On the Environmental Consequences of Intra-Industry Trade

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April 11, 2015

Abstract
In the trade and environment debate, the relevance of intra-industry trade (IIT) cannot be overemphasized. However, an empirical analysis of the environmental implications of such trade is long overdue. Although a number of studies have largely found overall trade to be pro-environment, the consequences of IIT may differ due to lower adjustment costs, easier technology absorption, and a distinct composition effect. In this light, we provide the first empirical investigation of IIT's impact on the environment. Apart from utilizing data on eight environmental indicators from roughly 200 countries over 2000-2005, we also attend to concerns over endogeneity by instrumenting for our trade and income variables. Across several sets of instruments, we consistently find (i) IIT to typically benefit the environment, (ii) overall trade to be less pro-environment than IIT, and (iii) concerns over endogeneity to be relevant.

JEL: C31, F18, Q56
Keywords: Intra-Industry Trade, Environmental Quality, Instrumental Variables

*The author is very grateful to Daniel Millimet for helpful comments. The author also wishes to thank conference participants at the Spring 2015 Midwest Economic Theory and International Trade Meetings. Corresponding author: Jayjit Roy, Department of Economics, Appalachian State University, Boone, NC 28608. Tel: (828) 262 6242. Fax: (828) 262 6105. E-mail: royj@appstate.edu.

1 Introduction

According to Antweiler et al. (2001, p. 877), the debate pertaining to the environmental effects of international trade "has at times generated more heat than light." While a number of studies have shed some light on the impact of overall trade on the environment, the environmental implications of intra-industry trade (IIT), i.e., trade in product lines within a sector, are relatively unexplored. However, the relevance of this issue cannot be overemphasized. Over the last few decades, much of the growth in international trade has been characterized by IIT sometimes involving pollution-intensive industries (Cole and Elliott 2003; Fung and Maechler 2005). Moreover, both industrialized and developing countries have witnessed this phenomenon (e.g., Balassa 1986; Kandogan 2003). While some of the expansion in IIT is attributable to commerce in differentiated final goods, trade in parts and components is responsible too (e.g., Greenaway and Milner 1987; Cabral et al. 2013). Interestingly, recent decades have also witnessed an increase in greenhouse gas emissions, climate change, land degradation, greater energy consumption, and reduced forest area (WTO and UNEP 2009; UNEP 2011). Thus, in the context of the relationship between trade and the environment, the role of IIT merits greater attention. In fact, an empirical examination of the IIT-environment nexus is long overdue.

The existing literature analyzing the effect of trade on the environment has typically decomposed the former's impact into scale, composition, and technique effects.[1] Briefly, the scale effect pertains to the *ceteris paribus* impact of trade on the volume of production and thereby the environment. The composition effect instead arises from trade's influence on the output mix (i.e., polluting versus non-polluting goods). Also, the technique effect refers to the environmental impact of a trade-induced demand for clean production technology.[2] Although the empirical contributions to this literature have mostly uncovered a beneficial impact of trade, the significance of IIT warrants further investigation due to several reasons. First, trade-induced adjustment costs arising due to the allocation of resources from import-competing to exporting sectors are likely to be smaller in case of IIT. Referred to as the Smooth Adjustment Hypothesis (e.g., Fung and Maechler 2005; Brülhart et al. 2006; Cabral and Silva 2006), this may facilitate the adoption of environmentally friendly production methods. Second, while international trade is a channel for transfer of technology from industrial to relatively less developed countries (e.g., Grossman and Helpman 1991; Keller 2004; Yasar and Paul 2007), according to Hakura and Jaumotte (1999, p. 3), IIT is expected to

[1] Copeland and Taylor (2004) and Kirkpatrick and Scrieciu (2008) provide reviews of the literature. Also, see Millimet and Roy (2014b).

[2] In a model of heterogeneous firms producing a differentiated good, Kreickemeier and Richter (2014) consider a reallocation effect arising due to trade-induced expansion of more efficient (and less polluting) firms. Also, allowing for IIT, McAusland and Millimet (2013) discuss trade's decoupling as well as variety-induced income and substitution effects.

be "more effective for technology transfer because countries are more likely to absorb foreign technologies when their imports are from the same sectors as the products they produce and export." Again, this may encourage the use of less polluting production techniques. Third, intuitively, the composition effect of trade is potentially sensitive to the extent of IIT. In other words, it seems plausible that changes in output mix across and within industries have different environmental consequences.

However, identification of the causal effect of IIT on the environment is not trivial due to the potential endogeneity of IIT attributable to two factors. First, unobservables such as environmental stringency and interest group influence are likely to be correlated with environmental quality as well as IIT. For instance, while theoretical studies such as Gürtzgen and Rauscher (2000), Haupt (2000), and Haupt (2006) find environmental regulation to alter the variety of goods traded, Cole and Elliott (2003) resort to empirics and conclude that IIT is influenced by environmental stringency. In addition, given the Pollution Haven Hypothesis, regulation is likely to impact foreign direct investment (e.g., Levinson and Taylor 2008; Kellenberg 2009; Millimet and Roy 2014a) and thereby IIT. Similarly, while liberalization favoring IIT is expected to face less political opposition (Grimwade 2001; Hoekman and Kostecki 2009), political pressure groups are also likely to affect environmental quality (e.g., Bernauer and Koubi 2009; Millimet 2014).

Second, a variable capturing the degree of IIT is potentially measured with error. According to Greenaway and Milner (1983, p. 900), "there are considerable difficulties associated with the computation of a meaningful summary statistic of the importance of intra-industry trade." For example, a measure of IIT is likely to be sensitive to the level of aggregation in the data. Interestingly, Gullstrand (2002, p. 322) states: "On the one hand, we ought to choose a rather refined product group in order to minimize IIT based on a classification system that groups products with very different factor content ... On the other hand ... a too refined product level, which separates varieties, may lead to downward bias" in IIT. Moreover, as discussed below, countries may not report some of their detailed trade (e.g., Carrère and Grigoriou 2014) and data on imports and exports may be expressed differently, i.e., cost, insurance, and freight (CIF) versus free on board (FOB). In fact, for a bounded measure of IIT, the error is likely to be nonclassical (e.g., Millimet 2011).

Before proceeding, it is worth noting that there exists a fairly sizeable literature analyzing the causal impact of overall trade intensity or openness on the environment. For instance, Frankel and Rose (2005) utilize cross-country data from 1990 and fail to uncover a harmful causal effect of trade on outcomes such as concentrations of sulfur dioxide (SO_2) and particulate matter, carbon dioxide (CO_2) emissions, access to clean water, and deforestation rate. Similarly, Chintrakarn and Millimet (2006) also obtain evidence of a beneficial causal effect upon examining (U.S.) subnational data. However, they find factors such as the effect's timing and the type of pollutant to be relevant. More recently, according to Managi et al. (2009), the environmental implications of openness also vary across OECD and non-OECD countries. Further, McAusland and Millimet (2013) posit that international trade is likely to be more pro-environment than intranational trade. Apart from providing a theoretical model, the authors use data across U.S. states and Canadian provinces to identify a beneficial (harmful) causal effect of international (intranational) trade on the environment. In addition, a number of studies examine the environmental consequences of openness by focusing exclusively on outcomes such as energy usage (Cole 2006; Chintrakarn 2013) and deforestation rate (Tsurumi and Managi 2014). Now, most of these studies typically control for income and treat both trade intensity and income as endogenous.[3] Accordingly, as discussed below, we consider IIT as well as openness and income to be endogenous.

The IIT-environment nexus has not been entirely neglected in the literature on trade and the environment. Apart from McAusland and Millimet (2013) and Kreickemeier and Richter (2014) (see footnote 2), some theoretical contributions discuss the environmental consequences of IIT. For example, Fung and Maechler (2005, 2007) examine the impact of IIT arising from strategic interactions between polluting firms under oligopoly. Further, Benarroch and Weder (2006) and Swart (2013) allow for IIT in polluting and non-polluting intermediate goods and analyze its effect on pollution; in their models, pollution arises during final good production. More recently, Benarroch and Gaisford (2014) discuss the environmental implications of trade liberalization in a model of monopolistic competition. However, to our knowledge, the impact of IIT on environmental quality is yet to be empirically analyzed.[4]

In this light, we contribute to the trade and environment debate by providing the first empirical study to examine the environmental implications of IIT. For our purpose, we utilize data on eight indicators of environmental quality from roughly 200 countries over the period 2000-2005. Further, due to the potential endogeneity of the trade and income variables, we resort to a Generalized Method of Moments (GMM) approach and instrument for them. Using eight sets of instruments, we arrive at striking results. First, IIT is typically pro-environment. Second, in comparison to overall trade, IIT has a more favorable effect on the environment. Again, this is plausible due to lower adjustment costs and easier technology absorption in case of IIT. Third, while the concerns over endogeneity are relevant, our results are fairly consistent across the instrument sets.

The rest of the paper is organized as follows. Section 2 describes the empirical methodology. Section 3 discusses the data. Section 4 presents the results, while Section 5 concludes.

[3] Frankel and Rose (2005) and Chintrakarn and Millimet (2006) discuss the endogeneity of openness and per capita income succinctly.

[4] That said, McAusland and Millimet (2013) use data across U.S. states and Canadian provinces and note that IIT is the dominant form of trade between industrialized nations. Also, while examining the impact of trade on the environment, Aralas and Hoehn (2010) control for the number of firms (or varities) per square kilometer.

2 Empirical Methodology

To examine the effect of IIT on the environment, we begin with a specification motivated by Frankel and Rose (2005) and Chintrakarn and Millimet (2006). Thus, the estimating equation is given by

$$Z_{it} = \beta_1 TRADE_{it} + \beta_2 IIT_{it} + \beta_3 \ln (Y/POP)_{it} + \beta_4 [\ln (Y/POP)]^2_{it} + S_{it}\theta + \varepsilon_{it} \tag{1}$$

where i indicates country, t denotes year, Z is a measure of environmental quality, $TRADE$ represents trade intensity or openness, IIT captures trade that is intra-industry, Y denotes gross domestic product (GDP), POP represents population, and S is a vector of observable attributes.[5] S includes (log) per capita land area as a measure of population density, a polity score, and year-specific dummies. The unobservables are denoted by ε and consist of all remaining factors affecting environmental quality. While we are unable to include country fixed effects due to insufficient variation in the data, we anyway resort to an instrumental variables (IV) approach. Also, the fixed effects would not address endogeneity arising due to measurement error and time-varying unobservables such as environmental policy and political attributes.

As discussed above, trade intensity, IIT, and GDP per capita are likely to be endogenous. Accordingly, we adopt a GMM approach and instrument for these variables. In keeping with the existing literature, to derive some of the instruments we begin by estimating a gravity model of trade given by

$$M_{ijt} = \delta_{it}\delta_{jt} \exp (W_{ijt}\eta)\, u_{ijt}. \tag{2}$$

Here, M_{ijt} is the (real) value of imports of country i from country j in year t, W_{ijt} is a vector of observable attributes, δ_{it} and δ_{jt} are country-by-time fixed effects controlling for multilateral resistance (Anderson and van Wincoop 2003), and u_{ijt} is an error term.[6,7] The following covariates are included in W: (log) distance between i and j, a binary indicator assuming the value unity if i and j are contiguous, a dummy variable taking the value one if i and j share a common language, a binary variable denoting whether i and j have ever been in a colonial relationship, an indicator for a country-pair having a common colonizer, and a binary variable depicting current colonial relationship between i and j in year t.[8] Following Santos Silva and Tenreyro (2006) and Henderson and Millimet (2008), the gravity model is estimated in levels using a Poisson pseudo-maximum likelihood estimator. For any country-year combination, the predicted values of bilateral trade are then aggregated across trading partners to obtain predicted trade intensity which is used as one of the instruments.

[5] The specification is reminiscent of the environmental Kuznets curve (e.g., Millimet et al. 2003; Copeland and Taylor 2004).

[6] The country-by-time dummies also control for country-specific factors that vary over time but not across trading partners.

[7] As discussed below, all real values are in 2005 dollars.

[8] See Anderson (2011) and Head and Mayer (2014) for a review of the gravity model.

Similarly, in order to arrive at predicted values of IIT, the first-stage is obtained from

$$BIIT_{ijt} = R_{ijt}\tau + \nu_{ijt} \tag{3}$$

where $BIIT_{ijt}$ denotes the extent of bilateral IIT between countries i and j during t and R_{ijt} and ν_{ijt} are its observable and unobservable determinants, respectively. Although Greenaway et al. (1999, p. 365) contend that the "empirical literature on intra-industry trade ... has failed to throw up a wholly conclusive set of determinants" of IIT, our choice of variables in R is motivated by studies such as Hummels and Levinsohn (1995), Bergstrand and Egger (2006), and Cabral et al. (2013). For instance, we include the minimum and maximum of (log) real GDPs of i and j in R to control for relative size. Similarly, (log) absolute value of the difference in real GDP per capita of i and j, (log) absolute difference in real capital-to-labor ratios, and (log) absolute difference in land areas per capita are also included to capture differences in endowments. In addition, R also consists of the trade cost variables in W above and time-specific dummies. Again, for any country in a year, the predicted values of bilateral IIT are averaged across partner countries to arrive at predicted IIT which is used as one of the instruments. Here, we employ a weighted average. In order to obtain country i's predicted IIT in a year, each predicted bilateral IIT value involving i is weighted by the sum of i's corresponding (predicted) bilateral imports and exports relative to the sum of i's (predicted) overall imports and exports.[9]

Next, the first-stage equations for GDP per capita and GDP per capita squared are specified as the following:

$$\ln (Y/POP)_{it} = Q_{it}\lambda + \zeta_{it}, \tag{4}$$

$$[\ln (Y/POP)]^2_{it} = Q_{it}\kappa + \phi_{it}, \tag{5}$$

where Q is comprised of predicted trade intensity, predicted IIT, the attributes included in S above, and variables such as the percent of working-age population or the age dependency ratio, the growth rate of population, the investment share of GDP, and some squared and interaction terms (discussed below); ζ and ϕ represent the unobervables. Apart from predicted IIT, the exclusion restrictions in Q are mostly in consonance with inquiries such as Frankel and Rose (2005) and Chintrakarn and Millimet (2006). Additionally, age dependency ratio is likely to affect GDP via productivity (e.g., Lin and Liscow 2013).

3 Data

The data are obtained from a number of sources. First, the information on environmental indicators come from the Quality of Government Institute's *Quality of Government Dataset* as well as the World Bank's

[9] The weights are normalized to sum to one.

World Development Indicators where the former contains data from sources such as the *Environmental Performance Index* (Esty et al. 2008). In addition, some of the information on environmental performance are obtained from the *Socioeconomic Data and Applications Center* (Smith et al. 2011) and *Gapminder World*.[10] Second, the data on population density, polity score, GDP per capita, age dependency ratio, population growth, and investment come primarily from the *World Development Indicators* and the *Quality of Government Dataset* which in turn rely on sources such as the *Polity IV Project* (Marshall et al. 2011). Moreover, the *Penn World Table* (Feenstra et al. 2013) is also consulted. Third, the data on gravity regressors are obtained from CEPII.[11] Finally, all of the trade data come from the *United Nations Commodity Trade Database* (UN Comtrade).[12]

Using the data, trade intensity or openness of country i in period t is defined as

$$TRADE_{it} = \frac{X_{it} + M_{it}}{GDP_{it}} \tag{6}$$

where X_{it} (M_{it}) is the total value of i's exports (imports) aggregated across partner countries. Moreover, the Grubel-Lloyd index (adjusted for trade balance) is employed to capture the extent of IIT. As explained in Grubel and Lloyd (1971), the measure varies between 0 and 1 with higher values indicating greater IIT. A number of studies such as Bernhofen and Hafeez (2001, p. 80) consider the Grubel-Lloyd index to be "the workhorse measure of intra-industry trade." In order to arrive at country i's index of IIT, the Grubel-Lloyd index for country i during t is obtained as

$$IIT_{it} = \frac{\sum\limits_k (X_{kit} + M_{kit}) - \sum\limits_k |X_{kit} - M_{kit}|}{\sum\limits_k (X_{kit} + M_{kit}) - \left|\sum\limits_k X_{kit} - \sum\limits_k M_{kit}\right|} \tag{7}$$

where k indexes industries.[13] Similarly, the degree of bilateral IIT between countries i and j in t is constructed as

$$BIIT_{ijt} = \frac{\sum\limits_k (X_{kijt} + M_{kijt}) - \sum\limits_k |X_{kijt} - M_{kijt}|}{\sum\limits_k (X_{kijt} + M_{kijt}) - \left|\sum\limits_k X_{kijt} - \sum\limits_k M_{kijt}\right|} \tag{8}$$

[10] See http://www.gapminder.org/data/.

[11] See http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8. Note that the distance measure is population-weighted and the common language indicator is defined with respect to official language.

[12] The data sources were accessed in August 2014.

[13] In (7), the triangle inequality implies that $\left|\sum\limits_k X_{kit} - \sum\limits_k M_{kit}\right| \leq \sum\limits_k |X_{kit} - M_{kit}|$. However, for some observations, $\left|\sum\limits_k X_{kit} - \sum\limits_k M_{kit}\right|$ exceeded $\sum\limits_k |X_{kit} - M_{kit}|$. Accordingly, the second terms in the numerator and denominator are replaced by $\max\left\{\sum\limits_k |X_{kit} - M_{kit}|, \left|\sum\limits_k X_{kit} - \sum\limits_k M_{kit}\right|\right\}$ and $\min\left\{\sum\limits_k |X_{kit} - M_{kit}|, \left|\sum\limits_k X_{kit} - \sum\limits_k M_{kit}\right|\right\}$, respectively. Moreover, the final results are qualitatively unchanged upon dropping these observations.

where X_{kijt} (M_{kijt}) is the value of i's exports to (imports from) j in industry k.[14]

Prior to proceeding, some comments pertaining to the UN Comtrade data as well as the trade measures are necessary.[15] First, imports and exports in UN Comtrade are recorded CIF and FOB, respectively.[16] Now, import data are generally considered to be more reliable than data on exports (e.g., Feenstra 2000; Brülhart 2009). Also, for calculating the extent of IIT, Grubel and Lloyd (1971) recommend measuring both imports and exports CIF or FOB. Accordingly, the trade measures in this study are primarily constructed from (bilateral) import data. For any country, the value of aggregate imports is obtained as the sum of its imports from partner countries. Similarly, a country's overall exports is derived from the total value of its goods imported by partner countries. These aggregate values are then used to calculate trade intensity. In cases where information on imports is missing, the corresponding export data are utilized whenever available. Moreover, even while calculating the Grubel-Lloyd indexes from disaggregate data, (bilateral) import values are relied upon to the extent possible.[17]

Second, the IIT indexes are constructed using data classified at the four-digit level of the Standard International Trade Classification (Revision 2).[18] Third, Grubel and Lloyd (1971, p. 497) also discuss an index (unadjusted for trade balance) but consider it to be "biased downward" and sensitive to both "trade imbalance and ... intra-industry trade." In addition, Egger et al. (2008) and Bergstrand and Egger (2006, p. 455), among others, remind that "the use of bilateral trade-imbalance-adjusted" index is often "preferable over unadjusted ones." Accordingly, we focus on the adjusted index. Fourth, some analyses pertaining to IIT restrict attention to manufacturing industries (e.g., Bernhofen and Hafeez 2001; Van Biesebroeck 2011; de Boyrie and Kreinin 2012). However, in keeping with studies such as Evenett and Keller (2002) and Brülhart (2009), we do not restrict the trade data to manufacturing sectors while constructing the Grubel-Lloyd index.

[14] For a very few observations, $\left|\sum_k X_{kijt} - \sum_k M_{kijt}\right|$ exceeded $\sum_k |X_{kijt} - M_{kijt}|$. Thus, again, the second terms in the numerator and denominator are replaced by $\max\left\{\sum_k |X_{kijt} - M_{kijt}|, \left|\sum_k X_{kijt} - \sum_k M_{kijt}\right|\right\}$ and $\min\left\{\sum_k |X_{kijt} - M_{kijt}|, \left|\sum_k X_{kijt} - \sum_k M_{kijt}\right|\right\}$, respectively.

[15] The ensuing discussion further highlights the issue of measurement error with respect to IIT.

[16] See http://comtrade.un.org/db/help/uReadMeFirst.aspx as well as Bergstrand et al. (2013). While the trade data are in current dollars, the US GDP deflator is used to used to express values in 2005 dollars.

[17] With respect to measuring IIT, Gullstrand (2002, p. 321) opines that "to minimize the biases due to geographical aggregation, bilateral trade flows are to be preferred over multilateral trade flows."

[18] A number of studies such as Evenett and Keller (2002), Egger et al. (2008), and Foster and Stehrer (2011) use four-digit data to compute the Grubel-Lloyd index. Also, note that countries may not report some of their detailed trade and the commodity classification system adopted may differ across countries; see http://comtrade.un.org/db/help/uReadMeFirst.aspx. Thus, our choice of the classification system and the aggregation level is also aimed at including most countries listed in Comtrade.

Fifth, some studies examining the determinants of IIT distinguish between horizontal and vertical types of the latter by calculating unit values of imports and exports (e.g., Greenaway et al. 1994, 1999; Kandogan 2003; Cabral et al. 2013). Intuitively, as discussed in Abd-el-Rahman (1991, p. 88), "comparable export and import unit values for a given product is synonymous with the comparable quality of exported and imported products." However, given the relatively incomplete data on quantities, we do not make this distinction. Thus, in keeping with Bergstrand and Egger (2006), Brülhart (2009), and others, we focus on overall IIT.

Sixth, the trade data at Comtrade are unavailable or incomplete for some countries over the sample period (e.g., Fontagné et al. 2006). For example, countries such as Afghanistan or Democratic Republic of the Congo do not report their imports or exports. For such countries, the import and export values are obtained from their partners' trade statistics.[19] Moreover, as discussed in Carrère and Grigoriou (2014, p. 1), it is also worth noting that trade data may be subject to "deliberate misreporting ... through misevaluation or misclassification ... to evade tariffs and taxes." Finally, we consider a substantially greater number of countries than the majority of existing research on the determinants and effects of IIT (e.g., Durkin Jr and Krygier 2000; Bernhofen and Hafeez 2001; Kandogan 2003; Bergstrand and Egger 2006; Egger et al. 2008).

Our data include roughly 200 countries for the years 2000 to 2005 and the summary statistics are presented in Table 1. While the average value of international trade intensity is consistent with the existing literature (e.g., Frankel and Rose 2005; Managi et al. 2009), the index of IIT values are also reasonable. Moreover, in keeping with the existing literature on trade and the environment, we analyze eight measures of environmental quality. Although the variable names are self-explanatory, a few comments are warranted. First, particulate matter refers to suspended particulates less than 10 microns in diameter (i.e., PM10). Second, access to improved water source denotes the percentage of (total and rural) population using improved drinking water sources. Third, the definition of deforestation rate follows from Tsurumi and Managi (2014) and is given by the difference between lagged and current forest area relative to lagged forest area. Fourth, age dependency ratio is the number of people older than 64 per 100 individuals between 15 and 64. Fifth, the combined polity score ranges from -10 to 10 (i.e., from strongly autocratic to strongly democratic).

Before turning to the main results, the first-stage estimates merit some attention. The estimates displayed in Table 2 pertain to the gravity equation in (2) and are broadly consistent with the existing

[19] Although Feenstra et al. (2005) suggest otherwise, the trade data disseminated by UN Comtrade are not based on a minimum threshold value of trade; see http://unstats.un.org/unsd/tradekb/Knowledgebase/World-Trade-Flows-19622000. Nonetheless, there are no observations with zero trade.

literature on the determinants of bilateral trade.[20] Next, Table 3 reports the estimates corresponding to the determinants of bilateral IIT in (3).[21] Here, given the dependent variable, the coefficient estimates are not counterintuitive. For example, in keeping with existing studies such as Kandogan (2003), Bergstrand and Egger (2006), and Cabral et al. (2013), one might expect distance to discourage IIT. However, according to Venables et al. (2003, p. 1), "differentiated products have lower price elasticities of demand (almost by definition), so any costs arising from distance will choke off trade *less* fast for these products, in which case intra-industry trade might be positively correlated with distance." Similarly, Zhang et al. (2005, p. 532) opine that "geographical distance ... has a significant and positive impact" on IIT.

In addition, it is worth noting that the extant literature has typically restricted attention to a few countries only. For instance, Greenaway et al. (1999, p. 365) focus "on a set of similar industrial countries." Similarly, while Durkin Jr and Krygier (2000) examine the U.S. and OECD partner countries, Bergstrand and Egger (2006) focus only on the latter. Moreover, Cabral et al. (2013) and Thorpe and Leitão (2013) focus on the EU and the U.S., respectively, along with their major trading partners. The results in Table 3 should also be viewed in light of the fact that some of the coefficient estimates are likely to differ across horizontal and vertical IIT (e.g., Kandogan 2003; Zhang et al. 2005; Cabral et al. 2013) and between manufacturing and non-manufacturing countries (e.g., Stone and Lee 1995). That said, our findings are somewhat consistent with the extant literature. For example the estimate pertaining to the difference in real GDPs per capita is in tune with Helpman (1987). Also, the coefficient estimate with respect to the difference in capital-to-labor ratios is in consonance with the findings in Gullstrand (2002).

[20] Note that the gravity model is estimated on a set of countries for which the trade data are available regardless of the information on environmental quality.

[21] Note that (3) is estimated using Ordinary Least Squares (OLS). While some studies in the extant literature resort to a logistic transformation of the dependent variable (e.g., Hummels and Levinsohn 1995; Bergstrand and Egger 2006), it entails omitting observations with Grubel-Lloyd indexes equal to zero or one. Moreover, in case of such a transformation, interpretation of the coefficient estimates is not trivial (Papke and Wooldridge 1996). Also, our OLS predicted values are mostly between zero and one with about 0.5% of the values outside this interval; these values are disregarded while calculating the predicted IIT. Nonetheless, we also estimated a fractional logit model (e.g., Lee and Han 2008) following Baum (2008). While the results are available upon request, the predicted values across the two specifications were found to be strongly correlated. Also, see Zhang et al. (2005).

4 Results

4.1 Trade Intensity

Prior to discussing the relationship between IIT and the environment, in Table 4, we revisit the impact of trade intensity on the environment without controlling for the degree of IIT.[22] This is a useful staring point given the existing literature on trade and the environment. Apart from estimating an Ordinary Least Squares (OLS) model, due to concerns over endogeneity of trade intensity, GDP per capita, and GDP per capita squared, we resort to eight sets of instruments referred to as IV Set #1, IV Set #2, ..., IV Set #8 in Table 4. As discussed in Murray (2006, p. 118), obtaining "similar results from alternative instruments enhances the credibility of instrumental variable estimates." All the sets include predicted trade intensity as well as age dependency ratio as instruments. Moreover, the first two sets include only one instrument in addition to predicted trade intensity and age dependency ratio thereby yielding exactly identified models. Thus, IV Set #1 and IV Set #2 also include investment share of GDP and population growth, respectively. The remaining sets consist of four instruments each and lead to overidentified models. IV Set #3, IV Set #4, and IV Set #5 are obtained after adding population growth, age dependency ratio squared, and the interaction between investment share of GDP and age dependency ratio, respectively, to IV Set #1. Upon adding age dependency ratio squared, population growth squared, and the interaction between population growth and age dependency, to IV Set #2, we arrive at IV Set #6, IV Set #7, and IV Set #8, respectively.

In Panels A and B, the dependent variables are (log) emissions of CO_2 and SO_2, respectively. While the results in Panel C pertain to (log) concentration of PM10, Panel D displays the estimates in case of (log) energy usage. Panel E (Panel F) considers percent of overall (rural) population with improved water access as the dependent variable. Moreover, the results corresponding to percent of forest area and deforestation rate are displayed in Panels G and H, respectively.

Now, across all dependent variables, the OLS results find openness to be associated with improved environmental quality. Also, most of the coefficient estimates are statistically significant at the $p < 0.01$ level of confidence. In other words, trade is associated with reduced emissions of CO_2 and SO_2 as well as less energy usage and concentration of PM10. Moreover, while the estimates pertaining to improved water access and forest area are positive, the association with deforestation rate is negative. In addition, trade intensity, per capita income, and per capita income squared are jointly significant at the $p < 0.01$ level in all cases. Nonetheless, we refrain from putting too much stock in the results obtained under exogeneity.

Turning to the GMM estimates, our instrument sets mostly fare well in terms of the usual IV specification tests. In other words, the Kleibergen-Paap (2006) rk statistic always rejects the null of underidenti-

[22] For brevity, coefficient estimates of the other regressors are not reported. They are available upon request.

fication and the Kleibergen-Paap F-statistic is typically large. That said, in case of energy usage and SO_2 emissions, the instruments in IV Set #1 and IV Set #5 are relatively weak. Moreover, Hansen's J-test supports the validity of our instruments across a number of overidentified models. However, the validity of the exclusion restrictions is sometimes rejected. This is especially true in case of CO_2 emissions and rural water access. Also, the exogeneity of trade intensity, per capita income, and per capita income squared is typically rejected at conventional levels of significance except particularly in some cases pertaining to SO_2 emissions. In addition, the Anderson and Rubin (1949) test (robust to weak instruments) always confirms the endogenous regressors to be jointly significant at the $p < 0.01$ level of confidence.

Focusing on SO_2 emissions, the estimates obtained using GMM are similar to the OLS estimate. In all cases where our instruments pass the specification tests, a one percent increase in trade intensity for the average country reduces emissions by about 0.35%.[23] However, the estimates are quite imprecise. In case of CO_2 emissions, the GMM estimates that are statistically significant at conventional levels of significance are again similar to the OLS estimate. Moreover, the estimates pertaining to CO_2 are substantially smaller (in absolute value) than the corresponding estimates for SO_2. In fact, focusing on instruments that pass the specification tests, the coefficient estimate pertaining to IV Set #2 is statistically insignificant and thus, consistent with the findings in Frankel and Rose (2005). Nonetheless, two of the instrument sets find trade intensity to significantly reduce CO_2 emissions. For example, from IV Set #5, a one percent increase in openness reduces emissions by roughly 0.13%.

Similarly, the results pertaining to PM10 concentrations and energy usage indicate that trade benefits the environment. Also, all the coefficient estimates are significant at the $p < 0.01$ level of confidence. In case of PM10, the IV estimates are often slightly larger (in absolute value) than the estimate obtained under exogeneity. While the OLS estimate suggests a one percent increase in trade intensity to be associated with a reduction of about 0.07% in concentration levels, the IV results report a causal effect of nearly 0.1% reduction. Also, for favorable IV specification tests, a similar change in trade intensity reduces energy usage by up to 1.6%. Interestingly, the corresponding OLS estimate suggests a reduction of less than 1%.

Next, the remaining results in Table 4 also paint a pro-environment picture of trade. With respect to improved water access, the coefficient estimates are positive, statistically significant, and often larger for rural population. Moreover, in Panels E and F, the estimates obtained using GMM are at times nearly twice as large as the corresponding OLS estimates. Similarly, openness has a favorable impact on the percentage of land area under forest cover. Across all instances of credible instruments, the IV estimates are statistically significant and typically at least as large as the OLS estimate. While trade intensity also significantly discourages the rate of deforestation, the GMM and OLS estimates are markedly similar.

[23] The average value is obtained from Table 1.

4.2 IIT and Trade Intensity

The environmental impacts of IIT and trade intensity are displayed in Table 5. Here, we treat IIT, trade intensity, GDP per capita, and GDP per capita squared as endogenous. As in the case of Table 4, for each dependent variable, we report the OLS results followed by the GMM estimates pertaining to eight sets of instruments. Across Tables 4 and 5, each instrument set consists of the same variables except the inclusion of predicted Grubel-Lloyd index in all sets of Table 5. Thus, while IV Set #1 and IV Set #2 continue to depict exactly identified systems, the models corresponding to IV Set #3, IV Set #4, ..., IV Set #8 are overidentified.

Focusing on the OLS estimates, it is interesting to note that both IIT and openness are associated with improved environmental quality as measured by reduced SO_2 and CO_2 emissions, energy usage, and PM10 concentrations. In fact, the trade variables are also associated with improved water access and greater forest area. Moreover, most of the coefficient estimates are significant at conventional levels of significance. Interestingly, unlike trade intensity, IIT is associated with increased deforestation rate. However, the corresponding estimate is statistically insignificant. Nonetheless, across all dependent variables, IIT, trade intensity, per capita income, and per capita income squared are jointly significant at the $p < 0.01$ level. Again, instead of discussing the potentially biased OLS estimates in greater detail, we turn to the GMM results in Table 5.

Here, the IV specification tests mostly continue to lend credibility to our estimates and suggest that the concerns over endogeneity are warranted. With respect to SO_2, IIT is evidenced to significantly reduce emissions across all our models. A one percent change in the Grubel-Lloyd index reduces average SO_2 emissions by up to 6.8%.[24] While the IV estimates are similar across the instrument sets, they are larger (in magnitude) than the OLS effect. For a similar change in IIT, our OLS estimate suggests a reduction of less than 0.25%. However, across all instrument sets, the effect of trade intensity on SO_2 emissions is not significant. While we witnessed such statistical insignificance in Panel A of Table 4, here, the coefficient estimates have the opposite sign.

In the case of CO_2 emissions, we again find IIT to significantly benefit the environment. More precisely, a one percent change in IIT reduces CO_2 emissions by at least 5.9%. Strikingly, the estimates pertaining to openness are often positive and statistically significant. In fact, a one percent change in trade intensity increases CO_2 emissions by up to 0.4%. Thus, after accounting for the role of IIT, overall trade intensity is witnessed to have an adverse environmental impact.

The IV results corresponding to PM10 and energy usage continue to find IIT to improve environmental

[24] Again, the average value comes from Table 1.

quality. The point estimates are statistically significant at the $p < 0.01$ level as well. Focusing on estimates that pass the IV specification tests, a one percent change in the index of IIT reduces PM10 concentration (energy usage) by up to about 2% (6.5%). Contrarily, trade intensity is evidenced to significantly encourage PM10 concentration. While overall trade discourages energy usage, the statistically significant GMM estimates corresponding to openness are considerably smaller (in magnitude) than those pertaining to IIT. Hence, as with respect to CO_2 emissions, IIT is again indicated to have a more favorable impact on the environment than overall trade.

Similarly, in Panels E and F, IIT improves water access across all specifications. The estimates mostly pass the IV specification tests and are significant at the $p < 0.01$ level of confidence. However, the effect of trade intensity is often insignificant especially with respect to the percentage of total population. Among the significant estimates, openness is evidenced to adversely impact access to water (Panel F). Additionally, based on the coefficient estimates pertaining to forest area and deforestation rate, IIT is again confirmed to be more pro-environment than overall trade. While both the trade variables appear to encourage environmental quality as measured by forest area and deforestation rate, the estimates are statistically significant only in case of IIT. Moreover, in case of forest area, the estimates pertaining to IIT are substantially greater than the effects of overall trade.

Summarizing, while we find the concerns over endogeneity to be relevant, our GMM results are largely consistent across the sets of instruments. In specifications where we omit IIT, overall trade intensity typically improves environmental quality. This is consistent with the existing evidence in the trade and environment debate. However, after accounting for the role of IIT, we often fail to uncover a beneficial effect of overall trade. In fact, for some indicators, openness is found to have a detrimental effect on the environment. On the contrary, IIT is typically characterized by a positive impact on the environment. Also, whenever both the trade measures are suggested to favor the environment, the beneficial effect of IIT is witnessed to be greater. Thus, strikingly, we find IIT to be more pro-environment than overall trade.

5 Conclusion

According to Copeland (2005, p. 1), the "central question underlying much of the recent work on trade and the environment is how globalization affects environmental quality and the sustainability of renewable resources." Additionally, Melitz and Trefler (2012, p. 91) refer to IIT as a phenomenon currently dominating the "international trade landscape." In this light, the role of IIT in the trade and environment debate warrants attention. Although the existing literature has largely found overall trade to be pro-environment, the environmental implications of IIT may differ due to lower adjustment costs, easier technology absorption, and a distinct composition effect.

In this light, we contribute to the empirical literature on trade and the environment by providing the first study to analyze the causal effect of IIT on the environment. For our purpose, we utilize data on eight indicators of environmental quality from roughly 200 countries over the period 2000-2005. Moreover, due to concerns over endogeneity of the trade and income variables, we resort to a GMM approach and rely on eight sets of instruments. In specifications where we omit IIT, overall trade intensity is typically found to benefit the environment. Strikingly, after accounting for the role of IIT, we often fail to uncover a beneficial effect of overall trade. In fact, for some indicators, openness is evidenced to harm the environment. Contrarily, the impact of IIT on the environment is typically favorable. Also, whenever both the trade measures appear to improve environmental quality, IIT is characterized by a more beneficial impact. Thus, IIT is witnessed to be more pro-environment than overall trade. Interestingly, although the concerns over endogeneity are found to be relevant, our results are consistent across all the sets of instruments.

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Table 1. Summary Statistics.

Variable	N	Mean	SD
Trade Measures			
Trade Intensity	1171	0.777	1.998
Predicted Trade Intensity	1171	0.827	2.746
Grubel-Lloyd Index	1308	0.455	0.238
Predicted Grubel-Lloyd Index	907	0.398	0.135
Measures of Environmental Quality			
Sulfur Dioxide (metric tons)	855	682537.500	2566063.000
Carbon Dioxide (metric tons)	1275	121000000.000	526000000.000
Particulate Matter (micrograms per cubic meter)	1080	51.539	37.895
Energy Use (metric tons of oil equivalent)	862	71100000.000	237000000.000
Access to Improved Water Source (% of population)	1205	84.392	17.783
Access to Improved Water Source (Rural) (% of population)	1176	77.841	21.945
Forest Area (% of land area)	1182	31.677	23.981
Deforestation Rate	975	0.001	0.015
Controls			
Per Capita GDP (2005 US$)	1171	9818.577	14837.030
Per Capita Land Area	1200	0.080	0.515
Polity	959	3.210	6.550
Age Dependency Ratio (% of working-age population)	1116	10.903	6.618
Population Growth	1193	1.528	1.415
Investment (% of GDP)	1121	22.336	8.543

Table 2. Gravity Equation Results.

Variable	Coefficient	Standard Error
ln(Distance)	-0.844*	0.011
Common Language	0.174*	0.027
Contiguity	0.498*	0.028
Ever Colonial Relationship	-0.006	0.041
Current Colonial Relationship	1.491*	0.163
Common Colonizer	0.036	0.056

‡ $p<0.10$, † $p<0.05$, * $p<0.01$. N=164013. Estimation is performed by a Poisson pseudo-maximum likelihood estimator. Country-by-year dummies are included. Standard errors are heteroskedasticity-robust.

Table 3. Determinants of Bilateral Intra-Industry Trade.

Variable	Coefficient	Standard Error
Minimum ln(GDP)	-0.066*	0.001
Maximum ln(GDP)	-0.062*	0.001
ln(|Difference in Per Capita GDP|)	-0.017*	0.002
ln(|Difference in Capital-to-Labor Ratio|)	0.006*	0.002
ln(|Difference in Per Capita Land Area|)	0.002*	0.001
ln(Distance)	0.080*	0.002
Common Language	-0.064*	0.005
Contiguity	-0.024†	0.010
Ever Colonial Relationship	-0.110*	0.010
Current Colonial Relationship	0.281*	0.046
Common Colonizer	-0.067*	0.007

‡ $p<0.10$, † $p<0.05$, * $p<0.01$. N=37503. Year-specific dummies are included. Standard errors are heteroskedasticity-robust.

Table 4. Impact of Trade Intensity on Environmental Quality.

	OLS	IV Set #1	IV Set #2	IV Set #3	IV Set #4	IV Set #5	IV Set #6	IV Set #7	IV Set #8
Panel A. log(SO2)									
Trade Intensity	-0.439‡	-0.438	-0.451	-0.409	-0.377	-0.446	-0.427	-0.456	-0.491
	(0.251)	(0.365)	(0.346)	(0.337)	(0.315)	(0.352)	(0.327)	(0.300)	(0.329)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		8.166	12.784	19.660	35.440	8.199	25.531	19.336	15.759
Overid Test				0.601	0.383	0.248	0.490	0.002	0.001
Endogeneity		0.136	0.037	0.034	0.106	0.104	0.033	0.218	0.031
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	789	782	789	782	782	782	789	789	789
Panel B. log(CO2)									
Trade Intensity	-0.156*	-0.162†	-0.027	-0.063	-0.089	-0.169†	-0.053	-0.066	-0.029
	(0.056)	(0.070)	(0.105)	(0.084)	(0.078)	(0.067)	(0.095)	(0.096)	(0.105)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		17.449	22.972	40.447	72.872	16.294	47.079	42.668	31.142
Overid Test				0.008	0.046	0.690	0.037	0.000	0.065
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	947	940	947	940	940	940	947	947	947
Panel C. log(PM10)									
Trade Intensity	-0.095*	-0.082*	-0.127*	-0.114*	-0.117*	-0.109*	-0.126*	-0.119*	-0.127*
	(0.012)	(0.019)	(0.013)	(0.012)	(0.011)	(0.015)	(0.012)	(0.011)	(0.012)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		15.264	23.066	38.186	69.223	13.991	45.895	41.924	30.939
Overid Test				0.001	0.001	0.000	0.905	0.176	0.964
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	943	936	943	936	936	936	943	943	943
Panel D. log(Energy)									
Trade Intensity	-1.259*	-1.424*	-2.018*	-1.895*	-1.603*	-1.534*	-1.760*	-1.829*	-2.019*
	(0.195)	(0.355)	(0.262)	(0.243)	(0.228)	(0.306)	(0.230)	(0.244)	(0.259)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		5.633	11.508	18.269	34.605	6.227	25.245	15.321	12.539
Overid Test				0.125	0.529	0.549	0.001	0.000	0.051
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	792	785	792	785	785	785	792	792	792

‡ $p<0.10$, † $p<0.05$, * $p<0.01$. Standard errors in parentheses are heteroskedasticity-robust. Trade intensity, log (per capita GDP), and square of log (per capita GDP) are instrumented for using predicted trade intensity and variables such as age dependency ratio, growth rate of population, investment share of GDP, age dependency ratio squared, the interaction between investment share of GDP and age dependency ratio, population growth squared, and the interaction between population growth and age dependency. Underid Test reports the p-value of the Kleibergen-Paap (2006) rk statistic with rejection implying identification. F-stat reports the Kleibergen-Paap F statistic for weak identification. Overid Test displays the p-value of Hansen J statistic with rejection implying invalid instruments. Endogeneity reports the p-value of endogeneity test of the endogenous regressors. Joint Sign. Endog. displays the p-value of Anderson-Rubin (1949) chi-square test of endogenous regressors. Other covariates include: log (per capita land area), a polity score, and year-specific dummies. See text for further details.

Table 4 (cont.). Impact of Trade Intensity on Environmental Quality.

	OLS	IV Set #1	IV Set #2	IV Set #3	IV Set #4	IV Set #5	IV Set #6	IV Set #7	IV Set #8
Panel E. Improved Water Access (% Pop.)									
Trade Intensity	1.080*	0.672‡	2.185*	2.017*	2.056*	1.251*	2.034*	2.179*	2.161*
	(0.237)	(0.402)	(0.616)	(0.394)	(0.384)	(0.293)	(0.573)	(0.605)	(0.609)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		18.454	22.636	40.418	71.798	17.050	46.029	41.601	30.135
Overid Test				0.000	0.000	0.030	0.221	0.959	0.797
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	945	938	945	938	938	938	945	945	945
Panel F. Improved Water Access (% Rural)									
Trade Intensity	1.254*	1.409*	2.841*	2.616*	2.460*	2.367*	2.506*	2.861*	2.927*
	(0.231)	(0.477)	(0.570)	(0.387)	(0.333)	(0.345)	(0.488)	(0.561)	(0.567)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		18.328	21.928	39.722	69.463	17.012	44.461	40.786	29.494
Overid Test				0.003	0.012	0.003	0.039	0.858	0.219
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	937	930	937	930	930	930	937	937	937
Panel G. Forest Area (% of Land Area)									
Trade Intensity	2.403*	2.700*	2.914*	2.860*	2.389*	3.883*	2.644*	2.715*	2.877*
	(0.459)	(0.674)	(0.420)	(0.445)	(0.525)	(0.547)	(0.440)	(0.433)	(0.415)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		17.606	23.178	40.010	72.192	16.373	47.334	42.547	31.076
Overid Test				0.742	0.520	0.001	0.014	0.008	0.566
Endogeneity		0.023	0.004	0.024	0.001	0.001	0.008	0.078	0.004
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	953	946	953	946	946	946	953	953	953
Panel H. Deforestation Rate									
Trade Intensity	-0.001*	-0.001‡	-0.001	-0.001†	-0.001†	-0.001‡	-0.001*	-0.001*	-0.001*
	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		16.009	18.757	31.736	60.141	15.407	38.954	38.780	24.593
Overid Test				0.911	0.846	0.649	0.594	0.455	0.202
Endogeneity		0.044	0.000	0.000	0.022	0.015	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	789	783	789	783	783	783	789	789	789

‡ p<0.10, † p<0.05, * p<0.01. Standard errors in parentheses are heteroskedasticity-robust. Trade intensity, log (per capita GDP), and square of log (per capita GDP) are instrumented for using predicted trade intensity and variables such as age dependency ratio, growth rate of population, investment share of GDP, age dependency ratio squared, the interaction between investment share of GDP and age dependency ratio, population growth squared, and the interaction between population growth and age dependency. Underid Test reports the p-value of the Kleibergen-Paap (2006) rk statistic with rejection implying identification. F-stat reports the Kleibergen-Paap F statistic for weak identification. Overid Test displays the p-value of Hansen J statistic with rejection implying invalid instruments. Endogeneity reports the p-value of endogeneity test of the endogenous regressors. Joint Sign. Endog. displays the p-value of Anderson-Rubin (1949) chi-square test of endogenous regressors. Other covariates include: log (per capita land area), a polity score, and year-specific dummies. See text for further details.

Table 5. Impact of Trade Intensity and Intra-Industry Trade on Environmental Quality.

	OLS	IV Set #1	IV Set #2	IV Set #3	IV Set #4	IV Set #5	IV Set #6	IV Set #7	IV Set #8
Panel A. log(SO2)									
Trade Intensity	-0.424‡	0.129	0.129	0.130	0.178	0.134	0.190	0.142	0.046
	(0.253)	(0.615)	(0.610)	(0.610)	(0.556)	(0.584)	(0.578)	(0.530)	(0.571)
IIT	-0.509	-13.773*	-13.794*	-13.778*	-14.129*	-13.959*	-14.898*	-14.612*	-13.430*
	(0.341)	(2.611)	(2.877)	(2.574)	(2.529)	(2.544)	(2.726)	(2.447)	(2.472)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		9.206	11.804	9.897	10.675	10.466	9.965	14.861	11.797
Overid Test				0.990	0.554	0.445	0.316	0.046	0.004
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	789	676	676	676	676	676	676	676	676
Panel B. log(CO2)									
Trade Intensity	-0.105‡	0.469*	0.544*	0.528*	0.525*	0.502*	0.521*	0.517*	0.525*
	(0.059)	(0.138)	(0.152)	(0.147)	(0.139)	(0.137)	(0.148)	(0.138)	(0.148)
IIT	-1.645*	-15.369*	-13.023*	-14.368*	-14.462*	-14.615*	-13.833*	-13.917*	-13.652*
	(0.290)	(2.321)	(2.130)	(2.073)	(2.043)	(2.163)	(2.064)	(1.897)	(1.969)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		12.376	15.977	13.101	13.840	13.310	13.328	15.641	14.279
Overid Test				0.126	0.201	0.305	0.293	0.106	0.295
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	947	802	802	802	802	802	802	802	802
Panel C. log(PM10)									
Trade Intensity	-0.073*	0.082*	0.070†	0.073*	0.068†	0.077*	0.068†	0.067*	0.067*
	(0.013)	(0.031)	(0.028)	(0.027)	(0.027)	(0.029)	(0.028)	(0.026)	(0.026)
IIT	-0.714*	-3.820*	-4.316*	-4.101*	-4.185*	-3.974*	-4.373*	-4.476*	-4.493*
	(0.084)	(0.510)	(0.527)	(0.469)	(0.482)	(0.472)	(0.515)	(0.480)	(0.483)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		11.143	15.373	13.039	13.836	13.458	13.183	14.892	13.708
Overid Test				0.212	0.130	0.424	0.706	0.230	0.089
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	943	802	802	802	802	802	802	802	802
Panel D. log(Energy)									
Trade Intensity	-1.242*	-1.734†	-2.884*	-2.698*	-2.041*	-2.005*	-2.377*	-2.400*	-2.581*
	(0.198)	(0.794)	(0.527)	(0.515)	(0.507)	(0.610)	(0.507)	(0.405)	(0.449)
IIT	-0.829†	-15.130*	-11.322*	-12.542*	-14.331*	-14.360*	-13.514*	-11.535*	-11.115*
	(0.376)	(3.099)	(2.688)	(2.564)	(2.593)	(2.717)	(2.606)	(2.187)	(2.380)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		4.885	12.252	10.049	10.399	7.330	10.227	23.056	14.313
Overid Test				0.131	0.613	0.600	0.003	0.001	0.012
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	792	676	676	676	676	676	676	676	676

‡ $p<0.10$, † $p<0.05$, * $p<0.01$. Standard errors in parentheses are robust. Trade intensity, IIT, log (per capita GDP), and square of log (per capita GDP) are instrumented for using predicted trade intensity, predicted IIT, and variables such as age dependency ratio, growth rate of population, investment share of GDP, age dependency ratio squared, the interaction between investment share of GDP and age dependency ratio, population growth squared, and the interaction between population growth and age dependency. Underid Test reports the p-value of the Kleibergen-Paap (2006) rk statistic with rejection implying identification. F-stat reports the Kleibergen-Paap F statistic for weak identification. Overid Test displays the p-value of Hansen J statistic with rejection implying invalid instruments. Endogeneity reports the p-value of endogeneity test of the endogenous regressors. Joint Sign. Endog. displays the p-value of Anderson-Rubin (1949) chi-square test of endogenous regressors. Other covariates include: log (per capita land area), a polity score, and year-specific dummies. See text for further details.

Table 5 (cont.). Impact of Trade Intensity and Intra-Industry Trade on Environmental Quality.

	OLS	IV Set #1	IV Set #2	IV Set #3	IV Set #4	IV Set #5	IV Set #6	IV Set #7	IV Set #8
Panel E. Improved Water Access (% Pop.)									
Trade Intensity	0.985*	-0.501	0.123	0.099	0.137	-0.365	0.106	0.160	0.130
	(0.252)	(0.329)	(0.429)	(0.331)	(0.332)	(0.279)	(0.418)	(0.436)	(0.426)
IIT	3.067	28.521*	47.508*	40.006*	42.060*	31.804*	46.371*	49.073*	47.897*
	(1.980)	(7.587)	(8.178)	(6.464)	(6.511)	(6.389)	(7.371)	(7.709)	(7.889)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		12.666	15.809	13.046	13.709	13.722	13.196	15.585	14.145
Overid Test				0.002	0.001	0.392	0.724	0.454	0.840
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	945	804	804	804	804	804	804	804	804
Panel F. Improved Water Access (% Rural)									
Trade Intensity	1.089*	-1.207*	-0.654	-0.687‡	-0.719‡	-1.050*	-0.728	-0.576	-0.590
	(0.252)	(0.429)	(0.496)	(0.413)	(0.395)	(0.386)	(0.459)	(0.495)	(0.473)
IIT	5.489†	58.208*	74.706*	66.021*	65.982*	61.538*	71.476*	77.309*	77.085*
	(2.407)	(10.143)	(11.996)	(10.043)	(10.003)	(9.418)	(10.966)	(11.321)	(11.307)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		12.741	15.791	13.030	13.623	13.882	13.141	15.634	14.193
Overid Test				0.030	0.050	0.373	0.367	0.278	0.162
Endogeneity		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	937	798	798	798	798	798	798	798	798
Panel G. Forest Area (% of Land Area)									
Trade Intensity	2.397*	0.876	0.695	0.686	0.524	1.132	0.703	0.124	0.743
	(0.476)	(0.710)	(0.651)	(0.649)	(0.681)	(0.709)	(0.657)	(0.595)	(0.624)
IIT	0.193	45.884*	40.250*	42.062*	36.413*	58.390*	35.974*	54.562*	39.281*
	(3.883)	(15.024)	(14.015)	(13.810)	(13.682)	(13.710)	(13.645)	(12.138)	(13.522)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		12.295	15.815	12.987	13.752	13.148	13.264	15.464	14.094
Overid Test				0.520	0.150	0.053	0.111	0.048	0.787
Endogeneity		0.011	0.014	0.011	0.005	0.000	0.013	0.002	0.010
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	953	808	808	808	808	808	808	808	808
Panel H. Deforestation Rate									
Trade Intensity	-0.001†	-0.001	-0.000	-0.000	-0.000	-0.000	-0.000	-0.001	-0.001
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
IIT	0.003	-0.015	-0.007	-0.016‡	-0.016	-0.015	-0.016	-0.021‡	-0.022‡
	(0.003)	(0.010)	(0.017)	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.011)
Underid Test		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F-stat		8.587	11.284	9.766	10.136	9.451	9.834	9.368	9.225
Overid Test				0.528	0.594	0.435	0.515	0.315	0.240
Endogeneity		0.050	0.001	0.000	0.032	0.054	0.000	0.000	0.000
Joint Sign. Endog.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
N	789	669	669	669	669	669	669	669	669

‡ p<0.10, † p<0.05, * p<0.01. Standard errors in parentheses are robust. Trade intensity, IIT, log (per capita GDP), and square of log (per capita GDP) are instrumented for using predicted trade intensity, predicted IIT, and variables such as age dependency ratio, growth rate of population, investment share of GDP, age dependency ratio squared, the interaction between investment share of GDP and age dependency ratio, population growth squared, and the interaction between population growth and age dependency. Underid Test reports the p-value of the Kleibergen-Paap (2006) rk statistic with rejection implying identification. F-stat reports the Kleibergen-Paap F statistic for weak identification. Overid Test displays the p-value of Hansen J statistic with rejection implying invalid instruments. Endogeneity reports the p-value of endogeneity test of the endogenous regressors. Joint Sign. Endog. displays the p-value of Anderson-Rubin (1949) chi-square test of endogenous regressors. Other covariates include: log (per capita land area), a polity score, and year-specific dummies. See text for further details.