Economics Working Paper Series

2018/015

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The Short and Long-Run Effects of International Environmental Agreements on Trade[*]

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July 2018

Abstract

Does the ratification of an international environmental agreement (IEA) reduce a country's competitiveness on world markets? In this paper, we take a gravity regression approach to answering this question by using industry-level bilateral trade data and employing time-varying country fixed effects to control for the endogeneity of treaty participation. We find that ratifying an IEA has significant (albeit small) negative effects on the exports of a country's median manufacturing industry as well as a compositional shift towards exporting cleaner goods. However, we also show that this negative competitive effect on the median manufacturing industry disappears in the long-run. In fact, the positive compositional shift becomes stronger in the long-run as a ratifying country sees a further decline in exports of dirtier industries which is more than compensated for by an increase in exports of cleaner industries, with an overall positive but negligeble effect on employment.

Keywords: international environmental agreements; trade flows; gravity equation
JEL Classification Codes: F14, F18, F53, F64, Q56

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[*] The authors would like to thank partipants at the Midwest International Economics Group Meeting at the University of Kentucky (2017) for useful comments on a previous version of this paper. All remaining errors are ours. Contact details: Josh Ederington, e-mail: `ederington@uky.edu`; Mihai Paraschiv, e-mail: `mihai.paraschiv@oswego.edu`; Maurizio Zanardi, e-mail: `m.zanardi@lancaster.ac.uk`

1 Introduction

Between 1976 and 2011 (i.e., the period considered in this paper) manufacturing as a percent of GDP declined from 22% to 12% in the U.S. and from 27% to 14% in Europe. Roughly the same period saw a decline in manufacturing employment from 31% of total employment in the U.S. in 1980 to just 17% in 2010. A similar decline, from 36% to 25%, occurred in Europe.[1] Several recent studies (e.g., Acemoglu et al. (2016), Autor et al. (2016), and Pierce and Schott (2016)) have pointed to globalization as a significant cause of such declines in high-income countries. Recently, these analyses have received a great deal of attention as the decline in manufacturing employment has been associated with increased income inequality, significant social change, and political pressures.[2] It is noteworthy that many people also tie the decline in the relevance of the manufacturing sector and employment to increased environmental standards in high-income countries. For example, survey evidence (e.g., from WorldPublicOpinion.org) suggests that a sizable majority of the American public believes that the U.S. strong environmental standards place it at a competitive disadvantage in global markets. Therefore, it is perhaps not surprising that the decision to join an international environmental agreement (IEA) is often controversial with much of the discussion centering around its effects on "competitiveness" in global markets (e.g., see the debate regarding whether the U.S. should have ratified the Kyoto protocol).

Given the relevance of the topic and the surrounding political debate over the past several decades, it could be assumed that we possess causal evidence that links the ratification of IEAs with losses of comparative advantage in the manufacturing sector of high-income countries. Instead, systematic evidence of this kind is limited and this is the very gap addressed by this paper. Starting from the premise that increased environmental regulation may increase production costs (at least for the most polluting industries), we analyze the effect of IEA ratification on bilateral industry-level exports within a gravity regression framework.

Previewing the results of our analysis, we find a small negative effect of IEA membership on exports for the typical (median) manufacturing sector in the short-run. However, we also find that this negative competitive effect disappears in the long-run. Thus, there is little, if any at all, evidence that the proliferation of IEAs over the past several decades has been a major contributor to the general trend of manufacturing decline in high-income countries. Instead, we find a significant (both quantitatively and statistically) compositional shift in exports away from "dirty" and towards "clean" industries the more IEAs an exporting country ratifies (compared to its trade partners). What is especially interesting is that we show that this compositional shift becomes stronger in the long-run. Thus, IEA ratification does appear to have contributed to the decline in manufacturing production in certain (high pollution-intensive) industries among member countries. However, this decline in dirty-good

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[1] Manufacturing to GDP ratios are calculated from the UN National Accounts database while employment ratios come from the World Bank's World Development Indicators.

[2] See, for example, Autor et al. (2013) who found not only negative effects of increased import competition from China on local wages and employment in the U.S., but also increased use of social programs such as disability insurance. In a similar vein, Dorn et al. (2014) link workers who face import competition with lower earnings, increased likelihood of drawing disability benefits, and lower tenures. Subsequent papers have tied globalization to many other outcomes (e.g., changes in marriage rates, health, political polarization).

exports has been more than compensated by an increase in exports of cleaner industries within these member countries. Translating these results in terms of employment, there is evidence of job losses in the short run and a net positive (but not large) employment effects in the long run.

The more recent literature on the impact of environmental policy on trade flows has typically used instrumental variable approaches (to control for the endogeneity of environmental policy) and panel data techniques (to address the unobserved heterogeneity across panels in addition to the endogenous environmental policy choice). One strand of this literature exploits cross-industry variation in the stringency of environmental regulation (e.g., estimated by industry pollution abatement costs) to test if industries facing an increase in environmental regulation observed a decline in net exports (e.g., see Ederington and Minier (2003), Ederington et al. (2005), and Levinson and Taylor (2008)). Another exploits regional variation in environmental stringency (e.g., estimated from survey data or fuel standards) to test if regions that increased regulatory stringency saw a decline in economic activity (e.g., see Tobey (1990), Millimet and List (2004), Kellenberg (2009), and Broner et al. (2012)). This paper is closer to the second vein as we are implicitly using the ratification of an IEA as a proxy for the regulatory stringency of a country's environmental policies. However, we also exploit cross-industry variation in emissions intensities to investigate whether the ratification of IEAs implies heterogenous effects across manufacturing industries. This approach (combined with the long time series of our data set) allows us to investigate potential general equilibrium effects (e.g., whether increased regulatory stringency actually increases exports in cleaner manufacturing industries). In addition, the use of IEA membership data allows us to address the policy-relevant question of how joining an IEA affects the competitiveness of a country's manufacturing exports on global markets.

The analysis conducted here is most comparable to that in Aichele and Felbermayr (2015), who analyze the effect of ratifying the Kyoto protocol on imports, carbon dioxide (CO_2) intensity of imports, and the CO_2 content of imports of member countries.[3] In common with their approach, we use a gravity framework along with time-varying country fixed effects to control for endogenous participation in IEAs. However, we rely on a much expanded dataset (i.e., 163 countries observed for almost 40 years versus their sample of 40 countries over the period 1995-2007) and a much broader spectrum of environmental agreements to provide systematic evidence on a broad set of agreements, disentangling possible heterogeneous effects by type of IEAs (i.e., targeting climate change, acid rain, or ozone depletion).[4] Our long time span also allows us to recover long-run effects of IEA participation. This is important because the short-run effects of IEA ratification might differ from the long-run impact given

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[3] Other relevant papers include Aichele and Felbermayr (2013) and De Santis (2012). Aichele and Felbermayr (2013) uses data on 117 exporters and 128 importers from 1997-2007 (and employs matching econometrics to attempt to control for endogenous participation) and estimates a negative effect of Kyoto membership on a country's aggregate export flows. De Santis (2012) uses data on 24 countries between 1988-2008 (and a gravity specification with time invariant fixed effects that controls for unobserved heterogeneity but not for the endogenous treaty participation) and estimates positive effects of Kyoto and Montreal protocol memberships on a country's exports.

[4] It is our focus on the competitiveness effects of IEAs that allows us to expand the dataset, since our approach requires little in terms of individual country and sector-specific emissions data.

lags arising from large fixed costs and uncertain emission-abatement innovations in manufacturing industries. Indeed, we find that the compositional change in trade flows changes dramatically in the long run with positive but small effects on employment.[5]

The rest of the paper is organized as follows. Section 2 provides a non-technical presentation of the theoretical and empirical work that analyzes how IEAs may affect exports, as well as summary of the IEAs included in the empirical analysis. Section 3 presents details about the data that we use and the construction of the covariates. Section 4 discusses the empirical approach and the baseline results: that ratifying an IEA leads to a compositional shift towards exporting cleaner manufacturing goods as well as a decline in net exports of the median manufacturing industry. In section 5 we distinguish between import and export flows to analyze the potential for IEA membership to lead to pollution leakage (i.e., IEA ratification leading to increased imports of dirty goods from non-member countries). Section 6 isolates the long-run effects of IEA ratification and shows that while the compositional shift towards cleaner exports gets stronger over time, the negative effect on the competitiveness of the median manufacturing industry disappears. Indeed, back-of-the-envelope calculations show no relationship between IEA membership and the long-run decline in manufacturing employment in high-income countries like the U.S. and Germany. Finally, Section 7 concludes.

2 International Environmental Agreements and Exports

This paper is concerned with IEAs as a source of comparative (dis)advantage for manufacturing industries and how they impact export performance, with the possibility that the impact is larger for pollution-intensive sectors. The basic mechanism is that ratifying an IEA commits a country to emission targets and/or pollution regulations that raise the cost of production within an industry. This cost can be direct (e.g., the incurrence of pollution abatement costs to reduce emissions or higher energy costs) or indirect (e.g., product standards which raise the cost of producing the good or regulations which increase the cost of intermediate inputs). In order to delve deeper in the consequences of these costs, the next subsection provides a theoretical background to understand that the effects need not be negative even if IEAs lead to cost. Furthermore, the effects may be different at different time horizons. With this understanding, the following subsection discusses the framework for IEA adoption and describes the three type of agreements (i.e., acid rain, ozone depletion, and climate change) that we include in the empirical analysis.

2.1 Theoretical Background

In investigating the effect of environmental regulations on industry competitiveness our paper adds to an already vast literature (see Dechezleprêtre and Sato (2017) for a recent survey). As mentioned, our approach is closest to those papers that use regional variation in environmental stringency. However, what makes our approach unique is not only the focus

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[5] Indeed, one of the main arguments of Ederington et al. (2005) is that emissions-intensive industries tend to have large fixed costs, which results in relocation only taking place slowly and with long lags.

on IEAs as a potential source of comparative disadvantage but also the long time-span of our data (1976-2011). This allows more flexibility in looking for both general-equilibrium shifts in production across sectors but also Porter-type induced innovation in response to environmental regulations.

First, consider an increase in environmental regulations brought about by attempting to achieve an overall emissions target. This will obviously affect some sectors, which emit the targeted pollutant intensively (i.e., dirty industries), more than others. While we expect to see negative competitiveness effects from IEA ratification on the more pollution-intensive manufacturing sectors, it is possible that even so-called clean sectors are negatively affected – either through upstream/downstream linkages with the dirty industries or through a rise in production costs from more costly inputs such as energy or transportation. However, at least in an open economy, one would expect a general equilibrium shift in production towards those cleaner sectors. The underlying mechanism is simple: some resources employed within the pollution-intensive sectors, which shrink because of regulation, are freed up and can be cheaply employed within the cleaner sectors that, in turn, expand. In this scenario, IEAs ratification implies a compositional shift in a nation's production and exports, with cleaner industries accounting for a larger share of output and outflows. However, these compositional shifts in production might happen only gradually over time given factor specificity and convex adjustment costs. Indeed, Heckscher-Ohlin-Samuelson models with perfect factor mobility were commonly viewed as long-run models in the trade literature, with short-run models typically assuming some form of capital specificity (e.g., see Neary (1978)). This implies that the competitiveness effects of an IEA in the short-run might be very different than the long-run effects with the main prediction we see from general equilibrium models such as Neary (1978) is that the compositional shifts from IEA membership should be larger in the long-run.

However, it is also possible to observe the substitution of domestic production with imported goods from countries outside the IEA (i.e., pollution leakage). This is the so-called pollution haven effect, which has caused concerns both for the politics of IEAs ratification (concerns about the competitiveness of manufacturing industries are central to these discussions) as well as the effectiveness of the IEAs themselves (the extent to which IEAs reduce global emissions versus simply shifting production towards low-regulation regions).[6] These concerns are especially pronounced for the multilateral environmental agreements studied in this paper, which target global pollutants, where member country abatement efforts might simply be offset by increasing production, and thus emissions, in non-member countries.

Alternatively, the so-called "Porter hypothesis" (see Porter and van der Linde (1995)) can be at play, in which environmental regulation acts as a catalyst for further research, innovation, and efficiency gains. In the strong version of the Porter hypothesis, more stringent regulations actually translate into increased competitiveness on the domestic and international fronts. While there is little evidence that such innovations can offset the costs of environmental regulations sufficiently to actually increase firm competitiveness, several pa-

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[6] See Copeland and Taylor (1994, 2005) for a discussion about the pollution haven effect. For an early theoretical discussion regarding the locational choice of industries in the presence of environmental regulation and regulation in general refer to McGuire (1982).

pers have found evidence that increased environmental regulations induce the development of new pollution-abatement technologies. For example Newell et al. (1999) and Popp (2002) find that higher energy prices lead to new technologies in energy efficiency while Jaffe and Palmer (1997) and Brunnermeier and Cohen (2003) find that stricter regulations lead to more environment-related patents. And Morgenstern et al. (2001) outline the existence of an overlap between production activities and regulation-compliance efforts.[7] Once again, however, induced innovation is more of a long-run phenomenon suggesting another mechanism by which the short-run competitiveness effects of an IEA might differ from its long-run effects. However, in this case the predictions of the induced innovation models are different than those of the general equilibrium models in that the negative effects of IEA on manufacturing competitiveness should be *less pronounced* in the long-run and potentially the compositional shifts towards cleaner production should be lower as well.[8]

In conclusion, the direction, magnitude, and time horizon of any trade effect stemming from the ratification of IEAs is a quintessential empirical question, which is exactly what this paper aims to answer.

2.2 International Environmental Agreements

The IEAs included in the analysis are listed in Table 1 and are divided into three groups based on the global environmental problem they are designed to address. Each of these categories (i.e., acid rain, ozone depletion, climate change) are described in more detail in the following subsections.

2.2.1 Acid Rain IEAs

IEAs designed to tackle the issue of air pollution and its transboundary effects were adopted as part of the 1979 Geneva Convention on Long Range Transboundary Air Pollution (LRTAP). Each of the subsequent protocols involved emission reduction targets aimed at a particular chemical associated with transboundary air pollution: primarily sulphur oxide (SO_x), nitrogen oxide (NO_x), non-methane volatile organic compounds (NMVOC), and ammonia (NH_3).

The first acid rain protocol, Helsinki (1985), mandated a 30% reduction in sulphur emissions while the subsequent Oslo (1994) protocol introduced additional reduction targets as well national standards with respect to energy efficiency and the sulphur content of fuels. The following Sofia protocol (1988) capped nitrogen oxide emissions at their 1987 levels and introduced emission standards and controls for major emission sources. The 1991 Geneva protocol to LRTAP was geared towards reducing emissions of volatile organic compounds (VOCs). Specifically, parties agreed to decrease their emissions of VOCs by at least 30% by 1999 (relative to 1988 levels). The Aarhus (1998) protocol mandated reductions for discharges of heavy metals (cadmium, lead, and mercury). Although no specific targets were

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[7] Other papers demonstrating induced innovation in response to environmental regulations include Aghion et al. (2016) and Calel and Dechezleprêtre (2016).

[8] This last prediction does require the additional assumption that any new technologies developed are more effective in reducing costs in the more pollution-intensive manufacturing industries.

introduced for annual emission levels, the protocol did emphasize concrete emission caps for major discharge sources (primarily various combustion processes employed across an array of industrial sectors). Under a second Aarhus protocol of 1998, parties were mandated to cease the production and use of persistent organic pollutants (POPs) in accordance to their specific timetables. However, some exemptions regarding the use of POPs were allowed.[9] The protocol also mandated environmentally sound strategies for recycling, destruction, and disposal of POPs. Similar to the protocol on heavy metals, the current agreement also included a list of specific emission caps applicable to different stationary sources. Finally, the 1999 Gothenburg protocol was aimed at targeting discharges associated with all of the previously introduced pollutants, plus ammonia. In addition to the provisions introduced as part of previous arrangements, the protocol added party-specific, emission reduction targets for sulphur compounds (SO_2), nitrogen oxides, ammonia, and non-methane volatile organic compounds.

2.2.2 Ozone Depletion IEAs

IEAs aimed at reducing and controlling the emission of substances with ozone altering and depletion characteristics were adopted under the auspices of the 1985 Vienna Convention for the Protection of the Ozone Layer (VCPOL). This comprises the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer and its subsequent amendments, London (1990), Copenhagen (1992), Montreal (1997), and Beijing (1999). Broadly speaking, the Montreal protocol was centered on limiting the consumption and production of chlorofluorocarbons (CFCs) and bromofluorocarbons (BFCs) relative to their calculated 1986 levels.

Subsequent amendments to the Montreal protocol targeted new substances with ozone altering or depleting features and introduced phase-out schedules for the targeted compounds. For example, the 1990 London amendment expanded the list of initial CFCs and mandated the gradual elimination of both the listed CFCs and BFCs by 2000. Hydrochlorfluorocarbons (HCFCs), also known as transitional substances, were developed as alternatives to CFCs but these compounds also display ozone depletion characteristics, albeit much lower than those of CFCs. HCFCs were added to the list of controlled substances under the 1992 Copenhagen amendment and were scheduled for elimination by 2030. The Copenhagen amendment also mandated the phase-out of CFCs (by 1995), BFCs (by 1993), carbon tetrachloride (by 1995) and hydrobromofluorocarbons (HBFCs) (by 1996). The 1997 Montreal amendment introduced a timetable for limiting the use and production of methyl bromide with a complete phase-out by 2005. Finally, the 1999 Beijing amendment mandated a complete phase-out of bromochloromethane by 2002. Additionally, it imposed significant consumption and production limitations on HCFCs, thus accelerating their phase-out process.

It should be noted that the ozone depletion IEAs differ from the acid rain and climate change IEAs in two ways. First, they focus more heavily on setting product standards (i.e., the phase-out of the use of certain chemical compounds within products) as opposed to overall emission reductions or process regulations. To the extent that these product standards are applied to products originating from non-ratifying nations, the competitive

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[9] The use of DDT, a pesticide, was permitted only in cases of absolute necessity (i.e., malaria and encephalitis outbreaks) and for only one year after its production was stopped.

effects of the Montreal protocol are potentially different than the climate change or acid rain agreements which primarily involved process regulations (see discussion in Ederington and Ruta (2016)). Indeed, the Montreal protocol and its subsequent amendments deviate from the typical IEA structure in that they often included provisions regarding international trade with non-members. Specifically, bans were introduced on both the import of controlled substances and products containing them. Regulations on the import of products produced with substances targeted under the protocol were also added.

Second, the substances targeted by the ozone agreements are associated with a different set of industrial processes than the acid rain and climate change agreements. Our measures of industry pollution intensity (see Table 2) are based on emissions targeted by the climate change and acid rain agreements and are quite highly correlated (see Table A1 in the Appendix). In contrast, according to a report published by the Intergovernmental Panel on Climate Change (see Sanz Sánchez et al. (2006)), the substances targeted by the Montreal protocol were employed in a different set of industrial processes. These include electronics and optical equipment, where the substances served as cleaning and de-greasing agents for circuit boards, and machinery n.e.c., where the substances aided as refrigerants for household and industrial air conditioning units, refrigerators, or freezers. The controlled substances were also used as aerosol propellants in the chemical and pharmaceutical sectors, or as solvents for the dry cleaning services. The compounds addressed under the protocol were also involved in the manufacturing of insulating foams, or as refrigerants in mobile air conditioning units, both of which were passed downstream to the transport equipment sector.

This discussion highlights the distinct nature of the ozone depletion IEAs. Although our empirical analysis does treat the three types of IEAs as homogenous, we later allow for heterogeneity in our coefficient estimates across IEA types, as well as for alternative measures of pollution intensity for the ozone depletion agreements.

2.2.3 Climate Change IEAs

Climate change IEAs were adopted as part of the 1992 United Nations Framework Convention on Climate Change (UNFCCC). Their end objective focuses on limiting and curbing anthropogenic emissions of all greenhouse gases (GHGs) not covered by the Montreal protocol. Concrete GHG emission reduction targets were introduced as part of the Kyoto (1997) protocol to the UNFCCC. Obviously, the principal provisions of the protocol centered around reducing carbon dioxide (CO_2) emissions. However, the protocol also sets emission targets for methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).

While similar to the acid rain IEAs in its focus on emission targets, the Kyoto protocol argued for "common but differentiated" responsibilities among parties. Some Kyoto parties

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[10] This set of countries excludes the U.S, which is included within Annex B but did not ratify the protocol. Countries were primarily grouped into Annex B based on the level of development. Even among Annex B countries there was flexibility with countries adopting different emissions targets, transitional countries being offered special treatment and the adoption of various market based strategies (e.g., emission trading between Annex B parties, Joint Implementation, and Clean Development Mechanisms) (see Grubb (2003)).

(Annex B countries) adopted explicit emissions targets.[10] In contrast, other parties (non-Annex B) did not face mandated emission targets under the agreement. In this paper, we focus on the set of countries that adopted explicit emission targets under the Kyoto agreement (i.e., Annex B countries) although we revisit this assumption later in the robustness section by distinguishing between Annex B and non-Annex B countries.

3 Data and Variable Construction

In order to test whether IEAs membership affects a country's manufacturing exports, three sets of data need to be merged: IEAs membership, sectoral emissions, and manufacturing trade flows.

Information on each nation's IEAs membership is gathered from the International Environmental Agreements Database Project (see Mitchell (2016)). In order to analyze the effects of multilateral IEAs on trade, we focus on multilateral agreements that involve either a negotiated reduction in emissions or the establishment of emission caps for one or more substances. Thus, our analysis does not include the *framework conventions*, which typically outline the rules, objectives, and other fundamental principles under which subsequent negotiations take place.[11] Instead, we focus our attention on the 13 major multilateral environmental *protocols* and any subsequent *amendments* that established air emission targets (or phase-out schedules) for member countries (i.e., acid rain, ozone depletion, and climate change protocols and their subsequent amendments).

IEA membership typically involves a three-step process: signature, ratification, and entry into force. As is common in the literature (see Slechten and Verardi (2016) and Aichele and Felbermayr (2015) among many others), the year of ratification is used as the official treatment date. By and large, the signature of IEAs is just a formality, with no immediate implications for the parties and the ex-post ratification decision. In addition, even though IEAs do not become legally binding until the date of entry into force, evidence (e.g. Baccini and Urpelainen (2014)) suggests that parties begin the process of bringing their emissions into compliance with the treaty obligations prior to that date.

Similar to Slechten and Verardi (2016), we use the count of ratified IEAs to measure a nation's environmental commitment. Thus, the relative measure of environmental stringency, for a given country pair *(xm)* at time t is constructed as the difference between the number of agreements ratified by the exporter (IEA_{xt}) and importer (IEA_{mt}):

$$d(IEA)_{xmt} = IEA_{xt} - IEA_{mt}. \tag{1}$$

As noted in Slechten and Verardi (2016), there is a fair degree of overlap in the timing and membership of IEAs which makes identification of the impact of individual agreements difficult (e.g., the acid rain agreements often occur within two or three years of each other across a similar set of adopting nations). Thus, we aggregate IEAs into a single variable to

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[11] The framework conventions do not include any any specific emission targets or phase-out schedules. Consistent with this approach, we also record Kyoto membership based on whether countries adopted a specific emissions target under the Kyoto framework. This distinction is explored in more detail in Section 4.3.

provide an estimate of the average effect of the ratified treaties.[12]

By construction, the linear differential implies a constant effect across all IEAs considered, regardless of their type. This strategy is suited to estimate the long-run effect of joining IEAs across the entire sample period. However, the heterogeneity of IEAs is an important dimension that should not be overlooked. Hence, we also construct relative measures of environmental stringency similar to (1) by using the count of ratified IEAs for each of the three IEA categories (i.e., acid rain, ozone deplation, and climate change) outlined in Section 2.2. The logic behind the bundling by category is simple and postulates that trade effects are more likely to be homogenous for IEAs belonging to the same category.

Data on sectoral emissions and output at ISIC 2 (revision 3) level are from the Environmental and Socio-Economic Accounts of the World Input Output Database (WIOD) (see Genty et al. (2012)) and are available for a subsample of 40 countries between 1995 and 2009. Emission data is available for eight pollutants: carbon dioxide (CO_2), methane (CH_4), carbon monoxide (CO), sulphur oxides (SO_x), nitrous oxide (N_2O), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), and ammonia (NH_3). WIOD emission data is compiled from various sources and is based on a combination of inventory-first methods (that, simply put, involve assigning emissions to each sector in accordance with its share in overall production) and energy-first methods (that start with energy consumption involved by different sectoral activities, proceed with scaling each activity by the appropriate emission factor, and aggregating back up to sectoral level). In general, the inventory-first method is typically used for calculating N_2O, CH_4 and NH_3 emissions while the energy-first method is used for NO_x, SO_x, NMVOC and CO. A combination of both is used for calculating sectoral CO_2 emissions.

Following Hettige et al. (1992, 1995), Broner et al. (2012), and Aichele and Felbermayr (2015), we first define sectoral emissions intensity as annual emissions relative to annual output.[13] It is common in the literature to decompose changes in a country's emissions over time into scale (changes in emissions due to a change in aggregate output), technique (changes in emissions due to a change in emission intensity), and composition (changes in emissions due to a change in the composition of output) effects. Since we are interested in the competitiveness effects of IEAs, it is important to isolate the effect of an IEA on industry scale and composition by holding emissions intensity (i.e., the technique effect) constant. Thus, to calculate sectoral emissions intensity we simply take sectoral averages over the 40 country, 14-year, WIOD subsample.[14] Taking sectoral averages across countries and time also reduces the possibility that country- or time-specific shocks are correlated with emissions intensity data as well as allowing us to abstract from differences in calculation methods across countries and time. The resulting average sectoral emissions are provided in Table 2 and

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[12] Slechten and Verardi (2016) also emphasize the high degree of correlation across pollutants (see Table A1 in the Appendix), which arises from the fact that industrial processes and other sources of pollution often generate multiple pollutants. Thus, agreements aimed at reducing SO_x emissions would also lead to a reduction in CO_2 emissions. This would suggest a degree of homogeneity in the effects on individual IEAs.

[13] Sectoral emission intensities are expressed in kilograms per \$1,000 of output at 1995 prices. Sectoral output is deflated using sector-specific price indexes.

[14] Emission intensity rankings do tend to be correlated across time and countries. Within the WIOD subsample, the cross-country correlation is around 0.95 while the correlation over time is around 0.50.

the rankings of industries by pollution intensity agree with prior expectations as industries involving minerals and metals processing or the manufacture of chemicals tend to exhibit high pollution intensities while industries associated with the production of textiles and food products exhibit lower pollution intensities, which is consistent with the list of dirty sectors constructed by Tobey (1990) who uses US pollution abatement operating costs. There is a also higher degree of correlation in our industry rankings across the different emissions (with the exception of N_2O and NH_3 which in turn are highly cotrrelated with each other; see Table A1 in the Appendix for correlations in the emission intensities of the various pollutants).

From this data, we calculate several measures of sectoral pollution intensity (D_s). First, following previous studies such as Broner et al. (2012) and Kahn (2000), we employ a binary measure where we assign sectors into clean and dirty bins based on the properties of the associated CO_2 emission intensity distribution. Using the 75^{th} percentile as a cut-off, we identify four dirty industries: non-metallic minerals; coke, refined petroleum and nuclear fuel; basic metals and fabricated metal; and chemicals and chemical products.[15] Second, as a continuous measure, we use the average sectoral emissions intensities calculated in Table 2. Note that this gives us 8 different measures for each industry based on the 8 different pollutants. Third, as a means of combining sectoral emission intensities into a single and continuous variable, we also construct a principal component (PC) of the eight measured pollutants. This procedure aims at extracting the most information from the individual components without multicollinearity concerns. On the negative side, the scale of the variable is meaningless. We utilize the first component, PC1, which on its own accounts for 59% of this information. Since it displays positive loadings on all emission intensities (see panel A in Table A2 for details), it has the obvious interpretation that higher values denote more polluting sectors.

Finally, trade data for 163 countries, observed as exporters and importers across manufacturing sectors, between 1976 and 2011 have been obtained from COMTRADE (see Table A3 in the Appendix for the list of countries). Originally classified in SITC (revision 2), exports have been matched into 14 ISIC 2 (revision 3) manufacturing sectors for the purpose of merging them with sectoral emission data.[16] In our regressions we also control for the level of trade and economic integration between the two countries. To this end, we use the data compiled by Jeffrey Bergstrand and his collaborators as part of the NSF - Kellogg Institute Data Base on Economic Integration Agreements Project. Integration is measured on a scale from 0 to 6, where 0 indicates no integration agreement between the two countries, 1 stands for a non-reciprocal preferential trade agreement, 2 is a reciprocal preferential trade arrangement, 3 is a free trade agreement, 4 is customs union, 5 is a common market (i.e., the European Union) while level 6 denotes an economic union (e.g., the Eurozone).

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[15] Notably the 75^{th} percentile-based dirty bin is similar to that used in other studies that have used pollution abatement costs per unit of value added (output, or total costs) or capital intensity to quantify sectoral "dirtiness" (e.g., see Jänicke et al. (1997), Mani and Wheeler (1998), Ederington et al. (2005), Kellenberg (2009), Grether et al. (2012), and Shapiro and Walker (2015)). The four sectors we identified as dirty also top the emission intensity rankings for pollutants targeted by acid rain IEAs (i.e., SO_x, NO_x, NMVOC, and NH_3).

[16] The correspondence tables provided by Affendy et al. (2010) were used. Our special thanks to Dr. Affendy for providing the correspondence table in Excel format.

4 Empirics

We analyze the effect of IEAs on international trade flows within a gravity equation framework, which is the standard tool for this type of ex-post empirical analysis (see Head and Mayer (2014)). In doing so, we need to take into accounts any unobserved determinants of trade flows. Often, these factors are exporter-, importer-, sector-, and time-specific (or any combination of these dimensions) and may range from geographical, historical, and cultural characteristics to infrastructure and preferences, to the sectoral supply and demand capacities of the exporter and importer. In order to deal with this issue, we follow the methodology of Aichele and Felbermayr (2015) and include time-varying country fixed effects. Another issue to take into account is the endogenous nature of IEA adoption. However, Aichele and Felbermayr (2015) also argue that the use of time-varying country fixed effects is an effective means of reducing any biases that may arise from omitting the determinants of IEA choices. This solution hinges on the fact that, like trade flows, IEA participation is multilateral in nature, as is clearly the case for the major global environmental agreements in our sample. That is, IEA participation depends on a country's relations with all other countries and, as a result, it is unlikely to be driven by just bilateral and time-varying industry-level shocks (see Aichele and Felbermayr (2015) for a discussion). The use of panel data techniques such as country-pair and time-varying fixed effects to account for latent factors that might determine trade flows and treaty participation is long-standing in the international trade literature – especially within the strand that analyzes trade agreements and their impact on trade (e.g., Soete and Van Hove (2017), Baier et al. (2014), Regolo (2013), Baier and Bergstrand (2007), or Baldwin and Taglioni (2007)). As a result, our basic specification is given by:

$$lnT_{xmst} = \beta_1 d(IEA)_{xmt} + \beta_2 d(IEA)_{xmt} \times D_s + \gamma TA_{xmt} + \nu_{xt} + \nu_{mt} + \nu_{st} + \nu_{xms} + \epsilon_{xmst}, \quad (2)$$

where T_{xmst} denotes the export flows from exporter x to importer m in sector s during year t. The regressors of interest are $d(IEA)_{xmt}$, which denotes the difference in the number of ratified IEAs by the exporter and importer, and the interaction term between $d(IEA)_{xmt}$ and D_s, which measures sectoral emission intensity (i.e., be it the log version of the eight pollutants, the principal component, or the binary variable) with higher values indicating more polluting industries. Thus, β_1 captures the average effect of IEA membership on all sectoral exports while β_2 captures its effect on the cross-industry composition of exports. Our only prior is that $\beta_2 < 0$. That is, all else constant, the ratification of an additional IEA by the exporting country reduces its exports by a greater degree in more pollution-intensive manufacturing sectors.[17]

We also include TA_{xmt} to account for the level of trade and economic integration between the two countries. As discussed before, the variable is measured on a scale from 0 to 6 (with higher values denoting deeper forms of integration) but the qualitative results are unchanged

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[17] Given the symmetry of our specification, the ratification of an IEA by an importing country will shift the composition of imports towards cleaner goods.

if we use a dichotomous version (i.e., $TA_{xmt} = 1$ if any type of trade agreement exists) or with different dummy variables for each type of agreement.

As argued earlier, ν_{xt} and ν_{mt} are the sets of time-varying, country fixed effects designed to control for unobserved trade determinants and the endogenous selection into IEAs. In order to estimate β_1, we follow Aichele and Felbermayr (2015) by imposing the restriction that these fixed effects are symmetric across import and export flows (i.e., the specification uses the same country dummy regardless of whether a country appears as an importer or exporter in the bilateral relationship), although we also relax this assumption to verify that it is not driving the results. Finally, we include a time-invariant bilateral fixed effect at the industry-level (i.e., ν_{xms}) to control for common gravity variables and sectoral aspects that do not vary over time (e.g., distance, common language, sector-specific transport costs). As both Ederington et al. (2004) and Levinson (2009) document a general compositional shift towards cleaner industries in both U.S. manufacturing production *and* imports (including imports from non-OECD countries), there seems to be evidence of a global shift in production towards cleaner goods. In consideration of the long span of our dataset (i.e., 36 years), we control for any such global shifts by including industry-time fixed-effects (ν_{st}).[18]

In the next subsection, we present our baseline results first followed by a focus on the heterogenous effects by sector and type of IEAs (i.e., acid rain, ozone depletion, and climate change). We then engage in a series of robustness checks in terms of methodology, regressors of interest, and samples. Taking stocks of these results, we address further questions related to pollution leakage (Section 5) and potential differences between short and long-run effects (Section 6).

4.1 Baseline Results

The results of our baseline specification are reported in Table 3, where each column uses a different measure of sectoral emission intensity (D_s). Focusing first on β_2 (i.e., the coefficient for the interaction between the IEA stock differential and sectoral pollution intensity), it is apparent that the estimates are negative and statistically significant in all but one specification (i.e., when using NMVOC emission intensity). Thus, our estimations confirm that a higher number of ratified IEAs, relative to one's trading partner, leads to lower (net) exports in the more pollution-intensive manufacturing sectors. To ease the interpretation of these estimates, we report the marginal effects of IEA ratification on exports at different points along the distribution of sectoral emission intensities at the bottom of the table.

In the first column, we use our binary measure of sectoral pollution intensity for D_s. As can be seen, IEA membership has a statistically significant but quantitatively minor effect on trade for our set of 10 clean industries, but a more substantial negative impact on exports for the set of 4 industries identified as dirty. Specifically, our results suggest that, holding all else constant, the ratification of an additional IEA will decrease exports in each of the 4 dirty industries by around 2.5% (with a symmetric increase in imports). In contrast, ratification of an additional IEA will decrease exports in our set of 10 clean industries by only 0.6%. This pattern repeats itself throughout the specifications in this table. Specifically,

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[18] The inclusion of time-varying industry fixed effects is not inconsequential as we uncover smaller compositional affects of IEAs on exports when they are included.

while we see only a small impact on exports from IEA ratification in the majority of the manufacturing sectors, we do observe significant compositional effects: quantitatively larger declines in exports of the more emission-intensive manufacturing sectors.

In columns 2-10 of Table 3, we use average sectoral emissions intensities as measures of D_s. As mentioned earlier, with respect to the compositional effect of IEA membership (β_2), the interaction term is consistently negative and highly significant (except for NMVOC). The marginal effects illustrate that there are only small effects of IEA membership on exports of the median manufacturing industry (typically, a decline in exports of around 1% or less). For example, in terms of carbon dioxide emissions (CO_2), the median industry saw a decline in exports of only 0.7%. Thus, for the period under consideration (1976-2011), the ratification of IEAs is only a minor source of comparative disadvantage for the typical (i.e., median) manufacturing industry.

However, while the ratification of IEAs might have only small effects on exports of a typical manufacturing industry, our results suggest it has larger effects on more pollution-intensive industries and, thus, the composition of a country's exports. The marginal effects of IEA ratification on exports of the most pollution-intensive manufacturing industries point to a decrease of 2-3% for each IEA joined. For example, the ratification of an additional IEA results in a 3.2% decline in exports within the most-CO_2 polluting industry (i.e., other non-metallic minerals) over the sample period (holding membership status of the importing country constant).

Finally, in column 10 of Table 3 we use the principal component measure as an indicator of sectoral dirtiness. The results are qualitatively unchanged. That is, minor effects on the median manufacturing industry (decline in exports of 0.9%) with larger comparative disadvantage effects on the dirtiest industries (decline in exports of 3.1%).

4.2 Industry-Level Results

The marginal effects of our baseline results in Table 3 show that IEA ratification leads to a compositional shift towards exporting relatively cleaner goods (and symmetrically importing relatively dirtier goods). In order to allow for sectoral differences in the most flexible way, we also estimate specification (2) on a sector-by-sector basis. This approach comes with the added bonus of allowing the time-varying country fixed effects and the coefficient on the IEA differential to differ across manufacturing sectors. Note that, in this case, we are estimating our $dIEA$ coefficient entirely from variation in trade flows across trading partners (i.e., changes in net exports in trade relations with countries that ratify the IEA versus those that do not).

The results are presented in Table 4 and mirror the conclusions of our benchmark specifications. To facilitate interpretation, we have arranged the industries by their CO_2 emission intensity, from the most (other non-metalic minerals) to the least (leather and footwear) intensive. For the most CO_2-intensive industry, the estimates show a 5.1% decline in exports that follows the ratification of an additional IEA. Similar declines of 2-4% appear in many of the other dirtier sectors (i.e., basic metals, chemicals and chemical products, etc., which are shown in the top half of Table 4). In contrast, the three industries with the lowest CO_2 emission intensities (i.e., food, beverages and tobacco, textiles and textile products, and leather and footwear) exhibit either no statistically/quantitatively significant negative effects of IEA ratification, or even a small positive effect regarding the latter. These results emphasize once more the compositional shift towards cleaner exports for countries that adopt international environmental agreements.

4.3 The Heterogeneity of IEAs

So far, our regressors of interest bundle the entire spectrum of IEAs (i.e., acid rain, ozone depletion, and climate change) into a single, linear, differential, count variable. However, since it assumes symmetric effects across all agreements, regardless of their type, this bundling may be too strong of an assumption. This is particularly the case for the ozone depletion agreements since the pollutants that they target (primarily CFCs and BFCs) are not included in the sectoral emissions intensity data and are not necessarily even correlated with acid rain or climate change pollutants. For example, the discussion about ozone depletion agreements in Section 2.2.2 suggests that machinery n.e.c. and transportation equipment are among the affected sectors. However, neither of the two is a significant source of either acid rain or climate change-relevant emissions.

Thus, we now re-estimate specification (2) while allowing the coefficient estimates to vary across the three major categories of IEAs: acid rain (AR), ozone depletion (OD), and climate change (CC).[19] The rationale behind the split is simple and revolves around the idea that IEAs belonging to the same category are more likely to have a homogeneous effect on a certain targeted pollutant, or group of targeted pollutants. For instance, the use of closed-loop catalysts in gas-powered passenger cars, initially aimed at reducing emissions of nitrogen oxides (NO_x), may also lead to significant declines in emissions of volatile organic compounds (VOC). Alternative techniques for reducing NO_x emissions may also result in lower sulphur dioxide (SO_2) emissions. Reductions of NO_x emissions were mandated under the 1988 Sofia Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution (LRTAP). Similarly, reductions of VOC, and SO_2 emissions were targeted as part of the Helsinki (1985), Geneva (1991), Oslo (1994), and Gothenburg (1999) protocols to the same LRTAP Convention.

The results obtained after separating IEAs by category are presented in Table 5. As before, the first column uses our binary measure of industry pollution intensity based on CO_2 emissions while columns 2-10 use average sectoral emissions and the associated principal component as alternative measures of sectoral pollution intensity. As can be seen, the results involving acid rain and climate change agreements are very similar. Both types of agreements result in small reductions in exports of the median manufacturing industry (typically around 0.5-2%) and exhibit similar compositional effects (i.e., statistically significant and negative coefficient estimates on the interaction terms) and thus larger reductions for the more pollution intensive industries. For the acid rain agreements, the decline in exports for an industry at the 75^{th} percentile of pollution intensity varies from 1.3% to 3.3% while for the climate change agreement it varies from 1.2% to 5.1%.

In contrast, the trade effects induced by the ratification of ozone depletion (OD) agreements appear to be very different. Throughout Table 5, the estimated coefficient on the

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[19] The only climate change IEA is the Kyoto protocol. The two terms are used interchangeably throughout.

interaction term for such agreements is actually positive and statistically significant. Thus, we actually see evidence of a small shift towards dirtier industries (at least as measured by emissions intensities) from ratification of the OD IEAs. The lack of evidence for a shift away from pollution-intensive exports is probably due to the fact that none of the eight pollutants included in our emissions data are targeted directly by the Montreal protocol and its subsequent amendments.

In Table 6 we re-estimate the industry level regressions from Section 4.2 but allow the coefficient estimates to vary over IEA categories. We first focus on the coefficients attached to the AR differential, which, to a large extent, are in line with the discussion above. Specifically, the estimates for the more pollution intensive industries (first row) are (almost) uniformly negative while the coefficient estimates for the less pollution intensive industries (second row) are typically positive. Thus, the negative compositional changes we observed in Tables 3 and 4 appear primarily driven by the set of acid rain agreements. In addition, one can see that the negative compositional change (shift to cleaner exports) from ratification of the Kyoto Protocol is almost entirely driven by large negative effects on exports of the most-pollution intensive industries (i.e., other non-metallic minerals and coke, refined petroleum, and nuclear fuel).

Finally, consistent with the results of Table 5, ratification of the OD IEAs exhibits no clear pattern when industries are ordered by CO_2 intensity (i.e., the coefficient estimates on both the first and second rows exhibit an equal mix of positive and negative coefficients). However, note that the ratification of OD IEAs negatively impacts exports of several industries where ozone depleting substances are used as production inputs (i.e., basic and fabricated metals, transport equipment, and machinery), for which the declines in exports range from 1.6 to 3.2% and are statistically significant. An exception is electrical and optical equipment, which actually exhibits a small export increase from ratification of the OD agreements. These results indicate the peculiarity of OD IEAs and the need to treat them differently. Thus, in Subsection 4.4.2 we attempt to construct OD IEAs-specific measures of sectoral pollution intensity to better assess the effects of ratifying such agreements.

4.4 Robustness Analysis

Having verified the existence of compositional effects stemming from the ratification of IEAs with (expected) differences across sectors and by type of IEA, it is important to ascertain that these results are robust before building on them to investigate further aspects (i.e., pollution leakage, dynamic effects, and employment changes). We first engage in methological checks and vary the way in which we identify the coefficients of interest. Then, we change our regressors of interest or sample of countries and sectors to make sure that the results are not driven by the sample composition or the construction of regressors. In order to save on space, all tables of results are relegated to the Appendix and include only three specifications for each robustness check, using the binary variable, CO_2, and principal component (with the remaining results available upon request).

4.4.1 Multilateral Resistance

One of the main motivations of this paper is to estimate whether the decline in manufacturing exports experienced in the United States of America and the European Union is tied to more stringent environmental regulations brought about by membership in IEAs aimed at reducing air pollution. However, as in Aichele and Felbermayr (2015), estimating the impact of IEA ratification (i.e., estimating β_1) rests on the assumption of *symmetric*, country fixed effects across both importer and exporter. That is, unobserved factors affect trade flows similarly, regardless if a country is an exporter and importer. The obvious question that arises is whether this assumption is driving our results. This concern is especially important as, since Anderson and Wincoop (2003), it has become common in the structural gravity regression literature to have separate importer and exporter fixed effects to control for multilateral resistance terms pertaining to the exporter and importer (see Head and Mayer (2014)).

Note, first, that we only require this symmetry assumption to be able to identify the coefficient β_1, which captures the baseline effect of IEAs on exports (irrespective of how polluting a sector is).[20] However, a large part of the analysis within this paper focuses on the compositional shifts in trade across manufacturing industries, β_2, which can be estimated even when the time-varying fixed effects are differing along the importer and exporter dimensions. Using this alternative methodology does not change our qualitative results, which are presented in the first three columns of Table A4. In particular, the estimated coefficient on the interaction term is negative, statistically significant, and virtually identical with the β_2 coefficients shown in Table 3. Once again, this implies that the ratification of IEAs (by the exporting country) results in a shift of exports towards cleaner industries over the time period. It is important to note that, since we cannot estimate β_1, we are not able to calculate the marginal effects of IEA ratification on sectoral exports along the emission-intensity distribution as done in Table 3. Nevertheless, to assist with the interpretation of these results, we calculate the marginal change of IEA ratification (by the exporting country) on the exports of an industry if it were moved from the 25^{th} to the 75^{th} percentile of emissions intensity. These relative marginal effects are shown at the bottom of Table A4 and they confirm the conclusions reached when examining the marginal effects in Table 3. Focusing on the first column, one can observe that the ratification of an IEA (by the exporter) decreases exports of a dirty (e.g., basic and fabricated metals) industry by 2% relative to exports of a clean industry (e.g., textiles and textile products). In the second column, exports of sectors located at the 75^{th} percentile of CO_2-intensity distribution (i.e., chemicals, and chemical products) decline by 1.5%, relative to those sectors located at the 25^{th} percentile (i.e., food, beverages, and tobacco). The remaining estimates illustrate a similar point. That is, exports of manufacturing sectors located at the 75^{th} percentile of the emission intensity distribution tend to see declines of 1.3% or less when compared to sectors at the 25^{th} percentile.

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[20] Intuitively, identification of β_1 comes from variation in net exports across trading partners. At any point in time, the $d(IEA)_{xmt}$ variable will be (linearly) increasing for some trading partners and decreasing for others as IEA ratification occurs. The assumption of symmetry results in a single time-varying country fixed effect across these trade flows which allows for identification. If we do not impose symmetry, then there will be two time-varying country fixed effects (one for the import side and one for the export side), which will absorb the variation in $d(IEA)_{xmt}$, and thus render β_1 as unidentifiable.

A different way to identify β_1 is to employ a non-linear version of relative environmental stringency between the exporting and importing countries:

$$d(IEA)^2_{xmt} = \frac{IEA^2_{xt} - IEA^2_{mt}}{(IEA_{xt}+1)(IEA_{mt}+1)}. \tag{3}$$

The above measure rests on the assumption of diminishing marginal effects to IEA ratification and the resulting non-linearity makes identification of the IEA differential (i.e., β_1) possible even when the multilateral resistance terms are proxied with asymmetric time-varying importer and exporter fixed effects for each country. Although the formula in (3) seems to be very different from the linear counterpart used in the main text, note that the correlation between the two measures is 0.84. With this alternative formulation, we can estimate:

$$lnT_{xmst} = \beta_1 d(IEA)^2_{xmt} + \beta_2 d(IEA)^2_{xmt} \times D_s + \gamma TA_{xmt} + \nu_{xt} + \nu_{mt} + \nu_{st} + \nu_{xms} + \epsilon_{xmst}. \tag{4}$$

The only distinction between this specification and that of (2) is our use of the non-linear measure of the IEA differential. The results of estimating (4) are presented in the first three columns of Table A5. As can be seen, the coefficient estimates are very similar to those for our linear specification in Table 3 and exhibit the same pattern (i.e., $\beta_1 < 0$ and $\beta_2 < 0$). The first three columns of Table A5 also shows the marginal effects of IEA ratification on exports for the average country pair at the midpoint of our sample period (i.e., 1994).[21] It is worth pointing out that a pattern similar to that in Table 3 emerges. Specifically, estimates underline a moderate, negative effect of IEA ratification on the typical manufacturing industry and a compositional shift towards cleaner industries. In this case, both effects are slightly muted, partly due to the diminishing marginal returns assumption embedded in the non-linear measure. That is, by 1994, many countries had signed multiple IEAs and thus the marginal effect of ratifying an additional IEA is reduced by construction.

Finally, and to further check the impact of the symmetry assumption, we re-estimate (4) but allow the time-varying fixed effects to vary across import and export flows. Results of this specification are reported in the last three columns of Table A5. The coefficient estimates (and marginal effects) outlined here are very similar to those in the first three columns of Table A5. Indeed, the major effect of relaxing the symmetry assumption is higher standard errors (and a somewhat reduced statistical significance) with almost no change in the coefficient estimates themselves. We interpret this as indicative evidence that the symmetry assumption regarding the country fixed-effects is not driving our results.

4.4.2 Montreal Protocol and Ozone Depletion Agreements

As seen in Section 4.3, there is a fair degree of heterogeneity across treaty types with regards to the effect of IEAs on the industrial composition of exports. Obviously, the main reason for this heterogeneity is that the acid rain and climate change agreements target emissions of pollutants that are similar and correlated across industries. Conversely, ozone

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[21] In 1994, the average exporter ratified approximately three IEAs whereas the importer ratified only two.

depletion IEAs are aimed at none of our considered emissions, but rather at substances such as CFCs, BFCs, or HCFCs. This creates a problem as data on releases of ozone depletion substances (ODSs) targeted under the Montreal Protocol, and its subsequent amendments, are not available. However, an idea of the industries affected by this set of agreements can be gained from the various reports that were produced in support of the Montreal protocol. For example, the United National Environmental Programme (UNEP) produced a series of reports (Ashford (2001), Kuijpers (2001), Staley (2001), Tope and Andersen (2001)) that summarize the major issues concerning the replacement of ODSs by involved industries. Those reports suggest that ODSs were used primarily for manufacturing of insulating foams and as refrigerating agents in stationary and mobile air conditioning and refrigeration units (suggesting machinery n.e.c. and transportation equipment as highly impacted sectors). These substances were also used for the manufacturing of various foams, or solvents used for high precision cleaning in the electrical and metal industries (suggesting electrical and optical equipment along with basic and fabricated metals as highly impacted sectors).[22] This list of 4 main impacted industries is in line with a 2006 IPCC report (see Sanz Sánchez et al. (2006)) about industrial processes that result in HCFC and HFC discharges across a range of ISIC 2 (revision 3) manufacturing sectors.[23] However, these reports also list a large number of other end-uses for ODSs (and thus potential other industries that might be affected). For example, ODSs were used as process agents in the chemical industry, dry cleaning agents in the clothing industry, pesticides and drying agents in tobacco-processing activities, and for the manufacturing of flexible foams for items ranging from packaging to shoes.[24]

Thus, using the UNEP reports, we construct a binary indicator for the set of four industries that are most commonly mentioned as using ozone depleting substances (ODSs): machinery nec., transportation equipment, electrical and optical equipment, and basic and fabricated metals (labeled D_s^{ods}). This first column of Table A6 provides the results for our base specification (i.e., (2)) in which D_s for the climate change (CC IEA) and acid raid (AR IEA) agreements is the binary indicator for the 4 industries with the highest CO_2 emissions (DIRTY) and D_s for the ozone depletion (OD IEA) agreements is the newly constructed binary indicator for ODSs (D_s^{ods}). As can be seen, the results are in line with prior expectations. That is, ratifying an ozone depletion agreement tends to reduce exports in the set of industries that are commonly mentioned as utilizing ozone-depleting substances. Specifically, while we find no apparent effect of OD membership on exports for our set of ten clean industries, we do find a decline in exports of about 1.2% in our set of four industries that use ODSs more heavily. In columns 2 and 3, we replace the DIRTY indicator for the CC and AR agreements with our carbon dioxide and principal component measures respectively and find similar results (a decline in exports of around 1.2% for ODSs-intensive industries).

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[22] An EPA study reported that 60% of methyl-chloroform usage was in metal cleaning while 70% of CFC-113 usage was in electronics cleaning (see Sheppard et al. (2004)).

[23] Starting in the early 1990s CFCs and HCFCs were replaced/substituted by HFCs. Thus, tracking industrial processes that release or use HFCs gives us additional insight about industries that may have been affected by the ratification of ozone depletion IEAs.

[24] In addition, data from the EORA MRIO Project (see Lenzen et al. (2012, 2013)) points to surprisingly high HFC (a common substitute for early ODSs) discharge intensities in some less-mentioned industries such as textiles and wearing apparel.

4.4.3 Kyoto Protocol and the Differential Treatment of Ratifiers

The Kyoto Protocol introduces yet another source of heterogeneity in allowing "common but differentiated" responsibilities among parties, with Annex B members adopting explicit emissions targets and non-Annex B members simply agreeing to "formulate programmes" to mitigate climate change (see Article 10 of the Kyoto Protocol). In the previous Sections we treated membership in the Kyoto agreement as being solely given by countries that both ratified the agreement *and* adopted explicit emission caps as part of the agreement. However, this raises the question of how Kyoto membership affected the trade flows of non-Annex B members. Thus, in the last three columns of Table A6 we consider the effect of these differentiated responsibilities by distinguishing between Annex B and non-Annex B members. Specifically, we construct two measures of our $d(IEA)_{xmt}$ variable for the climate change agreement in which one (CC IEA All) treats a country as a member, regardless of its responsibilities, so long as it ratified the Kyoto Protocol. The second measure (CC IEA) treats a country as an adopter if it ratified the Kyoto Protocol *and* accepted explicit emission caps (i.e, is an Annex B country).[25]

As can be seen from the last three columns in Table A6, Kyoto membership had rather different effects on Annex B and non-Annex B countries. Marginal effects for industries at different points in the distribution of pollution intensity are calculated at the bottom of the table for both Annex B (*Kyoto Ratifies w/ Cap*) and non-Annex B countries (*All Kyoto Ratifiers*). Interestingly, those countries which joined Kyoto but did not adopt any explicit emission restrictions (non-Annex B) actually saw increased manufacturing exports by a quantitatively and statistically significant 4%.[26] However, we do not find robust evidence for compositional changes for these non-Annex B members. Specifically, the coefficient estimate on the interaction term is small and statistically insignificant (at least for our binary and PC1 measures of pollution intensity). In contrast, the results for the Annex B members are similar to our previous estimates and, if anything, exhibit even stronger compositional switch towards cleaner production. For Annex B countries we find that industries below and at the median pollution intensity saw increases in exports of 2-5% while industries at the 75^{th} percentile and above saw declines of 2-5%. This stronger evidence for compositional shifts towards cleaner goods for Annex B countries is consistent with the idea that only IEA commitments that involve explicit emission targets are likely to have a significant effect on industry-specific comparative advantage.

4.4.4 Additional Sensitivity Analysis

Table A7 presents the results of several different sensitivity analyses to our baseline results provided in Table 3. Columns 1-3 exclude China (as importer and exporter) given the significant increase in Chinese trade over the past several decades. Given the large swings in the value of petroleum exports (often driven by the large swings in the price of

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[25] It is worth pointing out that, while an Annex B country, the United States of America did not ratify the Kyoto protocol. Because of this, we treat the U.S. as a non-ratifier. Further, Liechtenstein and Monaco are also Annex B countries but not in our sample.

[26] It should be noted that the vast majority of countries in our sample are members of Kyoto. Indeed, the only countries in our sample which failed to ratify Kyoto are Hong Kong, Macau, Taiwan and the U.S.

fuel), columns 4-6 exclude the coke, petroleum and nuclear fuels industry.[27] Finally, columns 7-9 take into account for exporter-importer differences in per-capita GDP.[28] Intuitively, a concern might be that the non-member countries in our sample have a different trend in trade patterns than the member countries and, to the extent these different trends are not captured by our time-varying country fixed effects, this could bias our estimates. It should be apparent from Table 1 that member countries tend to be the richer (typically OECD countries) while non-member countries are more likely to be developing country. Thus, we also run our specifications including controls for these income differentials (both directly and interacted with our IEA differential variable).

The results of these additional sensitivity checks are very similar to the baseline results. Dropping China from the sample does not lead to any difference while the exclusion of the petroleum sector leads to slightly larger (in absolute terms) coefficients but very similar marginal effects. The addition of the per-capita GDP difference does not affect our main results but demonstrate that exports are lower for larger differences in these welfare measures but less so for more polluting industries.

5 IEAs and Pollution Leakage

The results of the previous sections provide evidence for comparative disadvantage for pollution-intensive sectors that arises from IEA membership (i.e., a comparably larger reduction in net exports of more pollution-intensive manufacturing industries). However, because of the imposed symmetry (needed in order to estimate β_1), the previous specifications are silent on whether this effect is primarily driven by a reduction in exports by member countries or by an increase in imports from non-member countries. This distinction is important in the trade-environment literature because an increase in imports of pollution-intensive goods implies that production of dirty goods by IEA adopters might simply be replaced by increased production within non-member countries (i.e., pollution leakage). If IEAs are simply shifting production from member countries (with strengthened environmental standards) to non-members (with relaxed standards), the reduction in global emissions is comparably lessened.

Thus, to look for evidence of pollution leakage we consider a specification that uses separate exporter- and importer-specific measures of environmental commitment. This specification is depicted in (5), where IEA_{xt} denotes the number of ratified IEAs by the exporter while IEA_{mt} denotes the number of ratified IEAs by the importer.

$$lnT_{xmst} = \beta_3 IEA_{xt} \times D_s + \beta_4 IEA_{mt} \times D_s + \gamma TA_{xmt} + \nu_{xt} + \nu_{mt} + \nu_{st} + \nu_{xms} + \epsilon_{xmst}, \quad (5)$$

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[27] As can be seen in the industry-level regressions, the number of observations for the petroleum industry are significantly less than the other industries, and the coefficient estimates for the petroleum industry tend to be somewhat variable (see, especially, Table 6).

[28] The GDP-per-capita differential is computed as the exporter-importer difference in the natural logarithms of GDP per capita. GDP and population data are from version 8.1 of the Penn World Table Database (Feenstra et al., 2015).

Note that, since we have separate (linear) importer and exporter measures of IEA membership, we can no longer recover β_1 (the uniform effect of IEA ratification on manufacturing industry trade) since identification relied on variation across trading partners. However, we can still recover the compositional effect of IEA ratification across manufacturing industries (i.e., whether IEA ratification leads to a switch towards exporting cleaner goods). As we are only measuring compositional effects across industries, we run the specification while allowing for asymmetry in the country-year effects across import and export flows, just as in Table A4. Once again, our prior is that $\beta_3 < 0$ (i.e., ratification of an additional IEA would lead to a shift towards exporting relatively cleaner goods by the member country) and $\beta_4 \geq 0$ (i.e., ratification of an IEA leads to a shift towards importing relatively dirtier goods by the member country). However, the focus for this section is whether the estimated coefficient for β_4 is zero or positive: a positive coefficient would be evidence for pollution leakage (i.e., the signing of an IEA leads to a compositional shift towards imports of dirty goods from the rest of the world) while a zero coefficient would imply no replacement of dirty-good production from overseas.

5.1 Baseline Results

Given the degree of heterogeneity across IEAs demonstrated in Section 4.3, we estimate (5) using separate measures of IEA counts for our acid rain, ozone depletion, and climate change agreements. The results obtained this way are provided in Table 7. As in Section 4.4.2, when considering the climate change and acid rain agreements, we use sectoral emission intensities (D_s) as measures of pollution intensity. However, when considering the ozone depletion agreements, we use the binary indicator (D_s^{ods}) for the set of four industries that are more likely to release ozone depleting substances.[29] First focus on the climate change and acid rain agreements since those agreements target a common set of pollutants for which we have emissions data. As can be seen, our results exhibit the expected negative effect of IEA membership on exports of more pollution intensive goods (i.e., $\beta_3 < 0$). To interpret the magnitudes, we provide a series of relative, marginal effects of IEA ratification on exports. Just as before, we are contrasting the change in exports for an industry located at the 25^{th} percentile of the emission intensity distribution (e.g., food and beverages) with one at the 75^{th} percentile (e.g., chemicals, and chemical products). Typically, we observe a decline in exports of 1-4%, which is broadly consistent with our previous estimates. With respect to pollution leakage, in general we see signs (on β_4) that IEA ratification results in the country importing relatively more pollution-intensive manufacturing goods from abroad (i.e., $\beta_4 > 0$). This result is especially strong when we measure sectoral dirtiness by using CO_2 emissions (the first two columns). In these cases, IEA ratification results in a relative increase in imports of 4-5% (Kyoto) and 1-2% (Acid Rain IEAs) when moving from the cleaner (25^{th}) to dirtier (75^{th}) industries. While a similar pattern is seen for the other pollutants (β_4 is typically positive), the estimates are not as large and in several cases are

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[29] Results for the climate change and acid rain agreements are very similar if we continue to use D_s (instead of D_s^{ods}) as a measure of pollution intensity when estimating the effect of ratifying ozone agreements. Consistent with the results in Table 6, ratifying an ozone depletion agreement continues to be correlated with a shift in exports towards industries with high emission intensities (or high levels of D_s).

statistically insignificant.

Next, focus on the ozone depletion agreements where, as in Table A6, we employ our indicator variable for whether an industry is likely to use ozone depleting substances (D_s^{ods}). It is worth mentioning that, in Table 7, D_s^{ods} does not differ across columns. As before, the ozone depletion agreements exhibit a negative compositional effect on dirty exports (a decline of around 1.5% in the set of 4 industries that utilize ODSs). In addition, we see a small amount of pollution leakage, as the ratification of an ozone depletion agreement by an importing country increases the imports of ODS-intensive industries by around 0.9%.

Although there is serious economic and political concern about pollution leakage arising from IEAs, our results suggest that when it occurs it is not quantitatively very large.

5.2 Country Heterogeneity

While the previous sections assume that the effects of IEA ratification are symmetric across countries, one of the interesting aspects of more recent IEAs is that they often draw a distinction between developed and developing countries. The Kyoto Protocol to the United Nations Framework Convention on Climate Change did this directly by outlining emission targets on the more high-income (Annex B) countries, while allowing the vast majority of member countries to join without any firm commitments (and even the Annex B countries had differentiated emission targets). The Montreal Protocol and its subsequent amendments also tended to provide developing countries with technology assistance as well as reduced targets or delays in meeting commitments. In contrast, some of the earlier acid rain agreements tended to impose more consistent emission reduction targets which were applied symmetrically across member countries. The justification for this recent emphasis on differential treatment is that emission reduction targets would have an unfair competitive effect on developing countries due to the high fixed costs and technology requirements of many abatement technologies. Thus, in this section, we estimate if IEA ratification had a differential impact on developing countries by estimating if the compositional shift towards cleaner exports (and any subsequent pollution leakage) was stronger for developing country ratifiers.

To investigate this question we employ specification (5) but include an indicator variable, C_x, for whether the ratifying country is a developing country:[30]

$$\begin{aligned} lnT_{xmst} = \beta_3 IEA_{xt} \times D_s + \beta_4 IEA_{mt} \times D_s + \beta_5 IEA_{xt} \times D_s \times C_x + \\ +\beta_6 IEA_{mt} \times D_s \times C_x + \gamma TA_{xmt} + \nu_{xt} + \nu_{mt} + \nu_{st} + \nu_{xms} + \epsilon_{xmst}. \end{aligned} \tag{6}$$

In this case, as before, our priors are that $\beta_3 < 0$ and $\beta_4 \geq 0$, depending on whether or not pollution leakage occurs. That is, IEA ratification leads to a compositional shift towards dirtier exports and cleaner imports. The question of interest is whether this compositional

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[30] We distinguish between developed and developing countries using data from World Bank's Country Classification, which is available at https://datahelpdesk.worldbank.org/knowledgebase/articles/906519. Specifically, countries with levels of per-capita gross national income (GNI) greater than $12,236 in 2018 are classified as developed. Countries with per-capita GNIs below this threshold are classified as developing. A detailed account of our breakdown is provided in Table A3.

shift is larger for developing countries (i.e., $\beta_5 < 0$ and $\beta_6 > 0$) due to funding and technology limitations in these lower-income countries.

The results are provided in Table 8, where we also allow the coefficient estimates to vary over the different agreement types. As can be seen, this is important as there is no clear pattern across the agreements (i.e., whether IEA ratification results in a greater compositional shift in developing countries depends highly on the agreement).

First, consider the impact of IEA ratification on exports. Consistent with Table 7, the coefficient estimates for each agreement type are negative for developed countries (i.e., $\beta_3 < 0$ and thus ratifying an IEA is a source of comparative disadvantage for dirty manufacturing industries). With respect to the Kyoto Protocol we observe a positive coefficient estimate on the developing country interaction term (i.e., $\beta_5 > 0$) implying that, even among Annex B countries, developing countries that joined Kyoto observed a negative but reduced impact on dirty good exports. In contrast the developing country interaction term is negative for acid rain agreements (i.e., $\beta_5 < 0$), which implies that developing countries that joined the acid rain agreements saw comparatively larger reductions in pollution-intensive exports. Finally, the coefficient estimates on the developing country interaction term are, in general, not statistically significant for ozone depletion IEAs.

Thus, whether ratifying an IEA has a more negative competitive impact on low-income countries appears to depend highly on the terms and structure of the agreement itself. With respect to the effect on exports, the coefficient estimates seem consistent with the pattern of differential treatment within the agreement. Specifically, IEAs that involve differentiated emission targets (i.e., the Kyoto Protocol) bring about smaller comparative disadvantage effects for developing countries wheareas IEAs with more symmetric emission targets (i.e., the acid rain IEAs) lead to larger compositional shifts among developing country ratifiers.

However, the story does become less clear on the import side. Once again and consistent with Table 7, the ratification of IEAs by developed countries leads to the importation of more dirtier goods (i.e., $\beta_4 > 0$) for all agreement types. Thus, we once again find evidence that IEA ratification leads to moderate amounts of pollution leakage in higher-income countries (i.e., increased imports of dirty goods from non-member countries). However, the results for the developing country interaction effects are now reversed with the Kyoto Protocol leading to a *larger* shift towards pollution-intensive imports for developing countries (i.e., $\beta_6 > 0$) and the acid rain (AR) agreements seeing a smaller shift (i.e., $\beta_6 < 0$ or statistically insignificant).[31] Thus while we do observe heterogeneity across a country's level of development in the impact of IEA ratification on trade flows, no clear pattern emerges from our estimates.

6 IEAs and their Short-Run and Long-Run Effects on Trade

In the previous sections we were capturing the average treatment effect (ATE) of IEA ratification (i.e., the impact of ratifying an additional IEA on the average trade volume over the time period following ratification). However, part of the motivation for the longer-time span of our data set (1976-2011) is to capture both induced innovation and general

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[31] And, finally, we observe large, statistically significant, negative coefficient estimates for β_6 with respect to the ozone depletion agreements.

equilibrium effects from IEA membership. As discussed in Section 2, there are good reasons to expect that, given delays in both innovation and factor movements, the short-run effects of IEA membership on comparative advantage might differ from the long-run effects. Thus, to more directly look at this distinction, we construct a 10-year, lagged version of our $d(IEA)_{xmt}$ variable (i.e., $d(IEA)_{xm,t-10}$) and include it in our specification.[32]

$$\begin{aligned} lnT_{xmst} = \beta_1 d(IEA)_{xmt} + \beta_2 d(IEA)_{xmt} \times D_s + \beta_3 d(IEA)_{xm,t-10} + \\ + \beta_4 d(IEA)_{xm,t-10} \times D_s + \beta_5 \gamma TA_{xmt} + \nu_{xt} + \nu_{mt} + \nu_{st} + \nu_{xms} + \epsilon_{xmst} \end{aligned} \tag{7}$$

In this case, β_1 and β_2 capture the short-run effects of IEA ratification (ATEs within 10 years) while β_3 and β_4 capture changes in these estimates after 10 years of IEA membership. Given previous results, our priors are that $\beta_1 < 0$ and $\beta_2 < 0$. That is, IEA ratification results in short-run comparative disadvantage, especially in pollution-intensive manufacturing goods. Note that induced innovation (stricter regulations resulting in new technologies/techniques in the long-run so as to minimize pollution abatement costs) would result in $\beta_3 > 0$ (reduced comparative disadvantage in manufacturing in general) and potentially $\beta_4 > 0$ (reduced comparative disadvantage in more pollution-intensive goods). In contrast, larger general equilibrium effects would result in $\beta_4 < 0$. That is, larger compositional shifts towards cleaner production as factors of production have more flexibility to be reallocated across industries in the long-run.

As for our main results, we present the estimated short- and long-run effects for our baseline specification. Next, we investigate whether these estimates vary by industry and IEA type. Using the baseline results, we also assess the employment effects of IEA ratification while distinguishing among short- and long-run outcomes.

6.1 Baseline Results

We start by repeating the analysis of Section 4.1 but introduce 10-year lags for our $dIEA$ variable as in (7). As can be seen in Table 9, we find evidence for both induced innovation (i.e., $\beta_3 > 0$) and stronger general equilibrium effects (i.e., $\beta_4 < 0$) in the long run across all measures of pollution intensity.

At the bottom of the table we provide estimates of the marginal effects in the short run (ATE in the first 10 years after ratification) and long run (ATE post 10-years after ratification). Concentrating first on the short-run marginal effects, we see an even stronger evidence for comparative disadvantage from IEA ratification than in Section 4.1. For example, using the estimates of the first column which utilizes the binary indicator for D_s, we estimate that the ratification of an additional IEA will decrease exports in each of the four dirty industries by around 3.0% within the first 10 years. Likewise, the ratification of an additional IEA will decrease exports in the set of 10 clean industries by a smaller but still quantitatively significant 1.6%. A similar pattern of short-run comparative disadvantage in manufacturing and pollution-intensive goods to IEA ratification can be seen in the other columns, which involve estimates using alternate measures of D_s.

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[32] This is somewhat similar to the approach of Baier and Bergstrand (2007) who utilize lagged variables to capture the short-run versus long-run effects of trade agreements.

The average treatment effects after 10 years is given by the sum of β_1 and β_3 for our set of clean industries. As can be seen in the first column, the negative comparative disadvantage effects for the median manufacturing industry disappear. Indeed, the ratification of an additional IEA actually results in increased exports for the set of 10 clean industries (an increase of 2.5%). In contrast, we continue to see a long-run decrease in exports for the 4 dirty industries (a decline of 1.9%). A similar pattern of increased exports of clean manufacturing goods and decreased exports of pollution-intensive goods in the long-run is apparent in each of the other specifications that use different measures of pollutants. Thus, while we do find that IEA ratification has a negative effect on the competitiveness of the typical (median) manufacturing industry in the short-run, we do not find any evidence of negative effects in the long-run. Indeed, exports of the median manufacturing industry actually increase. This casts doubt on the storyline often presented in developed countries that IEA membership is linked with a *long-run decline* in manufacturing exports. One obvious possibility to explain these results is that induced innovation has reduced the costs of any increased regulations and thus allowed manufacturing production to recover (at least for the typical manufacturing industry).

Note, however, that the compositional shift towards cleaner manufacturing exports has only intensified over time in the sense that the gap between the clean and dirty industries has gotten larger in the long-run. Specifically, in both the short and long run we observe relatively larger net export declines for the four pollution-intensive industries (regardless of how pollution intensity is measured). However, in the short run, the difference in the ATE between our sets of dirty and clean industries is only about 1.4 percentage points. In contrast, in the long run, the difference in the ATE between the dirty and clean industries has become much larger with dirty manufacturing exports declining by about 2.8 percentage points more.[33] These results are based on a 10-year window, which is chosen in a rather ad-hoc fashon. However, the results are qualitatively similar when we repeat the analysis for 5, 8 and 12 year lags (see Table A9 in the Appendix).

As a second approach, we repeat the industry-level regressions of Table 5 while including the $d(IEA)_{xm,t-10}$ variable. In this case, the coefficient estimate for $d(IEA)_{xmt}$ provides the ATE for the first 10 years after ratification and the sum of the estimates for $d(IEA)_{xmt}$ and $d(IEA)_{xm,t-10}$ provides the long-run ATE. The results are provided in Table 10 and are striking. Joining an IEA results in a generally negative effect on exports across almost the entire range of manufacturing industries within the first ten years (i.e., the only positive effects on exports are recorded for the manufacture of furniture and recycled goods, and the manufacture of wood products). However, post-10 years, exports in almost every manufacturing industry have bounced back (positive and statistically significant coefficients on $d(IEA)_{xm,t-10}$ for 11 of our 14 manufacturing industries). Combining the two coefficient estimates we find that, after 10 years, IEA membership has typically reduced exports

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[33] A more direct way of observing these compositional shifts is to repeat the analysis of Table A4, in which we allow for asymmetric importer-year and exporter-year effects, and focus on recovering β_2, while still including the lagged $d(IEA)_{xm,t-10}$ variable. These results are provided in the last three columns of Table A4 and demonstrate similar results: a moderate compositional effect in the short run (i.e., shift towards exporting cleaner goods) and a much stronger compositional shift in the long run. This stronger compositional shift is bolstering the long-run general equilibrium effects discussed in Section 2.

in the more pollution-intensive industries (e.g., declines of 4.3% in non-metallic minerals, 2.6% in basic and fabricated metals, 2.3% in chemicals, and chemical products). However, such membership has actually resulted in increased exports in the cleaner manufacturing industries in the long run (e.g., increases of 5.1% in leather and footwear, 2.3% in textiles and textile products, 0.8% in food, beverages, and tobacco, etc.). Once again, these results are consistent with a story that induced innovation leads to the recovery of exports across all manufacturing industries, while lagged general equilibrium effects are suggestive of a compositional shift towards cleaner manufacturing.

6.2 Heterogeneity of IEAs

Given the evidence on the heterogeneity of IEAs established in Section 2.2, we re-estimate specification (7) but allow the coefficient estimates to vary across the three major categories of IEAs: climate change, acid rain, and ozone depletion. Note that, since ratification by Annex B countries for the Kyoto Protocol begins in 2001 and our dataset only extends to 2011, we cannot recover long-run estimates for our sole climate change agreement. Also, given that the ozone depletion agreements are not targeting our measured emissions, we use the binary indicator for the set of four industries that use ozone depleting substances more heavily (i.e., basic metals, transport equipment, electrical and optical equipment, and machinery n.e.c.), as our ozone depletion-relevant measure of D_s.

Results (and marginal effects of ratification for the short and long run) are provided in Table 11. Focusing first on the results for the climate change and acid rain agreements, note that both types of agreements continue to induce short-run comparative disadvantage in clean ($\beta_1 < 0$) and pollution-intensive manufacturing industries ($\beta_2 < 0$). Short-run marginal effects are provided at the bottom of Table 11 for the acid rain agreements and demonstrate negative effects of IEA ratification on both the typical manufacturing industry (declines in exports of around 2.5%) and the most pollution-intensive (declines of around 3-5%).

However, consistent with the results of the previous section, the long-run estimates for the acid rain agreements exhibit both a recovery of exports across all manufacturing industries ($\beta_3 > 0$) combined with increased compositional shifts across industries ($\beta_4 < 0$). The bottom panel of Table 11 provides the long-run estimates for the acid rain agreements. Note that ratification of an acid rain agreement actually leads (after 10 years) to a small increase in exports of the typical manufacturing industry (for the median industry an increase of less than 1%). However, our estimates suggest a continuing compositional shift away from pollution-intensive manufacturing as, in the long run, we estimate a decline of around 2-4% in the most pollution-intensive manufacturing industries.

With respect to the ozone depletion agreements, the results of Table 11 suggest a modest compositional shift in the short-run. That is, an increase of 0.5% in our set of 10 clean industries and a decline in exports of 0.6% for our set of 4 dirty industries. In contrast, in the long run, we observe almost no evidence of any negative comparative advantage effects from

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[34] This is potentially related to the fact that substitutes for ozone-depleting substances were readily-available and/or the use of such substitutes implied lower overall costs. Indeed, Slechten and Verardi (2016) underline that the use of CFC-free as opposed to CFC-based refrigerants is associated with energy savings.

the ratification of the ozone depletion IEAs. In fact, indeed, we observe almost a uniform increase of 3% across all manufacturing industries. This seems much more consistent with the induced innovation story than the results for acid rain agreements.[34]

An alternative perspective is provided by the industry-level results shown in Table 12. Results for the acid rain agreements are very similar with those in Table 11. In the short run we observe almost uniformly negative effects of IEA membership on manufacturing exports (the only statistically significant positive result on $dIEA_{xmt}$ for the acid rain agreements among the 14 industries is that concerning wood and products of wood and cork). However, the results are completely reversed in the long-run. That is, almost every industry sees a recovery in exports after 10 years (now, the only statistically significant negative result among the 14 industries on $dIEA_{xm,t-10}$ is for chemicals and chemical products). Combining the two estimates, we see long-run declines in the more pollution-intensive industries (decreases in exports of 2.3% in other non-metallic minerals, 3% in basic and fabricated metals, and 5.4% in chemicals and chemical products, etc.). However, after 10 years, we see that the ratification of an acid rain agreement is leading to (net) increases in exports of the cleaner industries (e.g., increases of 9.3% in leather and footwear and 7.9% in textiles and textile products).

Short-run estimates for the ozone depletion agreements are more mixed and, consistent with the results of Subsection 4.4.2, the estimates exhibit no clear pattern when industries are arranged by CO_2 intensity. However, for those industries that are estimated to be negatively affected by the ratification of an ozone depletion agreement (basic and fabricated metals, transport equipment, pulp, paper and printing and publishing, machinery n.e.c., textiles and textile products, and leather and footwear) we find that this negative impact is short lived. That is, for each of these industries (with the exception of textiles and textile products) we find a statistically significant recovery of exports (at the least bringing exports back to initial levels). Indeed, the results of Table 12 are suggestive of the fact that ozone depletion agreements appear to also have had no long-run negative effects on manufacturing exports.

6.3 IEAs and the Long Run Decline of Manufacturing Employment

As mentioned in the introduction, one of the motivations for this paper is to see the extent to which the long-run decline of manufacturing employment in the developed countries (e.g., United States and the European Union) is tied to the ratification of multilateral environmental agreements. The working hypothesis is that the adoption of international environmental agreements places manufacturing industries at a competitive disadvantage in world markets. In this regard, the results of the previous section are suggestive in that the negative competitive effects of IEA ratification on the median manufacturing industry disappear in the long-run. However, the ratification of IEAs could still have a negative effect on manufacturing employment (even in the long-run) if the compositional shifts caused by subsequent environmental regulations/standards shifted production away from more labor-intensive industries.

Thus, to provide some back-of-the-envelope estimates of the competitive effect of IEA ratification on manufacturing employment in high-income countries we make the following basic assumptions:

- A $1 increase in exports in an industry results in a $1 increase in domestic production in that industry (and only that industry);

- A \$1 increase in imports in an industry results in between \$0 and \$1 decrease in domestic production in that industry (and only that industry);
- The labor/output ratio for each industry is fixed and does not differ across sub-sectors within our aggregate industry classifications.

From our basic specification (7) $\beta_1+\beta_2\times D_s$ is (approximatively) the short-run percentage increase in exports (or decrease in imports) resulting from ratifying a single IEA while $(\beta_1+\beta_3)+(\beta_2+\beta_4)\times D_s$ is the percentage increase in exports in the long run. Let X_{js} be total exports for country j in industry s, M_{js} be total imports for country j in industry s and L_{js} be the labor/output ratio for industry s in country j. First, assume that any increase in imports does not crowd out domestic production. Then, by our three assumptions, the total change in manufacturing employment in the short-run due to ratifying an IEA for country j is given by

$$\sum_s[(\beta_1+\beta_2\cdot D_s)\cdot X_{js}\cdot L_{js}]. \tag{8}$$

Note that the above is only estimating the loss (or gain) in manufacturing employment due to changes in the competitiveness of a country's manufacturing in world markets (i.e., changes in employment due to changes in trade flows with the rest of the world). In addition, the above calculation is looking at the effects of IEA ratification on manufacturing employment holding the actions of the country's trading partners constant.

Second, assume that any increase in imports perfectly crowds out domestic production. Then, by combining the first and third of our assumptions, the total change in manufacturing employment in the short run due to ratifying an IEA for country j is given by

$$\sum_s[(\beta_1+\beta_2\cdot D_s)\cdot(X_{js}+M_{js})\cdot L_{js}]. \tag{9}$$

Thus, (8) and (9) can serve as upper and lower bounds on the employment changes driven by IEA ratification. The long-run employment changes can be calculated symmetrically using the long-run coefficient estimates. Using these formulas, we calculate the ratification effects on employment in the United States and Germany by using trade, employment, and output data from 2009[35] The results of these calculations are provided in Table 13 in the Appendix.

First, focus on the calculated employment effects of IEA ratification in the short run. In Table 13 the rows labeled *Marginal Effects (Lower Bound)* provide the employment calculations where an increase in imports is assumed to have no effect on domestic production while *Marginal Effects (Upper Bound)* assumes that an increase in foreign imports perfectly crowds out domestic production. In this discussion, and without loss of generality, we will just concentrate on the first column estimates which use the binary indicator of industry pollution-intensity (it should be immediately apparent that the story is consistent across

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[35] 2009 is the last year for which we have data on sectoral employment. Trade data and labor/output ratios for the U.S. and German manufacturing industries are given in Table A8.

the other measures of pollution intensity). As can be seen, we calculate that ratifying an additional IEA would result in manufacturing employment falling by between $47,000$ and $115,000$ in the U.S. and between $70,000$ and $123,000$ in Germany.[36] Given that, in 2009, total manufacturing employment in the U.S. was 12.578 million and 7.163 in Germany, these numbers are comparatively small (i.e., decreases of 0.91% and 1.71%, respectively). However, they still represent a noticeable change in manufacturing employment that might provide insight into why the decision to join a new IEA is so often controversial.

Next, focus on the calculated employment effects of IEA ratification in the long-run. Marginal effect estimates provided in Table 13 suggest that ratifying an additional IEA leads to an *increase* in manufacturing employment in the long-run of between $11,000$ and $32,000$ in the U.S. and between $13,000$ and $23,000$ in Germany. These are obviously very small increases relative to the size of manufacturing employment in both countries. However, they reinforce the conclusion of Section 6, that the long-run decline in manufacturing employment seen in many high-income countries (such as the United States and Germany) is most likely not related to the stringent environmental standards brought about by IEA membership.

7 Conclusions

This paper aims at providing some rigorous empirical evidence on the link, if any, between decreasing shares of manufacturing activities (i.e., exports and employment) in developed countries and membership in IEAs. Often regarded as part of the globalization process, IEAs are often portrayed and perceived as damaging to a country's competitiveness because of the implied costs of having to abide by more stringent regulations. Exploiting a large dataset that spans almost 40 years and more than 160 countries, we are able to provide answers on the link between the two phenomena. Crucially, we can distinguish between the short and long-run effects of IEAs on manufacturing exports and employment.

The main conclusion of this paper can be summarized in two points. First, over the last four decades the ratification of IEAs (especially by developed countries) does not appear to have had much impact on aggregate manufacturing exports or employment. Specifically, while we find a moderate negative effect of IEA ratification on the exports of the typical manufacturing industry (i.e., located at the median of the pollution intensity distribution) in the short-run, this negative competitive impact disappears in the long-run. In addition, some back-of-the-envelope calculations suggest that countries that ratify an IEA agreement have actually seen a (small) increase in manufacturing employment in the long-run (relative to the control group of non-ratifiers).

This finding does have implications for the policy debates that often emerge about

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[36] In both the U.S. and Germany the labor/output ratio in clean industries is (on average) larger than that for dirty industries and thus the compositional shift towards clean exports actually increases manufacturing employment. Thus, the short-run decline in employment is due entirely to the negative competitive effects of IEA ratification on the median manufacturing industry. Similarly, the difference in labor-output ratios between dirty and clean production is larger in the U.S. and thus the reason we estimate larger employment losses to IEA ratification in Germany, at least in the short-run, is entirely because German manufacturing is more open to foreign trade (i.e., the ratio of trade, especially exports, to domestic production is higher in Germany).

whether to join an IEA (especially those IEAs where many developing countries are either non-ratifiers or have differential commitments) and that often revolve around the effect of IEA ratification on a country's competitiveness. The main concern is that the environmental commitments required by such agreements would lead to an increase in manufacturing costs, which places that country's manufacturing base at a competitive disadvantage on world markets and thus leads to a long-run decline in manufacturing exports and employment. Our results suggest that such concerns are potentially overblown.

Our second main result is that joining an IEA does have substantial impact on the composition of a country's manufacturing exports. Specifically, for all environmental agreement types analyzed, we observe a statistically and quantitatively significant shift in net exports away from "dirty" industries and towards "clean" industries within countries that ratify IEAs. In addition, this compositional shift is actually larger in the long-run than the short-run. While this compositional shift is mostly seen as a decline in exports from dirty manufacturing industries (and simultaneous increase in exports of clean manufacturing industries), we also see some evidence for pollution leakage (i.e., an increase in dirty imports from non-ratifying countries).

While the focus of this paper is on the effect of IEA ratification on the "competitiveness" of a country's manufacturing sector, this second point has implications for the effectiveness of IEAs in reducing emissions. Specifically, previous papers (e.g., Slechten and Verardi (2016), Aichele and Felbermayr (2012), Grunewald and Martínez-Zarzoso (2011)) have found that the ratification of an IEA is correlated with a subsequent decline in a country's total emissions. Our results suggest that IEA ratification is also correlated with a subsequent shift towards exporting cleaner manufacturing goods. Thus, it seems possible that one of the main mechanisms by which IEAs reduce emissions is through inducing a compositional shift towards production of cleaner goods. If this is the case, and there exists a compensating shift towards production of dirty goods in non-member countries, that would imply that such IEAs are, perhaps, less effective in reducing global pollution than has been previously thought (e.g., Aichele and Felbermayr (2015, 2012)). We leave this possibility to explore in more detail in future work.

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Table 1: International Environmental Agreements

International Environmental Agreements (IEAs)	*First Ratified*	*Ratifiers as of 2011*
Geneva Convention on Long Range Transboundary Air Pollution (LRTAP)		
Helsinki Protocol for Reduction of Sulphur Emissions (1985)	1985	Albania, Austria, Belarus, Belgium and Luxembourg, Bulgaria, Canada, Czech Republic, Denmark, Estonia, Finland, France, Germany Hungary, Italy, Lithuania, Macedonia, Netherlands, Norway, Russia, Slovakia, Sweden, Switzerland, and Ukraine
Sofia Protocol on the Control of Nitrogen Oxides and their Transboundary Fluxes (1988)	1989	All Helsinki ratifiers plus Croatia, Cyprus, Greece, Ireland, Lithuania, Slovenia, Spain, the United Kingdom, and the United States of America
Geneva Protocol on the Control of Volatile Organic Compounds and their Transboundary Fluxes (1991)	1993	Austria, Belgium and Luxembourg, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Lithuania, Macedonia, Netherlands, Norway, Slovakia, Spain, Sweden, Switzerland, and the United Kingdom
Oslo Protocol on Further Reduction of Sulphur Emissions (1994)	1995	All Geneva ratifiers plus Canada, Cyprus, Greece, Ireland, and Slovenia; less Estonia, Russia, and the United States of America
Aarhus Protocol on Persistent Organic Pollutants (POP) (1998)	1998	Austria, Belgium and Luxembourg, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Italy, Latvia, Lithuania, Macedonia, Moldova, Rep.of, Netherlands, Norway, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom
Aarhus Protocol on Heavy Metals (1998)	1998	All Aarhus POP ratifiers plus the United States of America, less Iceland and Italy
Gothenburg Protocol to Abate Acidification, Euthrophication and Ground Level Ozone (1999)	2002	All Aarhus POP ratifiers plus the United States of America, less Cyprus, Estonia, Iceland and Italy
Vienna Convention for the Protection of the Ozone Layer (VCPOL)		
Montreal Protocol on Substances that Deplete the Ozone Layer (PSDOL) (1987)	1988	Australia, Austria, Azerbaijan, Belarus, Belgium and Luxembourg, Bulgaria, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Kazakhstan, Latvia, Lithuania, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Ukraine, the United Kingdom, the United States of America, Uzbekistan
London Amendment to Montreal PSDOL (1990)	1990	All nations in table A3 except Angola, Bermuda, Hong Kong, and Macau
Copenhagen Amendment to Montreal PSDOL (1992)	1993	All nations in table A3 except Angola, Bermuda, Guinea, Hong Kong, Kazakhstan, Macau, and Nepal
Montreal Amendment to Montreal PSDOL (1997)	1998	All nations in table A3 except Angola, Bermuda, Botswana, Cote d'Ivoire, Guinea, Hong Kong, Kazakhstan, Macau, Morocco, Mozambique, Nepal, Saudi Arabia, and Zimbabwe
Beijing Amendment to Montreal PSDOL (1999)	2000	All nations in table A3 except Angola, Azerbaijan, Bahrain, Bangladesh, Bermuda, Bolivia, Bosnia and Herzegovina, Botswana, Cape Verde, Chad, Cote d'Ivoire, Djibouti, Ecuador, Georgia, Guinea, Hong Kong, Iran, Kazakhstan, Kenya, Macau, Mauritania, Morocco, Mozambique, Nepal, Peru, Saudi Arabia, Syrian Arab Republic, and Zimbabwe
United Nations Framework Convention on Climate Change (UNFCCC)		
Kyoto Protocol (1997)	1998	All nations except Hong Kong, Macau, Taiwan and the United States of America
w/ emission target	2001	Australia, Austria, Bulgaria, Belgium and Luxembourg, Canada, Croatia, Czech Republic, Germany, Denmark, Estonia, Finland, France, Greece, Hungary, Iceland, Ireland, Italy, Japan, Lithuania, Latvia, Netherlands, Norway, New Zealand, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom

Source: International Environmental Agreements Database Project (Mitchell, 2016)

Table 2: Averages of Average Sectoral Emission Intensity 1995-2009 (kg./1000 US$ of output, 1995 prices)

Industry	**Code**	CO_2	**Industry**	**Code**	CH_4	**Industry**	**Code**	CO
Other Non-Metallic Mineral	26	2012.693	Coke, Refined Petroleum and Nuclear Fuel	23	9.700962	Coke, Refined Petroleum and Nuclear Fuel	23	56.35175
Coke, Refined Petroleum and Nuclear Fuel	23	1790.305	Chemicals and Chemical Products	24	2.004183	Basic Metals and Fabricated Metal	27t28	18.79473
Basic Metals and Fabricated Metal	27t28	874.7325	Basic Metals and Fabricated Metal	27t28	1.299794	Other Non-Metallic Mineral	26	7.091658
Chemicals and Chemical Products	24	660.0475	Other Non-Metallic Mineral	26	0.319088	Wood and Products of Wood and Cork	20	3.838641
Transport Equipment	34t35	288.3666	Rubber and Plastics	25	0.278427	Chemicals and Chemical Products	24	3.428976
Electrical and Optical Equipment	30t33	240.0343	Wood and Products of Wood and Cork	20	0.259807	Electrical and Optical Equipment	30t33	2.007596
Pulp, Paper, Printing and Publishing	21t22	221.2746	Pulp, Paper, Printing and Publishing	21t22	0.217131	Pulp, Paper, Printing and Publishing	21t22	1.709876
Manufacturing, Nec; Recycling	36t37	178.722	Food, Beverages and Tobacco	15t16	0.188376	Textiles and Textile Products	17t18	1.456747
Wood and Products of Wood and Cork	20	168.0145	Transport Equipment	34t35	0.099962	Machinery, Nec	29	1.230251
Machinery, Nec	29	154.7222	Manufacturing, Nec; Recycling	36t37	0.075411	Rubber and Plastics	25	1.192088
Food, Beverages and Tobacco	15t16	144.4299	Electrical and Optical Equipment	30t33	0.074839	Transport Equipment	34t35	1.175805
Rubber and Plastics	25	128.4155	Machinery, Nec	29	0.066796	Food, Beverages and Tobacco	15t16	1.115943
Textiles and Textile Products	17t18	111.3546	Leather, Leather and Footwear	19	0.030636	Manufacturing, Nec; Recycling	36t37	1.095354
Leather, Leather and Footwear	19	78.38114	Textiles and Textile Products	17t18	0.028154	Leather, Leather and Footwear	19	0.9842317

Industry	**Code**	SO_x	**Industry**	**Code**	N_2O	**Industry**	**Code**	NO_x
Coke, Refined Petroleum and Nuclear Fuel	23	7.318126	Chemicals and Chemical Products	24	0.710923	Other Non-Metallic Mineral	26	5.201103
Other Non-Metallic Mineral	26	3.538936	Coke, Refined Petroleum and Nuclear Fuel	23	0.023001	Coke, Refined Petroleum and Nuclear Fuel	23	2.041081
Wood and Products of Wood and Cork	20	3.492431	Other Non-Metallic Mineral	26	0.022848	Chemicals and Chemical Products	24	2.021937
Basic Metals and Fabricated Metal	27t28	2.608583	Wood and Products of Wood and Cork	20	0.01217	Basic Metals and Fabricated Metal	27t28	1.517885
Chemicals and Chemical Products	24	2.112412	Transport Equipment	34t35	0.010013	Wood and Products of Wood and Cork	20	1.289723
Pulp, Paper, Printing and Publishing	21t22	1.85892	Pulp, Paper, Printing and Publishing	21t22	0.009769	Pulp, Paper, Printing and Publishing	21t22	0.9934163
Transport Equipment	34t35	1.449131	Basic Metals and Fabricated Metal	27t28	0.009475	Transport Equipment	34t35	0.9286914
Electrical and Optical Equipment	30t33	1.403297	Manufacturing, Nec; Recycling	36t37	0.00884	Electrical and Optical Equipment	30t33	0.7728053
Rubber and Plastics	25	0.6849455	Food, Beverages and Tobacco	15t16	0.005857	Food, Beverages and Tobacco	15t16	0.6354523
Food, Beverages and Tobacco	15t16	0.6514341	Rubber and Plastics	25	0.005811	Machinery, Nec	29	0.5139199
Machinery, Nec	29	0.5173224	Electrical and Optical Equipment	30t33	0.003854	Textiles and Textile Products	17t18	0.4644238
Textiles and Textile Products	17t18	0.4558609	Machinery, Nec	29	0.003751	Manufacturing, Nec; Recycling	36t37	0.4119814
Manufacturing, Nec; Recycling	36t37	0.3302042	Textiles and Textile Products	17t18	0.002752	Rubber and Plastics	25	0.4008931
Leather, Leather and Footwear	19	0.2762419	Leather, Leather and Footwear	19	0.002649	Leather, Leather and Footwear	19	0.3167254

Industry	**Code**	$NMVOC$	**Industry**	**Code**	NH_3
Coke, Refined Petroleum and Nuclear Fuel	23	11.97268	Chemicals and Chemical Products	24	0.395625
Chemicals and Chemical Products	24	3.520325	Other Non-Metallic Mineral	26	0.035216
Other Non-Metallic Mineral	26	2.829419	Transport Equipment	34t35	0.01311
Wood and Products of Wood and Cork	20	2.375599	Food, Beverages and Tobacco	15t16	0.012987
Food, Beverages and Tobacco	15t16	1.563325	Basic Metals and Fabricated Metal	27t28	0.011506
Basic Metals and Fabricated Metal	27t28	1.302999	Pulp, Paper, Printing and Publishing	21t22	0.010045
Rubber and Plastics	25	1.039211	Manufacturing, Nec; Recycling	36t37	0.0091
Pulp, Paper, Printing and Publishing	21t22	0.9391091	Wood and Products of Wood and Cork	20	0.009077
Transport Equipment	34t35	0.8956406	Electrical and Optical Equipment	30t33	0.00876
Manufacturing, Nec; Recycling	36t37	0.7520927	Coke, Refined Petroleum and Nuclear Fuel	23	0.007745
Leather, Leather and Footwear	19	0.5458934	Rubber and Plastics	25	0.006302
Electrical and Optical Equipment	30t33	0.5204596	Machinery, Nec	29	0.005631
Textiles and Textile Products	17t18	0.5030886	Leather, Leather and Footwear	19	0.0024
Machinery, Nec	29	0.3936623	Textiles and Textile Products	17t18	0.001879

Note: CO_2, CH_4, and NO_x pollutants are targeted by the Kyoto (1998) protocol of the UN Framework Convention on Climate Change. SO_x, N_2O, NO_x, $NMVOC$, and NH_3 pollutants are targeted by the Convention on Long Range Transboundary Air pollution (LRTAP) and its protocols (Helsinki (1985) on SO_x, Sofia (1998) on NO_x and N_2O, Geneva (1991) on $NMVOC$, Oslo (1994) on SO_x, and Gothenburg (1999) on SO_x, NO_x and N_2O, $NMVOC$, and NH_3.

Table 3: Linear Environmental Stringency Differential and the Marginal Effects of IEA Ratification

Pollutant:	$DIRTY$	CO_2	CH_4	N_2O	NO_x	SO_x	$NMVOC$	NH_3	CO	$PC1$
Econ. Integration	0.137***	0.137***	0.137***	0.137***	0.137***	0.137***	0.137***	0.137***	0.137***	0.137***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(IEA)	-0.006***	0.045***	-0.018***	-0.020***	-0.013***	-0.010***	-0.011***	-0.027***	-0.008***	-0.012***
	(0.001)	(0.006)	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)
d(IEA) × D_s	-0.019***	-0.010***	-0.004***	-0.002***	-0.011***	-0.008***	-0.000	-0.003***	-0.004***	-0.003***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Obs.	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630
Adj. R-Squared	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Marginal Effects										
Minimum	-0.006***	0.001	-0.003*	-0.008***	-0.000	-0.000	-0.011***	-0.005***	-0.008***	-0.008***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
25th Percentile	-0.006***	-0.005***	-0.007***	-0.009***	-0.004***	-0.005***	-0.011***	-0.009***	-0.008***	-0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
50th Percentile	-0.006***	-0.007***	-0.011***	-0.011***	-0.010***	-0.013***	-0.011***	-0.010***	-0.009***	-0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
75th Percentile	-0.025***	-0.021***	-0.013***	-0.011***	-0.018***	-0.016***	-0.011***	-0.012***	-0.013***	-0.014***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Maximum	-0.025***	-0.032***	-0.027***	-0.019***	-0.032***	-0.026***	-0.012***	-0.023***	-0.024***	-0.031***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.005)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4: Linear Environmental Stringency Differential: Sector-by-Sector Estimates

Panel A *Sectors:*	*Other Non-Metallic Minerals*	*Coke, Refined Petroleum and Nuclear Fuel*	*Basic Metals and Fabricated Metals*	*Chemicals and Chemical Products*	*Transport Equipment*	*Pulp, Paper, Printing and Publishing*	*Electrical and Optical Equipment*
Econ. Integration	0.133^{***}	0.007	0.204^{***}	0.143^{***}	0.057^{***}	0.153^{***}	0.093^{***}
	(0.014)	(0.026)	(0.012)	(0.011)	(0.014)	(0.012)	(0.011)
d(IEA)	-0.051^{***}	0.005	-0.034^{***}	-0.024^{***}	-0.025^{***}	-0.024^{***}	-0.005^{*}
	(0.004)	(0.009)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)
Obs.	187,238	87,994	239,634	247,123	208,198	247,745	257,469
Adj. R-Squared	0.237	0.164	0.235	0.332	0.295	0.240	0.385
Panel B *Sectors:*	*Manufacturing, Nec.; Recycling*	*Machinery, Nec.*	*Wood and Products of Wood and Cork*	*Rubber and Plastics*	*Food, Beveerages and Tobacco*	*Textiles and Textile Products*	*Leather and Footwear*
Econ. Integration	0.133^{***}	0.053^{***}	0.136^{***}	0.159^{***}	0.173^{***}	0.185^{***}	0.187^{***}
	(0.011)	(0.010)	(0.015)	(0.012)	(0.012)	(0.013)	(0.015)
d(IEA)	0.031^{***}	-0.037^{***}	0.040^{***}	-0.026^{***}	-0.003	-0.003	0.014^{***}
	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)
Obs.	255,245	237,186	170,405	226,426	256,117	233,917	187,933
Adj. R-Squared	0.352	0.349	0.221	0.314	0.254	0.221	0.218
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Linear Environmental Stringency Differential and the Effects of IEA Ratification

Pollutant:	$DIRTY$	CO_2	CH_4	N_2O	NO_x	SO_x	$NMVOC$	NH_3	CO	$PC1$
Econ. Integration	0.137***	0.136***	0.137***	0.137***	0.137***	0.137***	0.137***	0.137***	0.137***	0.137***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(CC IEA)	-0.001	0.121***	-0.032***	-0.022	-0.018***	-0.012*	-0.011*	0.009	0.007	-0.023***
	(0.007)	(0.041)	(0.011)	(0.021)	(0.007)	(0.006)	(0.006)	(0.023)	(0.008)	(0.007)
d(CC IEA) × D_s	-0.050***	-0.024***	-0.011**	-0.002	-0.027***	-0.021***	-0.029***	0.005	-0.025***	-0.025***
	(0.015)	(0.007)	(0.005)	(0.004)	(0.009)	(0.008)	(0.009)	(0.005)	(0.007)	(0.005)
d(AR IEA)	-0.007***	0.067***	-0.026***	-0.037***	-0.016***	-0.012***	-0.013***	-0.054***	-0.010***	-0.014***
	(0.002)	(0.010)	(0.003)	(0.005)	(0.002)	(0.002)	(0.002)	(0.006)	(0.002)	(0.002)
d(AR IEA) × D_s	-0.026***	-0.015***	-0.007***	-0.005***	-0.015***	-0.010***	-0.001	-0.009***	-0.004**	-0.003**
	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
d(OD IEA)	-0.007***	-0.048***	0.010***	0.025***	-0.003	-0.004*	-0.004**	0.030***	-0.008***	-0.001
	(0.002)	(0.012)	(0.003)	(0.006)	(0.002)	(0.002)	(0.002)	(0.006)	(0.002)	(0.002)
d(OD IEA) × D_s	0.013***	0.008***	0.008***	0.006***	0.005**	0.004*	0.015***	0.007***	0.005***	0.007***
	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Obs.	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630
Adj. R-Squared	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Marginal Effects										
CC IEA (25th Percentile)	-0.001	0.001	-0.003	-0.011	0.003	0.002	0.007	-0.016***	0.003	0.010
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)
CC IEA (50th Percentile)	-0.001	-0.005	-0.014***	-0.013***	-0.011**	-0.019***	-0.009	-0.014***	-0.002	0.001
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)
CC IEA (75th Percentile)	-0.051***	-0.036***	-0.019***	-0.013***	-0.029***	-0.027***	-0.024***	-0.012***	-0.024***	-0.039***
	(0.013)	(0.010)	(0.007)	(0.006)	(0.008)	(0.008)	(0.007)	(0.006)	(0.007)	(0.009)
AR IEA (25th Percentile)	-0.007***	-0.005***	-0.006***	-0.009***	-0.004***	-0.006***	-0.012***	-0.008***	-0.010***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
AR IEA (50th Percentile)	-0.007***	-0.008***	-0.013***	-0.013***	-0.012***	-0.016***	-0.013***	-0.012***	-0.011***	-0.011***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
AR IEA (75th Percentile)	-0.033***	-0.027***	-0.017***	-0.013***	-0.022***	-0.020***	-0.014***	-0.015***	-0.015***	-0.016***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
OD IEA (25th Percentile)	-0.007***	-0.008***	-0.011***	-0.009***	-0.006***	-0.006***	-0.013***	-0.008***	-0.007***	-0.010***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
OD IEA (50th Percentile)	-0.007***	-0.006***	-0.003	-0.004***	-0.004***	-0.002	-0.005***	-0.005***	-0.006***	-0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
OD IEA (75th Percentile)	0.006	0.004	0.001	-0.003	-0.000	-0.001	0.002	-0.002***	-0.001	0.004***
	(0.004)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6: Linear Environmental Stringency Differential: Sector-by-Sector Estimates by IEA Type

Sector:	*Other Non-Metallic Minerals*	*Coke, Refined Petroleum and Nuclear Fuel*	*Basic Metals and Fabricated Metals*	*Chemicals and Chemical Products*	*Transport Equipment*	*Pulp, Paper, Printing and Publishing*	*Electrical and Optical Equipment*
Econ. Integration	0.132***	0.006	0.204***	0.143***	0.057***	0.153***	0.093***
	(0.014)	(0.026)	(0.012)	(0.011)	(0.014)	(0.012)	(0.011)
d(CC IEA)	-0.102***	-0.230***	-0.015	-0.005	-0.035	0.014	0.052***
	(0.025)	(0.059)	(0.022)	(0.021)	(0.025)	(0.022)	(0.020)
d(AR IEA)	-0.054***	0.019	-0.043***	-0.039***	-0.021***	-0.034***	-0.020***
	(0.006)	(0.013)	(0.006)	(0.005)	(0.006)	(0.006)	(0.005)
d(OD IEA)	-0.015*	0.072***	-0.019***	0.011*	-0.032***	-0.016**	0.010*
	(0.008)	(0.017)	(0.007)	(0.006)	(0.008)	(0.007)	(0.006)
Obs.	187,238	87,994	239,634	247,123	208,198	247,745	257,469
Adj. R-Squared	0.237	0.165	0.235	0.332	0.295	0.240	0.385
Sector:	*Manufacturing, Nec.; Recycling*	*Machinery, Nec.*	*Wood and Products of Wood and Cork*	*Rubber and Plastics*	*Food, Beveerages and Tobacco*	*Textiles and Textile Products*	*Leather and Footwear*
Econ. Integration	0.133***	0.052***	0.136***	0.159***	0.173***	0.185***	0.186***
	(0.011)	(0.010)	(0.015)	(0.012)	(0.012)	(0.013)	(0.015)
d(CC IEA)	0.102***	-0.005	0.049*	0.002	-0.016	-0.109***	-0.020
	(0.020)	(0.019)	(0.027)	(0.022)	(0.022)	(0.023)	(0.027)
d(AR IEA)	0.023***	-0.050***	0.051***	-0.042***	-0.006	0.024***	0.033***
	(0.005)	(0.005)	(0.007)	(0.006)	(0.005)	(0.006)	(0.007)
d(OD IEA)	0.023***	-0.016***	-0.002	0.011	0.011*	-0.031***	-0.030***
	(0.006)	(0.006)	(0.009)	(0.007)	(0.006)	(0.007)	(0.008)
Obs.	255,245	237,186	170,405	226,426	256,117	233,917	187,933
Adj. R-Squared	0.352	0.349	0.222	0.315	0.254	0.221	0.219
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Exporter and Importer IEAs and Dirty Exports, by IEA and IEA-Specific Pollutant Type

Pollutant:	$DIRTY$	CO_2	CH_4	N_2O	NO_x	SO_x	$NMVOC$	NH_3	CO	$PC1$
Econ. Integration	0.132***	0.131***	0.132***	0.132***	0.132***	0.132***	0.132***	0.132***	0.132***	0.132***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Exp. CC IEA × D_s	-0.052***	-0.018*	-0.014**	-0.006	-0.031***	-0.022**	-0.029**	-0.005	-0.018*	-0.016**
	(0.019)	(0.010)	(0.007)	(0.006)	(0.011)	(0.010)	(0.012)	(0.006)	(0.009)	(0.007)
Imp. CC IEA × D_s	0.046**	0.029***	0.007	-0.002	0.018	0.017	0.019	-0.013*	0.027**	0.027***
	(0.022)	(0.011)	(0.007)	(0.006)	(0.013)	(0.011)	(0.014)	(0.007)	(0.011)	(0.008)
Exp. AR IEA × D_s	-0.033***	-0.015***	-0.012***	-0.006***	-0.015***	-0.011***	-0.006**	-0.009***	-0.006***	-0.005***
	(0.005)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)
Imp. AR IEA × D_s	0.014**	0.013***	-0.001	0.003*	0.015***	0.008***	-0.007**	0.007***	0.001	-0.001
	(0.006)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
Exp. OD IEA × D_s^{ods}	-0.014**	-0.013**	-0.015***	-0.016***	-0.014**	-0.013**	-0.016***	-0.015***	-0.014**	-0.015***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Imp. OD IEA × D_s^{ods}	0.008*	0.008*	0.009*	0.009**	0.008*	0.008*	0.008*	0.009**	0.008*	0.009*
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Obs.	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623
Adj. R-Squared	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
Rep. × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Par. × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Marginal Diffserences (75th vs. 25th)										
Exp. CC IEA	-0.052***	-0.028	-0.021**	-0.006	-0.037***	-0.030**	-0.031**	-0.004	-0.020**	-0.033***
	(0.019)	(0.015)	(0.010)	(0.005)	(0.014)	(0.014)	(0.013)	(0.005)	(0.010)	(0.013)
Imp. CC IEA	0.046**	0.044***	0.010	-0.002	0.021	0.024	0.020	-0.009	0.029**	0.055***
	(0.022)	(0.017)	(0.011)	(0.006)	(0.015)	(0.016)	(0.014)	(0.005)	(0.012)	(0.015)
Exp. AR IEA	-0.033***	-0.023***	-0.018***	-0.005***	-0.017***	-0.016***	-0.006**	-0.007***	-0.007***	-0.011***
	(0.005)	(0.004)	(0.002)	(0.001)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)	(0.003)
Imp. AR IEA	0.014**	0.019***	-0.001	0.003	0.018***	0.011***	-0.008**	0.005***	0.001	-0.002
	(0.006)	(0.004)	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)	(0.001)	(0.003)	(0.004)
Exp. OD IEA	-0.014**	-0.013**	-0.015**	-0.016***	-0.014***	-0.013**	-0.016***	-0.015**	-0.014**	-0.015**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Imp. OD IEA	0.008**	0.008**	0.009**	0.009**	0.008**	0.008**	0.008**	0.009**	0.008**	0.009**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 8: Exporter and Importer IEAs and Dirty Exports, by IEA and IEA-Specific Pollutant Type

Pollutant:	$DIRTY$	CO_2	CH_4	N_2O	NO_x	SO_x	$NMVOC$	NH_3	CO	$PC1$
Econ. Integration	0.132***	0.131***	0.132***	0.132***	0.132***	0.132***	0.132***	0.132***	0.132***	0.132***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Exp. CC IEA × D_s	-0.055***	-0.020*	-0.025***	-0.011*	-0.036***	-0.036***	-0.057***	-0.008	-0.030***	-0.025***
	(0.020)	(0.010)	(0.007)	(0.006)	(0.012)	(0.011)	(0.013)	(0.007)	(0.010)	(0.007)
Exp. CC IEA × D_s × Dvl.	0.024	0.007	0.087***	0.043***	0.041	0.118***	0.206***	0.027	0.089***	0.066***
	(0.052)	(0.026)	(0.017)	(0.016)	(0.032)	(0.028)	(0.031)	(0.018)	(0.024)	(0.016)
Imp. CC IEA × D_s	0.033	0.019	0.005	-0.002	0.007	0.005	0.030**	-0.015*	0.020*	0.029***
	(0.024)	(0.012)	(0.008)	(0.007)	(0.014)	(0.012)	(0.015)	(0.008)	(0.012)	(0.008)
Imp. CC IEA × D_s × Dvl.	0.095*	0.054**	0.022	0.026*	0.072**	0.057**	-0.003	0.027	0.027	0.002
	(0.055)	(0.027)	(0.018)	(0.016)	(0.032)	(0.029)	(0.034)	(0.018)	(0.027)	(0.018)
Exp. AR IEA × D_s	-0.028***	-0.014***	-0.010***	-0.004**	-0.012***	-0.009***	-0.001	-0.007***	-0.004*	-0.004**
	(0.005)	(0.002)	(0.002)	(0.001)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Exp. AR IEA × D_s × Dvl.	-0.071***	-0.024***	-0.023***	-0.031***	-0.032***	-0.011	-0.063***	-0.031***	-0.022***	-0.018***
	(0.016)	(0.008)	(0.005)	(0.005)	(0.010)	(0.008)	(0.009)	(0.005)	(0.007)	(0.005)
Imp. AR IEA × D_s	0.018***	0.013***	0.000	0.006***	0.017***	0.007**	-0.004	0.010***	-0.000	-0.001
	(0.006)	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)	(0.004)	(0.002)	(0.003)	(0.002)
Imp. AR IEA × D_s × Dvl.	-0.028*	-0.008	-0.004	-0.010**	-0.013	-0.001	0.002	-0.014***	0.001	0.004
	(0.016)	(0.008)	(0.005)	(0.005)	(0.009)	(0.008)	(0.010)	(0.005)	(0.008)	(0.005)
Exp. OD IEA × D_s^{ods}	-0.011*	-0.008	-0.013**	-0.014**	-0.011*	-0.009	-0.015**	-0.013**	-0.010	-0.013**
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)
Exp. OD IEA × D_s^{ods} × Dvl.	-0.007	-0.010*	-0.003	-0.003	-0.006	-0.009	0.001	-0.004	-0.008	-0.003
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Imp. OD IEA × D_s^{ods}	0.038***	0.035***	0.038***	0.040***	0.038***	0.037***	0.039***	0.039***	0.037***	0.039***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Imp. OD IEA × D_s^{ods} × Dvl.	-0.043***	-0.040***	-0.044***	-0.046***	-0.043***	-0.042***	-0.045***	-0.045***	-0.043***	-0.045***
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Obs.	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623
Adj. R-Squared	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
Exp. × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Imp. × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 9: Linear 10-Year Lagged Environmental Stringency Differential and the Marginal Effects of IEA Ratification

Pollutant:	$DIRTY$	CO_2	CH_4	N_2O	NO_x	SO_x	$NMVOC$	NH_3	CO	$PC1$
Econ. Integration	0.136***	0.136***	0.136***	0.136***	0.136***	0.136***	0.137***	0.136***	0.136***	0.136***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(IEA)	-0.016***	0.021***	-0.022***	-0.019***	-0.020***	-0.019***	-0.019***	-0.024***	-0.017***	-0.020***
	(0.001)	(0.007)	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)	(0.004)	(0.001)	(0.001)
d(IEA) × D_s	-0.014***	-0.007***	-0.002*	0.000	-0.008***	-0.005***	0.003**	-0.001	-0.003**	-0.001*
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
lag d(IEA)	0.025***	0.063***	0.010***	-0.004	0.020***	0.022***	0.022***	-0.008	0.024***	0.020***
	(0.002)	(0.009)	(0.002)	(0.004)	(0.001)	(0.001)	(0.001)	(0.005)	(0.002)	(0.002)
lag d(IEA) × D_s	-0.014***	-0.007***	-0.007***	-0.005***	-0.009***	-0.008***	-0.009***	-0.006***	-0.004**	-0.004***
	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
Obs.	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630
Adj. R-Squared	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Short-Run Marginal Effects										
Minimum	-0.016***	-0.010***	-0.016***	-0.019***	-0.011***	-0.013***	-0.022***	-0.017***	-0.017***	-0.017***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)
25th Percentile	-0.016***	-0.015***	-0.018***	-0.019***	-0.014***	-0.016***	-0.021***	-0.018***	-0.017***	-0.018***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
50th Percentile	-0.016***	-0.016***	-0.019***	-0.019***	-0.018***	-0.020***	-0.019***	-0.019***	-0.018***	-0.018***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
75th Percentile	-0.030***	-0.026***	-0.020***	-0.019***	-0.024***	-0.022***	-0.018***	-0.019***	-0.020***	-0.020***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Maximum	-0.030***	-0.034***	-0.025***	-0.019***	-0.033***	-0.028***	-0.011***	-0.023***	-0.028***	-0.029***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)	(0.006)
Long-Run Marginal Effects										
Minimum	0.009***	0.020***	0.018***	0.009***	0.019***	0.020***	0.008***	0.015***	0.008***	0.008***
	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
25th Percentile	0.009***	0.011***	0.010***	0.007***	0.012***	0.012***	0.006***	0.006***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
50th Percentile	0.009***	0.008***	0.002	0.003*	0.004**	-0.001	0.003**	0.004**	0.005***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
75th Percentile	-0.019***	-0.012***	-0.002	0.002	-0.008***	-0.006***	0.000	0.001	-0.000	-0.003*
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Maximum	-0.019***	-0.028***	-0.031***	-0.021***	-0.028***	-0.022***	-0.012**	-0.024***	-0.018***	-0.035***
	(0.003)	(0.004)	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)	(0.005)	(0.008)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 10: Linear 10-Year Delayed Environmental Stringency Differential: Sector-by-Sector Estimates

Sector:	*Other Non-Metallic Minerals*	*Coke, Ref. Petroleum and Nuclear Fuel*	*Basic Metals and Fabricated Metals*	*Chemicals and Chemical Products*	*Transport Equipment*	*Pulp, Paper, Printing and Publishing*	*Electrical and Optical Equipment*
Econ. Integration	0.132***	0.007	0.204***	0.143***	0.056***	0.153***	0.093***
	(0.014)	(0.026)	(0.012)	(0.011)	(0.014)	(0.012)	(0.011)
d(IEA)	-0.056***	0.002	-0.039***	-0.026***	-0.031***	-0.030***	-0.014***
	(0.004)	(0.009)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)
lag d(IEA)	0.013**	0.007	0.013**	0.003	0.017***	0.016***	0.023***
	(0.006)	(0.012)	(0.005)	(0.005)	(0.006)	(0.005)	(0.004)
Obs.	187,238	87,994	239,634	247,123	208,198	247,745	257,469
Adj. R-Squared	0.237	0.164	0.235	0.332	0.295	0.241	0.386
Sector:	*Manufacturing, Nec.; Recycling*	*Machinery, Nec.*	*Wood and Products of Wood and Cork*	*Rubber and Plastics*	*Food, Beveerages and Tobacco*	*Textiles and Textile Products*	*Leather, Leather and Footwear*
Econ. Integration	0.132***	0.052***	0.134***	0.159***	0.172***	0.184***	0.184***
	(0.011)	(0.010)	(0.015)	(0.012)	(0.012)	(0.013)	(0.015)
d(IEA)	0.017***	-0.041***	0.025***	-0.027***	-0.010***	-0.018***	-0.009**
	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
lag d(IEA)	0.039***	0.010**	0.039***	0.003	0.018***	0.041***	0.060***
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)
Obs.	255,245	237,186	170,405	226,426	256,117	233,917	187,933
Adj. R-Squared	0.352	0.349	0.222	0.314	0.254	0.221	0.220
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 11: Linear 10-Year Lagged Environmental Stringency Differential and the Marginal Effects of Acid Rain IEA Ratification

Pollutant:	$DIRTY$	CO_2	CH_4	N_2O	NO_x	SO_x	$NMVOC$	NH_3	CO	$PC1$
Econ. Integration	0.136***	0.135***	0.136***	0.136***	0.136***	0.136***	0.136***	0.136***	0.136***	0.136***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(CC IEA)	-0.033***	0.042	-0.042***	0.000	-0.045***	-0.042***	-0.041***	0.049**	-0.022**	-0.051***
	(0.008)	(0.043)	(0.011)	(0.022)	(0.007)	(0.007)	(0.007)	(0.024)	(0.009)	(0.007)
d(CC IEA) × D_s	-0.038**	-0.015**	0.000	0.009**	-0.015	-0.007	-0.017*	0.020***	-0.025***	-0.023***
	(0.015)	(0.008)	(0.005)	(0.004)	(0.009)	(0.008)	(0.009)	(0.005)	(0.007)	(0.005)
d(AR IEA)	-0.022***	0.030***	-0.031***	-0.027***	-0.029***	-0.027***	-0.027***	-0.036***	-0.024***	-0.028***
	(0.002)	(0.011)	(0.003)	(0.006)	(0.002)	(0.002)	(0.002)	(0.006)	(0.002)	(0.002)
d(AR IEA) × D_s	-0.020***	-0.010***	-0.002*	-0.000	-0.010***	-0.004**	0.004*	-0.002	-0.004**	-0.002
	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)
lag d(AR IEA)	0.033***	0.088***	0.007*	-0.032***	0.027***	0.031***	0.030***	-0.053***	0.030***	0.028***
	(0.003)	(0.015)	(0.004)	(0.007)	(0.002)	(0.002)	(0.002)	(0.008)	(0.003)	(0.002)
lag d(AR IEA) × D_s	-0.014***	-0.011***	-0.013***	-0.013***	-0.014***	-0.016***	-0.013***	-0.018***	-0.001	-0.002
	(0.005)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
d(OD IEA)	0.005**	0.005**	0.005**	0.005**	0.005**	0.005**	0.005**	0.005**	0.005**	0.006**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
d(OD IEA) × D_s^{ods}	-0.012***	-0.011***	-0.012***	-0.011***	-0.012***	-0.011***	-0.011***	-0.012***	-0.011***	-0.012***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
lag d(OD IEA)	0.030***	0.029***	0.031***	0.031***	0.030***	0.030***	0.031***	0.031***	0.030***	0.031***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
lag d(OD IEA) × D_s^{ods}	0.009**	0.012***	0.007	0.006	0.009**	0.011**	0.006	0.007	0.010**	0.007
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Obs.	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630
Adj. R-Squared	0.246	0.246	0.246	0.245	0.246	0.246	0.245	0.246	0.245	0.246
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Short-Run Marginal Effects	AR	AR	AR	AR	AR	AR	AR	AR	AR	AR
Minimim	-0.022***	-0.015***	-0.023***	-0.027***	-0.018***	-0.021***	-0.031***	-0.023***	-0.024***	-0.025***
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
25th Percentile	-0.022***	-0.021***	-0.025***	-0.027***	-0.021***	-0.024***	-0.030***	-0.026***	-0.025***	-0.025***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
50th Percentile	-0.022***	-0.023***	-0.027***	-0.027***	-0.026***	-0.028***	-0.028***	-0.027***	-0.025***	-0.026***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
75th Percentile	-0.042***	-0.037***	-0.028***	-0.027***	-0.033***	-0.030***	-0.025***	-0.027***	-0.028***	-0.029***
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Maximum	-0.042***	-0.048***	-0.036***	-0.027***	-0.045***	-0.035***	-0.017***	-0.034***	-0.039***	-0.040***
	(0.003)	(0.004)	(0.005)	(0.005)	(0.005)	(0.004)	(0.006)	(0.005)	(0.006)	(0.009)
Long-Run Marginal Effects										
Minimum	0.011***	0.027***	0.032***	0.019***	0.025***	0.029***	0.011***	0.038***	0.006*	0.006**
	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)
25th Percentile	0.011***	0.014***	0.016***	0.014***	0.016***	0.017***	0.008**	0.013***	0.005*	0.006**
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
50th Percentile	0.011***	0.010***	0.002	0.003	0.004*	-0.003	0.003	0.006**	0.004	0.005*
	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
75th Percentile	-0.024***	-0.017***	-0.006**	0.002	-0.012***	-0.011***	-0.001	-0.001	0.000	-0.002
	(0.005)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
Maximum	-0.024***	-0.041***	-0.059***	-0.054***	-0.041***	-0.035***	-0.019**	-0.070***	-0.012	-0.024*
	(0.005)	(0.006)	(0.008)	(0.007)	(0.006)	(0.006)	(0.008)	(0.007)	(0.009)	(0.013)

Note: See next page for the remainder of the table.

Table 11: Linear 10-Year Lagged Environmental Stringency Differential and the Marginal Effects of Ozone Depletion IEA Ratification (contd.)

Pollutant:	$DIRTY$	CO_2	CH_4	N_2O	NO_x	SO_x	$NMVOC$	NH_3	CO	$PC1$
Short-Run Marginal Effects	OD	OD	OD	OD	OD	OD	OD	OD	OD	OD
Minimum	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.006^{**}
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
25th Percentile	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.006^{**}
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
50th Percentile	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.005^{**}	0.006^{**}
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
75th Percentile	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{**}
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Maximum	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{*}	-0.006^{**}
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Long-Run Marginal Effects										
Minimum	0.036^{***}	0.035^{***}	0.036^{***}	0.037^{***}	0.036^{***}	0.035^{***}	0.037^{***}	0.036^{***}	0.035^{***}	0.036^{***}
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
25th Percentile	0.036^{***}	0.035^{***}	0.036^{***}	0.037^{***}	0.036^{***}	0.035^{***}	0.037^{***}	0.036^{***}	0.035^{***}	0.036^{***}
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
50th Percentile	0.036^{***}	0.035^{***}	0.036^{***}	0.037^{***}	0.036^{***}	0.035^{***}	0.037^{***}	0.036^{***}	0.035^{***}	0.036^{***}
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
75th Percentile	0.033^{***}	0.035^{***}	0.032^{***}	0.031^{***}	0.033^{***}	0.034^{***}	0.031^{***}	0.032^{***}	0.034^{***}	0.032^{***}
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Maximum	0.033^{***}	0.035^{***}	0.032^{***}	0.031^{***}	0.033^{***}	0.034^{***}	0.031^{***}	0.032^{***}	0.034^{***}	0.032^{***}
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The dependent variable is the logarithm of sectoral exports.

Table 12: Linear 10-Year Delay Environmental Stringency Differential: Sector-by-Sector Estimates

Sector:	*Other Non-Metallic Minerals*	*Coke, Ref. Petroleum and Nuclear Fuel*	*Basic Metals and Fabricated Metals*	*Chemicals and Chemical Products*	*Transport Equipment*	*Pulp, Paper, Printing and Publishing*	*Electrical and Optical Equipment*
Econ. Integration	0.130***	0.005	0.203***	0.144***	0.058***	0.153***	0.092***
	(0.014)	(0.026)	(0.012)	(0.011)	(0.014)	(0.012)	(0.011)
d(CC IEA)	-0.145***	-0.281***	-0.038	-0.000	-0.031	-0.000	0.023
	(0.026)	(0.060)	(0.023)	(0.022)	(0.026)	(0.023)	(0.021)
d(AR IEA)	-0.074***	-0.004	-0.054***	-0.040***	-0.022***	-0.041***	-0.034***
	(0.007)	(0.014)	(0.006)	(0.006)	(0.007)	(0.006)	(0.005)
lag d(AR IEA)	0.051***	0.057***	0.024***	-0.014*	-0.012	0.012	0.028***
	(0.009)	(0.020)	(0.008)	(0.008)	(0.009)	(0.008)	(0.007)
d(OD IEA)	-0.007	0.081***	-0.015**	0.012*	-0.030***	-0.012*	0.016**
	(0.008)	(0.017)	(0.007)	(0.006)	(0.008)	(0.007)	(0.006)
lag d(OD IEA)	0.015	0.019	0.025***	0.051***	0.050***	0.034***	0.042***
	(0.009)	(0.020)	(0.008)	(0.007)	(0.009)	(0.008)	(0.007)
Obs.	187,238	87,994	239,634	247,123	208,198	247,745	257,469
Adj. R-Squared	0.238	0.165	0.236	0.332	0.295	0.241	0.386
Sector:	*Manufacturing, Nec.; Recycling*	*Machinery, Nec.*	*Wood and Products of Wood and Cork*	*Rubber and Plastics*	*Food, Beeverages and Tobacco*	*Textiles and Textile Products*	*Leather, Leather and Footwear*
Econ. Integration	0.131***	0.053***	0.133***	0.160***	0.173***	0.182***	0.182***
	(0.011)	(0.010)	(0.015)	(0.012)	(0.012)	(0.013)	(0.015)
d(CC IEA)	0.052**	-0.015	0.007	0.002	-0.037	-0.182***	-0.108***
	(0.021)	(0.020)	(0.028)	(0.023)	(0.023)	(0.024)	(0.028)
d(AR IEA)	0.001	-0.056***	0.032***	-0.045***	-0.016***	-0.008	-0.004
	(0.006)	(0.005)	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)
lag d(AR IEA)	0.051***	0.006	0.049***	-0.006	0.015**	0.087***	0.097***
	(0.007)	(0.007)	(0.009)	(0.008)	(0.008)	(0.008)	(0.010)
d(OD IEA)	0.031***	-0.012**	0.005	0.013*	0.016**	-0.021***	-0.017**
	(0.006)	(0.006)	(0.009)	(0.007)	(0.006)	(0.007)	(0.008)
lag d(OD IEA)	0.038***	0.037***	0.012	0.045***	0.046***	0.003	0.019*
	(0.007)	(0.007)	(0.010)	(0.008)	(0.007)	(0.009)	(0.010)
Obs.	255,245	237,186	170,405	226,426	256,117	233,917	187,933
Adj. R-Squared	0.352	0.349	0.222	0.315	0.254	0.222	0.220
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 13: Short- and Long-Run Marginal Effects of IEA Ratification on Manufacturing Employment

Pollutant:	$DIRTY$	CO_2	CH_4	N_2O	NO_x	SO_x	$NMVOC$	NH_3	CO	$PC1$
Lower Bounds										
Marginal Effects (X): U.S.A.										
Short Run	-47,049	-48,666	-48,710	-49,938	-46,108	-46,907	-52,238	-50,033	-48,381	-48,308
	(2,890)	(2,862)	(2,906)	(2,870)	(2,929)	(2,934)	(2,994)	(2,860)	(2,887)	(2,930)
Long Run	11,652	8,602	12,731	7,534	14,081	14,346	10,486	5,314	9,400	11,917
	(4,006)	(3,973)	(4,024)	(3,985)	(4,063)	(4,068)	(4,146)	(3,973)	(4,001)	(4,064)
Marginal Effects (X): Germany										
Short Run	-70,152	-71,875	-71,548	-72,394	-69,465	-70,051	-74,835	-72,933	-70,559	-70,606
	(4,157)	(4,146)	(4,158)	(4,152)	(4,174)	(4,168)	(4,237)	(4,154)	(4,169)	(4,194)
Long Run	13,098	9,868	13,482	8,851	14,930	15,231	13,505	5,087	12,768	15,249
	(5,769)	(5,758)	(5,765)	(5,768)	(5,793)	(5,784)	(5,870)	(5,774)	(5,778)	(5,816)
Upper Bounds										
Marginal Effects (X+M): U.S.A.										
Short Run	-115,480	-116,971	-119,622	-124,583	-112,518	-115,243	-131,353	-123,285	-119,964	-119,808
	(7,255)	(7,202)	(7,462)	(7,242)	(7,405)	(7,424)	(7,629)	(7,224)	(7,237)	(7,385)
Long Run	32,618	30,222	41,701	24,518	40,214	40,407	28,225	23,555	24,849	31,999
	(10,053)	(9,993)	(10,328)	(10,053)	(10,265)	(10,291)	(10,566)	(10,029)	(10,026)	(10,245)
Marginal Effects (X+M): Germany										
Short Run	-123,309	-125,555	-125,725	-127,509	-121,196	-122,346	-131,692	-128,233	-124,205	-124,203
	(7,325)	(7,303)	(7,334)	(7,313)	(7,376)	(7,374)	(7,453)	(7,309)	(7,345)	(7,399)
Long Run	23,549	19,466	25,324	16,115	28,726	29,670	23,592	10,520	22,625	27,417
	(10,163)	(10,141)	(10,167)	(10,160)	(10,236)	(10,229)	(10,325)	(10,158)	(10,180)	(10,261)

Note: Calculations are based on the estimates reported in Table 9 and identities 8 and 9, which are outlined is Section 6.3.

Table A1: Correlation of Emission Intensities

	CO_2	CH_4	N_2O	NO_x	SO_x	CO	$NMVOC$	NH_3
CO_2	1.00	0.78	0.59	0.91	0.82	0.85	0.75	0.55
CH_4	0.78	1.00	0.68	0.68	0.80	0.84	0.89	0.54
N_2O	0.59	0.68	1.00	0.65	0.53	0.38	0.67	0.93
NO_x	0.91	0.68	0.65	1.00	0.88	0.73	0.74	0.64
SO_x	0.82	0.80	0.53	0.88	1.00	0.83	0.79	0.45
CO	0.85	0.84	0.38	0.73	0.83	1.00	0.78	0.23
$NMVOC$	0.75	0.89	0.67	0.74	0.79	0.78	1.00	0.51
NH_3	0.55	0.54	0.93	0.64	0.45	0.23	0.51	1.00

The table displays the correlations of log. emission intensities for various pollutants across the 14 sectors considered. Note that sectoral emission intensities are 1995-2009 averages across a total of 40 countries. All intensities are measured in kg/USD1,000 of output; 1995=100 @ Real LCU/USD

Table A2: PC Analysis on Emission Intensities: Summary

	Eigen-value	Var. Covered	CO_2	CH_4	N_2O	NO_x	SO_x	CO	$NMVOC$	NH_3
Panel A										
PC1	4.68	0.59	0.40	0.42	0.09	0.28	0.44	0.42	0.44	0.08
PC2	2.05	0.26	0.02	-0.08	0.67	0.17	-0.08	-0.20	-0.04	0.68
PC3	1.10	0.14	0.43	-0.37	-0.19	0.71	0.02	-0.24	-0.24	-0.13
Panel B										
PC1 AR	2.32	0.58				0.48	0.62		0.59	0.18
PC2 AR	1.01	0.25				0.22	-0.25		-0.20	0.92
Panel C										
PC1 CC	1.67	0.56	0.68	0.69	0.24					
PC2 CC	0.96	0.32	-0.19	-0.15	0.97					

Note: Each panel displays the factor loadings for those principal components with eigenvalues greater than 1. The only exception appears in panel B. The proportion of emission intensity variance, across all 8 pollutants, acid rain (AR) pollutants, and climate change (CC) pollutants captured by each component, is also displayed.

Table A3: Exporters and Importers

Country

- *Albania*
- *Angola*
- Antigua and Barbuda
- *Argentina*
- *Armenia*
- Australia
- Austria
- *Azerbaijan*
- Bahamas
- Bahrain
- *Bangladesh*
- Barbados
- *Belarus*
- Belgium and Luxembourg
- *Belize*
- *Benin*
- Bermuda
- *Bhutan*
- *Bolivia*
- *Bosnia and Herzegovina*
- *Botswana*
- *Brazil*
- Brunei Darussalam
- *Bulgaria*
- *Burkina Faso*
- *Burundi*
- *Cambodia*
- *Cameroon*
- Canada
- *Cape Verde*
- *Central African Republic*
- *Chad*
- Chile
- *China*
- *Colombia*
- *Comoros*
- *Congo*
- *Costa Rica*
- *Croatia*
- Cyprus
- Czech Republic
- *Cote d'Ivoire*
- Denmark
- *Djibouti*
- *DoMin. ica*
- *DoMin. ican Republic*
- *Ecuador*
- *Egypt*
- *El Salvador*
- *Equatorial Guinea*
- Estonia
- *Ethiopia*
- *Fiji*
- Finland
- France
- *Gabon*
- *Gambia*
- *Georgia*
- Germany
- *Ghana*
- Greece
- *Grenada*
- *Guatemala*
- *Guinea*
- *Guinea-Bissau*
- *Honduras*
- Hong Kong
- Hungary
- Iceland
- *India*
- *Indonesia*
- *Iran*
- *Iraq*
- Ireland
- Israel
- Italy
- *Jamaica*
- Japan
- *Jordan*
- *Kazakhstan*
- *Kenya*
- *Korea*
- Kuwait
- *Kyrgyzstan*
- *Lao People's Democratic Republic*
- Latvia
- *Lebanon*
- *Lesotho*
- *Liberia*
- Lithuania
- Macau
- *Macedonia (the former Yugoslav Rep. of)*
- *Madagascar*
- *Malawi*
- *Malaysia*
- *Maldives*
- *Mali*
- Malta
- *Mauritania*
- *Mauritius*
- *Mexico*
- *Moldova, Rep. of*
- *Mongolia*
- *Morocco*
- *Mozambique*
- *Namibia*
- *Nepal*
- Netherlands
- New Zealand
- *Niger*
- *Nigeria*
- Norway
- Oman
- *Pakistan*
- *Panama*
- *Paraguay*
- *Peru*
- *Philippines*
- Poland
- Portugal
- Qatar
- *Romania*
- *Russian Federation*
- *Rwanda*
- Saint Kitts and Nevis
- *Saint Lucia*
- *Saint Vincent and the Grenadines*
- *Sao Tome and Principe*
- Saudi Arabia
- *Senegal*
- *Sierra Leone*
- Singapore
- Slovakia
- Slovenia
- *South Africa*
- Spain
- *Sri Lanka*
- *Sudan*
- *Suriname*
- *Swaziland*
- Sweden
- Switzerland
- *Syrian Arab Republic*
- Taiwan
- *Tajikistan*
- *Tanzania, United Rep. of*
- *Thailand*
- *Togo*
- Trinidad and Tobago
- *Tunisia*
- *Turkey*
- *Turkmenistan*
- *Uganda*
- *Ukraine*
- United Kingdom
- United States of America
- Uruguay
- *Uzbekistan*
- *Venezuela*
- *Viet Nam*
- *Yemen*
- *Zambia*
- *Zimbabwe*

All countries appear as both exporters and importers with the exception of Chad, Equatorial Guinea, Lao People's Democratic Republic, and Uzbekistan. These six nations are only observed as importers. Developing countries (GNI per capita ≤ $12,235) are marked in italics. According to the World Bank, these are low-income-, lower-middle-, and upper-middle-income countries. See https://datahelpdesk.worldbank.org/knowledgebase/articles/906519 for additional details.

Table A4: Linear and Linear 10-Year Lagged Environmental Stringency Differential and the Margins of IEA Ratification

Pollutant:	*Multilateral Resistance Terms*			*Multilateral Resistance Terms and Short- and Long-Run Effects*		
	$DIRTY$	CO_2	$PC1$	$DIRTY$	CO_2	$PC1$
Econ. Integration	0.132***	0.132***	0.132***	0.132***	0.132***	0.132***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(IEA) × D_s	-0.018***	-0.010***	-0.002***	-0.013***	-0.007***	-0.001
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
lag d(IEA) ×D_s				-0.014***	-0.007***	-0.004***
				(0.003)	(0.002)	(0.001)
Obs.	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623	3,014,623
Adj. R-Squared	0.822	0.822	0.822	0.822	0.822	0.822
Reporter × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Partner × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Rep. × Par. × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Marginal Differences (75th vs. 25th)						
	-0.018***	-0.015***	-0.005***			
	(0.002)	(0.002)	(0.002)			
Short-Run Marginal Differences						
				-0.013***	-0.011***	-0.002
				(0.002)	(0.002)	(0.002)
Long-Run Marginal Differences						
				-0.027***	-0.022***	-0.010***
				(0.003)	(0.002)	(0.002)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** p<0.01, ** p<0.05, * p<0.1.

Table A5: Non-Linear Environmental Stringency Differential

Pollutant:	*Non-Linear IEA Differential*			*Non-Linear IEA Differential and Multilateral Resistance Terms*		
	$DIRTY$	CO_2	$PC1$	$DIRTY$	CO_2	$PC1$
Econ. Integration	0.138***	0.138***	0.138***	0.132***	0.132***	0.132***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
NL d(IEA)	-0.008***	0.055***	-0.014***	-0.008	0.043***	-0.013**
	(0.003)	(0.014)	(0.003)	(0.007)	(0.015)	(0.006)
NL d(IEA) × D_s	-0.022***	-0.012***	-0.003	-0.017***	-0.010***	-0.001
	(0.005)	(0.003)	(0.002)	(0.005)	(0.002)	(0.002)
Obs.	3,042,630	3,042,630	3,042,630	3,014,623	3,014,623	3,014,623
Adj. R-Squared	0.245	0.245	0.245	0.822	0.822	0.822
Country × Year Effects	Yes	Yes	Yes			
Reporter × Year Effects				Yes	Yes	Yes
Partner × Year Effects				Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Marginal Effects 1994						
Minimum	-0.003***	0.000	-0.004***	-0.003	-0.000	-0.004*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)	(0.002)
25th Percentile	-0.003***	-0.002**	-0.004***	-0.003	-0.003	-0.004*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
50th Percentile	-0.003***	-0.003***	-0.004***	-0.003	-0.003	-0.004*
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
75th Percentile	-0.011***	-0.009***	-0.006***	-0.009***	-0.008***	-0.005*
	(0.002)	(0.001)	(0.001)	(0.003)	(0.003)	(0.002)
Maximum	-0.011***	-0.014***	-0.011***	-0.009***	-0.012***	-0.007**
	(0.002)	(0.002)	(0.004)	(0.003)	(0.003)	(0.005)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** p<0.01, ** p<0.05, * p<0.1.

Table A6: Linear Environmental Stringency Differential by IEA, and IEA-Specific Pollutant Type

Pollutant:	*Ozone Depletion-Specific Binary Indicator*			*Kyoto w/ and w/o Cap*		
	$DIRTY$	CO_2	$PC1$	$DIRTY$	CO_2	$PC1$
Econ. Integration	0.137***	0.136***	0.137***	0.137***	0.136***	0.137***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(CC IEA)	-0.001	0.122***	-0.023***	-0.018**	0.077*	-0.038***
	(0.007)	(0.041)	(0.007)	(0.008)	(0.045)	(0.008)
d(CC IEA) × Ds	-0.051***	-0.024***	-0.025***	-0.046***	-0.019**	-0.023***
	(0.015)	(0.007)	(0.005)	(0.016)	(0.008)	(0.006)
d(AR IEA)	-0.007***	0.064***	-0.014***	-0.005***	0.068***	-0.013***
	(0.002)	(0.010)	(0.002)	(0.002)	(0.010)	(0.002)
d(AR IEA) × Ds	-0.025***	-0.014***	-0.003**	-0.025***	-0.014***	-0.003**
	(0.004)	(0.002)	(0.001)	(0.004)	(0.002)	(0.001)
d(OD IEA)	0.000	-0.000	0.000	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
d(OD IEA) × $D^{ods}s$	-0.012***	-0.011***	-0.013***	-0.012***	-0.011***	-0.013***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(CC IEA All)				0.044***	0.117***	0.040***
				(0.007)	(0.036)	(0.006)
d(CC IEA All) × Ds				-0.013	-0.014**	-0.004
				(0.013)	(0.006)	(0.005)
Obs.	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630
Adj. R-Squared	0.245	0.245	0.245	0.245	0.245	0.245
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Kyoto Ratifiers w/ Cap						
Minimum				0.026***	0.050***	0.041***
				(0.008)	(0.011)	(0.009)
25th Percentile				0.026***	0.030***	0.037***
				(0.008)	(0.008)	(0.008)
50th Percentile				0.026***	0.023***	0.028***
				(0.008)	(0.007)	(0.007)
75th Percentile				-0.033**	-0.019*	-0.017*
				(0.014)	(0.010)	(0.009)
Maximum				-0.033**	-0.056***	-0.173***
				(0.014)	(0.018)	(0.039)
All Kyoto Ratifiers						
Minimum				0.044***	0.057***	0.045***
				(0.007)	(0.009)	(0.007)
25th Percentile				0.044***	0.049***	0.045***
				(0.007)	(0.007)	(0.007)
50th Percentile				0.044***	0.046***	0.043***
				(0.007)	(0.006)	(0.006)
75th Percentile				0.031***	0.028***	0.037***
				(0.011)	(0.009)	(0.008)
Maximum				0.031***	0.013	0.016
				(0.011)	(0.015)	(0.033)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** p<0.01, ** p<0.05, * p<0.1.

Table A7: Linear Environmental Stringency Differential and the Marginal Effects of IEA Ratification

Pollutant:	*Excluding China*			*Excluding Coke, Petroleum, and Nuclear Fuel*			*GDP Per Capita Differential*		
	$DIRTY$	CO_2	$PC1$	$DIRTY$	CO_2	$PC1$	$DIRTY$	CO_2	$PC1$
Econ. Integration	0.147***	0.147***	0.147***	0.142***	0.142***	0.142***	0.135***	0.135***	0.135***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(IEA)	-0.005***	0.046***	-0.011***	-0.006***	0.056***	-0.015***	-0.006***	0.045***	-0.012***
	(0.001)	(0.007)	(0.001)	(0.001)	(0.007)	(0.001)	(0.001)	(0.006)	(0.001)
d(IEA) × D_s	-0.019***	-0.010***	-0.003***	-0.022***	-0.012***	-0.007***	-0.019***	-0.010***	-0.003***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
d(GDPpc)							-0.132***	-0.374***	-0.099***
							(0.010)	(0.048)	(0.010)
d(GDPpc) × D_s							0.099***	0.048***	0.024***
							(0.017)	(0.009)	(0.005)
Obs.	2,962,871	2,962,871	2,962,871	2,954,636	2,954,636	2,954,636	3,038,936	3,038,936	3,038,936
Adj. R-Squared	0.232	0.232	0.232	0.253	0.253	0.253	0.245	0.245	0.245
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Effects × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Minimum	-0.005***	0.002	-0.006***	-0.006***	0.003	-0.004***	-0.006***	0.001	-0.008***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
25th Percentile	-0.005***	-0.004***	-0.007***	-0.006***	-0.005***	-0.005***	-0.006***	-0.005***	-0.008***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
50th Percentile	-0.005***	-0.006***	-0.008***	-0.006***	-0.007***	-0.008***	-0.006***	-0.007***	-0.009***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
75th Percentile	-0.025***	-0.020***	-0.013***	-0.006***	-0.013***	-0.015***	-0.026***	-0.021***	-0.014***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)
Maximum	-0.025***	-0.031***	-0.032***	-0.028***	-0.037***	-0.032***	-0.026***	-0.032***	-0.031***
	(0.002)	(0.003)	(0.006)	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.005)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A8: Sectoral Exports, Imports, Employment, and Labor/Output Ratios

Industry Name	*Industry Code*	*Exports (USD 1mil.)*	*Imports (USD 1mil.)*	*Employment (persons)*	*L/Out. Ratio (persons/USD 1mil.)*
				Germany	
Leather, Leather and Footwear	19	5,190.75	8,786.30	22,417.88	7.49
Wood and Products of Wood and Cork	20	6,424.55	4,778.83	126,709.76	6.02
Coke, Refined Petroleum, and Nuclear Fuel	23	1,343.72	2,024.04	20,386.22	0.25
Chemicals and Chemical Products	24	143,270.92	106,069.54	448,357.59	2.52
Rubber and Plastics	25	37,600.11	27,966.08	396,699.00	5.47
Other Non-Metallic Minerals	26	12,319.80	7,631.25	228,077.56	5.33
Machinery Nec.	29	131,283.17	55,063.42	1,127,716.90	4.34
Food, Beverages, and Tobacco	1516	50,472.75	43,839.48	861,626.31	5.16
Textiles and Textile Products	1718	19,775.41	34,178.07	145,228.88	6.19
Pulp, Paper, Printing and Publishing	2122	30,867.25	20,858.28	492,218.66	5.21
Basic Metals and Fabricated Metal	2728	77,356.54	58,685.55	1,079,957.00	4.37
Electrical and Optical Equipment	3033	137,036.67	108,713.60	1,024,399.60	4.70
Transport Equipment	3435	164,187.86	84,165.40	944,475.00	2.49
Manufacturing, Nec.; Recycling	3637	105,113.42	103,040.91	244,647.30	5.58
				United States of America	
Leather, Leather and Footwear	19	2,351.83	23,364.77	28,096.88	11.95
Wood and Products of Wood and Cork	20	7,914.45	8,389.16	359,638.47	4.86
Coke, Refined Petroleum, and Nuclear Fuel	23	4,495.04	4,966.82	117,075.64	0.25
Chemicals and Chemical Products	24	134,892.10	138,516.59	850,622.75	1.42
Rubber and Plastics	25	26,073.29	40,518.45	648,054.25	3.89
Other Non-Metallic Minerals	26	7,614.78	10,307.61	396,554.66	4.45
Machinery Nec.	29	86,159.50	96,811.59	1,054,470.30	3.83
Food, Beverages, and Tobacco	1516	43,680.54	49,736.73	1,722,984.60	2.27
Textiles and Textile Products	1718	7,471.35	75,381.99	429,845.63	7.97
Pulp, Paper, Printing and Publishing	2122	27,770.91	22,982.35	1,500,357.80	3.66
Basic Metals and Fabricated Metal	2728	57,460.91	75,954.10	1,687,341.80	3.60
Electrical and Optical Equipment	3033	163,405.92	210,511.38	1,717,203.90	3.58
Transport Equipment	3435	60,002.31	137,957.13	1,380,865.50	2.35
Manufacturing, Nec.; Recycling	3637	128104.86	122255.36	685.10	5.50

Note: Sectoral export and import figures are from COMTRADE and measured in millions of USD at current prices. Employment and output figures are from the World Input Output Database Socio-Economic Accounts and measured in units and millions of USD at current prices, respectively. Labor to output ratios are based on own calculations and measured as employees per USD1 million of output at current prices. All figures refer to year 2009.

Table A9: Linear 5-, 8-, and 12-Year Lagged Environmental Stringency Differentials and the Marginal Effects of IEA Ratification

Pollutant:	*5-Year Lagged Ratification Differential*			*8-Year Lagged Ratification Differential*			*12-Year Lagged Ratification Differential*		
	$DIRTY$	CO_2	$PC1$	$DIRTY$	CO_2	$PC1$	$DIRTY$	CO_2	$PC1$
Econ. Integration	0.137^{***}	0.136^{***}	0.137^{***}	0.136^{***}	0.136^{***}	0.136^{***}	0.136^{***}	0.136^{***}	0.136^{***}
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
d(IEA)	-0.016^{***}	0.009	-0.018^{***}	-0.015^{***}	0.017^{***}	-0.019^{***}	-0.015^{***}	0.025^{***}	-0.020^{***}
	(0.001)	(0.007)	(0.001)	(0.001)	(0.007)	(0.001)	(0.001)	(0.007)	(0.001)
d(IEA) × D_s	-0.008^{***}	-0.005^{***}	-0.000	-0.012^{***}	-0.006^{***}	-0.001	-0.015^{***}	-0.008^{***}	-0.002^{**}
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
lag d(IEA)	0.015^{***}	0.056^{***}	0.010^{***}	0.019^{***}	0.059^{***}	0.014^{***}	0.030^{***}	0.067^{***}	0.025^{***}
	(0.001)	(0.006)	(0.001)	(0.001)	(0.007)	(0.001)	(0.002)	(0.010)	(0.002)
lag d(IEA) × D_s	-0.017^{***}	-0.008^{***}	-0.004^{***}	-0.016^{***}	-0.008^{***}	-0.004^{***}	-0.013^{***}	-0.007^{***}	-0.004^{***}
	(0.002)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.003)	(0.002)	(0.001)
Obs.	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630	3,042,630
Adj. R-Squared	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245	0.245
Country × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Pair × Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Short-Run Marginal Effects									
Minimum	-0.016^{***}	-0.012^{***}	-0.018^{***}	-0.015^{***}	-0.011^{***}	-0.017^{***}	-0.015^{***}	-0.010^{***}	-0.017^{***}
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
25^{th} Percentile	-0.016^{***}	-0.015^{***}	-0.018^{***}	-0.015^{***}	-0.015^{***}	-0.017^{***}	-0.015^{***}	-0.015^{***}	-0.017^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
50^{th} Percentile	-0.016^{***}	-0.016^{***}	-0.018^{***}	-0.015^{***}	-0.016^{***}	-0.018^{***}	-0.015^{***}	-0.016^{***}	-0.018^{***}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
75^{th} Percentile	-0.024^{***}	-0.023^{***}	-0.018^{***}	-0.027^{***}	-0.024^{***}	-0.019^{***}	-0.030^{***}	-0.027^{***}	-0.021^{***}
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)
Maximum	-0.024^{***}	-0.028^{***}	-0.020^{***}	-0.027^{***}	-0.032^{***}	-0.025^{***}	-0.030^{***}	-0.035^{***}	-0.031^{***}
	(0.002)	(0.003)	(0.005)	(0.002)	(0.003)	(0.006)	(0.002)	(0.003)	(0.005)
Long-Run Marginal Effects									
Minimum	-0.001	0.008^{***}	-0.002	0.004^{**}	0.014^{***}	0.003^{*}	0.014^{***}	0.025^{***}	0.014^{***}
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
25^{th} Percentile	-0.001	0.000	-0.003^{**}	0.004^{**}	0.005^{***}	0.002	0.014^{***}	0.016^{***}	0.013^{***}
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
50^{th} Percentile	-0.001	-0.003^{*}	-0.005^{***}	0.004^{**}	0.002	0.000	0.014^{***}	0.013^{***}	0.011^{***}
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
75^{th} Percentile	-0.026^{***}	-0.019^{***}	-0.012^{***}	-0.024^{***}	-0.016^{***}	-0.008^{***}	-0.014^{***}	-0.007^{***}	0.002
	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)
Maximum	-0.026^{***}	-0.034^{***}	-0.037^{***}	-0.024^{***}	-0.032^{***}	-0.038^{***}	-0.014^{***}	-0.024^{***}	-0.031^{***}
	(0.002)	(0.003)	(0.006)	(0.003)	(0.003)	(0.007)	(0.003)	(0.004)	(0.009)

Note: Standard errors are shown in parentheses and clustered at the exporter-importer-industry level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.