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Is environmental goods trade beneficial for the environmental performance of the concerned countries?

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Abstract

This paper examines the impacts of environmental goods (EGs) trade on environmental performance of the concerned countries. The EGs have been disaggregated into renewable energy, environmental monitoring analysis and assessment equipment, and environmental protection and environmental preferable products. Environmental performance has been classified into environmental health and ecosystem vitality. The empirical analysis is carried out using data from the Asia Pacific Economic Cooperation (APEC) member countries covering the period of 2007-2014. The empirical results suggest positive impacts of EGs exports and imports on environmental performance. While exports of environmental goods have significant beneficial impacts on environmental health measure, the impact on ecosystem vitality measure is not impressive. These results support the reduction in barriers on EGs trade, which has policy implications towards increasing the technology, awareness, and environmental-regulation effects, and minimizing the scale effect of EGs exports.

Keywords:
Environmental goods trade; environmental health; ecosystem vitality; IV-Generalized methods of moments; Asia Pacific Economic Cooperation.

JEL Classification:
Q56; F14; F15

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1 Introduction

Attention on the trade in environmental goods (EGs) has been increasing in recent decades. For example, most of the currently negotiated free trade agreements have emphasized on promoting trade in EGs with the aim to improve the environmental performance of both the importing and exporting countries. Further, the trade-environment nexus was recognized by the members of the World Trade Organization (WTO) in the 1970s and was once again the center of attention at the Uruguay Round (1986-1994). The 2001 Doha Ministerial Declaration emphasized that the negotiations on reducing tariffs and non-tariffs on environmental goods and services should attempt to achieve a triple win situation for trade, environment and development. In September 2012, the agreement was made by the APEC leaders to reduce the applied tariffs on a list of 54 environmental goods by the end of 2015. Since then, interest has been building among APEC and non-APEC economies to find a way to re-engage in environmental goods tariff negotiations at the WTO. The WTO environmental goods agreement negotiations were formally launched in Geneva on 8 July 2014 and are ongoing after 18 rounds. Given those efforts in promoting EGs trade, the foremost and fundamental question for every country is whether EGs trade is beneficial for improving the environment.

Even though the relationship between trade and environment is examined by many studies, the results are mixed and there is a need for a more careful, structured, and disaggregated analytical approach (Emerson et al. 2011). Moreover, there are very few studies exploring the effect of EGs trade on the environment and no study comparing this effect between EGs exports and imports. While EGs imports are supposed to benefit the environment of the importing countries through the use of environmentally-friendly use of these goods, it is crucial to explore the impact of EGs exports on the exporting countries' environments. This analysis helps in answering an imperative and practical question related to the necessity of enhancement in EGs trade in general and EGs exports in particular; because, in the case where there is no impact of EGs trade on the environment, there is no reason for countries to concentrate on facilitating free trade in EGs.

Therefore, this study tries to fill the gap in the literature by exploring the association between EGs exports and imports on environmental performance at the disaggregated levels. EGs are disaggregated into three groups: (i) renewable energy (RE); (ii) environmental monitoring analysis and assessment equipment (EME); and (iii) environmental protection and environmental preferable products (EP-EPP). Environmental performance (EP) has been classified into environmental health (ENH) and ecosystem vitality (ENS).

The contribution of the paper is threefold; first, this is one of the pioneering works looking at the relationship between trade and environmental performance at the country-pair level specifically. Secondly, in terms of methodological improvements, differing from the current literature, the instruments for endogenous variables are modified to avoid the risk of correlation between the instrumental variables (IVs) and the error term of the main equation. The paper uses the IV-Generalized Method of Moments (IV-GMM) to deliver more efficient estimates in the presence of heteroscedasticity. Thirdly, this is the first kind of study examining the impact of EGs exports and imports on the environmental performance of the APEC economies.

The remainder of this study is structured as follows: The following section gives an overview of EGs exports and imports of APEC members. Section 3 briefly presents the theoretical framework addressing the relationship between trade and the environment, and the empirical results of most relevant studies. Section 4 presents data of APEC-member countries from 2007 to 2014 and discusses the empirical framework of the IV-GMM models. Section 5 discusses the empirical results concerning the determinants of environmental performance, with a focus on the contributions of EGs exports and imports. Section 6 concludes with policy suggestions for promoting the nexus of EGs trade and the environmental performance.

2 Trade in Environmental goods of APEC members: An overview

Overall, exports of APEC countries were greater than their imports in the two EGs categories of RE and EME most of the time during 2007-2014 as shown in Figures 1 and 2. While imports in these two subgroups were trending upward during this period, exports fluctuated with a significant reduction around 2011-2013, followed by a sharp climb in 2014. Therefore, imports were greater than exports for these two subgroups around 2011-2013, but exports overtook imports again in 2014.

Figure 1 **RE exports versus RE imports of APEC countries, 2007-2014**

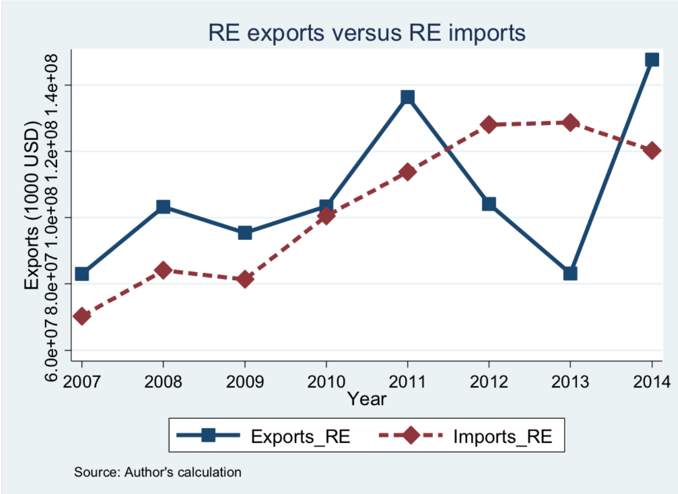
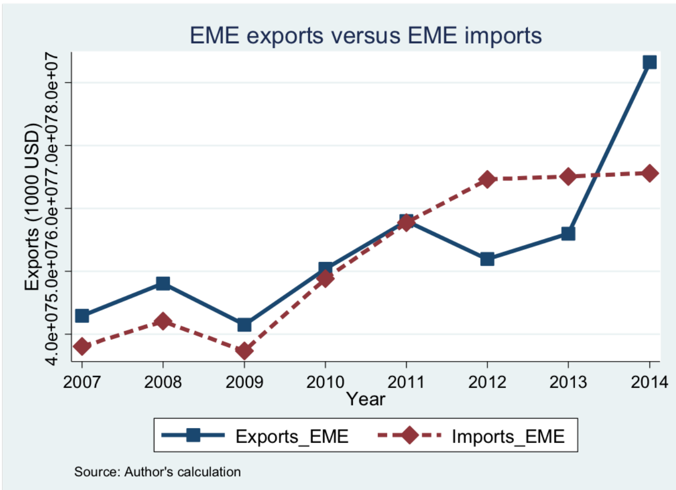
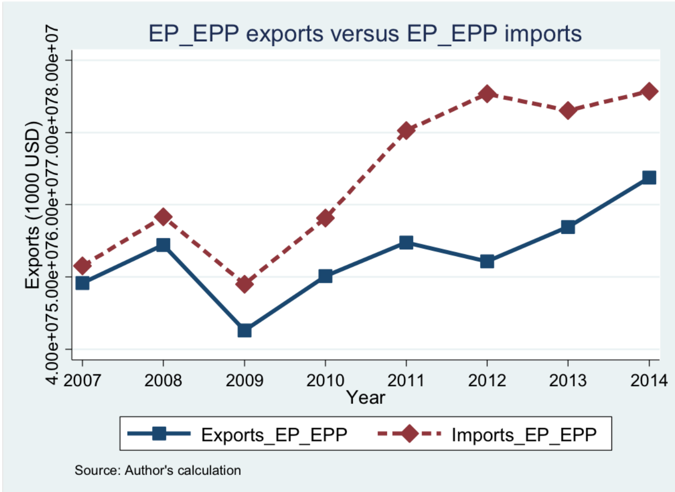


Figure 2 **EME exports versus EME imports of APEC countries, 2007-2014**



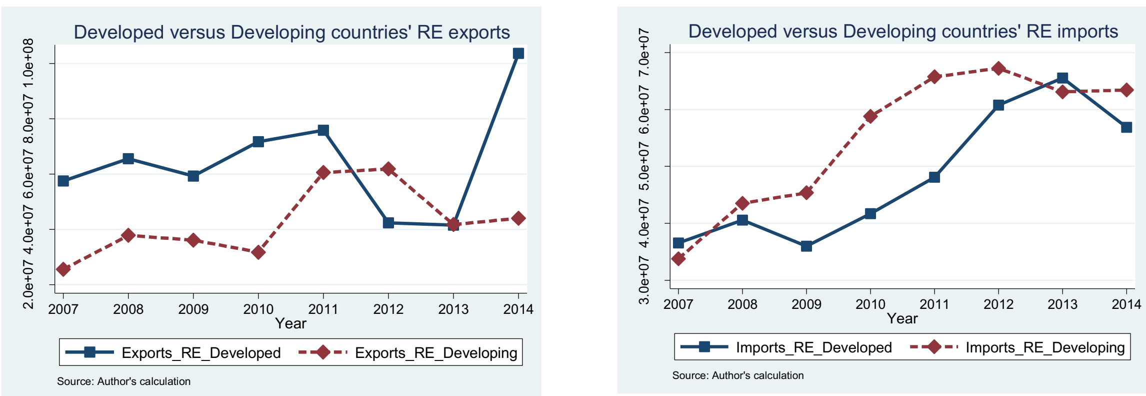
On the other hand, APEC countries' EP_EPP imports were consistently more than their EP_EPP exports, from 2007 to 2014 as shown in Figure 3.

Figure 3 **EP_EPP exports versus EP_EPP imports of APEC countries, 2007-2014**



However, there was a significant gap in EGs exports and imports between the APEC developed economies[1] and the APEC developing economies as shown in Figures 4-6. While EGs exports of the developed economies were more than those of the developing economies during this period, their imports showed the opposite.

Figure 4 **Developed versus developing economies' RE exports and imports, 2007-2014**

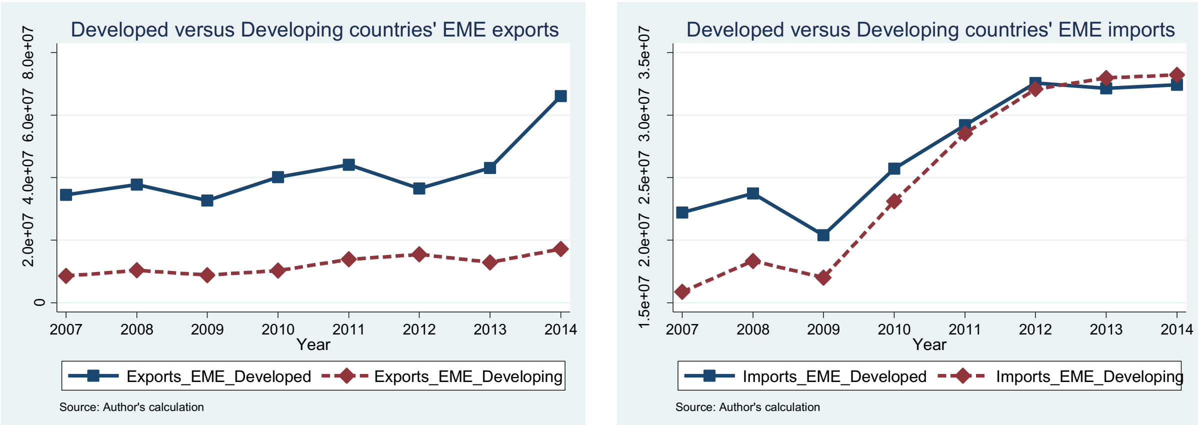


The only exception is that EME imports of the developed economies were more or less equal to those of the developing economies. However, in recent times developing countries' EME

[1] Developed economies in APEC in this paper include Australia, Canada, Hong Kong, Japan, Korea, New Zealand, Singapore, and the USA. Developing economies are the rest of APEC, except Taiwan.

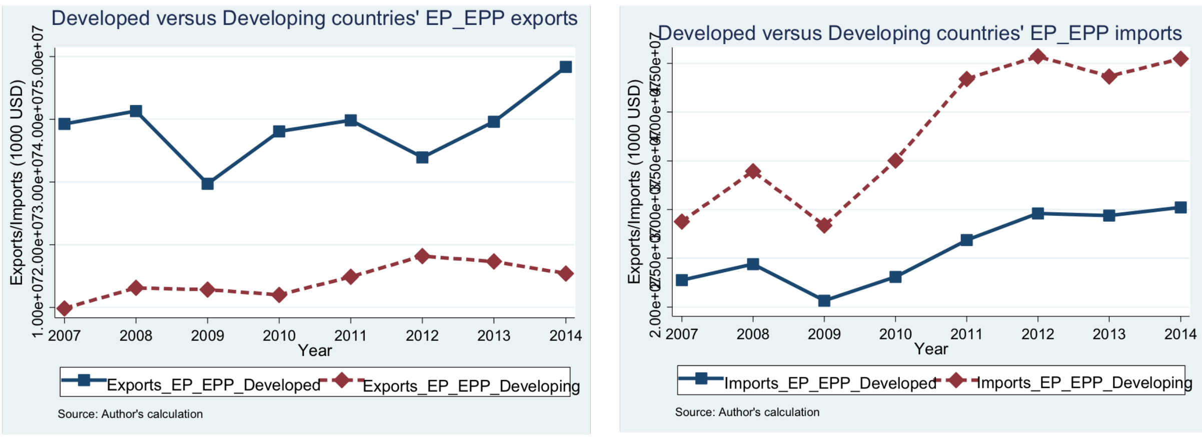
imports were higher than those of their counterparts in 2013 and 2014, though the gap was small (Figure 5).

Figure 5 **Developed versus developing economies' EME exports and imports, 2007-2014**



The gaps in EP_EPP exports and imports between the developed and developing economies as shown in Figure 6 were the biggest among EGs subgroups.

Figure 6 **Developed versus developing economies' EP_EPP exports and imports, 2007-2014**



3 Theoretical framework and empirical studies

3.1 Theoretical framework

The Environmental Kuznets Curve (EKC), the 'race to the bottom' synthesis, and the Pollution Haven Hypothesis (PHH) are among the most commonly used theories in analyzing the relationship between trade and environment. In the case of exports of environmental goods, the impact on the environment of the exporting countries operates both in the production stage and in the final environmental goods consumption stage. In the case of imports of environmental goods, the impact emanates mostly from the consumption stage in the importing countries. Hence, from the policy perspective, it is useful to gauge the impact of the components of trade – exports and imports – on the environment of the exporting countries, which is followed in this study.

EKC suggests that, at the first stage, income causes environmental degradation. However, after reaching a certain point of development, increase in income, on the one hand, leads to demand for higher environmental quality and cleaner technology; on the other hand, it raises the availability of technical, human and financial resources for environmental protection; thereby enhancing the environment. Therefore, the effect of income on environmental quality can be presented as the Environmental Kuznets Curve—the inverted U shaped relationship implying that an increase in income increases emissions in poor countries and reduces it in rich countries (Naughton 2006). There are three channels whereby trade can affect the environmental performance that shapes the EKC: by expanding the scale of economic activity, by altering the composition of economic activity, and by bringing about a change in the techniques of production (Grossman & Krueger 1991). Scale effect suggests that the increase in the size of an economy induced by trade expansion generates higher levels of pollution and ecosystem stress. The composition effect states that trade emanates from the specialization of goods in which countries have comparative advantage. The actual impact of the composition effect on the environment depends on how the economic structure of countries changes. Environment tends to increasingly worsen as the structure of the economy shifts from agriculture-based to industry-based, but it improves with the second structural transformation from energy-intensive heavy industry to services and technology-intensive industry (Panayotou 1993). The technique effect refers to a shift in production methods induced by trade liberalization and is thought to be positive for environmental quality. The technique effect can be divided into a technology effect and an income effect (Kleemann & Abdulai 2013). The OECD (1995) shows that 75 per cent of all international technology transfers stem from trade. As environmental quality is a normal good, if trade liberalization raises real income, the income effects will tend to reduce pollution via the demand of citizens for a cleaner environment (Copeland & Taylor 2004). Moreover, increased wealth accompanying trade provides access to improved technology and best practices that enable more efficient and environmentally sound production methods (Grossman a Krueger 1995), and investment in environmental amenities such as sewerage systems, piped drinking water, and better waste management. Ultimately, the impact of trade on environmental performance depends on change in economic structure.

The ‘race to the bottom’ hypothesis indicates that countries lower their environmental standards to attract foreign direct investment. In other words, countries converge on the regulatory practice of the least strict country as governments that attempt to maintain high standards will see their efforts undermined by the existence of less stringent regulations elsewhere. Therefore, wealthier countries may be forced to compete with developing countries and sacrifice environmental protection for short-term economic gain. This will lead to an overall lowering of environmental standards internationally (Jenkins et al. 2002). The ‘race to the bottom’ theory highlights competition as a driver of scale, technique, and composition effects as discussed by Emerson et al. (2011).

The ‘pollution haven hypothesis’ seems to be related to the ‘race to the bottom’ hypothesis. It states that investment shifts from countries with more stringent environmental policies to countries with less stringent ones. It is generally argued that more stringent domestic environmental policies tend to raise the costs of environmental ‘inputs’, putting the more polluting industries at a comparative disadvantage, lowering their exports and raising imports from countries with laxer environmental policies. Therefore, highly polluting industries have been transferred from developed countries to developing countries. On the one hand, the environmental concerns in developed economies caused them to enact strict environmental regulations, which increase the production cost of ‘dirty’ industries in these countries. On the other hand, developing countries with laxer environmental regulations are attractive to these sectors. Consequently, developing countries provide these industries with a ‘pollution haven’, and developed countries become net importers of these industries (Akbostanci et al. 2007).

In addition, Say’s law shows that production is the source of demand. One’s ability to demand goods and services from others derives from the income produced by one’s own acts of production. Therefore, increased income accompanying exports would increase domestic consumption of goods in exporting countries. Also, as per the Say's law that supply creates its own demand, the production of environmental goods may encourage the people to use those environmental goods produced within the country.

The environmental-regulation effect (Lai 2006) is also one channel for trade to affect the environmental performance. When a country becomes more integrated with the world economy, its exports become more responsive to environmental requirements imposed by importers, so the country must use environmentally friendly inputs for exports (Gönel et al. 2017) and environmentally friendly technologies.

Other reasons for a positive effect of openness on environmental quality (even for a given level of GDP per capita) are discussed by Frankel and Rose (2005). First, trade can spur managerial and technological innovation, which can have positive effects on both the economy and the environment. Second, the international ratcheting up of environmental standards is achieved through heightened public awareness.

3.2 Empirical studies

3.2.1 Proxy for the environment

Numerous variables are used in empirical studies as proxy for the environment, including local pollutions versus global pollutions, pollutant concentrations data versus emission data and recently, a few papers use overall comprehensive measure of environmental performance. The difference in the method used to construct these data is one of the sources for significant variations across results from different empirical works. According to Bernard & Mandal (2016), an ideal way to tackle this challenge is to use the overall environmental performance index to capture the overall impact of trade on the environment. Hence, this study uses the overall environmental performance and its two dimensions.

3.2.2 Determinants of environmental performance

Based on the discussion on channels through which trade affects the environment, while examining trade's impact on environmental performance, researchers include the scale effect (for example GDP), the composition effect (for example percentage of manufacturing and agriculture value added in GDP), and the technical effect (for example technological readiness) as determinants of the environmental performance.

In addition, factors determining the environmental performance are classified by Gallego-Alvarez et al. (2014) into two groups: socioeconomic (wealth or economic development, education) and institutional factors (administration effectiveness, control of corruption, political ideology). Even though few researchers note that governance is a driver of better environment performance (Zelli (2006 & 2007) and Scott (2004)), it is often overlooked in empirical studies of the trade-environment nexus (Emerson et al. 2011).

3.2.3 Methodologies adopted in empirical studies

Most of the studies in the 1990s did not address the reverse causality between environmental performance and trade, and GDP. Hence, it is rational to believe that those studies may be affected by the endogeneity arising from such reverse causality. The estimations with cross sectional data also restrict the scope of those studies (Bernard & Mandal, 2016). The instrumental variable (IV) for trade and income was first constructed by Frankel and Rose (2002 & 2005) to correct for reverse causality between environmental performance and trade, and income. To construct the IV for trade, they estimated the gravity model with distance, population, language, land border, land area, and landlocked on pairwise countries. Then, they aggregated the predicted trade of each exporting country to all its importing partners. At the end, the predicted value of trade and predicted GDP per capita were used as their instruments.

Many of the recent works have followed the approach of Frankel and Rose. Nevertheless, the approach of Frankel and Rose has been criticized by researchers, particularly for their construction of IV for income. Rodriguez and Rodrik (2000) argued that the predicted trade that Frankel and Rose constructed from geographically determined IV variables would also be correlated with income, because geography could likely to be a determinant of income. After adding some geographic variables into the equation of income, Rodriguez and Rodrik (2000) proved that those variables were highly statistically significant, which implied correlation with income. Also, the literature is not fully convinced by the arguments in support of potential correlations between growth and the rate of saving, and between growth and human capital. Bils and Klenow (1998) in their empirical work found bi-directional causality between growth and schooling. Further, there is also the possibility of correlation between environmental performances and variables used to construct the IV for income, such as investment and population growth rate. If this is the case, these IVs are not valid as they are correlated with the error term of the main equation. This fact makes the IVs for income still doubtful.

3.2.4 Results of the most relevant studies

The results from empirical works on the trade and environment interface are mixed. There is one strand of literature stating that trade expansion can improve wealth and bring in advanced technologies to developing countries, thus enabling countries to protect their environment. Antweiler et al. (2001) developed a theoretical model allowing examination of the impacts of trade on environmental performance through each of three channels: scale, composition, and technique. They found that trade created small changes in pollution concentrations through the composition channel; but technical and scale efforts, which were created by trade, reduced pollutions. The combining effect suggested that trade seemed to be good for the environment. Considering only the composition effect, Grossman and Krueger (1991) argued that NAFTA would have improved Mexico's environment because trade would induce the country's specialization in labour-intensive sectors that would cause less than average amounts of environmental damage. In terms of the impact of trade policy on the environment, Strutt and Anderson (2000) indicated that trade reforms would, in many cases, improve the environment at least with respect to air and water in Indonesia. Looking at the influence of trade on environment through environmental policies, Lapan and Sikdar (2017) examined the effect of intra industry trade on those policies in the presence of local and transboundary pollution when countries set their policies strategically, such as a pollution tax or pollution quotas. They showed that trade could lead to stricter environmental policies and consequently lower pollution than under autarky. Different from other studies, they showed that trade arises not because of the assumption that higher incomes lead to greater demand for cleaner environments, and hence decreased pollution, but rather because of the strategic effects associated with policy setting. Some researchers such as Omri et al. (2015) had used several pollutants as a proxy for environment to explore the correlation between financial development, CO_2 emissions, trade and economic growth for twelve Middle East and North Africa countries. They found no significant relationship between trade and CO_2 emission for 9 countries out of 12, but a positive and significant impact for 3 remaining countries. Shahbaz et al. (2013) found that trade openness reduced energy pollutants in the case study of Indonesia.

Another strand of literature argues highlighting the detrimental impacts of trade on the environment via increasing emissions and exhaustion of resources. Looking at the income effect, Lopez (1997) has concluded that an expanding trade seems to lead to further losses of biomass and deforestation; and the negative income effect of greater biomass losses is likely to more than off-set the positive income effect of reducing trade distortions. Using pollutants as a proxy for the environment in the trade-environment nexus, Harbaugh, Levinson, and Wilson (2002) reported a negative relationship between openness to trade and SO_2. Bernard and Mandakl (2016) have shown that, after correcting for endogeneity, trade openness had no impact on environmental performance, but it increased with CO_2 emission. Other researchers examined this relationship in specific countries: Machado (2000) proved a positive correlation between foreign trade and CO_2 emissions in Brazil. Halicioglu (2009) added trade openness to explore the relationship between economic growth, CO_2 emissions and energy consumption in Turkey. The results were that trade openness was one of the main contributors to economic growth while income raised the level of CO_2 emissions in Turkey. Furthermore, Tiwari et al. (2013) claimed that trade openness worsened the environmental quality in India.

However, many studies have claimed no impact of trade on the environment. Most of the studies in the 1990s found insignificant results and small effects of trade on the environment (Bernard & Mandal 2016), but these results seem to be influenced by the existence of endogeneity, as mentioned above. Ahmed (2014) has shown that openness has no impact on carbon emission in both the long and short terms for Mongolia. However, Bernard and Mandal (2016) also claimed no impact of trade on environmental performance, but a deleterious impact on CO_2 emission after factoring in endogeneity.

Yet, some scholars indicate the possibility of both positive and negative impacts of trade on the environment. Considering pollutants, Ahmed et al. (2016) found that openness induced CO_2 emission with increased national output in the short run, but reduced level of CO_2 emission in the long run. For China, Chang (2012) concluded that the long-term impact of trade and foreign direct investment (FDI) on industrial pollutants could be positive or negative, depending on the pollutants concerned. Using the overall environmental performance, Emerson et al. (2011) examined the impacts of trade on environmental performance, environmental health and ecosystem vitality by using cross section data. Their findings show that trade has a positive association with environmental health (statistically significant) and a negative relationship with ecosystem vitality (but statistically insignificant). They point out that the limitation of their study is the difficulty in exploring the relationship between trade, GDP and environmental performance because of dominant positive associations between trade and production. Correcting the simultaneity problem by constructing instruments for income per capita and openness to trade, Frankel and Rose (2005) have found that the net effect of trade openness on the environment could be positive or negative. Frankel and Rose (2009 and 2005) argued that openness as measured by the ratio of trade to income appeared to be beneficial for or had no detrimental impact on some measures of environmental degradation such as SO_2, NO_2 and PM, but had a detrimental effect on CO_2 (Frankel & Rose 2009).

Regarding the relationship between EGs trade and the environment, Gönel et al. (2017) explored the impact of EGs imports on air pollution in OECD countries and concluded that increases in imports of environmental goods and services were accompanied by decreasing levels of CO_2 emissions per capita and GHGs emissions per capita.

In summary, the results from empirical works on the trade-environment nexus are mixed. One of the main reasons for this comes from the different proxies for the environment. Another reason is the difference in methodologies, when, for example, endogeneity may cause bias for results of early works in the field. Even though current studies are not influenced by endogeneity, there is still concern about the correlation between growth and its determinants used to construct its IV, such as trade and human capital and more importantly, concern about the correlation between variables used to construct IV for income and dependent variable of the main equation. In addition, studies mainly explore the relationship between trade and a few pollutants, and there are very few empirical works on overall environmental performance. There are also very few studies on the relationship between EGs trade and the environment.

Therefore, the aim of this paper is to provide a better understanding of the relationship between EGs exports and imports and the environment, at the disaggregated (country-pair) level, with a focus on minimizing the unsolved methodology issues mentioned above.

4 Data and empirical framework

4.1 Data

The empirical study is based on the data from 20 APEC countries (excluding Taiwan) and all of their partner countries during the period 2007-2014. The GDP, population, gross savings (% of GDP), manufacturing and agricultural value added are retrieved from the World Bank database. The GDP is in constant 2010 US dollars. EGs exports and imports, based on HS 2007, were obtained from the Trade Analysis and Information System (TRAINS) using WITS from the UN COMTRADE database. The regulatory quality and voice index are downloaded from the World Governance Indicators. Simple distances have been downloaded from The

Center for International Prospective Studies (CEPII). Information about whether countries are contiguous, share a common language, and have ever had a colonial link (colony) is drawn from the CEPII data base. The statistical summary and notes on variables are presented in the Appendix.

In terms of EGs, though there has not yet been consensus on the definition of EGs or on what goods should be included in the EGs list, the WTO 153 list and the APEC 54 list are the two popular lists. This study has used the APEC's 54 list as it is the only list that has been applied in EG trade practices and agreements up to now. Most of the 54 EGs in the APEC list are included in the WTO list and this list contains goods from various points of view of environmental protection (Matsumura 2016). Three EG subgroups are made drawing on Vossenaar's (2013) approach: renewable energy (RE), environmental monitoring analysis and assessment equipment (EME), and environmental protection and environmental preferable products (EP-EPP)[2].

The Environmental Performance Index (EPI), which is presented in table 1, is developed by the Yale Centre for Environmental Law and Policy (YCELP) and the Centre for International Earth Science Information Network (CIESIN) at Columbia University. It is constructed from more than 20 indicators and decomposed into two dimensions: environmental health and ecosystem vitality. It identifies scores or targets for several core environmental policy categories and measures how close countries come to meet them. These targets were selected based on a review of environmental and health standards of international agreements, relevant environmental literature and expert opinion. The selected EPI indicators are weighted quite differently regarding significance and explanatory power. The selection of indicators and their weight are different from year to year. Each of the indicators was transformed into a proximity-to-target score, based on a theoretical scale of 0 to 100, with 0 being the worst observed value and 100 the best observed value. The environmental health, ecosystem vitality and overall environmental performance are calculated by the same method. As this index is published every two years, the data for missing years were extrapolated from past and future trends in this paper.

[2] This decomposition is based on utility of these goods. RE includes parts, accessories, devices and instruments that produce energy from sun, wind, hydro, biogas, biomass, and geothermal sources. EME contains instruments and appliances for measuring, monitoring and analyzing natural risks and pollution. EP comprises components, parts, devices used in waste treatment; and EPP are products that are produced from bamboo instead of wood.

Table 1 **Environmental Performance Index Framework, 2010**

Index	Objectives	Policy Categories	Indicators	Target
EPI	**Environmental Health**	Environmental burden of disease	Environmental burden of disease	10 DALYs per 1,000 population
		Air pollution (effects on humans)	Indoor air pollution	0% of population exposed
			Outdoor air pollution	<= 20 ug/m3
		Water (effects on humans)	Access to water	100% of population with access
			Access to sanitation	100% of population with access
	Ecosystem Vitality	Air Pollution (effects on ecosystem)	Sulfur dioxide emissions per populated land area	<= 0.01 Gg/sq km
			Nitrogen oxides emissions per populated land area	<= 0.01 Gg/sq km
			Non-methane volatile organic compound emissions per populated land area	<= 0.01 Gg/sq km
			Ecosystem ozone	0 ppb exceedance above 3000 AOT40.
		Water (effects on ecosystem)	Water quality index	Dissolved oxygen: 9.5mg/l (Temp<20°C), 6mg /l (Temp>=20°C); pH: 6.5 - 9mg/l; Conductivity: 500µS; Total Nitrogen: 1mg/l; Total phosphorus: 0.05mg/l; Ammonia: 0.05mg/l
			Water stress index	0% territory under water stress
			Water scarcity index	0% water overuse
		Biodiversity & Habitat	Biome protection	>= 10% weighted average of biomes protected
			Marine protection	>= 10% of country's exclusive economic zone protected
			Critical habitat protection	100% of critical habitats protected
	Ecosystem Vitality	Forestry	Growing stock change	ratio of growing stock in time2 to time1 >=1
			Forest cover change	no decline in forest cover
		Fisheries	Marine trophic index	no decline

			Trawling intensity	0% of exclusive economic zone trawled
		Agriculture	Agricultural water intensity	<= 10% of all water resources
			Agricultural subsidies	0 subsidies
			Pesticide regulation	22 points
		Climate Change	Greenhouse gas emissions per capita (including land use emissions)	2.5 Mt CO2 eq. (Estimated value associated with 50% reduction in global GHG emissions by 2050, against 1990 levels)
			CO2 emissions per electricity generation	0 g CO2 per kWh
			Industrial greenhouse gas emissions intensity	36.3 tons of CO2 per $mill (USD, 2005, PPP) of industrial GD

Source: Adapted from Emerson et al. (2011)

4.2 Empirical framework

The empirical study tries to tackle the criticism levelled against the approach of Frankel and Rose (2002) with respect to the endogeneity issue by using ‘distance’ as IV for exports and imports and gross saving (% of GDP) as IV for per capita income. As noted by Frankel and Rose (2002), geographic variables are plausibly exogenous to environmental performance. The exclusion of other variables such as trade, education, and population growth rate from the equation constructing IV for GDP per capita reduces the possibility of reverse causality between these variables and per capita income. More importantly, this exclusion helps to avoid the correlation between these variables and the error term of the main equation. However, the author acknowledges the potential reverse causality between gross saving (% of GDP) and GDP per capita, but the more serious issue of correlation between IV for income and the error term of the main equation is eliminated from the modeling.

Besides resolving a methodology issue, this approach also allows us to examine the trade-environment nexus at the disaggregated (country-pair) level. This disaggregated level will deliver the other layer of the picture. While at the aggregated level we can only know how the total trade of a country to all importing countries affects its environmental performance, country-pair data can provide understanding of the effect of each trade flow from one exporting country to each partner country on its environmental performance.

The paper uses panel data to control for unobservable heterogeneity that a cross-country approach cannot. As Baum et al. (2003) have pointed out that the conventional IV estimator is consistent, but is inefficient in the presence of heteroscedasticity, the IV-GMM is used instead of IV to make the estimations more efficient in the presence of heteroscedasticity of any unknown form. Unlike in earlier studies, this study has incorporated the influence of governance on environmental performance by including two institutional variables of regulatory quality and public voice.

The following empirical models are estimated to analyse the relationship between EGs exports and environmental performance. The dependent variables are environmental health and ecosystem vitality-two dimensions of the overall environmental performance.

$$\begin{aligned} ENH_{it} \text{ or } ENS_{it} = {} & \alpha + \beta_1 Ln(Exports(Imports)_{ijt} / GDP_{it}) + \beta_2 LnGDP\_per\_capita_{it} \\ & + \beta_3 Regulatory\_quality_{it} + \beta_4 Voice_{it} + \beta_5 Technology\_readiness_{it} \\ & + \beta_6 Agricultural\_value\_added_{it} + \beta_7 Manufacturing\_value\_added_{it} \\ & + e_{it} \qquad (1) \end{aligned}$$

where Ln is natural logarithm, 'ENH_{it}' is environmental health of country i in year t; ; 'ENS_{it}' is ecosystem vitality of country i in year t; Exports $(Imports)_{ijt}$ is EGs exports or imports, with EGs being decomposed into three subgroups: RE, EME, and EP-EPP in country i to country j in year t, and GDP_{it} is the gross domestic product of country i in year t; 'GDP per $capita_{it}$' refers to the gross domestic product per capita of country i in year t; '$Regulatory\_quality_{it}$' reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development of country i in year t; '$Voice_{it}$' reflects perceptions of the extent to which a country's citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media; '$Technology\text{-}readiness_{it}$' measures the percentage of individuals using the internet, fixed broadband internet subscriptions per 100 population, international internet bandwidth (kb/s) per internet user, and mobile broadband subscriptions per 100 population of country i in year t; '$Agricultural\_value\_added_{it}$' indicates the percentage of the added value of agriculture in GDP of country i in year t; '$Manufacturing\_value\_added_{it}$' indicates the percentage of the added value of manufacture in GDP of country i in year t; 'e_{it}' is the statistical error term.

Distance between importer and exporter is used as an IV for exports and imports, and gross savings (calculated as gross national income less total consumption, plus net transfers over GDP) is used as IV for GDP per capita.

The Cragg-Donald test is performed to check for weak instruments.

5 Results

The results from IV-GMM models are presented in Tables 2, 3 and 4. At the outset, the Cragg-Donald Wald F statistics, which are much higher than Stock-Yogo weak ID test critical values, show that distance and gross saving rate are not weak instruments for exports (or imports) and GDP per capita respectively. These results imply that the selected methodology is appropriate for this empirical study and the estimates are efficient.

5.1 The impact of EGs exports and imports on environmental health

The coefficients of exports and imports in GDP are statistically significant and positive for all EGs subgroups (as shown in Table 2). This is consistent with the results of Emerson et al. (2011) that show a positive relationship between trade flows and environmental health outcomes. The relationship between exports and environmental health is the strongest with EME, followed by RE, then EP-EPP (estimates of 0.266, 0.214 and 0.174 respectively). However, the size of the coefficients for imports of EGs subgroups shows a different order, with highest impact on EP_EPP, followed by RE and EME (0.861, 0.391, and 0.386 respectively). These results indicate that an increase in the share of EGs exports or imports in GDP enhances the environmental health of the APEC member countries.

In addition, the magnitude of impacts of EGs imports on environmental health is higher than that of EGs exports. This result is expected as EGs are selected to be in the EGs list mainly because their use is good for the environment, not based on their production process. Therefore, exporting countries do not, in most cases, benefit from their environmentally friendly use. The only exception is bamboo-based products in EP_EPP subgroup because these products are included in EGs list based on its use of environmentally friendly input of bamboo instead of wood, so it directly benefits the environment of exporting countries.

However, the production of EGs goods may benefit the environment of exporting countries as the production development in EGs enables lower prices of these goods for domestic consumers. Moreover, EGs production and exports are likely to increase producers' awareness of environmental protection and this may propagate throughout society. EGs production may also use more environmentally friendly inputs (especially in the case of environmentally friendly products). Another major explanation would be the spur of managerial and technological innovation accompanying trade and the international ratcheting up of environmental standards through heightened public awareness (Frankel & Rose 2005). All in all, the beneficial impact of EGs exports and imports on environmental health suggests that the technology, awareness, price, and environmental-regulation effects outweigh the scale effect in the case of APEC members.

GDP per capita has a positive and statistically significant relationship with environmental health for all subgroups RE, EME and EP-EPP in both cases, exports and imports. This result is expected as when income per capita increases, aspects of environmental health, such as access to water, and to sanitation, control of environmental burden of disease, or capacity to reduce indoor air pollution and outdoor air pollution, seem to be improved. The positive relationship between GDP and environmental health is consistent with the theory that the primary driver of environmental health is wealth, and with the results of Emerson et al. (2011).

The sign of both variables related to governance (regulatory quality and voice) is positive and significant for all EGs subgroups. This result is consistent with the inclusion of governance as a determinant of environmental performance of Gallego-Alvarez et al. (2014) and discussions of Nordström and Vaughan (1999), Zelli (2006 & 2007), and Scott (2004) who emphasise the role of governance as the major element within the trade and environment nexus. This indicates that the more the government can develop and implement sound policies to promote the private sector, the better will be the environmental health. Moreover, the more the people have freedom of expression, association, and participation in selecting the government, the better will be the environmental health. The reason seems to be that, in this case, citizens can better protect their rights in different aspects of the environmental health. This indicates that good governance can help to mitigate potential detrimental effects of scale and composition effects.

Technological readiness affects positively environmental health for all EGs subgroups. This is reasonable as when technology increases, it enables people to access the healthcare system more easily. It may also improve people's awareness of environmental problems and disease prevention.

Table 2 **Impact of EGs exports and imports on environmental health of exporting countries**

	Dependent variable: Environmental health					
	For exports			For Imports		
VARIABLES	For RE	For EME	For EP_EPP	For RE	For EME	For EP_EPP
Ln(Exports (Imports)/GDP)	0.214***	0.266***	0.174***	0.391***	0.386***	0.861***
	(0.0699)	(0.0768)	(0.0667)	(0.148)	(0.131)	(0.140)
Ln(GDP per capita)	9.633***	9.655***	10.19***	9.100***	8.582***	5.220***
	(0.805)	(0.835)	(0.827)	(1.812)	(1.587)	(1.429)
Regulatory quality	1.578***	0.787**	1.490***	1.191	0.990	1.766***
	(0.375)	(0.393)	(0.380)	(0.789)	(0.691)	(0.568)
Voice	2.034***	1.975***	1.683***	2.106***	2.163***	1.548***
	(0.160)	(0.161)	(0.154)	(0.265)	(0.254)	(0.216)
Technological readiness	2.016***	2.345***	1.895***	2.649***	3.392***	5.836***
	(0.373)	(0.381)	(0.358)	(0.884)	(0.796)	(0.672)
Agricultural value added/GDP	0.310***	0.288***	0.356***	0.0921	0.0687	-0.146
	(0.0703)	(0.0714)	(0.0711)	(0.144)	(0.130)	(0.127)
Manufacturing value added/GDP	0.0240	0.0265	0.0388**	0.0285	0.00869	-0.0965***
	(0.0170)	(0.0180)	(0.0168)	(0.0439)	(0.0390)	(0.0341)
Constant	-12.73*	-12.41*	-18.85***	-4.767	-2.442	31.51***
	(6.665)	(6.967)	(7.032)	(14.35)	(12.68)	(12.08)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Cragg-Donald Wald F statistic	399	422	560	88	126	192
Stock-Yogo weak ID test critical values	7.03	7.03	7.03	7.03	7.03	7.03
Observations	8,532	9,227	9,466	2,842	3,294	6,452

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

While the increase in manufacturing value added in GDP may lead to harmful impacts on some sub-indexes of environmental health, as it seems to increase the environmental burden of disease and air pollution; it may also have beneficial impacts on other sub-indexes with better access to drinking water and sanitation. As APEC members are at different stages of economic development, the overall effect depends on the effects of dominant countries. In addition, as shown in Figures 4-6, EGs exports of the developed countries were greater than those of the developing countries and vice versa for EGs imports, especially in the case of EP_EPP. Therefore, the developed countries seem to dominate in the dataset for exports, while the developing countries do in that for imports. The overall negative impact of this variable on environmental health in the case of EP_EPP imports may conform to the effect of the first structural transformation from agriculture into industry of the composition effect of the developing countries. And its overall positive impact in the case of EP_EPP exports seems to conform to the second structural transformation from energy-intensive industry to technology-intensive industry in the developed economies.

Agricultural value added in GDP has a positive impact on environmental health for three EGs subgroups in the case of exports and no impact in the case of imports. On the one hand, the agricultural sector usually is expected to cause pollution less than the manufacturing sector (Gönel et al. 2017); therefore, it helps to reduce the environmental burden of disease and air pollution, which means beneficial effects of agriculture on environmental health. On the other hand, the increase in the share of agriculture in GDP may suggest lower access to drinking water and sanitation for the population, which suggests detrimental effects of agriculture on environmental health. In the case of EGs exports, the former effects are likely to dominate, whereas these effects seem to cancel out each other in the case of imports. One reason might be the domination of the developed countries in the dataset for EGs exports and that of developing economies in the dataset for EGs imports. Therefore, the positive impact of agricultural value added on environmental health in this case seems to be a result of a more sustainable practice in agriculture in the developed economies. However, no impact of this variable on environmental health is caused by a less sustainable practice in agriculture in the developing economies.

5.2 The impact of EGs exports and imports on ecosystem vitality

The picture is quite similar with ecosystem vitality, where EGs exports and imports have a statistically significant and beneficial impact on ecosystem vitality, but the coefficients are only statistically significant for EP_EPP exports and EME, EP_EPP imports. These positive impacts may come from the fact that beneficial effects (technology effect, lower prices and awareness raising and environmental-regulation effect) outweigh detrimental effects (the scale) in these cases. The magnitude of impact of EGs imports seems to be higher than that of EGs exports. The explanation for this difference seems to be the same with the case of environmental health, coming from the environmentally friendly use of these products. In the case of exports, only EP_EPP exports have a beneficial impact on ecosystem vitality while exports of RE and EME have no impact. One main explanation would be that the input used in production of EPP is environmentally friendly. The reason for no impact on ecosystem vitality of RE and EME exports and RE imports might be that the scale effect seems to be dominant in these cases. Increased production caused by exports and imports of these EGs subgroups is likely to generate more air pollution, increase water scarcity, worsen biodiversity and habitat, and reduce growing stock of forestry.

Whereas GDP per capita has a positive impact on environmental health for all EGs subgroups, it has a negative impact on ecosystem vitality in the case of EGs exports, which might be a result of the scale effect. While technological readiness has a positive impact on environmental health, it has a tremendous impact on ecosystem vitality for all EGs subgroups. These may be explained by the negative impacts of these technologies on ecosystem vitality through the scale effect. In addition, internet technologies (one of two elements of technological readiness) may release a significant amount of CO_2 emissions. As in the case of environmental health, manufacturing value added in GDP has a negative impact on ecosystem vitality.

As in the case of environmental health, voice and regulation quality have a statistically significant and positive impact on ecosystem vitality. Manufacturing value added has a negative impact on this dimension of environmental performance in the cases of RE and EME exports. This might be a result of harmful impacts of manufacturing value added on air pollution, biodiversity and habitat, forestry and climate change in ecosystem vitality measures. This result does not contradict the explanation about the domination of the developed countries in the dataset for EGs exports. However, it is likely that these harmful effects are much more significant on ecosystem vitality than environmental health; therefore, they outweigh beneficial effects of the second structure transformation from energy-intensive to technology-intensive industry in the cases of RE and EME.

Table 3 **Impact of EGs exports and imports on ecosystem vitality**

	Dependent variable: Environmental ecosystem					
	For exports			**For Imports**		
VARIABLES	**For RE**	**For EME**	**For EP_EPP**	**For RE**	**For EME**	**For EP_EPP**
Ln(Exports (Imports)/GDP)	0.0885	0.124	0.119*	0.234	0.314**	0.541***
	(0.0746)	(0.0821)	(0.0704)	(0.158)	(0.145)	(0.148)
Ln(GDP per capita)	-3.597***	-2.776***	-2.541***	3.390	3.602*	-0.0480
	(0.981)	(1.006)	(0.963)	(2.287)	(2.121)	(1.906)
Regulatory quality	2.488***	2.110***	2.252***	-0.539	-1.110	0.860
	(0.512)	(0.525)	(0.503)	(1.073)	(0.993)	(0.829)
Voice	3.836***	4.003***	3.737***	3.781***	3.773***	3.917***
	(0.191)	(0.190)	(0.182)	(0.355)	(0.345)	(0.285)
Technological readiness	-1.007**	-1.635***	-1.578***	-3.345***	-2.879***	-1.635**
	(0.416)	(0.419)	(0.388)	(1.040)	(0.975)	(0.808)
Agricultural value added/GDP	0.177**	0.225**	0.254***	0.796***	0.848***	0.430**
	(0.0896)	(0.0907)	(0.0875)	(0.186)	(0.176)	(0.174)
Manufacturing value added/GDP	-0.0514**	-0.0424*	-0.0322	-0.0411	-0.0268	-0.0324
	(0.0228)	(0.0237)	(0.0220)	(0.0589)	(0.0543)	(0.0465)
Constant	104.8***	100.2***	97.19***	49.90***	47.30***	81.48***
	(8.228)	(8.568)	(8.322)	(18.84)	(17.46)	(16.48)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Cragg-Donald Wald F statistic	399	422	560	88	126	192
Stock-Yogo weak ID test critical values	7.03	7.03	7.03	7.03	7.03	7.03
Observations	8,532	9,227	9,466	2,842	3,294	6,452

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

However, as the developed countries dominate more in the dataset of exports in the case of EP_EPP than RE and EME, the harmful effects cancel the beneficial effects out, but cannot outweigh them.

Agricultural value added has a positive impact on ecosystem vitality in all cases. This is expected as the agricultural sector seems to emit less than the manufacturing sector as mentioned above, which improves the subindexes of air pollution and climate change in ecosystem vitality measures. In this case, this positive impact outweighs the harmful impact of agriculture on ecosystems such as water stress and scarcity, reduction in growing stock change and forest cover change caused by unsustainable agricultural practice.

6 Conclusions and Policy suggestions

This study brings a better understanding of the impact of EGs exports and imports of APEC economies on their environmental performance by using an econometric technique for adjusting IVs for endogenous variables over the most popular methods used in the literature.

The results show a strong beneficial relationship between EGs exports and the two dimensions of the environmental performance of environmental health and ecosystem vitality of the APEC member countries. The analysis shows similar results between EGs imports and the two categories of the environmental performance. The positive relationship is the strongest with EP-EPP imports, followed by EME imports, and RE imports and that of EGs exports is slightly lower. These results suggest that the environmental-regulation effect, lower prices, heightened awareness and the technical effect of EGs trade outweighs its scale and composition effects for APEC members. These results support the reduction in barriers on EGs trade and calls for countries within WTO to achieve agreement in reducing tariffs on EGs to spread the beneficial impact of openness in EGs on environmental performance globally. The difference in magnitude of the impact of trade in each EGs subgroup also helps policy makers in developing trade policy for each EGs subgroup. For example, more priority needs to be given to EP_EPP imports as their effect on the environment is highly significant.

In addition, these results encourage countries to promote EGs exports because not only do they benefit the importing countries' environment by their environmentally-friendly use, but they also have a positive impact on the exporting countries' environment. However, while exports of environmental goods have beneficial impacts on an environmental health measure, their estimated impact on an ecosystem vitality measure is not as encouraging. It suggests that the scale effects may cancel out part of the positive effect caused by the technology effect, lower prices, heightened awareness and environmental-regulation effects in the case of ecosystem vitality. These encourage countries to pay more attention to increasing these positive effects and minimizing the scale effect of EGs exports.

Moreover, the result also highlights the importance of regulatory quality and citizens' ability to participate in selecting the government, freedom of expression, freedom of association, and a free media in improving environmental health, ecosystem vitality, and overall environmental performance. Therefore, good governance seems to be an effective tool for countries to mitigate the detrimental effects of EGs trade.

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Appendix

Statistical summary and notes on variables

VARIABLES	Observations	min	max	Notes
Technological readiness	18,207	2.850	6.160	Range: 1-7
Voice	19,313	-1.670	1.650	Range: -2.5 (weak) to 2.5 (strong)
Regulatory quality	19,313	-0.680	2.230	Range: -2.5 (weak) to 2.5 (strong)
Saving	18,904	14.44	62.66	% of GDP
Agricultural value added/GDP	18,519	0.0354	22.10	% of GDP
Manufacturing value added/GDP	18,230	1.264	32.37	% of GDP
Environmental performance	18,243	38.17	88.90	Range: 0-100
Environmental health	18,243	35.10	100	Range: 0-100
Ecosystem vitality	18,243	28.66	78.80	Range: 0-100
Ln(GDP per capita)	19,313	7.057	10.90	
Ln(Distance)	18,958	4.107	9.892	