a reduction in CO_2 pollution intensity of about 16%. The results have important implications for firms in developing countries aiming to target high-income markets.

Keywords: exports, environment, climate change, emissions

JEL Classification: F14, F18, Q56

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1. Introduction

There is a large body of literature on the relationship between trade and the environment.[3] Most of the empirical work relies on cross-country variation in pollution levels and trade flows. There is, however, a growing literature on the relationship between exports and pollution at the firm level. In principle, lowering pollution levels could affect exports negatively, for instance, if abatement expenses lead to higher unit prices that jeopardize firms' international competitiveness. In general, however, empirical analyses that rely on micro-level panel data from different countries have found that exporters are generally less pollutant than nonexporters.

For example, using a panel of US establishment-level data, Holladay (2016) find a robust relationship between international trade and pollution levels. Exporters emit 9% to 13% less than nonexporters after controlling for establishment output and industry characteristics. Batrakova and Davies (2012) find in a panel of Irish firms that export status is negatively related to energy use for high-fuel-intensity firms. Richter and Schiersch (2017) employ firm-level data from Germany that contains detailed information on carbon dioxide (CO_2) emissions and show that exporting firms perform better environmentally than nonexporting firms. Li et al. (2020) compare the evolution of emissions of Chinese exporting firms before and after the country's accession to the WTO with the emissions of processing exporters that enjoy tariff exemptions in both periods. The authors show that the exporters' emissions decreased by 6% after China acceded to the WTO. Pei et al. (2020) also employ Chinese firm-level data and show that both export status and export intensity are associated with lower sulfur dioxide (SO_2) emissions intensity. Additionally, the authors show that exporters engage in higher abatement efforts compared to nonexporters. Cui et al. (2016) uses data for the United States and show that conditional on firm's productivity and other controls, exporting firms have lower emissions per value of sales than nonexporting firms in the same industry. Banerjee et al. (2021) employ a cross-sectional dataset of Indonesian firms and show that exporters engage more in pollution abatement behavior than nonexporters. More generally, Song and Sung (2014) show the existence of a positive causal relationship running from environmental regulation to export performance in South Korea's manufacturing sector.

There are several plausible channels behind these general findings. For instance, because exporting firms tend to be larger and more productive, these characteristics might themselves be associated with better environmental outcomes. For instance, Forslid et al. (2018) develop a model of trade and CO_2 emissions with heterogeneous firms in which firms make abatement investments and thereby have an impact on their emissions. The model shows that investments in abatements are positively related to firms' size. In essence, exporting allows for a larger production scale, which in turn supports more investments in abatement (as operating on a larger scale allows firms to spread the fixed costs of abatement investment across more units), which then leads to lower emissions per output. The authors find support for their model among a panel of Swedish firms.

There could be several additional channels. As exporters tend to be larger, they are often more concerned about their reputation. For example, Arora and Cason (1996) argue that large firms have higher public

[3] See, for example, Cherniwchan et al. (2017) for a review.

profiles and thus might have more incentives to control their emissions than smaller firms. Likewise, larger firms may receive more attention from regulators and watchdog groups.

Exporters may also have newer facilities that may be associated with more environmentally friendly infrastructure. Another channel is management quality: the same management skills that might induce more innovation and higher exports might also lead to better environmental performance. The empirical evidence behind most of the papers cited above suggests that larger, more productive firms have better environmental outcomes.

Missing in the above discussion, however, is the role that destination markets might play in making exporters more environmentally friendly. While larger, more productive, and better-managed firms might be in a better position to invest in abatement technology and thus emit less pollution, some firms might not necessarily do so if this is not important from the point of view of their buyers. In this paper, we argue that the destination market plays an important role in exporters' environmental performance. Exporters targeting destination markets that are keen to protect the environment are more likely to improve their environmental outcomes than those targeting markets where there is little concern for the environment. In other words, where you export matters for the environmental outcome of an exporting firm.

As far as we know, the notion that a firm's environmental outcomes are intrinsically linked to its destination market has not yet been analyzed using firm-level data.[4] Part of the difficulty in conducting an analysis of this sort lies in the export measure, as testing this hypothesis requires detailed data on export destinations. Studies that employ firm-level data to examine the relationship between exports and the environment tend to use crude measures of firm exports: either total exports (e.g. exports over output) or the export status of the firm. Instead, in this paper, we use a firm-level dataset from Chile that is merged with customs transaction data on exports by product and destination. Thus, for each firm, we know not only which products are exported but also which destination countries they are shipped to. This rich dataset allows us to test whether the destination of a firm's exports plays a role in its environmental performance.

Our empirical strategy employs a specification that controls for unobserved confounders by including a large set of fixed effects. We also explicitly include firm characteristics that have been found to drive environmental outcomes, as mentioned before, namely: size, productivity, a measure of the firm's management, as well as the share of foreign capital participation. We apply this specification to an instrumental variable regression to address potential endogeneity concerns between exporting and environmental performance.

[4] Cole (2006) argues that firms that compete in the global marketplace are likely to come under closer international scrutiny from their buyers, which may lead to better environmental outcomes. Distelhorst and Locke (2018) present insightful evidence that sellers that comply with labor and environmental standards export more than noncomplying firms. Neither of these papers, however, examine whether the environmental outcomes of the exporters change depending on the destination market. Cui (2017) presents a theoretical trade model with heterogenous firms, technology adoption, and environmental regulation. The analysis is focused on changes in environmental regulation at home but does not model the role of environmental regulations in the destination countries.

Importantly, we introduce the notion that the destination market matters. We specifically argue that consumers and buyers in high-income countries generally value clean environments more than consumers in developing countries. The degree to which exporters improve their environmental performance is therefore shaped by the extent to which they export to these markets. High-income markets may explicitly increase the environmental requirements for their suppliers or might implicitly value purchasing goods from firms that exhibit better environmental performances. For instance, there is evidence that lead firms, which are headquartered mostly in high-income countries, hold their suppliers accountable for their environmental actions. For example, the CDP Supply Chain Program is a platform where firm members are required to disclose their carbon emissions and plans to mitigate environmental degradation each year. In 2019, 115 lead firms, mostly from high-income countries, were active members of the CDP program, including companies like AstraZeneca, Bayer, Coca-Cola, Nestlé, BMW, Toyota, Intel, and Samsung. All the firms in the program also need to request that their suppliers disclose their own emissions. In 2019, they collectively received 5,595 responses from suppliers located across 90 countries. Moreover, 43% of these 115 lead companies reported that they stopped working with some of their existing suppliers based on the environmental performance that they disclosed (CDP Supply Chain Report, 2019). The example is consistent with increasing evidence that indicates that many corporations in the world require their suppliers to comply with environmental standards and regulations. Curkovic and Sroufe (2011) and Bellesi et al. (2005), for example, provide anecdotal evidence that many companies require their suppliers to comply with ISO 14001 certifications, including IBM, Xerox, Honda, Toyota, Ford, GM, Bristol-Myers Squibb, or Quebec Hydro.

Related to our work, Brambilla et al. (2012) show, in the context of labor skills, that high-income countries tend to value quality more than developing countries do, so firms targeting the former tend to use higher shares of skilled labor. Our study follows a similar line of reasoning in the context of trade and the environment: better environmental outcomes are likely to be necessary if firms wish to align themselves with the high value placed on clean environments in high-income countries. To test this hypothesis explicitly, we employ an empirical specification similar to that of Brambilla et al. (2012), in the sense that we include a measure of the firm's export intensity (the ratio of total exports to sales) and, importantly, a measure of the firms export intensity to high-income markets (the firm's share of total exports to high-income countries).

We found that exporting to high-income countries is an important driver for firms' environmental performance. Our baseline results show that a 10 percentage point (p.p.) increase in the share of exports to high-income countries is associated with a reduction in CO_2 pollution intensity (CO_2 emissions per unit of output) of about 16%. The findings are robust even after controlling for the impact of size and productivity on pollution intensity and after accounting for differences across firms in narrowly defined industries and locations.

We complement the analysis by looking at country-level environmental performance indexes. First, we show that income per capita is highly correlated with good environmental outcomes, which validates the argument that high-income countries tend to place value on clean environments. Second, we show that exporting to countries with high environmental index scores makes the results even stronger: depending on the index employed, a 10 p.p. increase in the share of exports to countries with high environmental index scores is associated with a reduction in CO_2 pollution intensity that ranges from 57% to 73%. This finding is consistent with the more general idea that exporters targeting destination markets that are keen to protect the environment are more likely to improve their environmental outcomes than exporters targeting destination markets where concerns for the environment are low. The finding also reveals why exporting to high-income countries is an important driver for firms' environmental performances: high environmental index scores are mostly associated with high-income countries. Accordingly, exporting to these markets is akin to exporting to markets where the environment is valued highly, as shown by more stringent environmental regulations and outcomes.

Our results have important implications for exporting firms. Consumers and buyers in countries where the environment is valued highly (which are mostly high-income countries) might explicitly increase the environmental requirements their suppliers must comply with or might implicitly value purchasing goods from firms whose environmental performances are positive. Accordingly, firms need to improve their energy efficiency relative to exporting to other countries to successfully break into these markets.

The rest of the paper is divided as follows. Section 2 describes the various datasets employed in this study. Section 3 presents the empirical strategy and discusses the results. Finally, section 4 provides some concluding remarks.

2. Data description

We use two datasets in this paper. First, we employ a firm-level panel dataset from Chile covering 1997–2010. Specifically, we employ the Annual National Industrial Survey (*Encuesta Nacional Industrial Annual*, ENIA) conducted by Chile's statistical office, the *Instituto Nacional de Estadísticas* (INE). The establishments included in the survey are coded with a unique identifier that allows them to be traced across the entire period. The survey contains information on firm characteristics, such as sales, production, inputs, and employment, among other variables. Importantly, while we do not observe emissions directly, the survey includes detailed information on energy consumption, including electricity, natural gas, carbon, petrol, benzine, liquified gas, and firewood. Accordingly, we construct measures of CO_2 emissions at the establishment level based on the observed energy consumption and time-invariant emissions factors. Specifically, we transform the consumption levels of each type of fuel into tons of CO_2 equivalents of energy using factor coefficients obtained from the United Nation's Intergovernmental Panel on Climate Change (IPCC), which provides policymakers with regular scientific assessments on climate change. The IPCC has developed factor coefficients for fossil fuels that are specific to each country—we use the coefficients for Chile for 2006. We complement these factor coefficients for fossil fuels with information from the Ministry of Energy of Chile on electricity consumption. Specifically, we employ the 2010 emissions factor associated with the national electricity system. Table A1 in the appendix provides the details.

The data on exports is taken from the Chilean National Customs Authority (*Servicio Nacional de Aduanas*) and includes the universe of Chilean exports at the transaction level. Specifically, each record includes information about the party engaged in the transaction, the good exported (at 8-digit HS level), the destination country, and the export value in US dollars. Importantly, the party in question is identified using a unique code that is used to merge this dataset with the survey described above. Accordingly, we have a complete record of the export transactions of each establishment in the annual survey, including detailed information on the products it exported and the destination markets these were shipped to.

After cleaning the dataset and eliminating observations with missing values, the survey comprises around 4,000 establishments per year, approximately 20% of which are exporters. Table 1 presents a simple comparison of exporters and nonexporters in terms of their emissions intensity, measured as tons of CO_2 equivalents of energy per US$1,000 of output. The upper panel shows the means of the emission intensities for all the firms, the nonexporters, and the exporters, as well as the difference between the nonexporters and the exporters. The difference is statistically significant, showing that nonexporters pollute more than exporters on average. The lower panel of the table presents a very simple linear regression where the emission intensity is the dependent variable and the covariates are a dummy variable that takes the value of 1 if the firm is an exporter, as well as sector (ISIC rev 3 at 4 digits), year, and municipality fixed effects. The table shows the coefficient for the exporter dummy, which is negative and significant at conventional levels. This indicates that exporters are more energy-efficient than nonexporters, even within narrowly defined sectors.

These preliminary results in table 1 are in line with the findings of the literature that exporters generally pollute less than nonexporters. In this paper, however, we are interested in moving beyond this comparison and assessing the extent to which the destination of the firm's exports drives its environmental performance. Specifically, we argue that exporters targeting high-income countries are more likely to improve their environmental outcomes than exporters targeting developing countries, where the environment is not valued as highly. As such, in the rest of the analysis, we will focus exclusively on establishments that are exporters.

Table 2 presents some basic statistics for these exporters. The shares of small, medium, and large firms are 35%, 49%, and 16%, respectively.[5] For the average firm, 32% of its sales are exports, and 31% of those exports are sold to high-income countries.[6] Table 3 shows the average emission intensity by broad sectors (ISIC rev3 2-digits).[7] In general, establishments in natural-resource intensive sectors (e.g. basic metal, nonmetallic mineral products, wood and wood products) tend to pollute more than establishments in other sectors.

3. Empirical estimation

In this section, we compare emission intensities across establishments, controlling for an array of characteristics and focusing particularly on the role of destination markets. Given the conceptual

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[5] Firm size, measured in terms of total employment, is defined by the INE using the following groups: small firms (less than 50 employees), medium size firms (between 50 and 250 employees), and large firms (more than 250 employees).

[6] We use alternative lists of high-income countries, based on groupings made by the OECD and the World Bank. The results remain very similar regardless of the list that we use. Table A2 in the appendix shows the OECD list of high-income countries, which the results in the rest of the paper are based on.

[7] In the empirical estimation, we control for sector differences across establishments at a more disaggregated level (ISIC 4-digit level).

similarities between our approach and that of Brambilla et al. (2012), we adopt an empirical specification that is similar in nature to their regression model. Specifically, we use the following baseline regression:

$$Z_{ijmt} = \alpha_1 \cdot \frac{EXP_{ijmt}}{Y_{ijmt}} + \alpha_2 \cdot \frac{EXP_{ijmt}^{HI}}{EXP_{ijmt}} + \bar{X}_{ijmt} \cdot \gamma + \theta_i + \theta_{jt} + \theta_{mt} + \in_{ijmt} \quad (1)$$

where Z_{ijmt} is the emission intensity of firm *i* in sector *j* that is located in municipality m in year t. The emission intensity is measured as tons of CO_2 equivalents of energy per US$1,000 of output. EXP_{ijmt} and Y_{ijmt} are the firm's total exports and total sales. We use the ratio of total exports to sales to capture the intensity of the exporting status. EXP_{ijmt}^{HI} is the firm's total exports to high-income destinations. Accordingly, the ratio of exports to high-income countries over total exports measures the composition of exports across destinations and captures the impact of exporting to high-income destinations once export intensity has been accounted for. $\bar{X}_{ijmt}$ is a vector of firm characteristics that include firm size (measured in terms of total employment), total factor productivity (measured as in Levinsohn and Petrin, 2003), the ratio of skilled workers to total employment, and the share of foreign capital. As mentioned in the introduction, size and productivity have been consistently found to be determinants of emission intensity. The share of skilled labor is included as a proxy for management quality, which has been found to be positively correlated with better environmental outcomes (Holladay, 2016). Finally, the share of FDI seeks to control for differences in capital ownership, as subsidiaries of multinational companies may be subject to more international monitoring than domestically owned firms. The term θ_i is a set of firm fixed-effects that captures time-invariant firm characteristics. The term θ_{jt} is a set of sector (at the ISIC rev. 3 4-digit level) x year fixed effects that captures time-variant sector characteristics. The term θ_{mt} is a set of municipality x year that controls for time-variant local conditions, like differences in the price of fuels. The inclusion of year fixed effects in θ_{jt} and θ_{mt} also implies that we are controlling for time effects capturing aggregate shocks that may affect all firms in a given year. Finally, $\in_{ijmt}$ is the error term that is clustered at the firm level.

The intuition behind equation (1) is that after controlling for time, sector, and location, as well as for a number of firm characteristics that have been found to be associated with environmental performance (including export intensity), the coefficient α_2 captures the impact of exporting to high-income destinations. One concern in estimating equation (1), however, is that if exporting is still correlated with unobserved factors that affect the firm's environmental performance, the estimation of α_2 will be biased. Accordingly, beyond the inclusion of a rich set of fixed effects and controls, we employ an instrumental variable (IV) estimation. Ideally, this should be a variable that affects exporting without impacting the environmental performance of the firm. We argue that a reasonable candidate for the IV is the average exchange rate experienced by the firm in international markets. Exchange-rate–based instruments have been used before by Revenga (1992), Park et al. (2010), and Brambilla et al. (2012).

We construct a measure of the average exchange rate experienced by the firm in international markets as follows:

$$IV_{it}^{EXP} = \sum_c erate_t^c \cdot \varphi_{it-1}^c \quad (2)$$

where $\sum_c erate_t^c$ is the exchange rate of country c (relative to the Chilean peso) in year *t*, and φ_{it-1}^c is the share of exports of firm *i* to country *c* in total exports. Following Brambilla et al. (2012), we also explore a specification where φ_{it-1}^c is the share of exports in total sales.

We use IV_{it}^{EXP} to instrument the first export variable in (1), that is, export intensity. Given the shares of exports to market *c* in year *t-1*, a higher exchange rate in year *t* would induce firm *i* to export more to this market. We expect the export intensity to be positively correlated with IV_{it}^{EXP} in the first-stage regressions, as a higher average exchange rate shall incentivize the increase in the firm's exports and thus its export intensity.

Following the same logic, our instrument for the ratio of exports to high-income countries over total exports is constructed as follows:

$$IV_{it}^{EXP^{HI}} = \frac{\sum_{c \in HI} erate_t^{c^{HI}} \cdot \varphi_{it-1}^{c^{HI}}}{\sum_c erate_t^c \cdot \varphi_{it-1}^c} \qquad (3)$$

where the numerator in (3) is the average exchange rate experienced by the firm in high-income countries, while the denominator is given by (2), that is, the average exchange rate in all the firm's markets. Accordingly, we expect the share of exports to high-income countries to be positively correlated with IV_{it}^{EXP} in the first-stage regressions. This is because a higher average exchange rate in high-income markets relative to the average overall exchange rate should incentivize an increase in the share of exports to high-income countries.

3.1 Estimation results

First, we estimate (1) without using instruments. The OLS results are shown in table 4. Column (1) confirms the findings in the literature that a firm's size and productivity are negatively related to emission intensity. Columns (2) and (3) introduce the export intensity and the share of exports to high-income countries, respectively. The coefficient estimate for the export intensity is actually positive although it is not very precisely estimated. Similarly, the coefficient estimate for the share of high-income exports is negative but only significant at the 10% level.

We now estimate the 2SLS regressions. By generating exogenous variation in the export variables via the instruments, these regressions aim to examine whether firms lower their emission intensity levels in response to an exogenous increase in the share of exports to high-income countries. Table 5 shows the results. The instrument for the export intensity variable in (1) is constructed using the share of exports to country *c* in total exports, while in (2) it is constructed using the share of exports to country *c* in total sales. The latter provides a much stronger instrument which is shown by the larger F statistics in (2) compared to (1). As expected, the instruments for the export intensity and the share of exports to high-income countries are both positive and significant.

Comparing the results from column (2) in table 5 from the OLS estimations show that the coefficient for the export intensity is no longer significant. Additionally, the coefficient estimate for the share of exports to high-income countries is again found to be negative and significant, and larger in absolute values than in the OLS regressions. The estimate in column (2) of table 5 implies that a 10 p.p. increase in the share of exports to high-income countries leads to a reduction in emission intensity of 0.022 tons of CO_2 equivalents of energy per US$1,000 of output. As the annual emission intensity of the average exporter is equal to 0.135 (see table 1), the coefficient estimate implies a reduction of emission intensity of about 16%.

Compared to the 2SLS, the OLS-estimated coefficient is biased downward. A priori, the OLS bias could go in either direction. On the one hand, shocks that simultaneously make firms export more to high-income countries and reduce emissions will make the OLS results biased upwards. For example, a cost reduction shock could simultaneously allow firms to expand exports to high-income countries and use more resources to lower their emission levels. On the other hand, shocks that simultaneously make firms pollute less and reduce exports to high-income countries (or with no impact on exports to high-income countries) will bias OLS results downwards. For example, if investing in abatement technology is limited by credit constraints (Andersen, 2016; Evans and Gilpatric, 2015), a positive credit shock may induce companies to abate more pollution, but this shock may not be relevant for companies that export to high-income countries, which are less likely to be credit constrained. In general, the OLS coefficient is likely to be biased because it is based on estimations that might be affected by uncontrolled shocks. Our 2SLS estimation, however, is based on changes in exports shares caused by changes in the exchange rate. Accordingly, the estimated coefficient only picks up the change in emission intensity that occurs when the firm reacts to the exogenous change in the destination of exports.

We also examine whether the coefficient estimate for the share of exports to high-income countries is consistent over time. The Kyoto Protocol, for example, was only signed in 1997. One might therefore argue that increasing environmental awareness among firms is a very recent trend. If this is the case, the coefficient estimate for the share of exports to high-income countries may not be significant during the early years of our sample period. To examine this, we create a dummy variable that is equal to 1 between 2003 and 2010, and we interact this dummy with the share of exports to high-income countries.[8] We include this variable as an additional regressor in the estimating equation.[9] The results are presented in the appendix (table A5). For comparison purposes, we repeat the result of table 5, column (2), in column (1). Column (2) of table A5 shows that the coefficient estimate for the share of exports to high-income countries is consistent over time. Note that the estimate for 1997–2002 is given by the coefficient of the un-interacted share of exports to high-income countries, while the estimate for 2003–2010 is given by the sum of the coefficients of the un-interacted and the interacted shares. However, the coefficient for the interacted share of exports to high-income countries is not statistically significant. Accordingly, we do not observe a change over time in the estimate for the share of exports to high-income countries.

3.2 Additional measures of export destinations

In this section, we employ additional measures of export destinations. This could be useful for exploring what is driving our main findings in greater detail. The key idea behind these findings is that consumers and buyers in high-income countries place more value on clean environments than consumers in

[8] We do the same for the instrument of this variable.

[9] We prefer this strategy to performing two separate regressions for two subperiods. The latter approach reduces the sample size for each subperiod, which tends to lead to less precise estimates.

developing countries. Accordingly, firms targeting these markets will need to improve their environmental performance in response to this attitude. If consumers in high-income countries are indeed more concerned about the environment than consumers in developing countries, the norms and regulations in place in these countries to protect the environment should be more stringent than in other parts of the world. If this is the case, our results should also hold when we use the share of exports to countries with stringent environmental regulations in the regressions instead of the share of exports to high-income countries. We examine this now.

Unfortunately, few indexes measure the stringency of environmental regulations for a large cross-section of countries. One index that has been widely cited, however, is provided by Eliste and Fredriksson (2002), who built on the work of Dasgupta et al. (2001). The analysis in Dasgupta et al. (2001) gathered information from individual country reports compiled under United Nations Conference on Environment and Development (UNCED) guidelines. Each report is based on identical survey questions and provides detailed information on the state of environmental policies, legislation, and enforcement within each country. Using this information, Dasgupta et al. (2001) developed an index of the stringency of environmental regulations for 31 countries. Eliste and Fredriksson (2002) then used the same methodology to extend the index to 60 countries. Table A3 in the appendix shows the list of countries ranked from highest to lowest stringency. The index reports scores for 1995, which is only two years before the period studied in this paper. We do not expect this ranking to change significantly during our period of analysis. In figure 1, we present the correlation between the stringency of environmental regulations and GDP per capita. There is clearly a positive slope in the relationship confirming the notion that high-income countries tend to exhibit more stringent environmental regulations.

We now use this index to recalculate our destination-based export variable by taking the group of countries in the upper tercile of this index, which have the strictest environmental regulations. We argue that firms that ship larger shares of their exports to these countries should exhibit lower emission intensity levels on average. To operationalize this idea, instead of including the share of exports to high-income countries in the regression, we include the share of exports to these countries. Column (1) in table 6 shows the results. The coefficient estimate for the share of exports to countries with high scores in the Eliste and Fredriksson (2002) index is negative and significant at conventional levels. A 10 p.p. increase in the share of exports to high-income countries leads to a reduction in emission intensity of 0.077 tons of CO_2 equivalents of energy per US$1,000 of output (equivalent to a reduction in emission intensity of about 57%). These results provide context for our earlier findings that firms targeting high-income markets lower their emission intensity levels. High-income countries tend to place more value on clean environments, and this is generally reflected in the stringency of their environmental regulations. Firms servicing countries with stringent environmental regulations, which to a large extent are high-income countries, exhibit lower emission levels.

We can push the use of environmental indexes further to construct our destination-based export variable. It is reasonable to argue that higher valuations for clean environments are reflected not only in the stringency of a country's regulations but also more generally in the country's preparedness to address environmental issues and in its environmental outcomes. Two well-known overall environmental indices that include a wide range of indicators are the Yale Environmental Performance Index (EPI) and its predecessor, the Environmental Sustainability Index (ESI). We focus on the ESI, which was published between 1999 and 2005, because it better matches our period of analysis. It includes country indicators that range from social and institutional capacities to foster effective responses to environmental challenges to measures of international cooperation for managing common environmental problems. Table A4 in the appendix shows the list of countries in the ESI-2001, ranked from best to worst performance. In figure 2, we present the correlation between the ESI and GDP per capita. Once again, a positive slope indicates that high-income countries tend to exhibit better overall environmental outcomes.

We re-calculate the export variable using the group of countries in the upper tercile of the ESI and include the share of exports to these countries in the regression.[10] Column (2) in table 6 shows the results. The coefficient for the share of exports to countries with high scores on the ESI is negative and significant and even larger in absolute values. A 10 p.p. increase in the share of exports to high-income countries leads to a reduction in emission intensity of 0.098 tons of CO_2 equivalents of energy per US$1,000 of output (equivalent to a reduction in emission intensity of about 73%). The findings in table 6 are consistent with the more general idea that exporters targeting destination markets that are keen to protect the environment are more likely to improve their environmental outcomes than exporters targeting destination markets where concern for the environment is low. They also reveal why exporting to high-income countries is an important driver of firms' environmental performances: high-income countries tend to score higher on environmental indexes, such that exporting to high-income markets is akin to exporting to markets where the environment is valued highly.[11] The results indicate that exporting to markets that exhibit strong environmental performances—which are largely high-income countries—leads to a reduction in the intensity of firms' emissions.

4. Concluding remarks

Empirical analyses that rely on micro-level panel data have found that exporters generally pollute less than nonexporters. In this paper, we examine the role of destination markets in the exporter's environmental performance for the first time. We argue that exporters targeting destination markets that are keen to protect the environment are more likely to improve their environmental outcomes than those targeting destination markets where concern for the environment is low.

The empirical evidence we use comes from a manufacturing survey of Chilean firms for 1997–2010. The survey is matched with customs information on firm-level exports and export destinations. The estimation strategy draws on changes in exchange rates as a useful source for identifying exogenous changes in exports and export destinations to explore whether firms choose their levels of emission intensity based on the destination of their exports.

The results consistently indicate that exporting to high-income countries induces firms to lower their emission intensity levels. Because consumers in high-income countries value clean environments more

[10] We adjust the instrument accordingly to reflect the exchange rate with respect to these countries.
[11] We also run additional regressions (not shown) using the upper tercile of the EPI-2010 index to calculate our destination-based export variable. The results are in line with those using the ESI.

than consumers in developing countries, firms targeting these markets need to improve their environmental performance in response. We further test this idea by recalculating our destination-based export variable using country indexes that measure different aspects of environmental performance. The results show that exporting to countries with high environmental index scores makes the results even stronger. Exporting to markets with strong environmental performances, which are largely comprised of high-income countries, leads to a reduction in the intensity of firms' emissions.

Our paper contributes to a growing literature on the relationship between exports and pollution at the firm level by showing that destination markets play a significant role in exporters' environmental performances. Our results have major implications for exporters seeking to break into high-income markets: as these markets value clean environments, firms wishing to service them need to improve their energy efficiency levels.

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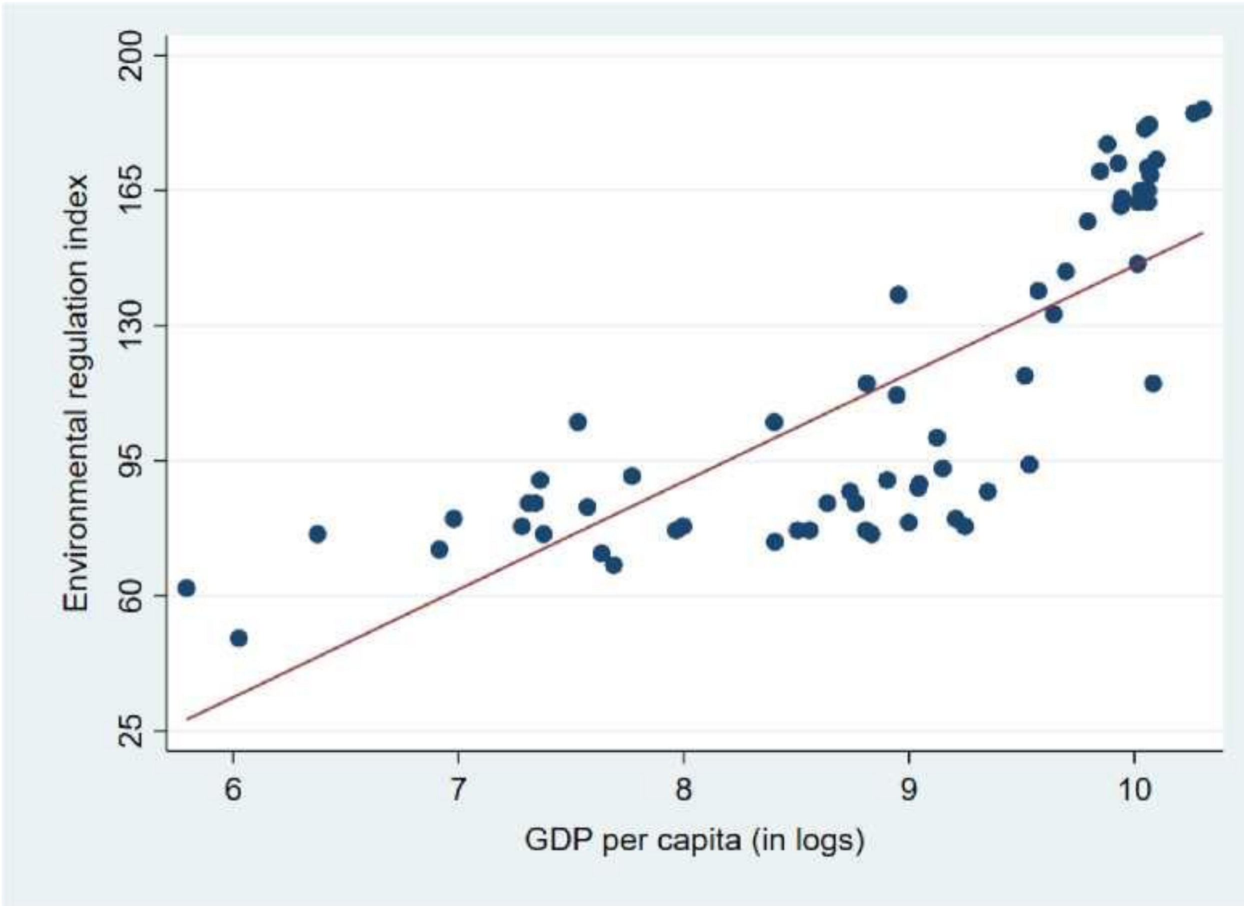
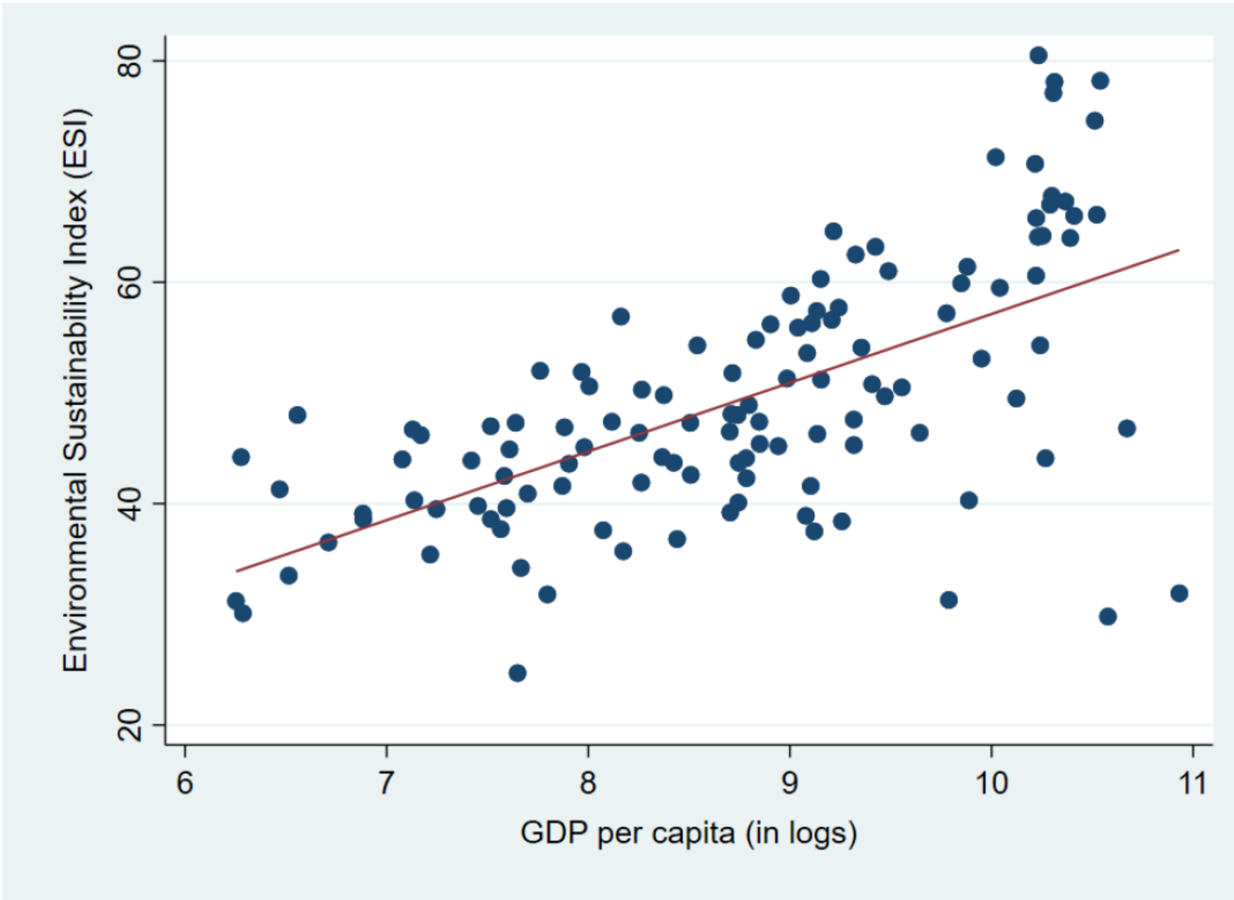
Figure 1: Environmental regulation index and GDP per capita



Note: The environmental regulation index is based on Eliste and Fredriksson (2002). The index and the GDP per capita are for the year 1995.

Figure 2: Environmental Sustainability Index (ESI) and GDP per capita



Note: The ESI and the GDP per capita are for the year 2001.

Table 1: Comparison of emission intensities

	Obs.	Mean	95% conf. interval
All firms	55,146	0.152	(0.148 0.157)
Nonexporters	43,831	0.157	(0.152 0.162)
Exporters	11,315	0.135	(0.127 0.142)
Difference		0.022	(0.011 0.330)
t-stat		4.051	
Emission int.	**= f(exporter, sector, year, location)**		
Exporter	-0.0481***		
	(0.0067)		
R-squared	0.047		

Note: Emission intensity measured as tons of CO_2 equivalents of energy per US$1,000 of output

Table 2: Basic statistics, firm characteristics

	Average 1997–2010
Number of firms per year	809
Small (%)	35
Medium (%)	49
Large (%)	16
Total exports/Sales (%)	32
Exports to HI countries/Total exports (%)	31

Table 3: Tons of CO_2 equivalents of energy per US$1000 of output, sector average

ISIC 2-digit	Description	1997–2010
27	Basic metals	0.294
21	Paper and paper products	0.256
26	Nonmetallic mineral products	0.214
20	Wood and wood products	0.170
17	Textiles	0.148
25	Rubber and plastics	0.137
30	Office and computing machinery	0.134
15	Food and beverages	0.134
28	Fabricated metal products	0.126
19	Leather	0.124
33	Medical, precision and optical instruments	0.107
36	Furniture	0.095
29	Machinery and equipment	0.091
24	Chemicals	0.087
35	Other transport equipment	0.080
18	Apparel	0.057
31	Electrical machinery	0.057
23	Coke and petroleum products	0.053
34	Motor vehicles	0.052
22	Publishing and printing	0.047
32	Communication equipment	0.041
16	Tobacco products	0.040

Table 4: OLS estimates

	(1)	(2)	(3)
Total employment	-0.0291**	-0.0301**	-0.0293**
	(0.0123)	(0.0123)	(0.0123)
Total factor productivity	-0.0406***	-0.0405***	-0.0410***
	(0.0125)	(0.0124)	(0.0126)
Share of skilled labor	-0.0276	-0.0285	-0.0296
	(0.0491)	(0.0491)	(0.0493)
Exports/Sales		0.0776*	0.0819*
		(0.0448)	(0.0455)
High-Income Exports/Exports			-0.0491*
			(0.0299)
R2	0.626	0.626	0.626
Observations	5,881	5,881	5,881

Notes: Each column reports the results of regressions for 1997–2010. The dependent variable is the annual emission intensity of the firm, measured as tons of CO_2 equivalents of energy per US$1,000 of output. The explanatory variables are total employment (in logs), total factor productivity, the share of skilled labor, the share of foreign capital, the ratio of total exports to sales, and the ratio of exports to high-income countries to total exports. Additional controls are sector (ISIC rev. 3 4-digit level) x year fixed effects, municipality x year fixed effects, and firm fixed effects. Robust standard errors in parentheses are clustered at the firm level.

***; **; * significant at the 1%, 5%, and 10% level, respectively.

Table 5: 2SLS estimations

Total employment	-0.0228	-0.0241*
	(0.0151)	(0.0128)
Total factor productivity	-0.0430***	-0.0429***
	(0.0133)	(0.0131)
Share of skilled labor	-0.0298	-0.0312
	(0.0475)	(0.0498)
Exports/sales	-0.1985	-0.0908
	(0.5687)	(0.1475)
High-income exports/exports	-0.2132**	-0.2201**
	(0.0934)	(0.0969)
R2	0.617	0.621
Observations	5,881	5,881
	First-stage results	
IV for the share of exports	0.0081***	0.0172***
IV for the share of HI exports	0.2644***	0.2677***
F statistic	3.8	32.9

Notes: Each column reports the results of regressions for 1997–2010. The dependent variable is the annual emission intensity of the firm, measured as tons of CO_2 equivalents of energy per US$1,000 of output. The explanatory variables are total employment (in logs), total factor productivity, the share of skilled labor, the share of foreign capital, the ratio of total exports to sales, and the ratio of exports to high-income countries to total exports. Additional controls are sector (ISIC rev. 3 4-digit level) x year fixed effects, municipality x year fixed effects, and firm fixed effects. In (1) the instrument for export intensity is constructed using the share of exports to country *c* in total exports, while in (2) and (3) it is constructed using the share of exports to country *c* in total sales. Robust standard errors in parentheses are clustered at the firm level.

***; **; * significant at the 1%, 5%, and 10% level, respectively.

Table 6: Exports to countries with high scores in environmental indices (EI)

	Eliste and Fredriksson Index (1995)	Environmental Sustainability Index (2001)
Total employment	-0.0662***	-0.0859***
	(0.0213)	(0.0240)
Total factor productivity	-0.0742***	-0.0803***
	(0.0203)	(0.0210)
Share of skilled labor	-0.0213	-0.0407
	(0.0391)	(0.0422)
Exports/sales	0.1685	0.1488
	(0.4503)	(0.4836)
High EI Exports/Exports	-0.4504**	-0.9509***
	(0.1932)	(0.3425)
Municipality FE	yes	yes
Firm FE	yes	yes
Sector FE x Year FE	yes	yes
R2	0.371	0.353
Observations	6,468	6,468
	First-stage results	
IV for the share of exports	0.0172***	0.0171***
	(0.0021)	(0.0020)
IV for the share of High EI exports	0.2570***	0.1907***
	(0.0233)	(0.0230)
F statistic	34.1	46.8

Notes: Each column reports the results of regressions for 1997–2010. The dependent variable is the annual emission intensity of the firm, measured as tons of CO_2 equivalents of energy per US$1,000 of output. The explanatory variables are total employment (in logs), total factor productivity, the share of skilled labor, the share of foreign capital, the ratio of total exports to sales, and the ratio of exports to high-income countries to total exports. Additional controls are sector (ISIC rev. 3 4-digit level) x year fixed effects, municipality x year fixed effects, and firm fixed effects. Robust standard errors in parentheses are clustered at the firm level.

***; **; * significant at the 1%, 5%, and 10% level, respectively.

Appendix

Table A1: Coefficients employed to calculate greenhouse gas emissions associated with fuel type

Fuel type	Factor	tons of CO_2 per
Coal	25.8	terajoule
LPG	17.2	terajoule
Natural gas	15.3	terajoule
Petrol	42.3	terajoule
Firewood	30.5	terajoule
Electricity	0.45	MWh

Source: United Nations Intergovernmental Panel on Climate Change (IPCC), and Ministry of Energy of Chile.

Table A2: High-income countries from OECD

Australia	Japan
Austria	Korea
Belgium	Latvia
Canada	Lithuania
Chile	Luxembourg
Czech Republic	Netherlands
Denmark	New Zealand
Estonia	Norway
Finland	Poland
France	Portugal
Germany	Slovakia
Greece	Slovenia
Hungary	Spain
Iceland	Sweden
Ireland	Switzerland
Israel	United Kingdom
Italy	United States

Table A3: Stringency of environmental regulation index

Country	Index	Country	Index	Country	Index
Switzerland	186	Greece	133	Zimbabwe	83
United States	185	Korea, Rep.	117	Argentina	80
Germany	182	Iceland	115	Bangladesh	80
Sweden	181	South Africa	115	Brazil	79
Finland	177	Poland	112	Philippines	78
Norway	173	China	105	Turkey	78
United Kingdom	172	Tunisia	105	Zambia	78
Canada	171	Hungary	101	Dominican Republic	77
Ireland	170	Czech Republic	94	Jordan	77
Austria	169	Trinidad and Tobago	93	Morocco	77
Denmark	165	Pakistan	91	Paraguay	77
Netherlands	165	Chile	90	Malawi	76
Australia	163	India	90	Senegal	76
Belgium	162	Mexico	89	Thailand	76
Japan	162	Uruguay	88	Egypt	74
France	161	Jamaica	87	Tanzania	72
New Zealand	157	Venezuela	87	Nigeria	71
Italy	146	Colombia	84	Papua New Guinea	68
Spain	144	Ecuador	84	Mozambique	62
Portugal	139	Ghana	84	Ethiopia	49
Bulgaria	138	Kenya	84		

Source: Eliste and Fredriksson (2002).

Table A4: Environmental Sustainability Index, 2001

Country	Index	Country	Index	Country	Index
Finland	80.5	Zimbabwe	52.0	Tunisia	43.7
Norway	78.2	Nicaragua	51.9	El Salvador	43.7
Canada	78.1	Ecuador	51.8	Pakistan	43.6
Sweden	77.1	South Africa	51.3	Indonesia	42.6
Switzerland	74.6	Mauritius	51.2	Senegal	42.5
New Zealand	71.3	Venezuela	50.8	Jamaica	42.3
Australia	70.7	Armenia	50.6	Morocco	41.9
Austria	67.8	Gabon	50.5	Uzbekistan	41.6
Iceland	67.3	Mongolia	50.3	Kazakhstan	41.6
Denmark	67.0	Sri Lanka	49.8	Malawi	41.3
United States	66.1	Malaysia	49.7	India	40.9
Netherlands	66.0	Israel	49.5	Tanzania	40.3
France	65.8	Paraguay	48.9	Korea	40.3
Uruguay	64.6	Fiji	48.1	Jordan	40.1
Germany	64.2	Central African Rep	48.0	Zambia	39.8
United Kingdom	64.1	Belarus	48.0	Kyrgyz republic	39.6
Ireland	64.0	Poland	47.6	Bangladesh	39.5
Slovakia	63.2	Moldova	47.4	Macedonia	39.2
Argentina	62.5	Bulgaria	47.4	Togo	39.1
Portugal	61.4	Guatemala	47.3	Algeria	38.9
Hungary	61.0	Papua New Guinea	47.3	Benin	38.6
Japan	60.6	Ghana	47.0	Burkina Faso	38.6
Lithuania	60.3	Honduras	46.9	Iran	38.4
Slovenia	59.9	Singapore	46.8	Syria	37.9
Spain	59.5	Nepal	46.7	Sudan	37.7
Costa Rica	58.8	Egypt	46.5	China	37.6
Estonia	57.7	Trinidad and Tobago	46.4	Lebanon	37.5
Brazil	57.4	Azerbaijan	46.4	Ukraine	36.8
Czech Republic	57.2	Turkey	46.3	Niger	36.5
Bolivia	56.9	Mali	46.2	Philippines	35.7
Chile	56.6	Dominican Republic	45.4	Madagascar	35.4
Latvia	56.3	Mexico	45.3	Vietnam	34.2
Russia	56.2	Thailand	45.2	Rwanda	33.5
Panama	55.9	Bhutan	45.1	Kuwait	31.9
Cuba	54.9	Cameroon	44.9	Nigeria	31.8
Colombia	54.8	Mozambique	44.2	Libya	31.3
Italy	54.3	Albania	44.2	Ethiopia	31.2
Peru	54.3	Belgium	44.1	Burundi	30.1
Croatia	54.1	Romania	44.1	Saudi Arabia	29.8
Botswana	53.6	Uganda	44.0	Haiti	24.7
Greece	53.1	Kenya	43.9		

Source: Environmental Sustainability Index (ESI).

Table A5: Subperiod analysis

	(1)	(2)
Total employment	-0.0241*	-0.0238
	((0.0128)	(0.0127)
Total factor productivity	-0.0429***	-0.0429***
	(0.0131)	(0.0131)
Share of skilled labor	-0.0312	-0.0314
	(0.0498)	(0.0497)
Exports/sales	-0.0908	-0.1033
	(0.1475)	(0.1470)
High-income exports/exports	-0.2201**	-0.2501**
	((0.0969)	(0.1277)
High-income exports/exports x d2003–2010		0.0368
		(0.1009)
R2	0.617	0.621
Observations	5,881	5,881
	First-stage results	
IV for the share of exports	0.0172***	0.0173***
IV for the share of HI exports	0.2677***	0.2903***
F statistic	32.9	22.3

Notes: Each column reports results from 2SLS regressions for 1997–2010. The dependent variable is the annual emission intensity of the firm, measured as tons of CO_2 equivalents of energy per US$1,000 of output. The explanatory variables are total employment (in logs), total factor productivity, the share of skilled labor, the share of foreign capital, the ratio of total exports to sales, the ratio of exports to high-income countries to total exports, and the ratio of exports to high-income countries to total exports interacted with a dummy variable that is equal to 1 between 2003 and 2010 (column 2 Additional controls are sector (ISIC rev. 3 4-digit level) x year fixed effects, municipality x year fixed effects, and firm fixed effects. Robust standard errors in parentheses are clustered at the firm level.

***; **; * significant at the 1%, 5% and 10% level respectively.