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# Trade Liberalization and Trade Performance of Environmental Goods: Evidence from Asia-Pacific Economic Cooperation Members

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## Contents

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In this article, we study the impact of trade liberalization, including reductions in both tariff and nontariff trade barriers, on environmental goods (EGs) exports. Using bilateral trade data from 20 Asia-Pacific Economic Cooperation members, we find that tariff reduction in an exporting country has a larger positive impact on its exports of EGs than tariff reduction in an importing country. Our results also show that a lower nontariff barrier in an importing country increases its imports of EGs. A considerable amount of heterogeneity also exists in subsample results based on countries' income levels.

**Keywords**: environmental goods; trade liberalization; trade performance; Asia-Pacific Economic Cooperation

## I. Introduction

The liberalization of trade of environmental goods and services (EGSs) has been high on WTO's agenda during the past decade when paragraph 31(iii) of the Doha Declaration in 2001 called for a reduction or elimination of tariff and nontariff barriers on EGSs (WTO, 2001). Over the past two decades, environmental goods (EGs) trade has grown faster than trade of industrial goods due to increasing concerns about climate change and environmental degradation (Avery and Boadu, 2004; Blazejczak et al., 2009). However research on the relationship between EGs trade liberalization and EGs export performance is surprisingly limited and most existing studies primarily focus on the impact of trade liberalization in the conventional manufacturing sector (Jenkins, 1996; Babatunde, 2006; Edwards and Lawrence, 2008; Alessandrini et al., 2011). A few exceptions include Hamwey (2005), Howse and van Bork (2006), Hufbauer and Kim (2010), and Yoo and Kim (2011). For example, Hamwey (2005) argue that appropriately designed, trade liberalization could allow less developed countries to significantly expand their production and exports of EGs and promote industrial diversification of their economies. Yoo and

Kim (2011) find that a reduction in trade barriers for EGs will benefit both less developed and developed countries.

A better understanding of the impact of reducing EGs trade barriers is critical for several reasons (WTO, 2011; Balineau and Melo, 2013). Conceptually, lower tariff or nontariff barriers may decrease the cost of environmental technologies and stimulate innovation and technology transfer across countries, which in turn can further increase EGs trade. With increased EGs trade, countries, especially less developed countries, would be able to address more effectively their environmental concerns such as energy inefficiency and lack of access to clean water and sanitation, better achieving their sustainable development objectives. Furthermore, at a global level, given the role that EGs trade plays in environmental protection, all countries would benefit from a cleaner environment through lower trade barriers and better EGs trade performance.

In this article, we explore the relationship between EGs trade liberalization and exports of EGs with bilateral data from Asia-Pacific Economic Cooperation (APEC) countries. Our study on the impact of trade liberalization on EGs export performance contributes to the existing literature in two respects.[1]

First, we include measures of both tariff and nontariff barriers (NTBs) to EGs trade. Tariffs are routinely accounted for in studies of how, in general, trade liberalization affects a country's aggregate trade performance (Santos-Paulino, 2002a, b; Santos-Paulino and Thirlwall, 2004; Alessandrini et al., 2011). Though it has long been recognized that trade liberalization is reflected in the reduction of the average tariff rate as well as fewer nontariff restrictions (Balassa, 1982), NTBs are either left out or captured by a dummy variable indicating simplifications of quantitative restrictions (Hoque and Yusop, 2010). Many agree that NTBs are less transparent than tariffs and it is more difficult to negotiate and reduce NTBs than tariff barriers (Ray, 1987; Ando and Fujii, 2001). To better understand the relationship between trade liberalization and EGs trade, it is necessary to explicitly control NTBs. In this study, we measure NTBs by the number of technical barriers to trade (TBT) and sanitary and phytosanitary (SPS) concern notifications as they are considered by many as the major nontariff obstacles to EGs trade in developed countries (Alavi, 2007).

Second, to the best of our knowledge, this article is among the first ones to systematically study the effect of trade liberalization in both importing and exporting counties. Most existing research focuses on the impact of lowering trade barriers in either the importing countries or the exporting countries (Santos-Paulino, 2002a, b; Babatunde, 2006; Edwards and Lawrence, 2008; Hoque and Yusop, 2010; Alessandrini et al., 2011). However, as Ratnaike (2012) points out, a country's domestic market openness and the market liberalization of its trade partner are both critical to this country's export performance. So, it is essential to take into consideration the trade barriers in both trade partners in the model.

Using bilateral EGs export data among 20 APEC countries over the period of 1996–2011, we find that reducing tariffs in an exporting country has a strong and positive effect on its exports of EGs while changes in tariff rates in its trade partner (or the importing country) do not seem to have a significant impact on its EGs exports. NTBs in the exporting country seem to be positively associated with its exports of EGs, a possible reason for which is that a country with more TBT and SPS concern notifications on imported EGs might be producing high-quality EGs itself and a high quality of products is often associated with improved export performance. On the other hand, lower NTBs in the importing country tend to increase its EGs imports. These results are robust to subsample regressions with

different categories of EGs. We do observe a significant amount of heterogeneity in the effects of trade liberalization on bilateral EGs exports in countries with different levels of income. For instance, the beneficial effect of tariff reduction on exports of EGs is most evident for uppermiddle income countries with a gross national income per capita between $4086 and $12 615.

The rest of our article proceeds as follows: Section II reviews the literature related to the impact of trade liberalization on trade performance. Section III provides a brief overview of EGs trade among APEC members over our sample period. The empirical model and data are presented in Section IV and empirical results are discussed in Section V. We provide conclusion in Section VI.

# II. Literature Review

## Trade liberalization and trade in general

The empirical evidence of the relationship between trade liberalization and general trade performance seems to be, at best, mixed. A number of papers have argued that trade liberalization tends to increase a country's exports and/or imports directly or under certain circumstances. For example, Edwards and Lawrence (2008) find that trade liberalization in South Africa in the 1990s not only increases imports in the region but also boosts exports by reducing both input costs and the relative profitability of domestic sales. Hoque and Yusop (2010) examine the impact of trade liberalization on aggregate import in Bangladesh. The authors consider the reduction of tariff barriers as well as the simplification of nontariff measures. They find that a lower average tariff rate increases imports in Bangladesh substantially in the short run, but does not have a significant effect in the long run while simplifying nontariff measures have a significantly positive impact on imports in the long run. Thomas et al. (1991), with a broader cross-section of countries, conclude that exports of manufacturing goods tend to rise following trade liberalization reforms and countries that reform their trade policies have a better trade performance than nonreformers (see also Michaely et al., 1991). Greenaway et al. (1997) study 13 less developed countries (LDCs) and point out that if LDCs undergo trade liberalization under WTO rules but without necessary technological changes they may get locked in a 'development trap' and experience long-term terms of trade deterioration. Similarly, Nenci and Pietrobelli (2008) find that a formalized trading system is necessary to guarantee a beneficial effect of trade liberalization on trade growth in Latin America.

Other studies, however, have found little evidence supporting a significant relationship between trade liberalization and a country's trade performance (Agosin, 1991; Clarke and Kirkpatrick, 1991; Greenaway and Sapsford, 1994; Shafaeddin, 1994; Jenkins, 1996; Ghani, 2011; Ratnaike, 2012). For example, with data on member countries of Organization of the Islamic Conference (OIC), Ghani (2011) finds that on average, the ratio of imports, exports, and trade over GDP in these countries have not improved since they started liberalizing trade in the 1970s. Ratnaike (2012) investigates both the steady-state and the transitional impact of trade liberalization within selected OECD countries. Their results show that the trade policy is largely an insignificant determinant of export performance of countries in their sample.

## Trade liberalization and EGs trade

As mentioned previously, the literature on trade liberalization and EGs trade performance is quite limited. But the existing studies on this topic tend to highlight the potential gains from liberalization in EGs trade. Howse and van Bork (2006) show that liberalizing trade in EGs in the OECD and APEC leads to a rise in EGs production and exports globally. Particularly, the rise in EGs production and exports is larger

in developed countries, Asian economies, and economies in transition than in countries in Africa and Latin America. Jha (2008) examines imports of 153 environmental products, aggregated into 10 categories, to LDCs. The author finds that tariffs have a statistically significant impact on trade of four of the 10 categories of EGs. Focusing on four basic clean energy technologies in 18 top greenhouse gas emitting LDCs, the World Bank (2007) estimates that the removal of tariffs on those technologies would result in an increase in EGs trade by up to 7% in these countries and the removal of both tariff and nontariff barriers could boost EGs trade in these countries by as much as 13%. A more recent study by Hufbauer and Kim (2010), combining OECD, APEC, and World Bank's lists of EGs that cover 211 HS six-digit products, shows that the elimination of tariffs on EGs would increase the world imports of EGs by about $56 billion, accounting for around 12% of the total imports of the 211 products worldwide. Similar results are also found in the work of Yoo and Kim (2011) with updated trade data. According to Yoo and Kim, discussions on improving market access to EGs are underway within regional initiatives among APEC, East Asian countries, and G-20 countries and lowering trade barriers to EGs benefits both LDCs and developed economies.

## III. EGs Trade of Asia-Pacific Economic Cooperation (APEC) Members

As Steenblik (2005) points out that although EGs can be natural candidates for trade liberalization initiatives, negotiators face a quite difficult task since 'environmental goods' are not well defined. Some products used for environmental protection such as a pipe or a pump often have alternative uses that are not related to, for instance, removal of contaminants from soil or ground water. Both APEC and OECD have done a substantial amount of work in constructing the list of EGs. In our study, we choose to focus on the APEC sample as the APEC list of EGs can be 'readily distinguished by custom agents and treated differently for tariff purposes' (Steenblik, 2005, p. 3). In contrast, the OECD list of EGs is intended for demonstrating the scope of the environmental industry and can be rather broad.

The APEC group started identifying industries that would benefit from trade liberalization in November 1995, followed by nominations of sectors for early voluntary liberalization in May 1997. Initiated by Canada, Chinese Taipei, Japan and the US, nine economies eventually proposed products under the category of 'environmental goods and services'. In subsequent meetings in 1998, the list of EGs was finalized. In the Appendix, we provide the APEC list of EGs with their corresponding 6-digit harmonized system (HS) codes.

Looking over the period of 1996–2011 in the AsiaPacific region, the average tariff rate on EGs was 2.95% in 2011, declining by 60.9% from 7.55% in 1996. All members of APEC have experienced a reduction in their average MFN tariff rates on EGs as shown in Fig. 1, with the exception of Brunei and Indonesia. Brunei's average tariff rate rose by 0.55 percentage points and Indonesia's average tariff rate rose by 1.06 percentage points between 1996 and 2011. Thailand saw the largest average tariff rate reduction of 28.37 percentage points from 32.21% to 3.84%, followed by an 11.61 percentage points' reduction in Peru, a 9.84 percentage points' reduction in Papua New Guinea and an 8.35 percentage points' reduction in China. Between 1996 and 2011, the average share of duty-free EGs to all EGs in APEC also grew steadily from 28.89% to 51.21%. Countries with the largest increase in the share of duty-free EGs include Papua New Guinea with a 98.99 percentage points' increase, Peru with a 91.92 percentage points' increase and Canada with a 73.17 percentage points' increase. On the other hand, the share of duty-free EGs in Indonesia and Vietnam declined by 28.75 percentage points and 2.46 percentage points, respectively. Together with a general reduction in tariff barriers to EGs, however, 11

of the 20 APEC economies have established NTBs in the form of TBT and SPS as shown in the Appendix. Over the period of 1996 to 2011, there were 43 EGs TBT and SPS notifications made by APEC members, among which 14 were made by the US, 11 by China and 6 by Japan. In terms of the number of EGs covered in the notifications classified by HS codes, a total of 74 EGs at the HS 6-digit level are involved in TBT and SPS notifications from these 11 countries and 47 products or 45% of the 104 EGs on the APEC's list are involved in China's notifications.

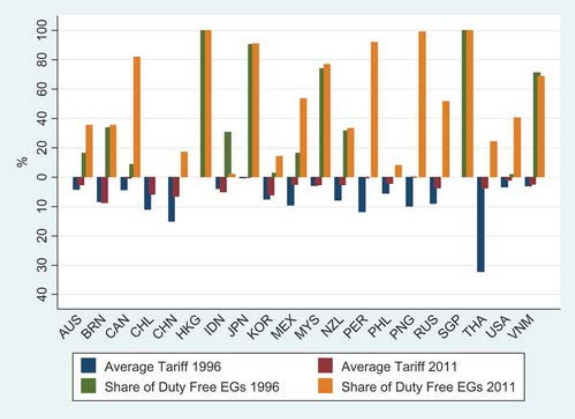


**Fig. 1. Average MFN tariff rates and share of duty free EGs**

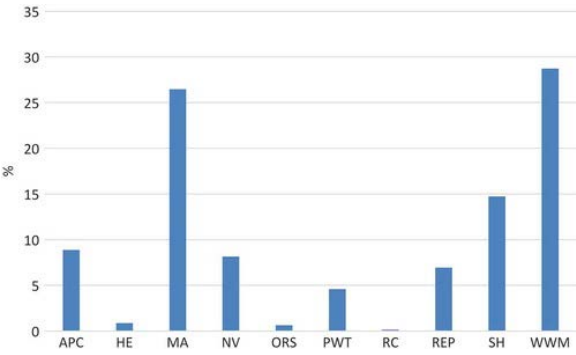


**Fig. 2. Average share of categorical EGs exports to total EGs exports**

Notes: APC = air pollution control; H/E = heat/energy management; M/A = monitoring/analysis, N/V = noise/vibration abatement; ORS = other recycling systems; PWT = potable water treatment; R/C = remediation/cleanup; S/H = solid/ hazardous waste; WWM = wastewater management; REP = renewable energy plant.

China, Japan and the US are the three largest EGs exporters in APEC. Between 1996 and 2011, the share of EGs exports from the US and Japan in EGs exports of all APEC countries declined gradually from 36.21% to 22.36% and from 35.61% to 22.53%, respectively. In the meantime, the share of EGs exports of China rose from 4.06% to 17.67% and share of EGs exports of other less developed APEC countries also rose slightly.

With respect to different categories of EGs, shares of air pollution control products (APC), monitoring/analysis products (M/A) and products related to renewable energy plant (REP) in overall EGs

exports rose over the period of 1996–2011. Shares of noise/vibration abatement products (NV), solid/hazardous waste products (S/H) and wastewater management products (WWM) went down and shares of products in heat/energy management (H/E), other recycling systems (ORS), potable water treatment (PWT) and remediation/cleanup (R/C) remained constant. Classification of EGs with corresponding HS codes at the 6-digit level is listed in the Appendix. Figure 2 shows the exports of EGs in these 10 categories as a share of overall EGs exports averaged across 1996–2011.

## IV. Empirical Model and Data

Our empirical specification is based on the gravity model, which predicts that bilateral trade flows mainly depend on trade partners' economic sizes and geographical distance between them. The original form of the trade gravity model proposed by Tinbergen (1962) and Poyhonen (1963) can be stated as:

$$T_{ij} = AG_iG_j/G_{ij} \quad (1)$$

where $T_{ij}$ is a measure of bilateral trade flows between country *i* and country *j*; $G_i$ and $G_j$ represent the economic size of countries *i* and *j*, respectively; $D_{ij}$ is the geographical distance between *i* and *j* and *A* is a constant. The gravity model for empirical estimation is typically specified as a log-linear equation and augmented with other control variables that can affect trade flows. In this article, we adopt the augmented gravity model specified in Equation 2 as our baseline model for analysis:

$$\begin{aligned} LnX_{ijt} = {} & \beta_0\beta_1 Ln\left(GD\beta_0 + GDP_{jt}\right) + \beta_2 \mathrm{Lndist}_{ij} \quad (2) \\ & + \beta_3 \mathrm{border}_{ij} + \beta_4 \mathrm{sim}_{ijt} + \beta_5 \mathrm{indus}_{jt} \\ & + \beta_6 \mathrm{Lncarbon}_{jt} + \beta_7 \mathrm{tariff}_{it} + \beta_8 \mathrm{tarif}f_{it} \\ & + \beta_9 ntb_{it} + \beta_{10} ntb_{jt} + \beta_{11} \mathrm{WTO}_{ijt} \\ & + \beta_{12} \mathrm{FTA}_{ijt} + \varepsilon_{ijt} \end{aligned}$$

where $LnX_{ijt}$ is the log value of exports of 104 products on the APEC EGs list from country *i* to country *j* in year *t*. Both countries' GDPs are included ($GDP_i$ and $GDP_j$) to measure economic sizes as well as to serve as proxies for demand for imported products and supply of exported products (Yandle et al., 2002). The variable $\mathrm{Lndist}_{ij}$ is the log value of the great circle distance between *i* and *j*; $\mathrm{border}_{ij}$ dummy is equal to one if the two countries share a border; $\mathrm{sim}_j$ represents the economic similarity between countries *i* and *j*, measured by relative country size as suggested by Egger (2002). Specifically:

$$\mathrm{sim}_{ijt} = \ln\left[1 - \left|\left(\frac{GDP_i}{GDP_i+GDP_j}\right)^2 - \left(\frac{GDP_j}{GDP_i+GDP_j}\right)^2\right|\right] \quad (3)$$

It has been argued that a high level of industrialization is often associated with more stringent environmental regulations in a country, making the country more likely to import environmental goods (Jha, 2008). In this study, we include the rate of industrialization in country j (indusjt) measured by country j's industrial production as a share of its GDP. However, it needs to be noted that 'industrialization' may underestimate the stringency of environmental regulations in a service-led developed economy. In particular, if more stringent environmental regulations lead to increased EGs imports as expected, then this measure of industrialization can overestimate the effect of environmental regulations stringency on EGs trade. To address this issue, we also use another proxy for

environmental regulation stringency (erj) based on individual countries' participation in international environmental treaties for robustness checks. Following Busse (2004), Kirkpatrick and Shimamoto (2008) and Smarzynska and Wei (2001), an *er* index is created for each country in year t by assigning one point to this country for ratifying an international environmental treaty or 0.5 point for signing a treaty prior to year t. [2] The next variable $\mathrm{Lncarbon}_{jt}$ is the log value of carbon dioxide emission metric tons per person in country *j,* which helps to describe the current environmental status of country *j*. We expect Lncarbonjt to have a positive coefficient as increased carbon emissions can increase domestic demand for imported EGs due to rising environmental concerns.

Our main variables of interest include both measures of tariff and nontariff barriers with tariff denoting the simple average of most favoured nation (MFN) EGs tariff rates and ntb denoting the NTBs measured by the number of accumulated TBT and SPS concern notifications in a country. Coefficients on importing country *j*'s tariff and nontariff trade barriers are expected to be negative as low trade barriers tend to be associated with increased imports in a country (or exports from country *i*). We, however, do not have any prior expectations of the impact of reducing exporter *i*'s trade barriers on its export performance. Reduced trade barriers in country *i* can bring in lower-cost EGs components and raw materials. Lower trade barriers can also promote competition in domestic EGs market in country *i*, and possibly give domestic firms an incentive to improve their efficiency as well as the quality of EGs produced. As a result, one would expect lower trade barriers in a country to have a positive impact on its EGs exports (Dholakia and Kapur, 2004). On the other hand, increased import competition in country *i*'s domestic EGs market can force domestic firms to reduce their EGs output and possibly to exit the market when reduced output leads to a higher average cost of production, which may in turn result in a reduction in exports of EGs from country *i*. [3]

The $WTO_{ijt}$ dummy variable is equal to one when both countries *i* and *j* are WTO members and $FTA_{ijt}$ equals one when country *i* and country *j* have any free trade agreement in force. We expect that being WTO members or having a free trade agreement in effect helps promote trade flows between two countries and the coefficients on WTO and FTA should be positive. Our sample includes bilateral export flows between 20 APEC member economies from 1996 to 2011.[4] Detailed variable definitions and data sources and the correlation matrix of variables are presented in the Appendix. Summary statistics are provided in Table 1. The correlation matrix shows that all coefficients of association are no more than 0.5 with most below 0.2, indicating that our model would not suffer from severe multicollinearity.

**Table 1. Summary statistics**

| Variable | Obs. | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| $LnX_{ijt}$ | 5172 | 15.944 | 3.366 | −0.152 | 23.329 |
| $border_{ij}$ | 6080 | 0.058 | 0.234 | 0 | 1 |
| $lndist_{ij}$ | 6080 | 8.786 | 0.866 | 5.754 | 9.889 |
| $Ln(GDP_{it} + GDP_{jt})$ | 6080 | 27.575 | 1.411 | 23.182 | 30.605 |
| $sim_{ijt}$ | 6080 | −1.657 | 1.424 | −7.441 | 0 |
| $indus_{jt}$ | 6080 | 35.545 | 11.345 | 7.105 | 74.113 |
| $er_j$ | 6080 | 95.36 | 30.49 | 29 | 175.5 |
| $Lncarbon_{jt}$ | 6080 | 1.58 | 1.088 | −0.805 | 3.318 |
| $tariff_{it}$ | 6080 | 4.701 | 4.763 | 0 | 32.21 |
| $tariff_{jt}$ | 6080 | 4.701 | 4.763 | 0 | 32.21 |
| $ntb_{it}$ | 6080 | 0.653 | 1.704 | 0 | 14 |
| $ntb_{jt}$ | 6080 | 0.653 | 1.704 | 0 | 14 |
| $WTO_{ijt}$ | 6080 | 0.807 | 0.395 | 0 | 1 |
| $FTA_{ijt}$ | 6080 | 0.177 | 0.382 | 0 | 1 |

# V. Empirical Results

## Aggregate environmental goods exports

We report regression results based on aggregate EGs exports among APEC members in Table 2. Regression 2.1 includes dyad fixed effects and regression 2.2 includes importer and exporter fixed effects. Anderson and Van Wincoop (2003) state that bilateral trade depends not only on bilateral trade barriers, but also on each individual country's trade barriers with all other trade partners. They refer to this as the 'multilateral resistance effect', which can be controlled in a panel setting by including importer and exporter fixed effects (Rose and Van Wincoop, 2001) or time varying country fixed effects. In regression 2.3, we include time-varying importer and exporter dummies.

Signs of estimated coefficients on traditional gravity model variables in Table 2 are in general consistent with our expectations. Coefficients on $border_{ij}$, $\ln(GDP_i + GDP_j)$ and $sim_{ij}$ are significantly positive in two of the three regressions and the coefficient on

**Table 2. Trade liberalization and aggregated environmental goods export**

| | Dyad FE | Country FE | Time varying FE |
|---|---|---|---|
| Variables | 2.1 | 2.2 | 2.3 |
| $\ln(GDP_{it} + GDP_{jt})$ | 0.854*** | 0.798*** | −0.944 |
| | (0.1010) | (0.1430) | (0.7760) |
| $lndist_{ij}$ | | −1.437*** | −1.416*** |
| | | (0.1240) | (0.1300) |
| $border_{ij}$ | | 0.618 | 0.653* |
| | | (0.3820) | (0.3950) |
| $sim_{ijt}$ | 0.464*** | 0.376*** | −0.359 |
| | (0.0837) | (0.0890) | (0.3220) |
| $indus_{jt}$ | 0.0163*** | 0.017* | −0.0113 |
| | (0.0050) | (0.0089) | (0.0983) |
| $lncarbon_{jt}$ | 0.374*** | 0.362** | −0.666 |
| | (0.0907) | (0.146) | (1.666) |
| $tariff_{it}$ | −0.0445*** | −0.0442*** | −0.0810*** |
| | (0.0044) | (0.0064) | (0.0147) |
| $tariff_{jt}$ | −0.0031 | −0.0029 | 0.0221 |
| | (0.0047) | (0.0067) | (0.0294) |
| $ntb_{it}$ | 0.0189* | 0.0189 | −0.0318 |
| | (0.0105) | (0.0121) | (0.0214) |
| $ntb_{jt}$ | −0.0468*** | −0.0469*** | −0.0703 |
| | (0.0112) | (0.0167) | (0.0495) |
| $WTO_{ijt}$ | 0.421*** | 0.431*** | 0.918*** |
| | (0.0726) | (0.1080) | (0.3030) |
| $FTA_{ijt}$ | 0.0735 | 0.0786 | 0.103 |
| | (0.0512) | (0.0640) | (0.0746) |
| Observations | 5172 | 5172 | 5172 |
| R-squared | 0.260 | 0.260 | 0.429 |

*Notes*: Year dummies are always included in the regression.
Robust SEs are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

log distance between countries *i* and *j* is significantly negative in all regressions. These results indicate that, in general, countries that are large have similar economic sizes and are geographically closer trade more EGs with each other, which echo findings in the literature focusing on aggregate trade flows. Shown in regressions 2.1 and 2.2, the coefficient on $indus_j$ is positive and significant, indicating a positive

impact of more stringent environmental regulations in a country on the demand of EGs imports. The estimated coefficient on carbon emission ($lncarbon_j$) in an importing country *j* is positive and significant in regressions 2.1 and 2.2 and the results imply that domestic pressure to reduce carbon emission also seems to have a prominently positive impact on EGs import demand in a country.

The WTO membership dummy has a positive coefficient significant at the 1% level in all regressions in Table 2. This indicates that the WTO membership promotes bilateral trade of EGs. Regression 2.3 suggests that both partners *i* and *j* being WTO members are associated with a 43.1% increase in the exports of EGs from *i* to *j* relative to the case where at least one of *i* and *j* is not a WTO member. In contrast, having a free trade agreement in place does not seem to promote EGs exports from country *i* to country *j* as the coefficient on $FTA_{ij}$ is not significantly different from zero in Table 2.

Note that the time-varying fixed effect model includes at least $2nT$ dummies with n representing the number of countries and *T* the time span. In our sample with 20 importing and 20 exporting countries over 16 years, this means regression 2.3 includes at least 640 dummies. This significantly reduces the degrees of freedom of the regression. Increased computational intensity and potentially high degree of collinearity caused by the large number of dummy variables might explain why estimated results in regression 3.3 sometimes are not quite consistently with the regressions 3.1 and 3.2. Consequently, in the rest of this study, we will focus on results from the dyad fixed effects model and the country fixed effects model for interpretation.

The coefficient on the average tariff rate of EGs in an exporting country (tariffi) is negative in all regressions in Table 2 and statistically significant at the 1% level. This reveals some evidence supporting that trade liberalization in the exporting country tends to have a dominant positive effect on its EGs export performance and this positive effect is fairly large and economically significant. For example, regression 2.2 suggests that a one-percentage point decrease in the average tariff rate on EGs in a country is associated with a 4.42% increase in its EGs exports. These results are consistent with previous studies arguing that import tariffs in many countries would hamper their ability to export possibly by raising the price of imported inputs used to produce exported products. For instance, with data from 26 LDCs, Tokarick (2006) finds that import tariffs are equivalent to a 12.5% tax on a country's exports in terms of the impact of import tariffs on the price of exports. As a result, a reduction in import tariffs would likely lead to an increase in exports of a country.

n increase in exports of a country. On the other hand, the estimated coefficient on an importing country's average tariff ($tariff_j$) for EGs is not statistically different from zero. Our expectation is that a reduction of tariffs should promote imports of EGs in a country. A possible explanation for the insignificant coefficient on $tariff_j$ might be that in APEC countries, tariffs have become much less important in restricting imports over time while certain nontariff barriers are more commonly used to regulate imports of EGs. This is also partially reflected by the negative and significant coefficient on NTBs in the importing country ($ntb_j$) in two of the three regressions in Table 2.

With respect to estimated coefficients on NTBs, as mentioned above, lowering the importing country's nontariff barriers tends to increase its imports of EGs and this is consistent with our expectation as well as findings from previous research (Kee et al., 2009). The estimated coefficient on the exporter's nontariff barriers (ntbi) is positive in regressions 2.1 and 2.2 and significant in regression 2.1. The positive coefficient on NTBs in the exporting country could be caused by the fact that TBT and SPS are often used to guarantee technical and sanitary standards and strict standards also serve as

indicators of the quality of EGs in a country. In other words, more TBT and SPS concerns in a country can indicate that the county itself produces EGs of a high quality and the positive coefficient on NTBs in an exporter might be reflecting that a higher quality of EGs in a country can lead to a better export performance.

Next, we conduct robustness checks and provide the results in Table 3. In regressions 3.1 and 3.2, we replace the industrialization measure ($indus_{jt}$) by the alternative measure of environmental regulation stringency ($er_{jt}$). In addition, countries that experience high trade in EGs

**Table 3. Robustness checks: aggregated environmental goods export**

| | Dyad FE | Country FE | Dyad FE IV | Country FE IV | Dyad FE (no lncarbon) | Country FE (no lncarbon) | Dyad FE (no indus) | Country FE (no indus) | PPML country FE |
|---|---|---|---|---|---|---|---|---|---|
| Variables | 3.1 | 3.2 | 3.3 | 3.4 | 3.5 | 3.6 | 3.7 | 3.8 | 3.9 |
| $\ln(GDP_{it} + GDP_{jt})$ | 0.840*** | 0.782*** | 1.282*** | 1.166*** | 0.859*** | 0.807*** | 0.823*** | 0.765*** | 0.986*** |
| | (0.140) | (0.140) | (0.153) | (0.150) | (0.142) | (0.142) | (0.145) | (0.145) | (0.164) |
| $\ln dist_{ij}$ | | −1.422*** | | −1.436*** | | −1.438*** | | −1.436*** | −0.575*** |
| | | (0.124) | | (0.0957) | | (0.123) | | (0.124) | (0.0691) |
| $border_{ij}$ | | 0.614 | | 0.652** | | 0.613 | | 0.617 | 1.211*** |
| | | (0.383) | | (0.286) | | (0.382) | | (0.383) | (0.183) |
| $sim_{ijt}$ | 0.476*** | 0.782*** | 0.695*** | 0.516*** | 0.448*** | 0.370*** | 0.457*** | 0.366*** | 0.353*** |
| | (0.117) | (0.140) | (0.124) | (0.0906) | (0.119) | (0.0886) | (0.121) | (0.0897) | (0.0777) |
| $indus_{jt}$ | | | 0.0205*** | 0.0213*** | 0.0223** | 0.0228*** | | | −0.0078 |
| | | | (0.0055) | (0.0056) | (0.0087) | (0.0088) | | | (0.0116) |
| $er_j$ | 0.0420*** | 0.0420*** | | | | | | | |
| | (0.0103) | (0.0103) | | | | | | | |
| $lncarbon_{jt}$ | 0.534*** | 0.525*** | 0.446*** | 0.425*** | | | 0.463*** | 0.455*** | 0.406*** |
| | (0.141) | (0.142) | (0.101) | (0.101) | | | (0.142) | (0.143) | (0.146) |
| $tariff_{it}$ | −0.0440*** | −0.0437*** | −0.0304*** | −0.0303*** | −0.0440*** | −0.0438*** | −0.0445*** | −0.0443*** | −0.0275*** |
| | (0.0058) | (0.0058) | (0.0056) | (0.0057) | (0.0064) | (0.0064) | (0.0063 | (0.0063) | (0.0061) |
| $tariff_{jt}$ | −0.0105 | −0.0103 | −0.0111* | −0.0112* | −0.0054 | −0.0050 | −0.0054 | −0.0052 | −0.0160*** |
| | (0.0065) | (0.0064) | (0.0063) | (0.0064) | (0.0068) | (0.0068) | (0.0065) | (0.0064) | (0.0053) |
| $ntb_{it}$ | 0.0198 | 0.0198 | 0.0319*** | 0.0319*** | 0.0166 | 0.0167 | 0.0197 | 0.0197 | 0.0149 |
| | (0.0126) | (0.0126) | (0.0118) | (0.0119) | (0.0122) | (0.0121) | (0.0125) | (0.0125) | (0.0109) |
| $ntb_{jt}$ | −0.0619*** | −0.0624*** | −0.0525*** | −0.0524*** | −0.0406** | −0.0409** | −0.0542*** | −0.0546*** | 0.0046 |
| | (0.0170) | (0.0173) | (0.0125) | (0.0126) | (0.0163) | (0.0165) | (0.0170) | (0.0173) | (0.0118) |
| $WTO_{ijt}$ | 0.445*** | 0.454*** | 0.451*** | 0.457*** | 0.499*** | 0.508*** | 0.415*** | 0.424*** | 0.515*** |
| | (0.109) | (0.110) | (0.0760) | (0.0763) | (0.106) | (0.106) | (0.108) | (0.109) | (0.0849) |
| $FTA_{ijt}$ | 0.138** | 0.141** | 0.0799 | 0.0851 | 0.0777 | 0.0830 | 0.0727 | 0.0775 | 0.204** |
| | (0.0665) | (0.0652) | (0.0533) | (0.0527) | (0.0664) | (0.0652) | (0.0654) | (0.0643) | (0.0882) |
| Observations | 5172 | 5172 | 4579 | 4579 | 5172 | 5172 | 5172 | 5172 | 5700 |
| R-squared | 0.266 | 0.266 | 0.256 | 0.256 | 0.257 | 0.257 | 0.258 | 0.258 | 0.959 |

*Notes*: Year dummies are always included in the regression.
Robust SEs are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

might choose to lower its trade barriers, presenting a two-way causality issue between EGs exports and trade barriers. To control for this potential reverse causality or endogeneity problem, we adopt instrumental variable (IV) estimation in regressions 3.3 and 3.4. Following Martínez-Zarzoso and Maruotti (2011) and Poumanyvong et al. (2012), we use lags of trade barriers as instruments and the number of lags is adjusted according to the Sargan-Hansen test of over-identifying restrictions (Baum et al., 2003). In regressions 3.5–3.8, when we keep either the measure of the degree of industrialization ($indus_{jt}$) or the environmental status of a country ($lncarbon_{jt}$) as conceptually, a strong correlation between these two variables might exist suggested by the environmental Kuznets curve.[5] Furthermore, approximately 15% of all observations of exports of EGs in our sample are zeroes and these zero observations are excluded from our baseline regressions when natural logs of exports are taken. Santos-Silva and Tenreyro (2006) point out that zero values are quite common in trade and excluding them may lead to potential estimation bias. In addition, by Jensen's inequality, a log-linear model may not be able to provide an unbiased estimation of mean effects when errors are heteroscedastic. To address these concerns, we include the zero values and use the Poisson pseudo-maximum likelihood (PPML) method proposed by Santos-Silva and Tenreyro with lagged trade barriers to control for the potential endogeneity in regression 3.9.

In general, results in Table 3 are qualitatively similar to those in Table 2, suggesting that our baseline results are robust across different specifications. Note that the PPML regression results are not directly comparable to results from other regressions as the PPML model includes zero values of exports and the estimated coefficients in the PPML specification have implications on the extensive margins of EGs exports (or the establishment of a new trade relationship) while estimated coefficients in other regressions indicate the impact changes in control variables on intensive margins of EGs exports (or the increase in trade between the existing trade partners). For example, the estimated coefficient on NTBs in the importing country in regression 3.1 shows that NTBs in an importing country tend to have a negative impact on intensive margins of EGs exports, but may not necessarily make two countries more/less likely start new trade of EGs with each other.

## Subcategories of EGs

In this subsection, we explore the export performance of EGs in five different categories, namely Air Pollution Control (APC) products, Monitoring/ Analysis (M/A) products, Renewable Energy Plant (REP) products, Solid/Hazardous Waste (SHE) products and Waste Water Management (WWM) products. These five categories are chosen as they account for more than 85% of EGs exports from APEC members and also have a sufficient number of observations available to provide reliable regression results. For the purpose of brevity, only estimated coefficients using the IV method on tariff and nontariff trade barriers, the WTO dummy and the FTA dummy are reported in Table 4. Other estimated coefficients are available upon request.

**Table 4. Trade liberalization and export performance of subcategories of EGs**

| | APC | APC | M/A | M/A | REP | REP | SH | SH | WWM | WWM |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dyad FE IV | Country FE IV | Dyad FE IV | Country FE IV | Dyad FE IV | Country FE IV | Dyad FE IV | Country FE IV | Dyad FE IV | Country FE IV |
| Variables | 4.1 | 4.2 | 4.3 | 4.4 | 4.5 | 4.6 | 4.7 | 4.8 | 4.9 | 4.10 |
| $tariff_{it}$ | −0.0607*** | −0.0610*** | −0.0539*** | −0.0542*** | −0.0200 | −0.0181 | −0.0306*** | −0.0323*** | −0.0390*** | −0.0382*** |
| | (0.0097) | (0.0098) | (0.0146) | (0.0147) | (0.0162) | (0.0163) | (0.0086) | (0.0086) | (0.0074) | (0.0075) |
| $tariff_{jt}$ | −0.0096 | −0.0092 | −0.135*** | −0.138*** | −0.0004 | 0.0005 | −0.0079 | −0.0071 | −0.0135 | −0.0127 |
| | (0.0104) | (0.0105) | (0.0313) | (0.0316) | (0.0153) | (0.0154) | (0.0096) | (0.0097) | (0.0085) | (0.0087) |
| $ntb_{it}$ | 0.0636*** | 0.0668*** | 0.0159 | 0.0174 | 0.123*** | 0.125*** | 0.0140 | 0.0153 | 0.0102 | 0.0118 |
| | (0.0151) | (0.0153) | (0.0134) | (0.0135) | (0.0207) | (0.0209) | (0.0151) | (0.0152) | (0.0126) | (0.0128) |
| $ntb_{jt}$ | −0.0215 | −0.0213 | −0.0177 | −0.0158 | −0.0116 | −0.0115 | −0.0704*** | −0.0694*** | −0.0665*** | −0.0662*** |
| | (0.0160) | (0.0162) | (0.0143) | (0.0144) | (0.0221) | (0.0223) | (0.0161) | (0.0162) | (0.0134) | (0.0136) |
| $WTO_{ijt}$ | 0.605*** | 0.675*** | 0.554*** | 0.541*** | 1.172*** | 1.218*** | 0.790*** | 0.800*** | 0.520*** | 0.529*** |
| | (0.116) | (0.117) | (0.114) | (0.115) | (0.183) | (0.182) | (0.118) | (0.118) | (0.0920) | (0.0927) |
| $FTA_{ijt}$ | 0.201*** | 0.244*** | 0.0547 | 0.105 | −0.127 | −0.107 | −0.0814 | −0.0599 | 0.136** | 0.113* |
| | (0.0776) | (0.0760) | (0.0723) | (0.0708) | (0.114) | (0.111) | (0.0788) | (0.0769) | (0.0641) | (0.0632) |
| Observations | 4007 | 4007 | 3741 | 3741 | 3204 | 3204 | 3948 | 3948 | 4391 | 4391 |
| R-squared | 0.174 | 0.172 | 0.280 | 0.280 | 0.165 | 0.165 | 0.125 | 0.125 | 0.160 | 0.159 |

*Notes*: Year dummies are always included in the regression.
Other controls included in the regressions are: $border_{ij}$, $ln(GDP_i + GDP_j)$, $lndist_{ij}$, $sim_{ij}$, $lncarbon_j$, $indus_j$.
Robust SEs are in parentheses.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

There are two notable points in Table 4. First, the WTO membership of both trade partners again has a robustly positive impact on exports of EGs across all subcategories with the estimated coefficient ranging from 0.52 to 1.218. Among the five categories of EGs, the WTO membership of both exporting and importing countries seem to have the largest impact on exports of REP and SH products. For instance, regressions 4.6 and 4.8 suggest that if both the exporter and the importer are WTO members, the value of REP product exports from one country to the other will rise by 122% and the value of SH product exports will rise by 80% compared to exports within a dyad with at least one non-WTO member.

Second, with respect to impacts of trade barriers on EGs exports, results in Table 4 are in general consistent with our results in previous tables. The estimated coefficient on tariff in the exporting country is negative in all regressions and significant at the 1% level in eight of the 10 regressions in Table 4. For example, a one percentage point reduction in the average tariff rate in the exporting country may increase exports of APC, M/A, SH and WWM products approximately by 6%, 5.4%, 3% and 3.9%, respectively. The estimated coefficient on tariff in the importing country is negative in nine of the 10 regressions and significant in the M/A regressions. Nontariff trade barriers in the exporting country tend to have a positive impact on EGs exports shown by a positive coefficient in all regressions, which is statistically significant at the 1% level for APC and REP products. The positive coefficient on NTBs in an exporting country, as explained previously, may be caused by the fact that TBT and SPS concern notifications can to a certain extent capture the quality of EGs of a country. A country with more TBT and SPS concern notifications on imported EGs may be a country that produces high-quality EGs itself. The estimated coefficient on NTBs in the importing country (ntbjt) is negative across different subcategories of EGs and significant for SH and WWM products. This shows a negative impact of NTBs on a country's EGs imports, which is consistent with our general expectation.

## Subsample regressions based on income levels

In Table 5, exporting countries in our sample are divided into three income groups based on the World Bank income classifications: the lower-middle income group, the upper-middle income group and the high-income group.[6] A list of countries in each group is provided in the Appendix.

**Table 5. Trade liberalization and export performance of different countries**

| | Lower-middle income | Lower-middle income | Upper-middle income | Upper-middle income | High income | High income |
|---|---|---|---|---|---|---|
| | Dyad FE IV | Country FE IV | Dyad FE IV | Country FE IV | Dyad FE IV | Country FE IV |
| Variables | 5.1 | 5.2 | 5.3 | 5.4 | 5.5 | 5.6 |
| $tariff_{it}$ | 0.331*** | 0.294*** | −0.0287*** | −0.0299*** | 0.0822 | 0.0826 |
| | (0.112) | (0.0923) | (0.0086) | (0.0088) | (0.0720) | (0.0727) |
| $tariff_{jt}$ | −0.0145 | −0.0144 | −0.0187 | −0.0198 | −0.0059 | −0.0059 |
| | (0.0202) | (0.0211) | (0.0140) | (0.0143) | (0.0054) | (0.0055) |
| $ntb_{it}$ | −0.263** | −0.225** | 0.0719*** | 0.0777*** | −0.0187 | −0.0140 |
| | (0.117) | (0.112) | (0.0268) | (0.0267) | (0.0120) | (0.0119) |
| $ntb_{jt}$ | −0.0273 | −0.0415 | −0.0884*** | −0.0886*** | −0.0222 | −0.0214 |
| | (0.0369) | (0.0378) | (0.0253) | (0.0258) | (0.0121) | (0.0122) |
| $WTO_{ijt}$ | 0.359** | 0.396** | 0.223 | 1.028*** | 0.425*** | 0.422*** |
| | (0.175) | (0.179) | (0.168) | (0.390) | (0.0984) | (0.0996) |
| $FTA_{ijt}$ | −0.0055 | −0.0573 | 0.115 | 0.186 | 0.0336 | 0.0388 |
| | (0.152) | (0.155) | (0.112) | (0.136) | (0.0521) | (0.0524) |
| Observations | 762 | 762 | 1623 | 1623 | 2194 | 2194 |
| R-squared | 0.215 | 0.209 | 0.256 | 0.255 | 0.375 | 0.374 |

Table 5 shows some interesting heterogeneity in the relationship between trade barriers and EGs export performance across countries. As we can see, upper-middle income group results related to the impact of changes in trade barriers on EGs exports are most consistent with our previous results – the estimated coefficient on tariffs in the exporting country being negative and significant, the estimated coefficient on NTBs in the exporting country being positive and significant and the estimated coefficient on NTBs in the importing country being negative and significant. In contrast, lowering trade barriers does not seem to have a significant impact on EGs exports in the high income group as the estimated coefficients on tariffs and NTBs are not significant at conventional levels. This might be because high-income APEC countries on average already have a fairly low trade barrier and the additional benefit of trade promotion by furthering, lowering the tariff and nontariff trade barriers can be quite small compared to other countries in our sample.

For lower-middle income countries, the estimated coefficient on the exporter's import tariffs is positive and significant while the estimated coefficient on the exporter's NTBs is negative and significant. The signs on these coefficients are opposite to our expectations and indeed are very different from the results in the upper-middle and high income groups. The positive coefficient on tariffit in the lower-middle income group may be explained by the fact that most APEC lower-middle income countries have been experiencing a trade deficit in EGs. For instance, in the year 2011, the average trade deficit in EGs in lower-middle income APEC countries was equivalent to 77% of their total EGs trade (imports plus exports). Raising import tariffs on EGs could increase domestic production cost and possibly have a negative impact on country *i*'s EGs exports as we point out earlier. However, given that most lowermiddle income APEC countries are net importers of EGs, a higher import tariff may also help protect domestic EGs industries in country *i* from competing with more experienced producers in upper-middle or high-income APEC countries. This would suggest a positive relationship between the average import tariff on EGs and a country's export of EGs and our results of the positive coefficient on tariff in the exporting country might have a dominant domestic protection effect of import tariffs on EGs.

Different from tariffs that directly change the price of traded products, NTBs such as TBTs and SPS mainly restrict or regulate the quality of imported EGs. For lower-middle income APEC economies, restricting the quality of their imports might result in a mismatch between higher-quality imported inputs and domestically produced lower-quality EGs, which can lower production efficiency, lead to an increase in production cost in domestic EGs industries and deter its exports of EGs. This possibly explains the negative coefficient on NTBs in a lower-middle income exporter in the APEC group.

## VI. Conclusions and Policy Implications

Our study explores the relationship between trade liberalization and exports of EGs. Using data on bilateral exports of 104 EGs among 20 APEC countries over the period of 1996–2011, we find that a lower average tariff rate on EGs in the exporting country tends to increase its EGs exports while the average tariff rate in the importing country have no significant impacts on its EGs imports. Instead, importing countries are likely to rely more on nontariff barriers to restrict EGs imports as shown by the significantly positive effect of lowering NTBs in an importing country. Results focusing on different categories of EGs are in general consistent with results based on aggregate EGs exports while results based on exporting countries with different levels of income show a considerable amount of heterogeneity in the effect of trade liberalization on exports of EGs. Furthermore, WTO does promote bilateral trade in EGs between members particularly for exporters with a high income level. Our results suggest that aggregate EGs trade (exports) between two WTO members is at least 40% higher than trade between a dyad with one or both partners not in the WTO.

Our results have important policy implications. First, a continuing effort from trading partners to focus on lowering EGs trade barriers is important for APEC countries. In 2012, APEC constructed a 'new' list of EGs and member countries have committed to reduce applied tariff rates of 54 EGs in sixdigital HS codes to 5% or less by the end of 2015, which serves as an optimistic starting point for further liberalization of EGs. As NTBs can often be more restrictive to EGs trade in a country than tariffs, in future trade negotiations, attention should also be given to reducing NTBs. Second, our results suggest that it may not be in the best interest of governments to simply apply uniform trade liberalization policies to all EGs categories. 'Tailor-made' policies that fit to different characteristics of industries are

necessary. Heterogeneity in the effects of trade liberalization on EGs exports across income groups also calls policy attention to NTBs reductions in lower-middle income countries and on tariff reductions in uppermiddle income countries. In addition, the list of EGs may be extended to cover some 'Environmental Preferable Products' (EPPs), which are products having a less or reduced negative impact on the environment, to gain more support for further EGs negotiations from APEC less developed members.

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## Footnotes

[1]Existing studies typically discuss the disagreement among countries on the definition of EGs (Lendo, 2005; Steenblik, 2005), the global demand for EGs (Blazejczak et al., 2009; Carlsson et al., 2010), and EGs trade negotiation strategies (Chaytor, 2002; Yu, 2007).

[2] For example, if prior to year 1996 a country has signed 10 international environmental treaties with 7 of them being in force, then the environmental regulation index for this country for the year of 1996 would be 7 * 1 + 3 * 0.5 = 8.5.

[3] Take the photovoltaic industry as an example. Wyden (2012) points out that the market share of the US and European manufacturers in the photovoltaic industry has been declining while the market share of Chinese manufacturers is on the rise. Lower trade barriers on EGs imports in China has made low-cost polysilicon, one of the most important raw materials for solar panels, readily available to domestic Chinese solar panel producers and provides them with an advantage in exporting solar panels and solar cells. However, when a large quantity of low-priced photosensitive semiconductor devices flow into the US and European markets, their domestic manufacturers of photovoltaic products face an increased import competition and may have to shut down or exit the market eventually.

[4] Chinese Taipei is not included as its 6-digit HS code trade data are not available.

[5] The correlation coefficient between these two variables is fairly small, −0.1.

[6] Economies are divided according to 2012 GNI per capita, calculated using the World Bank Atlas method. The groups are: lower middle income, $1036–$4085; upper middle income, $4086–$12 615; and high income, $12 616 or more.

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Table A1. Classification of environmental goods proposed under APEC's EVSL initiative

| Category | HS 6-digit code | Category | HS 6-digit code | Category | HS 6-digit code | Category | HS 6-digit code |
|---|---|---|---|---|---|---|---|
| R/C | 2302.10 | PWT | 8413.81 | REP | 8502.31 | M/A | 9027.40 |
| WWM | 3926.90 | M/A | 8414.10 | S/H | 8505.90 | M/A | 9027.50 |
| WWM | 4601.20 | APC | 8414.59 | S/H | 8514.10 | M/A | 9027.80 |
| WWM | 5603.14 | M/A | 8414.80 | S/H | 8514.20 | M/A | 9027.90 |
| WWM | 5911.90 | S/H | 8417.80 | S/H | 8514.30 | M/A | 9028.10 |
| M/A | 6902.10 | S/H | 8417.90 | S/H | 8514.90 | M/A | 9028.20 |
| M/A | 6902.20 | REP | 8419.19 | REP | 8541.40 | M/A | 9028.30 |
| M/A | 6902.90 | M/A | 8419.40 | WWM | 8543.89 | M/A | 9028.90 |
| M/A | 6903.10 | H/E | 8419.50 | R/C | 8907.10 | M/A | 9030.10 |
| M/A | 6903.20 | M/A | 8419.60 | R/C | 8907.90 | M/A | 9030.20 |
| M/A | 6903.90 | M/A | 8421.19 | M/A | 9015.40 | M/A | 9030.31 |
| M/A | 6909.19 | WWM | 8421.21 | M/A | 9015.80 | M/A | 9030.39 |
| M/A | 7017.10 | WWM | 8421.29 | M/A | 9015.90 | M/A | 9030.83 |
| M/A | 7017.20 | APC | 8421.39 | M/A | 9022.29 | M/A | 9030.89 |
| M/A | 7017.90 | M/A | 8421.91 | M/A | 9022.90 | M/A | 9030.90 |
| APC | 8404.10 | APC | 8421.99 | M/A | 9025.11 | M/A | 9031.10 |
| APC | 8404.20 | ORS | 8422.20 | M/A | 9025.19 | M/A | 9031.20 |
| APC | 8405.10 | WWM | 8428.33 | M/A | 9025.80 | M/A | 9031.30 |
| N/V | 8409.91 | WWM | 8436.80 | M/A | 9025.90 | M/A | 9031.80 |
| APC | 8409.99 | S/H | 8462.91 | M/A | 9026.10 | M/A | 9031.90 |
| REP | 8410.11 | S/H | 8472.90 | M/A | 9026.20 | M/A | 9032.10 |
| REP | 8410.12 | ORS; S/H | 8474.10 | M/A | 9026.80 | M/A | 9032.20 |
| REP | 8410.13 | ORS | 8474.32 | M/A | 9026.90 | M/A | 9032.81 |
| REP | 8410.90 | WWM; ORS | 8479.82 | M/A | 9027.10 | M/A | 9032.89 |
| WWM | 8413.60 | S/H; WWM | 8479.89 | M/A | 9027.20 | M/A | 9032.90 |
| WWM | 8413.70 | PWT | 8479.90 | M/A | 9027.30 | M/A | 9033.00 |

*Notes*: APC = air pollution control; H/E = heat/energy management; M/A = monitoring/analysis, N/V = noise/vibration abatement; ORS = other recycling systems; PWT = potable water treatment; R/C = remediation/cleanup; S/H = solid/hazardous waste; WWM = wastewater management; REP = renewable energy plant.

Table A2. Nontariff trade barriers over 1996–2011

| Rank | Members | Numbers of notifications involving EGs | Percentage of the total notifications | Number of HS codes covered | HS codes covered as a share of all EGs |
|---|---|---|---|---|---|
| 1 | CHN | 11 | 25.58 | 47 | 45.19 |
| 2 | USA | 14 | 32.56 | 9 | 8.65 |
| 3 | JPN | 6 | 13.95 | 6 | 5.77 |
| 4 | NZL | 1 | 2.33 | 4 | 3.85 |
| 5 | IDN | 4 | 9.3 | 2 | 1.92 |
| 6 | AUS | 1 | 2.33 | 1 | 0.96 |
| 7 | CAN | 1 | 2.33 | 1 | 0.96 |
| 8 | HKG | 2 | 4.65 | 1 | 0.96 |
| 9 | KOR | 1 | 2.33 | 1 | 0.96 |
| 10 | PER | 1 | 2.33 | 1 | 0.96 |
| 11 | SGP | 1 | 2.33 | 1 | 0.96 |
| Total/average | | 43 | 9.09 | 74 | 6.47 |

Table A3. Variable definitions and data sources

| Variables | Definition | Source |
|---|---|---|
| $\text{Export}_{ijt}$ ($X_{ijt}^{k}$) | Aggregated exports in constant 2005 prices US dollar from economies *i* to economies *j* at time *t*, for the selected environmental goods | UNCTAD-COMTRADE |
| $\text{GDP}_i$, $\text{GDP}_j$ | Importing and exporting countries' GDP | World Bank |
| $\text{dist}_{ij}$ | Bilateral geographic distances from countries *i* to countries *j* | CEPII |
| $\text{border}_{ij}$ | Dummy variable = 1 if the two economies *i* and *j* are contiguous | CEPII |
| $\text{sim}_{ijt}$ | $\text{sim}_{ijt} = \ln\left[1-\left\lvert\left((\text{GDP}_{it})/(\text{GDP}_{it}+\text{GDP}_{jt})\right)^2-\left((\text{GDP}_{jt})/(\text{GDP}_{it}+\text{GDP}_{jt})\right)^2\right\rvert\right]$ | World Bank |
| $\text{indus}_{jt}$ | Industrial production (as a percentage of GDP) of economies *j* at time *t* | World Bank |
| $er_{jt}$ | Stringency of environmental regulation in country *j* at year *t*, measured by participation information of multiple environmental treaties calculated by authors | Environmental Treaties and Resource Indicators (ENTRI), http://sedac.ciesin.columbia.edu/entri/ |
| $\text{carbon}_{jt}$ | Carbon dioxide emissions (metric tons per person) of economies *j* at time *t* | World Bank |
| $\text{tariff}_{it}$, $\text{tariff}_{jt}$ | Simple averaged MFN applied tariffs for total environmental goods in APEC list, respectively, for economies *i* and *j* | WTO |
| $\text{tariff}_{it}^{k}$, $\text{tariff}_{jt}^{k}$ | Simple averaged MFN applied tariffs environmental goods of category *k* in economies *i* and *j*, respectively (for subsample regressions) | |
| $\text{ntb}_{it}$, $\text{ntb}_{jt}$ | Nontariff barriers measured by the accumulated numbers of TBT and SPS notifications involving EGs in economy *i* and j, respectively. | WTO |
| $\text{WTO}_{ijt}$ | Dummy variable = 1 when both *i* and *j* are WTO members | WTO |
| $\text{FTA}_{ijt}$ | Dummy variable = 1 when the economic partnership agreement (EPA) or free trade agreement (FTA) is in force between *i* and *j* | www.globalpes.com; Organization of American States |

Table A4. Correlation matrix

| | $border_{ij}$ | $lndist_{ij}$ | $Ln(GDP_{it} + GDP_{jt})$ | $sim_{ijt}$ | $indus_{jt}$ | $er_j$ | $Lncarbon_{jt}$ | $tariff_{it}$ | $tariff_{jt}$ | $ntb_{it}$ | $ntb_{jt}$ | $WTO_{ijt}$ | $FTA_{ijt}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $border_{ij}$ | 1 | | | | | | | | | | | | |
| $lndist_{ij}$ | −0.288 | 1 | | | | | | | | | | | |
| $Ln(GDP_{it} + GDP_{jt})$ | 0.018 | 0.112 | 1 | | | | | | | | | | |
| $sim_{ijt}$ | 0.032 | −0.033 | −0.430 | 1 | | | | | | | | | |
| $indus_{jt}$ | 0.073 | −0.098 | −0.174 | −0.094 | 1 | | | | | | | | |
| $er_j$ | −0.034 | 0.220 | 0.382 | 0.031 | −0.448 | 1 | | | | | | | |
| $Lncarbon_{jt}$ | −0.009 | 0.030 | 0.313 | −0.037 | −0.103 | 0.344 | 1 | | | | | | |
| $tariff_{it}$ | 0.014 | 0.056 | −0.097 | 0.057 | −0.039 | −0.072 | −0.012 | 1 | | | | | |
| $tariff_{jt}$ | 0.014 | 0.056 | −0.097 | 0.057 | 0.347 | −0.103 | −0.081 | 0.067 | 1 | | | | |
| $ntb_{it}$ | 0.015 | −0.033 | 0.388 | −0.157 | 0.023 | 0.052 | 0.003 | −0.193 | −0.084 | 1 | | | |
| $ntb_{jt}$ | 0.015 | −0.033 | 0.388 | −0.157 | −0.180 | 0.230 | 0.218 | −0.084 | −0.193 | 0.077 | 1 | | |
| $WTO_{ijt}$ | 0.007 | 0.042 | −0.003 | −0.049 | −0.086 | −0.135 | 0.062 | −0.128 | −0.128 | 0.115 | 0.115 | 1 | |
| $FTA_{ijt}$ | 0.160 | −0.302 | −0.002 | 0.049 | 0.131 | −0.101 | 0.029 | −0.077 | −0.082 | 0.119 | 0.110 | 0.156 | 1 |

Table A5. List of countries based on World Bank income classifications

| Income group | Country code | Country name |
|---|---|---|
| Lower-middle income | IDN | Indonesia |
| | PHL | Philippines |
| | PNG | Papua New Guinea |
| | VNM | Vietnam |
| Upper-middle income | CHN | China |
| | MYS | Malaysia |
| | THA | Thailand |
| | RUS | Russia |
| | CHL | Chile |
| | MEX | Mexico |
| | PER | Peru |
| High income | BRN | Brunei Darussalam |
| | HKG | Hong Kong |
| | SGP | Singapore |
| | AUS | Australia |
| | JPN | Japan |
| | KOR | Korea |
| | NZL | New Zealand |
| | CAN | Canada |
| | USA | United States of America |