November 2017

Fondazione Eni Enrico Mattei

Working Paper

056.2017

Trade in Environmental Goods: Empirical Exploration of Direct and Indirect Effects on Pollution by Country's Trade Status

Natalia Zugravu-Soilita

Climate Change: Economic Impacts & Adaptation
Series Editor: Francesco Bosello

Trade in Environmental Goods: Empirical Exploration of Direct and Indirect Effects on Pollution by Country's Trade Status

By Natalia Zugravu-Soilita, University of Versailles Saint-Quentin-en-Yvelines

Summary

Based on panel data covering 114 countries in the world, this study investigates the direct, indirect and total effects of trade flows in environmental goods (EG) on total CO_2 and SO_2 emissions. Our system-GMM estimations reveal positive direct scale – [between-industry] composition effects prevailing on the negative direct technique – [within-industry] composition effects (if any), as well as compensating the significant indirect technique effects channelled by the stringency of environmental regulations and per capita income. If the net importers of EGs (namely from the APEC54 and WTO26 lists) are recurrently found to face increased pollution (in particular CO_2 emissions) due to direct scale-composition effects of trade in EGs, the EGs' net exporters are more likely to see their local pollution to decrease, in particular thanks to income-induced effects. We show that the direct, indirect and total effects of trade in EGs depend on the country's net trade status, the EGs' classification and the pollutant considered.

Keywords: Environmental Goods, Environmental Policy, Net Exporter, Net Importer, Pollution, Trade

JEL Classification: F13, F14, F18, Q53, Q56, Q58

Address for correspondence:
Natalia Zugravu-Soilita
University of Versailles Saint-Quentin-en-Yvelines
UFR des Sciences Sociales / CEMOTEV
47, Bd Vauban
78280 Guyancourt
France
E-mail: natalia.zugravu@uvsq.fr, nzugravu@yahoo.com

Trade in environmental goods: empirical exploration of direct and indirect effects on pollution by country's trade status

Natalia ZUGRAVU-SOILITA

University of Versailles Saint-Quentin-en-Yvelines
UFR des Sciences Sociales / CEMOTEV
47, Bd Vauban
78280 Guyancourt
FRANCE

Fax : +33 1 39 25 57 00
e-mail: natalia.zugravu@uvsq.fr,
nzugravu@yahoo.com

Trade in environmental goods: empirical exploration of direct and indirect effects on pollution by country's trade status

This version: September 2017

Abstract

Based on panel data covering 114 countries in the world, this study investigates the direct, indirect and total effects of trade flows in environmental goods (EG) on total CO_2 and SO_2 emissions. Our system-GMM estimations reveal positive *direct scale – [between-industry] composition* effects prevailing on the negative *direct technique – [within-industry] composition* effects (if any), as well as compensating the significant *indirect technique* effects channelled by the stringency of environmental regulations and per capita income. If the net importers of EGs (namely from the APEC54 and WTO26 lists) are recurrently found to face increased pollution (in particular CO_2 emissions) due to direct scale-composition effects of trade in EGs, the EGs' net exporters are more likely to see their local pollution to decrease, in particular thanks to income-induced effects. We show that the direct, indirect and total effects of trade in EGs depend on the country's net trade status, the EGs' classification and the pollutant considered.

Keywords: environmental goods; environmental policy; net exporter; net importer; pollution; trade
JEL classification: F13, F14, F18, Q53, Q56, Q58

1. Introduction

Numerous studies have explored the environmental impact of international trade, but their results are still not conclusive.[1] This ambiguity would come from the diverse and opposing macro-level channels and micro-level mechanisms of transmission of the effects of trade on the environmental quality. The macro-level channels, through the *scale effect* (linking the emission changes to the overall level of economic activity), the *composition effect* (reflecting changes in pollution due to changes in the composition of the economic activity) and the *technique effect* (linking the changes in pollution to changes in emission intensities of each industry), have been extensively investigated, both theoretically and empirically. As predicted by the theory, scale effects are found to increase pollution and technique effects to lower emissions. The sign of the composition effects would vary across countries and the time-period explored. When investigating the impact of trade on the environmental quality, the academic literature has generally tended to focus on the relationship between the competitiveness of pollution-intensive industries and the stringency of environmental regulations, with particular attention paid to the *Pollution Haven Hypothesis*. Following this hypothesis, under free trade, stringent environmental regulations in one country lead to the relocation of pollution-intensive industries in countries with laxer regulations. Therefore, a scale effect on pollution should occur in the country hosting those pollution-intensive industries, which would consequently raise the overall pollution level. If pollution havens may theoretically arise from differences in the environmental carrying capacity, institutional capacity and environmental policy (Brander and Scott Taylor, 1998; Copeland and Taylor, 2003), their empirical validation is not a simple issue and depends, among other things, on the *differences in technology* between industrial and developing country investors (Dean, Lovely and Wang, 2009), the *stringency level* of the environmental regulations in the host economy (Ben Kheder and Zugravu, 2012), the *abundance of exhaustible resources* in the host country (Dam and Scholtens, 2012), the *multinationals' (vertical versus horizontal) motives* (Rezza, 2013; Tang, 2015), the *corruption level* in the host country and *multinationals' pollution intensity* (Manderson and Kneller, 2012) and *externalities* associated with *foreign firms' agglomeration* (Wagner and Timmins, 2009).[2]

A broad conclusion of the literature on the link between trade and environment is that international trade has a weak effect, or no effect, on pollution via the composition effect, and the recent emission reductions across the countries in the world would have resulted from a significant negative (income-induced) technique effect (Antweiler, Copeland and Taylor, 2001; Cole and Elliott, 2003; Grether, Mathys and de Melo, 2009; Levinson, 2009; Managi, Hibiki and Tsurumi, 2009; Brunel and Levinson, 2016). However, following a recent and constructive literature review by Cherniwchan, Copeland and Taylor (2017), the standard decomposition at the industry level would miss a reduction in emissions likely to arise from a trade-induced reallocation of output across firms in the same sector but with different emission intensities (from dirty to clean firms). That would underestimate the effects

[1] See for example Grossman and Krueger (1993), Copeland and Taylor (2004), Levinson (2009), Managi, Hibiki and Tsurumi (2009), Lovely and Popp (2011), Cherniwchan, Copeland and Taylor (2017).

[2] For more comprehensive and recent reviews of the literature on the pollution haven hypothesis, see also Taylor (2005), Kellenberg (2009), Brunel and Levinson (2016), Cherniwchan, Copeland and Taylor (2017), Zugravu-Soilita (2017).

of trade by misclassifying such reductions as technique (usually income-induced) effects. Thus, by reviewing the recent theoretical and empirical research at plant, firm, industry and national levels, Cherniwchan, Copeland and Taylor (2017) introduce and discuss new hypotheses that specify within-industry effects of trade on the environmental quality, by linking: (i) market share reallocations and selection effects to changes in industrial emissions (i.e., the *firm-reorganization effect* or *Pollution Reduction by Rationalization Hypothesis*); (ii) changes in abatement and emission intensities to increased foreign competition brought about by trade liberalization (i.e., the *domestic outsourcing effect* or *Distressed and Dirty Industry Hypothesis*); and (iii) firm level decisions to shift abroad production of dirty intermediate inputs to trade liberalization with countries having laxer environmental regulations (i.e., the *offshoring effect* or *Pollution Offshoring Hypothesis*)[3].

The academic literature on the environmental impact of international trade is quite extensive. Nonetheless, we still cannot validate the thesis that trade openness yields both economic and environmental gains for all the countries in the world. We could suppose that the failure to find conclusive empirical evidence for this thesis is due to a high focus of the existing investigations on the pollution-intensive goods. Alternatively, we could question the environmental impact of trade in goods deemed environmentally or climate-friendly. For instance, if stringent environmental regulations are usually found to harm the competitiveness of pollution-intensive industries, thus leading to their relocation in countries with laxer regulations, this tension could be removed in the case of '***environmental goods***' (***EGs***); *i.e.* their economic competitiveness would, in contrast, be enhanced by stricter environmental regulations. In this study, we consider *'environmental goods'* as the products manufactured with a scope of environmental protection (i.e. preventing, reducing and eliminating any degradation of the environment) and/or for the purpose of resource management (i.e. preserving and maintaining the stock of natural resources)[4].

Considering that all increase in the availability of EGs through trade openness represents an opportunity for a ***'triple win'*** relationship between **trade**, **development** and the **environment** (Yu, 2007), Paragraph 31(iii) of the Doha mandate, agreed to by all Members of the World Trade Organization (WTO) in 2001, calls for a reduction or, as appropriate, elimination of tariffs and non-tariff barriers on environmental goods and services. As mentioned by Sauvage (2014), 'while increased trade in EGs is not an end in itself, the environmental benefits this entails can contribute to global improvements in environmental quality'. The author suggests that strict environmental policy could effectively complement trade policy to increase demand for EGs not only domestically, but also abroad, thus allowing the achievement of global environmental targets.

[3] This hypothesis would be more subtle than the pollution haven hypothesis because it assumes that only the dirtiest parts of production (pollution-intensive intermediate goods) are offshored, and not the dirty final goods. Whereas it is quite difficult to find empirical validation for the pollution haven hypothesis, the pollution offshoring hypothesis might still work, especially when much of the dirty goods trade is intra-industry (Cherniwchan, Copeland and Taylor, 2017).

[4] Definition largely used by Eurostat, OECD, APEC, and WTO. This paper will focus on EGs without considering environmental services, because of data availability. This should not weaken our contribution to the academic literature on this topic. Indeed, without undermining the importance of environmental services in achieving environmental goals, the negotiations within WTO have, to date, been more active for EGs.

First, **trade** should be facilitated and thus intensified through the reduction or elimination of both tariff and non-tariff barriers. For instance, Hufbauer and Kim (2010) suggest that tariff elimination on EGs would increase world imports of these goods by approximately USD 56 billion. The World Bank (2007) advocates an increase of 7% of trade in wind, solar, clean coal and efficient lighting technologies in 18 top greenhouse gas (GHG)-emitting developing countries as a consequence of the removal of tariffs, and, if simultaneously accompanied by the removal of non-tariff barriers, trade gains could rise to 13%. Alternatively, Balineau and De Melo (2011) explain a weak increase in EGs' imports due to tariff reduction during the last decade by the existing (weak) tariff levels and import elasticity of demand. Recent research (Jha, 2008; Sauvage, 2014; Nguyen and Kalirajan, 2016) examining the factors determining trade in EGs highlights that lowering tariffs may increase trade, but higher gains could be obtained by the removal of non-tariff barriers. Trade in EGs is found to be sensitive to the economic size of the country, the national environmental performance indicators, technical assistance, foreign direct investments, etc. Despite low tariffs on many EGs in some developing countries, imports of EGs are still scarce because of a lack of technical assistance and, more generally, because of extremely weak purchasing power. In this context, market creation and capacity building should be prioritized to measures seeking for improved market access (Zhang, 2011).

Second, the liberalization of trade in EGs should be beneficial for **development**, as it would stimulate innovation and further technology transfer by reducing their costs on the local markets. For instance, Schmid (2012) shows that international projects (in particular the Clean Development Mechanism under the Kyoto protocol) are more likely to be accompanied by technology transfers when tariffs are low in the host countries. By increasing energy generation from new and renewable sources and goods, and more broadly, by enhancing the preservation of natural resources and by preventing environmental degradation, trade in EGs should help countries achieve the tools necessary to address key environmental priorities as part of a sustainable development strategy. According to the WTO, EGs' trade liberalization should benefit both developed and developing countries by enabling both environmental performance and economic development. In particular, because of tariff reductions, the exporters of EGs would benefit from getting new markets. Therefore, additional employment and income in the eco-industrial activities should contribute to the economic development in exporting countries. However, Hamwey et al. (2003) suggest that direct commercial profits from EGs' trade liberalization should primarily benefit the most advanced WTO member countries, enjoying a better access to EGs markets in the developing countries. Indeed, the international trade of EGs is largely dominated by firms from the developed countries, representing about 90% of world supply of EGs (GIER, 2009). Because tariffs applied to EGs are higher in the developing countries than in the developed countries, EGs' trade liberalization could be mainly *economically* beneficial to the advanced economies. Moreover, given that most of the developing countries are net importers of EGs, liberalization of these products could worsen their trade deficits. In addition, EGs' import tariffs could contribute to welfare improvement in the [net] importing countries by allowing them to capture a part of international eco-industrial firms' revenues. Hence, economic gains from EGs' liberalization would be for developed countries and the environmental gains for developing countries (Vikhlyaev, 2004).

Third, trade liberalization in EGs, making cleaner technologies more widely available, especially in developing countries, must be good for the **environment**. Market expansion resulting from trade liberalization should put pressure on local prices by increasing competition between imported and domestic goods. Lower compliance costs should finally facilitate setting (and reaching) stringent GHG emission targets. The literature investigating the link between trade in EGs and environmental performance is mainly theoretical and has been focusing on the environmental policy design in the context of EGs' trade liberalization (Feess and Muehlheusser, 2002; Copeland, 2005; Canton, Soubeyran and Stahn, 2008; Greaker and Rosendahl, 2008; David, Nimubona and Sinclair-Desgagné, 2011; Nimubona, 2012; Sauvage, 2014). For instance, Feess and Muehlheusser (2002) show that, when the domestic eco-firms are likely to benefit from higher emission tax rates, the home government would set stricter environmental regulations than foreign governments, which would lead to national leadership in pollution control.[5] Stricter environmental regulations would induce more firms to pay the initial R&D cost to enter the eco-industry, which should lead to an increased export market share of the domestic eco-industry. An empirical illustration of these last effects is proposed by Costantini and Mazzanti (2010). By employing a gravity model of trade, the authors find that environmental and energy taxes in the EU-15 countries between 1996 and 2007 have been associated with higher EGs exports. Although stringent environmental regulations lead to more environmental R&D by domestic firms in a small open economy, Greaker (2006) suggests that foreign eco-firms would also increase their R&D spending and sales of EGs to this country. Similarly, Greaker and Rosendahl (2008) show that stricter environmental policy is good for the domestic polluting industry, allowing it to get abatement equipment easier and at lower costs. Nonetheless, the authors suggest that this increase in demand for EGs from the domestic polluting industry may benefit foreign eco-firms at the expense of the domestic eco-industry. Hence, an especially stringent environmental policy should not be a suitable industrial policy for small open economies wishing to develop new successful export-oriented sectors. Moreover, while increased emission tax rates should induce new abatement suppliers to enter the market, David, Nimubona and Sinclair-Desgagné (2011) show it might not increase abatement efforts, because the demand for the abatement goods becomes more price inelastic when taxes are severe, thus leading the eco-firms to reduce their output.

An interesting research question emerging from the above-discussed literature is the interaction between the environmental policy and the EGs' tariffs in countries that are not exporters or even not producers of such goods. For instance, Nimubona (2012) develops a theoretical framework to investigate the EGs' trade liberalization effects in a developing country that is a non-competitive producer of abatement technologies and, thus, it is dependent on EGs imports. The author suggests that, when weak tariffs on EGs cannot sufficiently extract rents generated by severe environmental policy for an imperfectly competitive eco-industry, the government might choose to reduce the stringency of pollution taxes to maximize domestic social welfare. This can finally result in increased domestic pollution levels. Hence, following Nimubona (2012), exogenous reductions of EGs tariffs in the developing

[5] However, the authors assert that the home government is also likely to lower its tax rate when there is learning by doing.

countries would lead their governments – which are facing a loss of rents extracted from foreign eco-firms – to lower emission taxes. In conclusion, recent theoretical studies (Perino, 2010; David, Nimubona and Sinclair-Desgagné, 2011; Nimubona, 2012; Bréchet and Ly, 2013; Dijkstra and Mathew, 2016) find comparable results from quite different models; that is, despite increasing the expected cleanliness of production, EGs' trade liberalization may finally increase overall pollution. More precisely, the increased availability of cleaner technology due to trade liberalization would cause a 'backfire effect'[6] and the improved welfare would come at the expense of the environment. Total pollution should increase because more production is allowed by the government enjoying the opportunity for cleaner production. To avoid such negative outcomes, Nimubona (2012) suggests using quantitative abatement standards as an alternative pollution policy instrument accompanying the EGs' trade liberalization.

Given these contrasting results of the recent academic research on the expected effects of EGs trade liberalization, we can cast doubt on the 'triple win' scenario presumed by international organizations (in particular, the OECD and WTO). Although a 'double win' for welfare and trade has received quite reliable empirical proofs, the last and certainly not the least important and desired 'win' – in terms of environmental performance – is still the subject of debate. To bring further insights to this issue, it becomes important to ask the following questions: ***How does EGs trade ultimately affect the environmental quality? Are the non-competitive producers (or net importers) affected in the same way as the leading exporters of EGs?*** These questions form the research objective of our empirical study, which aims to estimate the effect of EGs trade on pollution in countries with different trade profiles. Whereas the above reviewed theoretical studies allow understanding the micro-level mechanisms at work, their empirical check is still a difficult task because of poor or virtually inexistent (cross-country) firm-level data on EGs imports and exports. Nevertheless, empirical data are available for the investigation of the macro-level channels through which EGs trade would affect the environment. However, we should be careful with their interpretations, which might be mis-specified when the micro-level mechanisms are omitted from the analysis (see Cherniwchan, Copeland and Taylor, 2017).

In spite of a series of reports by international organizations (OECD, 2001, 2005; WTO, 2001; UNCTAD, 2003; Bora and Teh, 2004; World Bank, 2007), the academic literature includes very few empirical studies on the potential effects of EGs' trade on environmental quality (e.g., Wooders, 2009; de Alwis, 2015; Zugravu-Soilita, 2016). For instance, by focusing on a particular group of EGs (i.e. Renewable Energy Plant sub-group considered to be of high potential to reduce GHG) Wooders (2009) suggests that the elimination of these products' tariffs would not have sufficiently high potential to reduce greenhouse gas emissions (0.1–0.9% of projected 'reference' case GHG emissions from fossil fuel combustion worldwide in 2030). On the contrary, by exploring direct and conditional effects on the pollution of trade intensity in EGs, de Alwis (2015) asserts that EGs trade liberalization would be associated with declining SO_2 emissions, regardless of income levels. Moreover, this negative effect would be

[6] This term comes from the energy economics literature and is used to designate situations of a rebound effect exceeding 100%.

stronger in the capital abundant countries. However, Zugravu-Soilita (2016) underlines that these results are partial and too optimistic, because de Alwis (2015) investigates only direct effects for a narrow sample of countries (62 countries; likely to introduce a selection bias) and the possible endogeneity problem in the relationship between trade in EGs, income (and thus the income-induced technique effect) and pollution is missing in their analysis. By proposing a deeper investigation of the direct and indirect effects for transition economies from Central and Eastern Europe, Zugravu-Soilita (2016) found: (i) a negative total impact of trade intensity in EGs (pooled OECD + Asia-Pacific Economic Co-operation [APEC] list) on CO_2 emissions mainly through an indirect income effect; (ii) a total positive effect on water pollution (BOD emissions) because of the prevailing, direct scale-composition effect; and (iii) no significant total effect on SO_2 emissions. Results are further diverging for specific pollutants and EGs categories (e.g., end-of-pipe, integrated solutions, environmentally preferable products). For instance, trade intensity in end-of-pipe abatement technologies would reduce only SO_2 emissions through a direct technique effect. However, we should mention that these empirical results, specific to the transition economies during a particular time period in the early 2000s (when these countries opened their economies considerably), may not give generalized conclusions for all countries in the world, and an empirical investigation including all the economies for which data are available would be of high academic value and policy implications. Moreover, as suggested by the theoretical literature linking EGs trade to the stringency of the environmental policy, particular attention must be paid to the countries that are not [or just non-performing] producers of EGs.

Consequently, **the originality of our study** is twofold. First, we perform a comparative empirical study on the EGs' trade impact on pollution in a large set of highly heterogeneous countries by exploring distinctions between '*EGs' net importer*' and '*EGs' net exporter*' trade status. Second, the empirical strategy employed allows us to estimate the macro-level channels (direct and indirect effects, via income and environmental policy) through which the trade of EGs affects pollution. More precisely, this study seeks to investigate the impacts of EGs' trade on total CO_2 and SO_2 emissions in 114 countries (70–75% of data points corresponding to situations of 'net importer' and 25–30% – 'net exporter') between 1996 and 2011[7], by using instrumental variable regressions and system-GMM estimations that simultaneously explain the pollution, the stringency of environmental regulations and the per-capita income.

This paper is structured as follows. After the introduction of our research objectives and the literature review in section 1, section 2 depicts some stylized facts on trade in EGs. Section 3 presents the theoretical background of our empirical model, and the estimation strategy and data are specified in section 4. The empirical results are discussed in section 5. The last section presents conclusions and some policy implications, and identifies directions for further research.

2. EGs' classifications and stylized facts

Several criteria for the identification of EGs have been suggested so far. The criterion of [prevalent] final use (e.g.

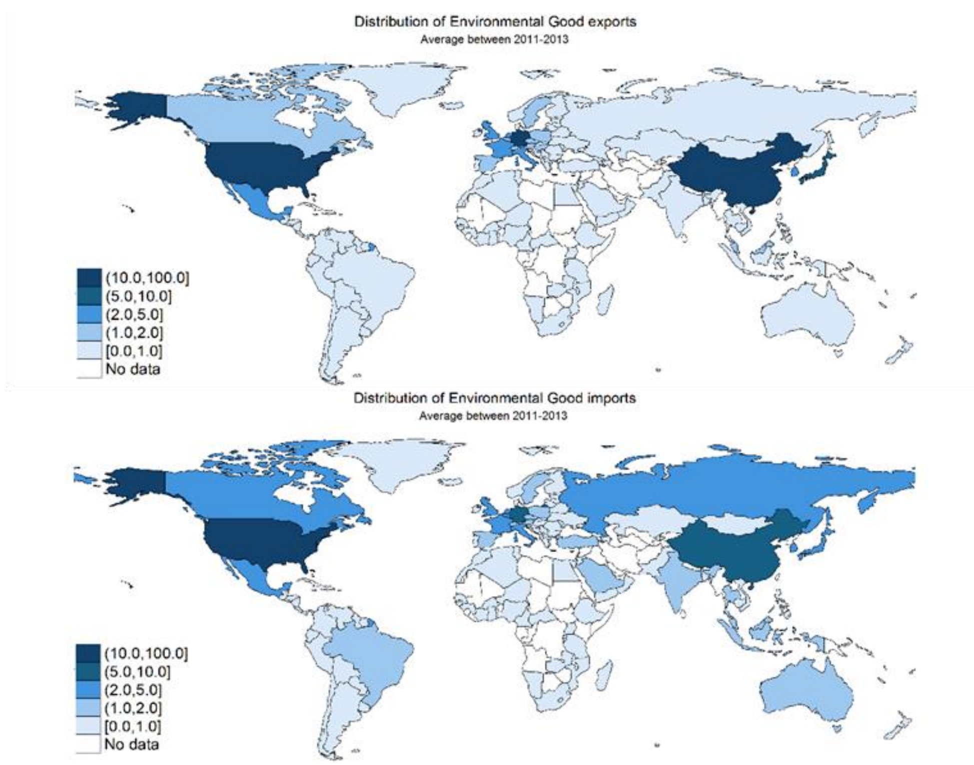
[7] See Table A.1 in the appendix A.

equipment used in environmental activities, such as pollution control and waste management) has reached a broad support. The lists compiled by OECD and the 21 member economies of Asia-Pacific Economic Co-operation forum (APEC) in the late 1990s have been the references so far (see Steenblik, 2005). Another criterion would be the identification of products that cause less damage to the environment during one of their life-cycle stages because of the manner they are manufactured, collected, used, destroyed or recovered, i.e. the so-called 'environmentally preferable products (EPPs)'. Nevertheless, the identification of EPPs generally relies on labelling and certification measures, and because EPPs differentiate among 'like products', the WTO has not yet considered to engage negotiation on these products. A performance criterion (e.g. energy efficiency during product use) was also proposed, but could be difficult to apply in a dynamic perspective because of the reality of technological progress and innovation.

The lack of an international agreement is mainly due to the practical difficulties in defining EGs (Steenblik, 2005, 2007; Balineau and de Melo, 2013). First, the inadequacy of the Harmonized System's (HS) descriptors at the six-digit level does not allow the designation of specific goods that are really deemed climate-friendly. Indeed, the more digits there are in a classification code, the more specific the description of the corresponding product. However, the HS codes are harmonized only up to the six-digit level. As highlighted by Zhang (2011), HS categories at the six-digit level include products that may have both environmental and non-environmental uses. The author brings the example of windmill pump, which despite of being a single-use product is identified as part of HS 841381, which also includes other pumps. Second, the identification difficulty of EGs concerns the 'double-use' problem, *i.e.* the existence of products with multiple uses, some of which are not environmental. For example, the gas turbines of HS 841182 may be used for electricity generation from biogas, which is rather climate-friendly, but they may also have other non-environmental applications (e.g., as aircraft turbines). In fact, they are very few HS codes at the six-digit level that perfectly match single-use EGs (e.g., HS 841011/2 for hydraulic turbines, HS 850231 for wind-powered electric generating sets). As stated by Zhang (2011), liberalizing dual-use products may have adverse effects on most of the developing countries. In particular, a broad liberalization of products may weaken their established domestic industries and sharply reduce their tariff revenues, which still represent an important share in government revenues. In addition, the problem of goods defined in terms of their relative environmental performance in use may require moving the targets as technology improves over time. For instance, whereas natural gas is less carbon emitting than coal, it is more polluting than wind power and even more polluting than a coal-fired power plant coupled with carbon capture and storage technology. There also might be serious doubts about the use of some products (e.g., bio-fuels) to save energy for example (Steenblik, 2007; Hufbauer, Charnovitz and Kim, 2009). Finally, conflicting interests and differing perceptions of the benefits from the liberalization of EGs may also explain – in some measure – the different definition approaches proposed. By mostly submitting goods in which they have a revealed comparative advantage and by usually being willing to exclude the goods with high tariffs from the negotiations, the countries often prove their mercantilist behaviour (Balineau and de Melo, 2013).

WTO members pursuing the Doha Round mandate to liberalize EGs have struggled over the last decade to define what exactly constitutes an 'environmental good' and, thus, to agree on an EGs list. Quite a few EGs lists have been proposed for negotiation (see Sugathan, 2013), ranging from the apparently non-debatable, but also not further explored, ***'WTO core list of 26'*** products (agreed to by Australia, Colombia, Hong Kong, Norway and Singapore in 2011) to the large ***'combined WTO list of 408'*** EGs.[8] At the same time, the APEC members meeting in Vladivostok (Russia) on 9 September 2012 were committed to reduce applied tariffs on 54 EGs to 5% or less by the end of 2015. Hence, the Vladivostok Declaration, representing the first international agreement to liberalize trade on a set of EGs, remains the main reference of EGs classification so far. In particular, the ***'APEC list of 54'*** EGs contains 15 sub-headings for *renewable energy*, 17 for *environmental monitoring, analysis and assessment equipment*, 21 for *environmental-protection* (principally air pollution control, management of solid and hazardous waste, as well as water treatment and waste-water management), and 1 sub-heading for *environmentally preferable products* (bamboo). However, it should be noted that only 12 of the codes on the APEC list are sufficiently precise to ensure that liberalization will only pertain to EGs; in contrast, 9 codes include products that have broad (non-environmental) applications (e.g., used in the petroleum, nuclear, mining and automobile industries).[9]

Figure 1 Distribution of EGs exports and imports



Source: UNEP, Trade in Environmental Goods (http://web.unep.org/greeneconomy/trade-environmental-goods)

[8] The WTO408 list includes many of the OECD and APEC goods and most of the products from the 'Friends of the Environment list'.

[9] See Reinvang (2014) and Vossenaar (2013) for more details about the APEC list.

Despite little progress in EGs trade liberalization, the global trade of EGs has significantly risen in recent years, both in developed and developing countries, representing USD 1 trillion annually. EGs market is expected to more than double its 2012 estimated value by 2022, growing from USD 1.1 trillion to some USD 2.5 trillion.[10] UNEP (2013) states that between 2001 and 2007 the total EGs (OECD+APEC broad lists) export value has grown by more than 100%. The maps in Figure 1 display the distribution of EGs world exports and imports. We can see that EGs exports are much more concentrated in a couple of leading economies (e.g. China, Germany, Japan, and the US) compared to EGs imports (developing countries typically being net importers).

With regard to the agreed APEC list of 54 EGs, Vossenaar (2013) shows that their trade value represented approximately 5% of the total APEC economies' imports and exports of manufactured products in 2011, with China, USA, Japan, Korea and Chinese Taipei the five largest traders and the top five exporters. Hong Kong enters among the top five importers at the expense of Chinese Taipei. Whereas Singapore, Mexico and Canada are the next largest traders in terms of both imports and exports, New Zealand, Chile and Peru are very small traders. Between 2002 and 2011, EGs exports raised by about 19% a year compared to only 12% for all manufactured goods. Imports grew during the same period by about 16% compared to 10% for all manufactured products. Despite a sharp decrease (about 16%) in EGs imports in 2009, their value in 2011 was 30% above the previous peak value in 2008.[11]

Today, WTO is pursuing negotiations for establishing an Environmental Goods Agreement (EGA), which were launched in July 2014 by 17 WTO members (including the EU; representing 46 countries)[12] accounting for the majority (about 90%) of the world trade in EGs. Building on the list of 54 EGs agreed by APEC, the objective of EGA is to eliminate tariffs on a broad range of EGs, thus allowing the addition of new products in the future, and to address non-tariff barriers. Once the WTO Members in the EGA represent a critical mass of global trade in EGs, the eliminated tariffs agreed by the participants in the negotiations would have to be applied to all WTO members: *i.e.* the agreement should be extended on a 'Most Favoured Nation' basis to all WTO members.

In this study, in addition to the APEC list of 54 EGs (**APEC54**), which is on the core of our research and the reference list in the negotiation debates, we explore and compare the effects on pollution of trade in EGs on the WTO lists. In particular, the narrow and more 'credible' list of 26 EGs (**WTO26**) is worth empirical investigation because of its prompt and univocal validation by a set of very active countries in the field of EGs liberalization. However, because most of the developing countries do not yet have well-developed markets for such products and would be more likely to benefit from a larger EGs list, we also investigate the WTO combined list of 408 EGs (**WTO408**). Our Table A.1 in Appendix A displays the list of countries, for which data necessary to our study are

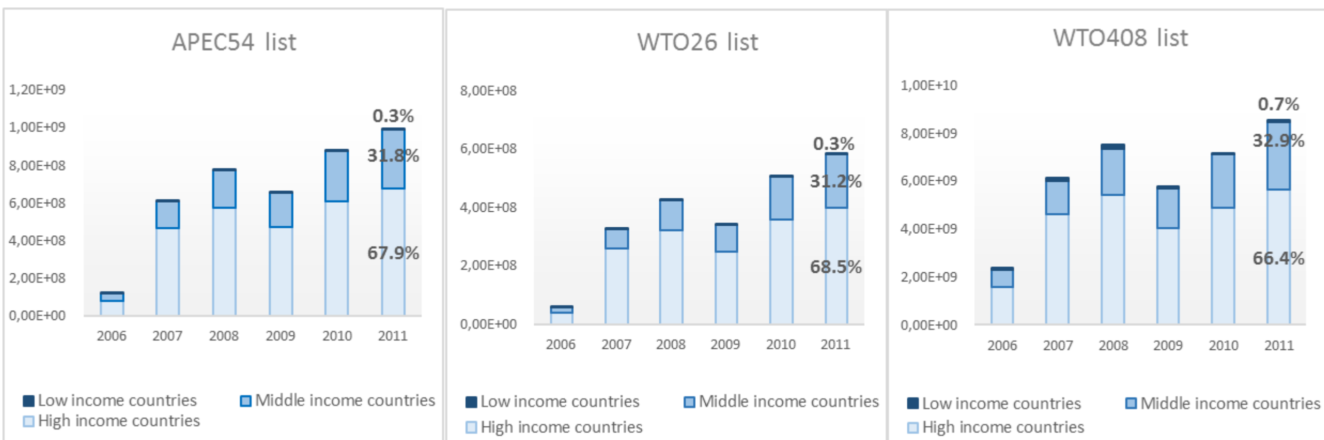
[10] http://www.international.gc.ca (Trade/Opening New Markets/Trade Topics/WTO Environmental Goods Agreement (EGA))

[11] Source of figures : Vossenaar (2013)

[12] Australia, Canada, China, Costa Rica, Chinese Taipei, the European Union, Hong Kong (China), Japan, Korea, New Zealand, Norway, Switzerland, Singapore, United States, Israel, Turkey and Iceland.

available, by counting the number of observations—years— when they were net exporter or net importer of EGs from a specific list. As we can see, a very few countries are predominantly net exporters of EGs in the three classification lists; for example, Finland, Philippines, Sweden, Japan, Republic of Korea, China, etc. Countries that are mainly net exporters in the narrow lists of EGs (**APEC54** and **WTO26**) are not necessarily net exporters of EGs largely considered (**WTO408**) (e.g., Austria, Italy, Denmark, Ukraine, South Africa, Switzerland, etc.). Conversely, net importers in EGs from APEC54 and WTO26 may be, simultaneously, net exporters of EGs from the **WTO408** list (e.g., Algeria, Belarus, Brunei, Cote d'Ivoire, Costa Rica, Lithuania, Mexico, Turkmenistan, Venezuela, etc.). Moreover, as shown in Figure 2, if the high income countries[13] dominate trade in EGs from different classification lists (66–69%), the least developed – and, in particular, the low income countries – get a market share that is twice as high (which still remains extremely weak) when passing from the reduced EGs' lists (**APEC54**, **WTO26**) towards the large WTO list of 408 EGs.

Figure 2 Trade in EGs from different classification lists, 2006–2011



Source: Author, using UN CONTRADE data

Finally, as there are a very few EGs of single use enjoying a specific HS six-digit level code – and these are in particular products under the category of renewable energy technologies – we perform some additional estimations for EGs from specific WTO408 list categories; for example, WTO_{RE} - Renewable Energy, WTO_{ET} - Environmental Technologies, WTO_{WMWT} – Waste Management and Water Treatment, and WTO_{APC} – Air Pollution Control.

3. Theoretical framework and empirical strategy

3.1. Theoretical framework and empirical model

Following the conventional function used in the environmental economics literature to investigate changes in

[13] Following the World Bank's classification, based on income per habitant.

pollution (e.g. Grossman and Krueger, 1993; Copeland and Taylor, 1994, 2005; Levinson, 2009; Managi, 2011), we can write total emissions $\boldsymbol{E}$ as the sum of emissions from each of activity/sector, $\boldsymbol{e_i}$, which may be further written as the total output, $\boldsymbol{Y}$— *i.e., **the scale effect***—, multiplied by each sector's share in this output, $\boldsymbol{\gamma_i}$ ($\gamma_i = y_i/Y$)— *i.e.* ***the composition effect***—, and the emission per unit of $\boldsymbol{y}$ produced (the sector's emission intensity), $\boldsymbol{\tau_i}$ — *i.e.* ***the technique effect***.

$$\boldsymbol{E = \sum_i e_i = Y \cdot \sum_i \tau_i \cdot \gamma_i}, \tag{1}$$

In vector notation, we have:

$$\boldsymbol{E = Y \cdot \tau' \cdot \gamma}, \tag{2}$$

where $\mathbf{E}$ and $\mathbf{Y}$ are scalars representing the total emissions and economic output (i.e., GDP), respectively; τ and γ are $n \times 1$ vectors.

At the same time, as suggested by Antweiler, Copeland and Taylor (2001), firms have access to abatement technology (i.e., improved environmental technologies and/or efficient management), which is generally costly. By assuming that pollution is directly proportional to output, and that pollution abatement is a constant return to scale activity, a sector's emission $\boldsymbol{e}$ may be written:

$$\boldsymbol{e = y \cdot \tau(\theta_\tau, a) = y \cdot (\theta_\tau \cdot a)^{-1}} \tag{3}$$

where $\boldsymbol{\theta_\tau}$ is the productivity of environmental technologies and $\boldsymbol{a}$ is the pollution abatement effort. With constant environmental technologies, pollution abatement efforts increase and emissions decline when the price of pollution abatement technologies decreases.

Taking the natural log of equation (2)(4) and combining it with equation (3) yields:

$$\boldsymbol{\ln E = \ln Y + \ln \gamma - \ln \theta_\tau - \ln a} \tag{4}$$

All else constant (e.g., mix of activities/sectors, environmental techniques and pollution abatement effort), the first term measures the increase in emissions when scaling up economic activity (**GDP**). Keeping constant output, environmental technologies and abatement efforts by the economic sector, the second term reflects the (between-industry) composition effect; that is, emissions increase if more resources are devoted to polluting sectors. A common proxy for this composition effect is the capital-to-labour ration (**K/L**). Theoretically, if a country is more capital abundant, it has a comparative advantage in capital-intensive activities, which are also empirically found to be more pollution intensive (see Mani and Wheeler, 1998; Antweiler, Copeland and Taylor, 2001; Cole and Elliott, 2003, 2005; Managi, Hibiki and Tsurumi, 2009).

The last two terms represent the technique (including within-industry reorganization) effects. Following Zugravu-Soilita (2017), we distinguish between '*autonomous*' and '*exogenous*' technique effects. Changes in production methods may affect pollution intensity through two ways:

- First, '*exogenous*' or '*induced*' technique effects appear when technological change and abatement efforts occur in response to regulatory mandates. These effects may be captured by a variable measuring the stringency of environmental regulations (***ER***).[14] Although stringent environmental regulations are not always associated to cleaner technologies, in particular when not efficiently implemented and/or enforced, numerous empirical investigations (e.g., Eskeland and Harrison, 2003; Arimura, Hibiki and Johnstone, 2007; Cao and Prakash, 2012) show that stringent, well-designed environmental policy is – all else equal – associated with an increased investment in environmental R&D accelerating environmental innovation and thus lowering pollution intensities.

- Second, an '*autonomous*' technique effect may reduce pollution when investment in environmental technologies occurs more or less automatically for exogenous reasons, e.g. technical progress, increased availability of more performing technologies (higher values for $\boldsymbol{\theta}$) and eventually less expensive (lower price of abatement technologies should increase abatement effort, i.e., higher values for $\boldsymbol{\alpha}$). We shall capture this '*autonomous*' technique effect in our empirical model by introducing two variables: **GNI/cap** and **Trade_EGs**.[15] As it is commonly assumed that environmental quality is a normal good, per capita income (**GNI/cap**) is supposed to capture the *willingness (and capacity) to pay to reduce pollution, to innovate, etc*. Following the strategy of Antweiler, Copeland and Taylor (2001), GDP and GNI/cap enter our pollution equation simultaneously in order to distinguish between the scale of the economy (GDP – measuring the intensity of the economic activity) and income (GNI/cap – capturing the richness of a country's inhabitants and economic agents, and more specifically, their willingness-to-pay for environmental goods). With regard to **Trade_EGs**, provided trade in EGs does not affect either the economic structure or the production levels, it is assumed to have a negative (technique) effect on pollution by increasing the availability of less expensive and/or more performing EGs[16]. Otherwise, a 'rebound' or even a 'backfire' effect may occur: i.e. despite the marginal abatement cost reduction, one may be encouraged to produce more by maintaining the same total initial level of abatement effort when environmental regulations do not evolve. The sign of **Trade_EGs** variable should indicate the dominant direct effect on pollution: the '*autonomous*' technique (if negative) or scale-composition (if positive). We should however stress that a negative coefficient could also capture effects from within-industry reorganizations in favour of less polluting firms (i.e., *within-industry composition effect*) due to increased availability of less costly EGs, without necessarily introducing new/more efficient techniques (see Cherniwchan, Copeland and Taylor, 2017). As this specific effect may not be captured by our K/L variable, which is a proxy for the macro-channel and

---

[14] We should note that anything raising GNI/cap generates an endogenous rise in the stringency of the environmental standards (through willingness to pay and increased public concern (and pressure) for environmental quality). Thus, ER variable may suffer from endogeneity bias when included with GNI/cap.

[15] See Table B.1 in appendix B for variables' definitions and sources.

[16] Characterized by negative own-price elasticity, the local price of EGs is supposed to decrease when demand for these goods increases.

does not reflect micro-mechanisms, we qualify any prevailing negative effect in our empirical estimations based on macro-data as '***a technique-rationalization effect***'.

Finally, it is highly stressed that trade openness (**Open**) is a key variable in explaining the changes in pollution through the scale, composition and technique effects (see Lucas et al., 1992; Dean, 2002; Harbaugh, Levinson and Wilson, 2002; Copeland and Taylor, 2004; Frankel and Rose, 2005). A country's overall trade openness can have a direct impact on pollution by (i) increasing economic growth through tariff reduction; (ii) shifting production from pollution-intensive to more ecological goods, or vice-versa; and (iii) promoting the diffusion and the use of technological innovations.

In conclusion, following the theoretical and empirical literature on pollution demand and supply, we can derive a reduced-form equation that links pollution emissions to a set of economic factors of which trade in EGs:

$$\ln E = \beta_0 + \beta_1 \cdot \ln GDP + \beta_2 \cdot \ln \frac{K}{L} + \beta_3 \cdot \ln ER + \beta_4 \cdot \ln \frac{GNI}{cap} + \beta_5 \cdot \ln Trade\_EGs + \beta_6 \cdot \ln Open + \varepsilon \quad (5)$$

We expect positive coefficients for the scale and (between-industry) composition effects; that is, **GDP** and **K/L**, and negative coefficients for **ER** and **GNI/cap** variables, capturing the technique effects. The coefficients of our trade variables **Open** and **Trade_EGs** should reflect the *prevailing* ***direct impact*** on emissions of the country's trade openness ([total exports + total imports]/GDP) and its trade (export + import) in EGs, respectively[17]: if **positive** – a ***scale-composition effect*** and if **negative** – a ***technique-rationalization effect***.

Introducing in this equation interaction terms between our variable of interest **Trade_EGs** and a dummy (***Net_ImEGs***) taking value 1 if the country is a 'net importer' of the specified EGs and 0 otherwise, should allow us to explore the specific effects of trade in EGs in countries that are weak performers. In fact, we qualify as 'net importer' a country in a specific year when its EGs imports are superior to EGs exports. It should be noted that this dummy could rather illustrate situations of a 'non-performing' country in the EGs sector, because it also integrates observations of zero trade in EGs[18].

Finally, ***indirect effects*** shall be estimated by endogenizing ***ER*** and ***GNI/cap*** variables (the possible transmission channels, in particular through technique effects), in a system of simultaneous equations (see next sub-section for our empirical strategy).

---

[17] To better capture the effects of EGs' trade liberalization, one would prefer using EGs' trade openness (or intensity); that is, (EGs exports + EGs imports)/GDP (let's call it **Trade_EGs/GDP**). Because **Trade_EGs/GDP** appears to be highly correlated with our variable **Open** (see Figure B.1 in appendix B), we chose a **Trade_EGs** variable that should be less likely to suffer from possible collinearity with respect to overall trade openness. Moreover, as tariffs are currently amply low to have significant economic impacts and their further cuts should mainly affect volumes of trade, countries would be ultimately interested to understand the economic and environmental impacts of (increased) trade flows and competitiveness.

[18] In our dataset, **Trade_EGs** has a few zeros. Following a commonly used technique, we added 1 to each observation before taking logs.

3.2. Data and empirical strategy

Table B.1 in Appendix B defines all the variables used in our empirical study and their sources. Our explained variable **E** represents sequentially total CO_2 and SO_2 emissions. We have make the choice to explain total pollution instead of industrial emissions alone, because environmental degradation is resulting not only from the production, but also – and even mostly – from using resources. Moreover, the EGs is an industry sector devoted to solving, limiting or preventing environmental problems that are not confined to the manufacturing sectors only, but also integrating solutions for renewable energy, transportation and residential sectors. In addition, trade liberalization increases transportation of EGs, which, thus, is also responsible for air pollution. To investigate the possibility of a 'double win' (environmental and income) scenario from the increased trade in EGs, we therefore aim to get a broader picture of the possible effects.

Whereas many of our indicators come directly from official data sources (e.g., world development indicators [GDP, GNI, K, L…]) and institutional quality from the World Bank, latitude from CEPII and international trade from UN-COMTRADE, we have also computed several indicators for which relevant and comparable data across countries are still not available (or limited to a few countries and/or years). More precisely, we built an indicator of stringency of the environmental regulations (**ER**), by using a methodology similar to that employed in Zugravu-Soilita, Millock and Duchene, (2008), Ben Kheder and Zugravu (2012), and Zugravu-Soilita (2017)[19]. In particular, our ER index is computed as an average Z-score of four indicators: (i) ratification of a selection of Multilateral Environmental Agreements (MEAs) and Protocols[20]; (ii) energy efficiency (GDP/unit of energy used) corrected for the latitude (in order to control for climate conditions); (iii) number of companies certified ISO 14001, weighted by GDP; and (iv) density of international non-governmental organizations (NGOs) (members per million of population). Therefore, this index should simultaneously capture 'pressure' and 'outcome' aspects, and control for enforcement coming from public authorities and industries, as well as from the population's ability to organize in lobbies (NGOs, etc.) to enhance national behaviour in a more environmentally friendly direction. Finally, we computed data on international trade in different EGs categories by combining the UN COMTRADE's world-trade database with the EGs' classification lists specified at the HS six-digit level by APEC and WTO.

Working with a panel-data model, we first need to test for serial correlation in the idiosyncratic error term that, if present, leads to biased standard errors and less efficient results. The F-statistic from the Wooldridge test for

---

[19] See these studies for a review of indicators previously used to measure the stringency of environmental regulations and their limitations for the purpose of an international comparison. They also bring quite robust validation tests for the use of a Z-score index measuring different aspects likely to proxy the stringency of the environmental policies worldwide; for example, signed and/or ratified MEAs, international NGOs, country's energy performance, ISO14001 certification, adhesion to the Responsible Care® Program, the existence of an air-pollution regulation, etc.

[20] Ramsar (1971), CITIES (1973), Migratory species of wild animals (1979), Transboundary air pollution (1979), Protection of ozone layer/Vienna (1985), Basel (1989), UNFCCC (1992), Biological diversity (1992), Safety of radioactive waste management (1997), Kyoto Protocol (1997), Access to information… in environmental matters (1998), Protection of environment through criminal law (1998), Persistent organic pollutants (2001).

autocorrelation in our panel-data model (F(1,113)=0.120 with Prob>F=0.7302) does not allow us to reject the null hypothesis of no first-order autocorrelation[21]. Hence, the model may be estimated without any transformation of our data. If the potential problem of serial correlation is ruled out, our panel data may suffer from unobserved country-specific effects. Indeed, the Breusch-Pagan/Cook-Weisberg test for heteroscedasticity (Chi2(1)=106.87 with Prob>Chi2=0.0000) suggests rejecting the null of constant variance. To deal with heterogeneity in our data, we perform ordinary least squares (OLS) estimations with robust standard errors, generalized least squares (GLS) random-effects (RE) and fixed-effects (FE) estimations, and generalized method of moments (GMM) regressions. In addition to being robust to large heterogeneity[22], the GMM estimator is typically used to correct for bias caused by endogenous explanatory variables.

Because GMM is inefficient relative to OLS if all variables are exogenous, it is important to show that there are endogenous explanatory variables in the model. The Durbin-Wu-Hausman test suggests that ***GNI/cap***, ***ER*** and ***Trade_EGs*** variables are endogenous and their OLS estimates are inconsistent. Indeed, income can have a technique effect on pollution through two channels: (i) a direct effect through consumers' behaviour/producers' investment decisions based on the willingness to pay for the environment; and (ii) an indirect effect by enforcing environmental policy. Therefore, the removal of tariff barriers in a net EGs importing country could lead to a loss of income and a lower demand for environmental quality. At the same time, the increased availability of EGs through tariffs that are cut should increase demand for such goods; this should decrease compliance costs and induce the local government to set more ambitious environmental standards (Nimubona, 2012). Similarly, as the demand for EGs essentially is being determined by the stringency of environmental regulations, enforced environmental policy is expected to drive international trade in EGs (Sauvage, 2014). Finally, trade in EGs and environmental regulations normally evolve in response to the emission levels; that is, the higher the pollution emissions and the greater their damage, the more the government (and citizen) would be willing to put pressure on compliance, thus inducing more abatement and increased trade in EGs.

To deal with this endogeneity problem, we first perform a set of GMM estimations based on instrumental variables (IV-GMM), with robust standard errors (see Table C.2 in Appendix C). The solution provided by IV methods consists of considering an additional variable called an instrument for the endogenous explanatory variable. In general, we may have many explanatory variables and more than one of them correlated with the error term. In that case, we need at least that many instrumental variables that satisfy the exclusion restriction; that is, the instruments must be [highly] correlated with the endogenous explanatory variables, which is conditional on the other covariates, and is uncorrelated with the error term. The common procedure of dealing with endogenous variables is to use their lagged values in order to 'exogenize' them. Because the dependent variable in equation 5

[21] Following Drukker (2003), this test has good size and power properties in reasonable sample sizes. Under the null hypothesis of no serial correlation, the residuals from the regression of the first-differenced variables should have an autocorrelation of −0.5.

[22] The GMM estimator has the advantage of being consistent and asymptotically normally distributed whether country-specific effects are treated as fixed or random because it eliminates them from the specification.

($\mathbf{E}_t$) cannot possibly cause $\mathbf{GNI/cap}_{t-1}$, $\mathbf{ER}_{t-1}$, or $\mathbf{Trade\_EGs}_{t-1}$, replacing $\mathbf{GNI/cap}_t$, $\mathbf{ER}_t$ and $\mathbf{Trade\_EGs}_t$ with their lagged values, it should avoid concerns that our explanatory variables are endogenous to pollution (**E**). However, by commenting on simultaneity bias and the use of lagged explanatory variables, Reed (2015) cautions that 'this is only an effective estimation strategy if the lagged values do not themselves belong in the respective estimating equation, and if they are sufficiently correlated with the simultaneously determined explanatory variable'. In addition, Bellemare, Masaki and Pepinsky (2017) show that consistent IV estimation with lagged values of endogenous variables requires that there are no dynamics in the error term. As argued by the authors, 'lag identification replaces the assumption of *selection on observables* with the assumption of *no dynamics among unobservables*', the latter needing to be addressed and defended explicitly. That said, Bellemare, Masaki and Pepinsky (2017) discuss several kinds of data that may generate processes in which lagged explanatory variables could be appropriate. For instance, by assuming no unobserved confounding (or properly dealing with it through appropriate estimation techniques), the lag-identification may be suitable when there is reverse but only contemporaneous causality, and the causal effect of the endogenous variable operates with a one-period lag only. This implies testing that there is no contemporary correlation between the endogenous variable X and the dependent variable Y; that is, we should have a zero coefficient on β_1 in the regression $Y_t = \beta_1 X_t + \beta_2 X_{t-1}$. We check for this condition and our results in Table C.1 (Appendix C) validate the use of one-period lagged ***GNI/cap***, ***ER*** and ***Trade_EGs*** variables. More precisely, variables $\boldsymbol{GNI/cap_t}$, $\boldsymbol{ER_t}$ and $\boldsymbol{Trade\_EGs_t}$ are not significant when included simultaneously with their one-year lags ($\boldsymbol{GNI/cap_{t-1}}$, $\boldsymbol{ER_{t-1}}$ and $\boldsymbol{Trade\_EGs_{t-1}}$), which in contrast are highly significant, at the 1% level (see model (2) in Table C.1 in Appendix C). These results are quite robust to the inclusion of a time trend and for alternative estimation techniques (see models (4)-(6) in Table C.1 and model 1 in Table C.2, Appendix C). In addition to including lagged variables as valid instruments, we also use ***Corrup*** (corruption),[23] which should affect emissions only indirectly through its impact on ***ER***, and eventually on ***GNI/cap*** and ***Trade_EGs***, but never with direct effects. Indeed, ***Corrup*** has no significant effect when entering directly in the emissions equation (model (2) in Table C.2, Appendix C), but appears to affect pollution indirectly through its impact on ***ER*** (model (3) in Table C.2, Appendix C). With this additional instrument, our model becomes overidentified (otherwise, exactly identified) and the Sargan-Hansen test (Chi2(1) with Prob>Chi2=0.3565) does not allow us to reject the joint null hypothesis: i.e. our instruments are valid instruments because they are uncorrelated with the error term, and the excluded instruments are correctly excluded from the estimated equation. Finally, following the Montiel-Pflueger robust weak instrument test, the null is rejected at the 5% level and we conclude that our instruments are strong in the sense that the bias is no more than 5% of the worst-case bias (established in a worst-case scenario of completely weak instruments).

Our IV-GMM estimates are both robust to arbitrary heteroscedasticity and intra-cluster (country) correlation. Actually, in a panel dataset, we may want to allow observations belonging to each country and coming from a

[23] See Table B.1 in appendix B for variables' definitions and sources.

particular time-period to be arbitrarily correlated. We chose to apply (one-way) clustering by unit (i.e. country) to control for country-specific effects and include a time trend variable to capture the time-fixed effects of other omitted variables.

OLS, GLS and IV-GMM regressions give significant and quite robust results concerning the impact of trade in EGs: i.e. all else equal, ***Trade_EGs*** increases CO2 emissions. However, these regressions only inform us about the direct effects. Therefore, we further specify and estimate simultaneous equations using the system-GMM technique that, in addition to controlling for endogeneity, should allow us to identify the indirect effects on pollution of trade in EGs (i.e., through ER and GNI/cap). The reduced-form equations are derived from the literature. In particular, the stringency of environmental regulations is found to be significantly influenced, among others, by the environmental quality (current emission levels), income, trade and corruption.[24] With regard to the income reduced-form equation, we retain long-term determinants from the endogenous growth literature; that is, production factors' (labour, physical capital) endowment, trade, geography, and institutions.[25] The following section discusses – in detail – our empirical results from system-GMM estimations.

4. Empirical results

4.1. Impact of trade in EGs from the APEC54 list

Our results from the system-GMM regressions are displayed in Appendix D (see Tables D.1 – D.6). As predicted by the theory, we find support for the scale, composition and technique effects in the pollution regressions; that is, all else equal, whereas any raise in total economic output (GDP) and capital-to-labour ratio increases CO_2 and SO_2 emissions, income and stringency of the environmental regulations are found to reduce pollution. We also find a significant negative time trend highlighting worldwide technological advances and successful global action to control emissions. Regarding the ER-channel equation, as expected, pollution and willingness to pay for the environment (proxied by per capita income) are found to increase environmental regulations' stringency, whereas corruption appears to induce laxer regulations. At the same time, higher institutional quality and capital abundance exert a positive effect on per capita income (GNI/cap-channel equation). All else equal, trade openness is found to increase pollution in our pooled country sample, mainly through an indirect effect channelled by per capita income. This result is consistent with the body of empirical studies having found that trade openness is increasing income inequality in an overall sample of heterogeneous countries, and may even decrease the average income in the developing countries that are unable to take advantage of knowledge accumulation and technology spillovers.[26]

---

[24] See for instance Damania, Fredriksson and List (2003), Fredriksson *et al.* (2005), Greaker and Rosendahl (2006), Zugravu-Soilita, Millock and Duchene (2008).

[25] See Frankel and Romer (1999), Gallup, Sachs and Mellinger (1999), Acemoglu, Johnson and Robinson (2001), Easterly and Levine (2003), Sachs (2003), Hibbs and Olsson (2004), Rodrik, Subramanian and Trebbi (2004).

[26] See for example Kanbur (2015) and Sakyi, Villaverde and Maza (2015) for recent literature reviews. As shown by Kali, Méndez and Reyes (2007), in addition to volume of trade, the structure of international trade has higher implications for development.

All the above-mentioned findings are highly robust in our different model specifications, explaining CO_2 and SO_2 total emissions.

We now focus on the effects of our variable of interest, that is, ***Trade_EGs***. For a broader analysis, we consider in this study two types of indirect effects: (i) ***exclusive*** *indirect effects*, as more restrictive concept including only those influences mediated by the channel variable(s); and (ii) ***incremental*** *indirect effects*, as a wider concept including all compound paths subsequent to our endogenous variables of interest (or channel variables).[27] We present below direct, computed indirect and total effects of trade in EGs on pollution (CO2 and SO2 emission) for the pooled country sample, and by making a distinction between EGs' *net importers* and EGs' *net exporters*. Detailed estimation results are available in Appendix D.

As shown in Table 1, the prevailing direct effect of trade in EGs (from APEC54 list) on pollution is positive—a scale-composition effect—, but not negative—a technique effect—, as expected. This result might validate the assumption of backfire effects and/or support the 'multiple use' fears with respect to trade in EGs, especially in countries with laxer environmental regulations that are generally low performers in EGs. Indeed, we find a statistically highly significant, positive, direct effect only for *net importers* of EGs (APEC54 list).

Table 1 Direct, indirect and total effects of trade in EGs (APEC54 list) on pollution

	Effects on:					
	CO2			SO2		
	ALL	*Net importer*	*Net exporter*	**ALL**	*Net importer*	*Net exporter*
Effects of trade in $\mathbf{EGs}_{\mathbf{APEC54}}$:						
Direct (a)	**0.233****** (0.055)	***0.289****** (0.053)	*0.122** (0.065)	**0.230***** (0.068)	***0.307****** (0.066)	*0.046* (0.092)
Indirect *exclusive* mediated by ***ER*** (b)	**-0.072***** (0.024)	***-0.065****** (0.022)	***-0.058****** (0.020)	**-0.090**** (0.037)	***-0.076***** (0.036)	*-0.057** (0.032)
Indirect *incremental* mediated by ***ER*** (bb)	**-0.192***** (0.061)	***-0.204****** (0.069)	***-0.116***** (0.046)	**-0.394**** (0.175)	***-0.462***** (0.199)	*-0.115* (0.136)
Indirect *exclusive* mediated by ***GNI/cap*** (c)	**-0.035**** (0.014)	***-0.032****** (0.012)	***-0.058****** (0.020)	-0.029 (0.018)	*-0.025* (0.016)	*-0.051** (0.026)
Indirect *incremental* mediated by ***GNI/cap*** (cc)	**-0.042***** (0.016)	***-0.037****** (0.013)	***-0.068****** (0.021)	-0.035* (0.021)	*-0.030* (0.018)	***-0.061***** (0.028)
TOTAL (excl. ind. eff.: ***a + b + c***)	**0.126**** (0.052)	***0.191****** (0.048)	*0.006* (0.062)	0.112 (0.073)	***0.207****** (0.068)	*-0.061* (0.089)
TOTAL (incr. ind. eff.: ***a + bb +cc***)	-0.001 (0.056)	*0.048* (0.057)	*-0.062* (0.047)	-0.198 (0.142)	*-0.184* (0.167)	***-0.130***** (0.060)

Legend: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors in parentheses. Tables D.1 and D.2 in the appendix D display the detailed regression results. For instance, the indirect *exclusive* effect of trade in EGs on CO_2 emissions mediated by GNI is the compound path EGs→GNI→CO_2 (it excludes the indirect path operating through ER [i.e., EGs→GNI→ER→CO_2]), whereas the indirect *incremental* effect is the combination of two compound paths: EGs→GNI→CO2 + EGs→GNI→ER→CO_2. More precisely, the indirect exclusive marginal effect on CO_2 of trade in EGs mediated by income is **−0.035**=0.0609*(−0.574) and the indirect incremental effect is **−0.042**=0.0609*(−0.574) + 0.0609*0.0822*(−1.36). Point estimates and significance levels for (possibly)

[27] See Bollen (1987) for these different concepts. The legend for Table 1 illustrates the calculation of these effects.

non-linear combinations of parameter estimates are computed using the **nlcom** command in Stata. Calculations are based on the 'delta method', an approximation appropriate in large samples.

If trade in EGs appears to have no direct technique effect on pollution in our sample, it is found to reduce emissions through indirect technique effects, mediated by the stringency of environmental regulations (**ER**) and per capita income (**GNI/cap**). Naturally, incremental indirect effects are found to be significantly larger than the exclusive indirect effects, with the former still not high enough to compensate the direct harmful effects. This is particularly true for the *net importers* of EGs, where the total (direct plus indirect) effects on CO_2 and SO_2 emissions remain positive with exclusive indirect effects, and at best become non-significant when incremental indirect effects are considered. With regard to *net exporters*, trade in EGs is found to have no statistically significant total effect on CO_2 emissions, and to reduce SO_2 emissions only when indirect incremental effects mediated by income are included.

Our empirical results support the theoretical predictions by Greaker (2006) and Greaker and Rosendahl (2008) according to which environmental regulations that are too strict might not be the most suitable industrial policy for the countries with performing/emerging export-oriented eco-industrial firms. In fact, trade in EGs is found to have indirect marginal effects on CO_2 emissions, mediated by ***ER***, which is significantly higher for *net importers* than for *net exporters*. Moreover, these indirect effects are found to be non-significant in the models explaining SO_2 emissions for *net exporters*, where the unique indirect technique effect is mediated by ***GNI/cap***. Hence, governments in the EGs' *net exporting* countries might be reluctant to increase standards/taxes in order not to increase exposure of the export-oriented eco-sectors to foreign competition. Conversely, the EGs' *net importing* countries, which are non- (or weak) performers in this sector, would be more likely to increase the stringency of the environmental regulations in order to further enhance availability of EGs at more competing prices. Finally, the indirect effects of trade in EGs, mediated by per capita income, are higher for *net exporters* compared to *net importers*, with the former's eco-firms enjoying new/larger markets whereas the latter's ones – if present – might see their domestic markets narrowing.

4.2. Alternative classifications of EGs

In this subsection, we perform system-GMM estimations and marginal effects' calculations for trade in EGs listed by WTO (as alternative classifications for the APEC54 list). Indeed, with the classification of EGs being a continuous process – depending on technological progress and current negotiations – the estimations for different categories of EGs should check the robustness of our basic empirical results and allow the generalization of our conclusions.

When focusing on the narrow WTO list of 26 EGs (Table 2 below, with the estimation results in Tables D.3 and D.4 in appendix D), we find similar results compared to trade in EGs from the APEC54 list, with one important difference regarding *net exporters*; that is, the total effect of trade in EGs, including incremental indirect effects, on CO2 emissions is now significant and negative (like the total effect on SO_2 emissions).

Table 2 Direct, indirect and total effects on pollution of trade in EGs from alternative classifications

	Effects on:					
	CO2			SO2		
	ALL	*Net importer*	*Net exporter*	**ALL**	*Net importer*	*Net exporter*
Effects of trade in **EGs$_{WTO26}$**:						
Direct	**0.177***** (0.051)	***0.213***** (0.051)	*0.053* (0.059)	**0.208***** (0.057)	***0.240***** (0.055)	*-0.013* (0.077)
Indirect *exclusive* mediated by ***ER***	**-0.056***** (0.020)	***-0.052***** (0.020)	***-0.053***** (0.019)	**-0.071**** (0.033)	*-0.059** (0.033)	*-0.063** (0.036)
Indirect *incremental* mediated by ***ER***	**-0.141***** (0.048)	***-0.155***** (0.055)	***-0.079**** (0.039)	**-0.316**** (0.134)	***-0.362**** (0.143)	*-0.046* (0.117)
Indirect *exclusive* mediated by ***GNI/cap***	**-0.031**** (0.013)	***-0.029**** (0.012)	***-0.053***** (0.019)	-0.017 (0.015)	*-0.017* (0.014)	*-0.039** (0.022)
Indirect *incremental* mediated by ***GNI/cap***	**-0.037**** (0.015)	***-0.034**** (0.014)	***-0.062***** (0.021)	-0.020 (0.017)	*-0.020* (0.017)	*-0.048** (0.025)
TOTAL (with exclusive indirect effects only)	0.090* (0.049)	***0.132***** (0.045)	*-0.053* (0.057)	0.12* (0.066)	***0.164***** (0.063)	*-0.115* (0.073)
TOTAL (with incremental indirect effects)	-0.001 (0.047)	*0.023* (0.047)	***-0.088**** (0.041)	-0.129 (0.117)	*-0.143* (0.127)	***-0.107**** (0.053)
Effects of trade in **EGs$_{WTO408}$**:						
Direct	**0.398***** (0.078)	***0.422***** (0.078)	***0.318***** (0.090)	0.150 (0.112)	*0.157* (0.119)	*0.122* (0.118)
Indirect *exclusive* mediated by ***ER***	**-0.086***** (0.028)	***-0.072**** (0.029)	***-0.073***** (0.027)	-0.059* (0.032)	*-0.050* (0.032)	*-0.051* (0.033)
Indirect *incremental* mediated by ***ER***	**-0.243***** (0.069)	***-0.261***** (0.079)	***-0.215***** (0.069)	-0.206 (0.152)	*-0.216* (0.160)	*-0.180* (0.153)
Indirect *exclusive* mediated by ***GNI/cap***	**-0.113***** (0.035)	***-0.124***** (0.037)	***-0.128***** (0.041)	**-0.125***** (0.048)	***-0.133***** (0.050)	***-0.139**** (0.054)
Indirect *incremental* mediated by ***GNI/cap***	**-0.129***** (0.036)	***-0.141***** (0.038)	***-0.145***** (0.043)	**-0.143***** (0.049)	***-0.152***** (0.050)	***-0.159***** (0.056)
TOTAL (with exclusive indirect effects only)	**0.199***** (0.074)	***0.225***** (0.075)	*0.118* (0.085)	-0.034 (0.108)	*-0.026* (0.116)	*-0.068* (0.114)
TOTAL (with incremental indirect effects)	0.027 (0.081)	*0.020* (0.085)	*-0.042* (0.082)	**-0.199**** (0.096)	***-0.21**** (0.097)	***-0.217**** (0.090)

Legend: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors in parentheses. See the legend at Table 1 for the explanations regarding the computation of marginal effects, and Tables D.3 and D.4 for the detailed estimation results.

Therefore, whereas trade in EGs from narrow lists (**APEC54** and **WTO26**) is likely to benefit the environment in the *net exporting* countries due to gains in income, it is found to increase CO_2 and SO_2 emissions in the EGs *net importing* countries where the harmful direct scale-composition effects are not offset by the (still weak) indirect technique effects.

With regard to the WTO's broader list of EGs (**WTO408**), the results are quite similar to those found for the APEC54 list of EGs when exploring CO_2 emissions. That is, trade in EGs has a direct harmful effect on pollution in both the *net importing* and the *net exporting* countries, which is completely compensated by the indirect technique effects in the *net exporting* countries, but the total effects remain positive (at best non-significant with the incremental indirect effects included) in the *net importing* countries. Interesting results are found for the SO_2 emissions, on which trade in EGs from WTO408 list has no significant direct effect for both *net importers* and *net exporters*. Given the nature of emission sources for different pollutants, we could suppose that the direct harmful effect on CO2 emissions (when compared to SO2 emissions) is at least partly driven by the international transportation of EGs (in addition to 'multiple use' and possible 'backfire effects'). In addition, while only ***ER*** in the *net importing* countries channels the indirect technique effect of trade in EGs from the APEC54 list, trade in EGs from the WTO408 list reduced SO2 emissions merely through its indirect effect on ***GNI/cap***. As a result, the total effect of trade in EGs (WTO408) on SO_2 emissions is negative for both *net importers* and *net exporters*. Therefore, we can see that income is an essential channel for reducing emissions through trade in EGs, and its impact is significantly higher when considering the broad list of EGs from WTO (WTO408), for both *net importers* and *net exporters*.

Finally, having in mind the 'multiple use' problems and specific comparative advantages of different countries for different EGs categories, we perform additional estimations for distinct, homogenous groups of EGs in the WTO408 list: i.e., $\boldsymbol{WTO_{RE}}$ - Renewable Energy, $\boldsymbol{WTO_{ET}}$ - Environmental Technologies, $\boldsymbol{WTO_{WMWT}}$ – Waste Management and Water Treatment, and $\boldsymbol{WTO_{APC}}$ – Air Pollution Control. To save space, Table 3 displays only direct and total effects (including indirect exclusive or incremental indirect effects) for each EGs category, while Tables D.5 and D.6 in Appendix D present detailed estimation results. We find that only trade in EGs from the '***renewable energy***' category performs direct and total negative (i.e., prevailing technique/rationalization) effects on both CO_2 and SO_2 emissions, in both *net importing* and *net exporting* countries; however, the result is significant only at the 10% level for *net importers*. As stated in section 2, '***renewable energy***' EGs are the few range of goods identified by a 'unique HS code' and, thus, are more likely to be 'single-use' products. Hence, trade in these EGs, which are designed and used to reduce emissions from one of the most polluting sources (energy sector), reduces CO_2 and SO_2 emissions by increasing the availability of these products in the *net importing* countries and by improving the performance of this eco-sector in the *net exporting* countries. The higher and most significant marginal impacts are naturally found for the latter. Trade in EGs from the '***environmental technologies***' category is also found to reduce pollution due to a direct technique effect, but only for *net importers* and SO2 emissions. Trade in these EGs appears to increase CO_2 emissions in both *net importing* and *net exporting* countries, and has no statistically significant effect on SO_2 emissions in the *net exporting* countries. One explanation to this result is that '*environmental technologies*' are usually more efficient in abating SO_2 emissions (some techniques achieving SO_2 removal of more than 90%)[28] compared to CO2 emissions, the carbon capture (and storage) being an innovative and still the most expensive technology. Finally, we do not find support for liberalizing trade in EGs from the '***waste management and water treatment***' category because of the harmful (direct and total) effects on CO_2 and SO_2 emissions found for both *net importers* and *net exporters*. With regard to the '***air pollution control***' category, we cannot formulate specific recommendations because no significant direct and total effects were found in our empirical estimations. The last result is somehow surprising as we investigate air pollution, and that would be the right EGs category to have a direct technique effect on CO_2 and SO_2 emissions. In passing, we mention that trade in EGs from the 'air pollution control' category have indirect technique effects passing by ER and GNI/cap, but these results are at best statistically significant at the 5% level.

[28] Source: EEA (2008)

Table 3 Direct, indirect and total effects on pollution of trade in EGs, different categories in WTO408 list

	Effects on:					
	CO2			**SO_2**		
	ALL	*Net importer*	*Net exporter*	**ALL**	*Net importer*	*Net exporter*
Effects of trade in **EGs_{WTORE}**:						
Direct	**-0.264**** (0.118)	*-0.196** (0.118)	***-0.270***** (0.128)	**-0.317***** (0.107)	***-0.305****** (0.096)	***-0.414****** (0.121)
TOTAL (with exclusive indirect effects only)	**-0.265**** (0.107)	*-0.205** (0.106)	***-0.271***** (0.112)	**-0.282***** (0.101)	***-0.284****** (0.090)	***-0.357****** (0.111)
TOTAL (with incremental indirect effects)	**-0.127**** (0.063)	*-0.095** (0.055)	***-0.120***** (0.061)	0.233 (0.212)	*0.201* (0.193)	*0.298* (0.263)
Effects of trade in **EGs_{WTOET}**:						
Direct	**0.299***** (0.073)	***0.321****** (0.067)	***0.253****** (0.079)	-0.109 (0.120)	***-0.227***** (0.115)	*-0.073* (0.113)
TOTAL (with exclusive indirect effects only)	**0.210***** (0.077)	***0.213****** (0.078)	***0.178***** (0.074)	**-0.205**** (0.103)	***-0.333****** (0.103)	*-0.151* (0.102)
TOTAL (with incremental indirect effects)	0.047 (0.059)	*0.025* (0.064)	*0.030* (0.053)	-0.038 (0.131)	*0.012* (0.159)	*-0.044* (0.119)
Effects of trade in **$EGs_{WTOWMWT}$**:						
Direct	**0.381***** (0.120)	***0.330****** (0.121)	***0.302***** (0.128)	**0.728***** (0.140)	***0.720****** (0.132)	***0.667****** (0.149)
TOTAL (with exclusive indirect effects only)	**0.272**** (0.109)	***0.250***** (0.109)	*0.181* (0.117)	**0.495***** (0.124)	***0.544****** (0.111)	***0.416****** (0.123)
TOTAL (with incremental indirect effects)	0.074 (0.088)	*0.068* (0.077)	*0.011* (0.081)	-0.678 (0.463)	*-0.587* (0.448)	*-0.635* (0.436)
Effects of trade in **EGs_{WTOAPC}**:						
Direct	-0.018 (0.071)	*-0.002* (0.072)	*-0.108* (0.074)	0.053 (0.085)	*0.170** (0.095)	*-0.055* (0.072)
TOTAL (with exclusive indirect effects only)	-0.023 (0.064)	*0.004* (0.066)	*-0.100* (0.065)	0.079 (0.085)	***0.206***** (0.094)	*-0.012* (0.074)
TOTAL (with incremental indirect effects)	-0.020 (0.037)	*-0.002* (0.038)	*-0.047* (0.040)	-0.015 (0.085)	*-0.071* (0.107)	*0.065* (0.095)

Legend: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors in parentheses. Tables D.5 and D.6 in Appendix D display the detailed regression results.

5. Conclusions

OLS, GLS and IV-GMM regressions of total CO_2 emissions of 114 countries on their trade in EGs between 1996 and 2011 suggest that, all else equal, trade in EGs has a positive (harmful) direct effect on pollution. However, these findings do not allow an explanation of the forces at work. To explore the possible transmission channels – in particular through technique effects – we perform system-GMM estimations by simultaneously regressing CO_2 (and sequentially SO_2) stringency of environmental regulations and per capita income on trade in EGs. Focusing on the trade in EGs from the APEC54 list, our results suggest a positive direct effect on pollution qualified as a *scale – [between-industry] composition* effect, which supports the general fears concerning 'backfire effects' and/or 'multiple use' of EGs. Because such effects are mostly specific to countries with lax environmental regulations and who are generally low performers in EGs, we also explored marginal effects by net trade status. As expected, we found a statistically highly significant and positive direct effect only for the net importers of EGs. With regard to

EGs' trade effects channelled by environmental policy and income, our results find strong evidence of indirect technique effects by highlighting some interesting particularities for countries with different trade status: that is, the indirect technique effects are mostly channelled by income in the EGs' net exporting countries and primarily pass through the stringency of the environmental regulations in the EGs' net importing countries. Hence, our empirical results validate scale, composition and technique effects of trade in EGs on CO_2 and SO_2 emissions. However, the negative, indirect technique effects do not compensate the positive, direct scale-composition effects in the EGs' net importing countries, with the total effect on pollution being harmful. At best, the total effect on pollution might be non-significant regardless of the net trade status, and even negative on SO2 emissions for the EGs net exporters, when *incremental indirect effects* (including all compound paths subsequent to channel variables) are considered instead of *exclusive indirect effects* (including only the influence mediated by the channel variables). If liberalization of trade in EGs from the APEC54 list, by increasing trade flows, should bring economic benefits, it would increase CO_2 and SO_2 emissions in these EGs' net importing countries without significantly affecting pollution in the net exporting countries. Thus, the environmental gains from trade in EGs from the APEC54 did not find strong empirical support from our estimations.

For robustness checks, we performed comparative estimations on trade in EGs from the WTO26 list, also a narrow classification like the APEC54 list (but even stricter, because it was reduced to 26 goods). A stricter list should better designate EGs thus avoiding 'multiple use' problems. Our previous results are quite robust, with a single distinction regarding EGs' net exporters: when broader investigating indirect effects (i.e., incremental effects), the total effect is negative on both CO_2 and SO_2 emissions (but this result is significant at the 5% level). However, we still did not find direct technique (negative) effects, as expected.

Trade in EGs from narrow lists seems to be safer for net exporters. Our stylized facts have shown that these are essentially developed and leading emerging countries. Because the developing countries still lack the purchasing power and technical skills necessary for creation and consolidation of such EGs (APEC54/WTO26) markets, it becomes interesting to investigate broader classifications, like the WTO408 list for which many developing countries enjoy comparative advantages. Unsurprisingly, because of broadly designated goods ('multiple use' problems) and negative externalities from their transportation, traded EGs from WTO408 list exert a direct harmful scale-composition effect on CO_2 emissions, regardless of countries' net trade status, which is completely offset by indirect technique effects only in the EGs' net exporting countries. However, an interesting result is that their total impact on SO_2 emissions is negative (with incremental indirect effects) for both net exporters and net importers. This finding is due to indirect technique effects (mainly through income) and no statistically significant direct scale-composition effects. We suppose the absence of significant direct effects to be explained by opposing forces at work of likely similar magnitudes; that is, negative *direct technique – (within-industry) composition (rationalization)* effect and positive *direct scale – (between-industry) composition* effect, which may not be distinguished for EGs' lists of heterogeneous products.

Consequently, we finish our empirical investigation by performing regressions for distinct, homogenous categories of EGs in the WTO408 list. EGs from 'Waste Management and Water Treatment' and 'Air Pollution Control' categories are found to increase pollution mainly through a direct scale-composition effect, or at best to not affect it significantly (depending on the pollutant and category considered). In contrast, our results found direct and total negative effects on CO_2 and SO_2 emissions for trade in EGs classified as 'Renewable energy products/technologies', for both net exporters and net importers. Indeed, this category is among the few classifications allowing the designation of single-use EGs. Finally, trade in EGs from the 'Environmental Technologies' category is found to increase CO_2 emissions in all the countries through a dominating direct, scale-composition effect, regardless of their net trade status, and to reduce SO_2 emissions only in the net importing countries (with a non-significant effect for net exporters). This last result confirms the higher efficiency of environmental technologies in directly abating SO2 emissions.

As policy implications, our results support boosting trade in carefully defined EGs in terms of their end-use or purpose in order to avoid/reduce the direct harmful scale-composition effects on pollution that are found to prevail on the technique effects in the case of multiple-use products. Because the EGs' net exporters were found to enjoy both economic and environmental (in terms of local pollutant emissions) gains more recurrently than the EGs' net importers, EGs' trade enhancement should be facilitated, in addition to tariff reductions, by EGs' market creation and (institutional and technical) capacity building in developing countries.

Finally, income appears to be an essential channel for reducing emissions through trade in EGs, for both net importers and net exporters (the latter still benefiting the most). Consequently, further research should better explore this channel to understand the mechanisms for different net trade status: e.g. tariff revenues (in that case, the trade liberalization of EGs could worsen environmental quality through income losses); within-industry reorganization in favour of the most efficient firms due to increased availability of EGs; increased revenues from high value-added eco-activities, etc. Constructing firm or sector level data to investigate micro-level mechanisms should be the next preoccupation in this direction.

References

Acemoglu, D., Johnson, S. and Robinson, J. A. (2001) 'The colonial origins of comparative development: An empirical investigation', *American Economic Review*, 91(5), pp. 1369–1401. doi: 10.1257/aer.91.5.1369.

de Alwis, J. M. D. D. J. (2015) 'Environmental Consequence of Trade Openness for Environmental Goods', *Sri Lankan Journal of Agricultural Economics*, 16(1), pp. 79–98. doi: http://doi.org/10.4038/sjae.v16i1.4606.

Antweiler, W., Copeland, B. R. and Taylor, M. S. (2001) 'Is free trade good for the environment?', *American Economic Review*, 91(4), pp. 877–908. doi: 10.1257/aer.91.4.877.

Arimura, T., Hibiki, A. and Johnstone, N. (2007) 'Empirical Study of Environmental R&D: What Encourages Facilities to be Environmentally Innovative?', *in Johnstone, Nick (2007). Corporate Behaviour and Environmental Policy. Cheltenham, UK: Edward Elgar; and Paris: OECD*.

Balineau, G. and de Melo, J. (2013) 'Removing barriers to trade on environmental goods: an appraisal', *World Trade Review*, 12(4), pp. 693–718. Available at: http://econpapers.repec.org/RePEc:cup:wotrrv:v:12:y:2013:i:04:p:693-718_00.

Balineau, G. and De Melo, J. (2011) 'Stalemate at the Negotiations on Environmental Goods and Services at the Doha Round', *FERDI, Working Paper; WP 28.2011*.

Bellemare, M. F., Masaki, T. and Pepinsky, T. B. (2017) 'Lagged Explanatory Variables and the Estimation of Causal Effect', *The Journal of Politics*, ONLINE: Ma(0), p. 0. doi: 10.1086/690946.

Bollen, K. A. (1987) 'Total, Direct, and Indirect Effects in Structural Equation Models', *Sociological Methodology*. [American Sociological Association, Wiley, Sage Publications, Inc.], 17, pp. 37–69. doi: 10.2307/271028.

Bora, B. and Teh, R. (2004) 'Trade and tariffs on environmental goods', *Paper presented at the workshop on environmental goods WTO Secretariat, Geneva*.

Brander, J. A. and Scott Taylor, M. (1998) 'Open access renewable resources: Trade and trade policy in a two-country model', *Journal of International Economics*, 44(2), pp. 181–209. doi: 10.1016/S0022-1996(97)00029-9.

Bréchet, T. and Ly, S. (2013) 'The many traps of green technology promotion', *Environmental Economics and Policy Studies*, 15(1), pp. 73–91. doi: 10.1007/s10018-012-0035-5.

Brunel, C. and Levinson, A. (2016) 'Measuring the stringency of environmental regulations', *Review of Environmental Economics and Policy*, 10(1). doi: 10.1093/reep/rev019.

Canton, J., Soubeyran, A. and Stahn, H. (2008) 'Environmental taxation and vertical cournot oligopolies: How eco-industries matter', *Environmental and Resource Economics*, 40(3), pp. 369–382. doi: 10.1007/s10640-007-9158-8.

Cao, X. and Prakash, A. (2012) 'Trade Competition and Environmental Regulations: Domestic Political Constraints and Issue Visibility', *Journal of Politics 74(1)*.

Cherniwchan, J., Copeland, B. and Taylor, M. S. (2017) 'Trade and the Environment: New Methods, Measurements, and Results', *Annual Review of Economics*. Annual Reviews, 9. doi: 10.1146/annurev-economics-063016-103756.

Cole, M. A. and Elliott, R. J. R. (2003) 'Determining the trade-environment composition effect: The role of capital, labor and environmental regulations', *Journal of Environmental Economics and Management*, 46(3), pp. 363–383. doi: 10.1016/S0095-0696(03)00021-4.

Cole, M. A. and Elliott, R. J. R. (2005) 'FDI and the Capital Intensity of "Dirty" Sectors: A Missing Piece of the Pollution Haven Puzzle', *Review of Development Economics*. Blackwell Publishing Ltd., 9(4), pp. 530–548. doi: 10.1111/j.1467-9361.2005.00292.x.

Copeland, B. (2005) 'Pollution Policy and the Market for Abatement Services', *Mimeo, University of British Columbia, Vancouver, Canada*.

Copeland, B. R. and Taylor, M. S. (1994) 'North-South Trade and the Environment', *Source: The Quarterly Journal of Economics*, 109(3), pp. 755–787. doi: 10.2307/2118421.

Copeland, B. R. and Taylor, M. S. (2003) *Trade and the Environment*. STU-Stud. Princeton University Press. Available at: http://www.jstor.org/stable/j.ctt5hhnzk.

Copeland, B. R. and Taylor, S. M. (2004) 'Trade, Growth, and the Environment', *Journal of Economic Literature*, 42(1), pp. 7–71. doi: doi: 10.1257/002205104773558047.

Copeland, B. and Taylor, M. S. (2005) 'Trade and the Environment: Theory and Evidence', *Princeton, NJ: Princeton University Press*.

Costantini, V. and Mazzanti, M. (2010) 'On the Green Side of Trade Competitiveness? Environmental Policies and Innovation in the {EU}', *Research Policy*, 41(2010.94), pp. 132–153. Available at: http://ideas.repec.org/p/fem/femwpa/2010.94.html.

Dam, L. and Scholtens, B. (2012) 'The curse of the haven: The impact of multinational enterprise on environmental regulation', *Ecological Economics*, 78(C), pp. 148–156. Available at: http://econpapers.repec.org/RePEc:eee:ecolec:v:78:y:2012:i:c:p:148-156.

Damania, R., Fredriksson, P. G. and List, J. A. (2003) 'Trade liberalization, corruption, and environmental policy formation: Theory and evidence', *Journal of Environmental Economics and Management*, 46(3), pp. 490–512. doi: 10.1016/S0095-0696(03)00025-1.

David, M., Nimubona, A. D. and Sinclair-Desgagné, B. (2011) 'Emission taxes and the market for abatement goods and services', *Resource and Energy Economics*, 33(1), pp. 179–191. doi: 10.1016/j.reseneeco.2010.04.010.

Dean, J. (2002) 'Does Trade Liberalization Harm the Environment? A New Test', *Canadian Journal of Economics, 35(4)*, pp. 819–842.

Dean, J. M., Lovely, M. E. and Wang, H. (2009) 'Are foreign investors attracted to weak environmental regulations? Evaluating the evidence from China', *Journal of Development Economics*, 90(1), pp. 1–13. doi: 10.1016/j.jdeveco.2008.11.007.

Dijkstra, B. R. and Mathew, A. J. (2016) 'Liberalizing trade in environmental goods and services', *Environmental Economics and Policy Studies*, 18(4), pp. 499–526. doi: 10.1007/s10018-015-0121-6.

Drukker, D. M. (2003) 'Testing for serial correlation in linear panel-data models', *Stata Journal*, 3(2), pp. 168–177. doi: The Stata Journal.

Easterly, W. and Levine, R. (2003) 'Tropics, germs, and crops: how endowments influence economic development', *Journal of Monetary Economics*, 50(1), pp. 3–39. Available at: http://econpapers.repec.org/RePEc:eee:moneco:v:50:y:2003:i:1:p:3-39.

EEA (2008) 'EN08 Emissions (CO2, SO2 and NOx) intensity of public conventional thermal power (electricity and heat) production', *(https://www.eea.europa.eu/data-and-maps/indicators/en08-emissions-co2-so2-and-1)*.

Eskeland, G. S. and Harrison, A. E. (2003) 'Moving to greener pastures? Multinationals and the pollution haven hypothesis', *Journal of Development Economics*, 70(1), pp. 1–23. doi: 10.1016/S0304-3878(02)00084-6.

Feess, E. and Muehlheusser, G. (2002) 'Strategic environmental policy, clean technologies and the learning curve', *Environmental and Resource Economics*, 23(2), pp. 149–166. doi: 10.1023/A:1021249404533.

Frankel, J. A. and Romer, D. (1999) 'Does trade cause growth?', *American Economic Review*, 89(3), pp. 379–399. doi: 10.1257/aer.89.3.379.

Frankel, J. A. and Rose, A. K. (2005) 'Is Trade Good or Bad for the Environment? Sorting Out the Causality', *Review of Economics and Statistics*, 87(1), pp. 85–91. doi: 10.1162/0034653053327577.

Fredriksson, P. G., Neumayer, E., Damania, R. and Gates, S. (2005) 'Environmentalism, democracy, and pollution control', *Journal of Environmental Economics and Management*, 49(2), pp. 343–365. doi: 10.1016/j.jeem.2004.04.004.

Gallup, J. L., Sachs, J. D. and Mellinger, A. D. (1999) 'Geography and Economic Development', *International Regional Science Review*, 22(2), pp. 179–232. doi: 10.1177/016001799761012334.

GIER (2009) 'Global demand for environmental goods and services on the rise: good growth opportunities for German suppliers', *[German Institute for Economic Research-DIW Berlin]. Weekly Report No20/2009*, 5.

Greaker, M. (2006) 'Spillovers in the development of new pollution abatement technology: A new look at the Porter-hypothesis', *Journal of Environmental Economics and Management*, 52(1), pp. 411–420. doi: 10.1016/j.jeem.2006.01.001.

Greaker, M. and Rosendahl, E. (2006) 'Strategic Climate Policy in Small, Open Economies', *Discussion Paper n448, Statistics Norway*.

Greaker, M. and Rosendahl, K. E. (2008) 'Environmental policy with upstream pollution abatement technology firms', *Journal of Environmental Economics and Management*, 56(3), pp. 246–259. doi: 10.1016/j.jeem.2008.04.001.

Grether, J.-M., Mathys, N. A. and de Melo, J. (2009) 'Scale, Technique and Composition Effects in Manufacturing SO2 Emissions', *Environmental and Resource Economics*, 43(2), pp. 257–274. doi: 10.1007/s10640-008-9237-5.

Grossman, G. M. and Krueger, A. B. (1993) 'Environmental Impacts of A North American Free Trade Agreement', *In Barber P. (ed.), The US-Mexico Free Trade Agreement. MIT Press, Cambridge, MA.*

Hamwey, R., Hoffmann, U., Vikhlyaev, A. and Vossenaar, R. (2003) 'Liberalization of International Trade in Environmental Goods and Services', *, Background Paper, Sub-Regional Brainstorming Workshop on the Trade and Environment Issues Contained in Paragraphs 31 and 32 of the WTO Doha Ministerial Declaration*.

Harbaugh, W. T., Levinson, A. and Wilson, D. M. (2002) 'Reexamining the Empirical Evidence for an Environmental Kuznets Curve', *Review of Economics and Statistics*, 84(3), pp. 541–551. doi: 10.1162/003465302320259538.

Hibbs, D. A. and Olsson, O. (2004) 'Geography, biogeography, and why some countries are rich and others are poor', *PNAS, Vol. 101, No. 10*, 3715–3720.

Hufbauer, G. C., Charnovitz, S. and Kim, J. (2009) 'Global Warming and the World Trading System', *Peterson Institute for International Economics*.

Hufbauer, G. C. and Kim, J. (2010) 'Reaching a Global Agreement on Climate Change: What are the Obstacles?', *Asian Economic Policy Review*, 5(1), pp. 39–58.

Jha, V. (2008) 'Environmental Priorities and Trade Policy for Environmental Goods: A Reality Check', *ICTSD Trade and Environment Series Issue, Paper No.7. Geneva: ICTSD*.

Kali, R., Méndez, F. and Reyes, J. (2007) 'Trade structure and economic growth', *The Journal of International Trade & Economic Development*, 16(2), pp. 245–269. doi: 10.1080/09638190701325649.

Kanbur, R. (2015) 'Globalization and inequality', *Handbook of Income Distribution*, 2, pp. 1845–1881. doi: 10.1016/B978-0-444-59429-7.00021-2.

Kellenberg, D. K. (2009) 'An empirical investigation of the pollution haven effect with strategic environment and trade policy', *Journal of International Economics*, 78(2), pp. 242–255. doi: 10.1016/j.jinteco.2009.04.004.

Ben Kheder, S. and Zugravu, N. (2012) 'Environmental regulation and French firms location abroad: An economic geography model in an international comparative study', *Ecological Economics*, 77. doi: 10.1016/j.ecolecon.2011.10.005.

Levinson, A. (2009) 'Technology, international trade, and pollution from US manufacturing', *American Economic Review*, 99(5), pp. 2177–2192. doi: 10.1257/aer.99.5.2177.

Lovely, M. and Popp, D. (2011) 'Trade, technology, and the environment: Does access to technology promote environmental regulation?', *Journal of Environmental Economics and Management*, 61(1), pp. 16–35. doi: 10.1016/j.jeem.2010.08.003.

Lucas, R. E. B., Wheeler, D., Hettige, H. and World Bank. Office of the Vice President Development Economics. (1992) *Economic development, environmental regulation and the international migration of toxic industrial pollution : 1960-88*, *Policy research working papers WPS 1062*.

Managi, S. (2011) 'Technology, Natural Resources and Economic Growth: Improving the Environment for a Greener Future', *Edward Elgar Publishing Ltd, Cheltenham, UK.*

Managi, S., Hibiki, A. and Tsurumi, T. (2009) 'Does trade openness improve environmental quality?', *Journal of Environmental Economics and Management*, 58(3), pp. 346–363. doi: 10.1016/j.jeem.2009.04.008.

Manderson, E. and Kneller, R. (2012) 'Environmental Regulations, Outward FDI and Heterogeneous Firms: Are Countries Used as Pollution Havens?', *Environmental and Resource Economics*, 51(3), pp. 317–352. doi: 10.1007/s10640-011-9500-z.

Mani, M. and Wheeler, D. (1998) 'In Search of Pollution Havens? Dirty Industry in the World Economy, 1960 to 1995', *The Journal of Environment & Development*, 7(3), pp. 215–247. doi: 10.1177/107049659800700302.

Melitz, M. J. (2003) 'The impact of trade on intra-industry reallocations and aggregate industry productivity', *Econometrica*, 71(6), pp. 1695–1725. doi: 10.1111/1468-0262.00467.

Nguyen, V. S. and Kalirajan, K. (2016) 'Export of environmental goods: India's potential and constraints', *Environment and Development Economics*. Cambridge University Press, 21(2), pp. 158–179. doi: 10.1017/S1355770X15000224.

Nimubona, A. D. (2012) 'Pollution Policy and Trade Liberalization of Environmental Goods', *Environmental and Resource Economics*, 53(3), pp. 323–346. doi: 10.1007/s10640-012-9564-4.

OECD (2001) 'Environmental goods and services: the benefits of further global trade liberalization', *Paris*.

OECD (2005) 'Policy brief: opening markets for environmental goods and services', *Paris*.

Perino, G. (2010) 'Technology diffusion with market power in the upstream industry', *Environmental and Resource Economics*, 46(4), pp. 403–428. doi: 10.1007/s10640-010-9347-8.

Reed, W. R. (2015) 'On the Practice of Lagging Variables to Avoid Simultaneity', *Oxford Bulletin of Economics and Statistics*, 77(6), pp. 897–905. doi: 10.1111/obes.12088.

Reinvang, R. (2014) 'The APEC list of Environmental Goods: An analysis of content and precision level', *Report number 2014/08. Oslo: Vista Analysis AS*.

Rezza, A. A. (2013) 'FDI and pollution havens: Evidence from the Norwegian manufacturing sector', *Ecological Economics*, 90, pp. 140–149. doi: 10.1016/j.ecolecon.2013.03.014.

Rodrik, D., Subramanian, A. and Trebbi, F. (2004) 'Institutions Rule : The Primacy Over in Economic and Integration Geography Development *', *Journal of Economic Growth*, 9(2), pp. 131–165.

Sachs, J. D. (2003) 'Institutions don't rule: Direct effects of geography on per capita income', *NATIONAL BUREAU OF ECONOMIC RESEARCH, Working Paper 9305*, NBER Worki, pp. 1689–1699. doi: 10.1017/CBO9781107415324.004.

Sakyi, D., Villaverde, J. and Maza, A. (2015) 'Trade openness, income levels, and economic growth: The case of developing countries, 1970–2009', *The Journal of International Trade & Economic Development*, 24, pp. 860–882. doi: 10.1080/09638199.2014.971422.

Sauvage, J. (2014) 'The Stringency of Environmental Regulations and Trade in Environmental Goods', *OECD Trade and Environment Working Papers, 2014/03*.

Schmid, G. (2012) 'Technology transfer in the CDM: the role of host-country characteristics', *Climate policy*. Routledge.

Steenblik, R. (2005) 'Environmental Goods: A Comparison of the APEC and OECD Lists', *Paris: OECD*.

Steenblik, R. (2007) 'Biofuels-At What Cost? Government Support for ethanol and biodiesel in selected OECD countries: A synthesis of reports addressing subsidies in Australia, Canada, the European Union, Switzerland and the United States', *Global Subsidies Initiative of the International Institute for Sustainable Development (IISD), Geneva, Switzerland*.

Sugathan, M. (2013) 'Lists of Environmental Goods: An Overview', *Information Note. December 2013, International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org*.

Tang, J. (2015) 'Testing the Pollution Haven Effect: Does the Type of FDI Matter?', *Environmental and Resource Economics*, 60(4), pp. 549–578. doi: 10.1007/s10640-014-9779-7.

Taylor, M. S. (2005) 'Unbundling the Pollution Haven Hypothesis', *Advances in Economic Analysis & Policy*. doi: 10.2202/1538-0637.1408.

UNCTAD (2003) 'Environmental goods: trade statistics of developing countries', *TD/B/COM.1/EM.21/CRP.1, Geneva*.

UNEP (2013) 'Green Economy and Trade: trends, challenges, and opportunities', *Available at: http://www.unep.org/greeneconomy/Portals/88/GETReport/pdf/FullReport.pdf*.

Vikhlyaev, A. (2004) 'Environmental Goods and Services–Defining Negotiations or Negotiating Definitions?', *Journal of World Trade*, 38(1), pp. 93–122.

Vossenaar, R. (2013) 'The APEC List of Environmental Goods: An Analysis of the Outcome & Expected Impact', *International Centre for Trade and Sustainable Development, Geneva, Switzerland, www.ictsd.org*.

Wagner, U. J. and Timmins, C. D. (2009) 'Agglomeration effects in foreign direct investment and the pollution haven hypothesis', *Environmental and Resource Economics*, 43(2), pp. 231–256. doi: 10.1007/s10640-008-9236-6.

Wooders, P. (2009) 'Greenhouse gas emission impacts of liberalising trade in environmental goods', *Winnipeg, Man: International Institute for Sustainable Development*.

World Bank (2007) 'International Trade and Climate Change', *Washington DC: World Bank*.

WTO (2001) 'Doha declarations', *Geneva*.

Yu, V. (2007) 'WTO Negotiating Strategy on Environmental Goods and Services in the WTO', *International Centre for Trade and Sustainable Development (ICTSD)*.

Zhang, Z. (2011) 'Trade in Environmental Goods, with Focus on Climate-Friendly Goods and Technologies', *FEEM Working Paper No. 77.2011*.

Zugravu-Soilita, N. (2016) 'Trade in environmental goods and sustainable development: What are we learning from the transition economies' experience?', *FAERE Working Paper, 2016.16*.

Zugravu-Soilita, N. (2017) 'How does Foreign Direct Investment Affect Pollution? Toward a Better Understanding of the Direct and Conditional Effects', *Environmental and Resource Economics*, 66(2), pp. 293–338. doi: 10.1007/s10640-015-9950-9.

Zugravu-Soilita, N., Millock, K. and Duchene, G. (2008) 'The Factors Behind CO2 Emission Reduction in Transition Economies', *FEEM Working paper n° 2008.58*.

Appendices

A. List of countries

Table A.1 Countries in the sample with trade status between 1996 and 2011 (max. 16 obs.)

Country	APEC54 Net Exporter	APEC54 Net Importer	WTO26 Net Exporter	WTO26 Net Importer	WTO408 Net Exporter	WTO408 Net Importer
1. Albania	2	14	2	14	0	16
2. Algeria	0	14	0	14	14	0
3. Angola	0	16	0	16	0	16
4. Armenia	0	16	1	15	0	16
5. Australia	5	11	8	8	1	15
6. Austria	15	1	14	2	4	12
7. Azerbaijan	0	16	0	16	4	12
8. Bangladesh	1	15	1	15	1	15
9. Belarus	2	14	4	12	15	1
10. Belgium	2	14	0	16	1	15
11. Benin	0	16	0	16	0	16
12. Bolivia	2	14	0	16	9	7
13. Bosnia and Herzegovina	0	16	8	8	0	16
14. Brazil	1	15	3	13	2	14
15. Brunei Darussalam	0	14	0	14	14	0
16. Bulgaria	2	14	6	10	2	14
17. Cambodia	0	16	0	16	0	16
18. Cameroon	1	15	1	15	1	15
19. Canada	3	13	2	14	2	14
20. Chile	0	16	0	16	0	16
21. China	9	7	15	1	16	0
22. Cote d'Ivoire	1	15	0	16	15	1
23. Congo	0	16	0	16	2	14
24. Colombia	0	16	0	16	4	12
25. Costa Rica	6	10	4	12	11	5
26. Croatia	11	4	6	9	0	15
27. Cyprus	3	12	2	13	0	15
28. Czech Republic	5	5	8	2	9	1
29. Germany	10	6	5	11	11	5
30. Denmark	16	0	16	0	7	9
31. El Salvador	0	16	0	16	0	16
32. Ecuador	1	15	9	7	0	16
33. Egypt	0	16	0	16	3	13
34. Eritrea	0	12	1	11	0	12
35. Estonia	8	2	5	5	0	10
36. Ethiopia	0	16	0	16	0	16
37. Finland	16	0	16	0	16	0
38. France	3	13	0	16	1	15
39. Gabon	0	16	0	16	0	16
40. Georgia	0	16	0	16	0	16
41. Ghana	0	16	0	16	0	16
42. Greece	0	16	2	14	0	16
43. Guatemala	1	15	0	16	0	16
44. Hong Kong (SAR, China)	10	5	9	6	8	7
45. Honduras	0	16	0	16	0	16
46. Hungary	13	3	6	10	11	5
47. India	4	12	9	7	10	6
48. Indonesia	10	6	13	3	14	2
49. Iceland	0	16	0	16	0	16
50. Ireland	14	2	15	1	13	3
51. Iran, Islamic Republic of	0	12	0	12	0	12
52. Israel	12	4	9	7	7	9
53. Italy	9	7	12	4	2	14
54. Japan	16	0	16	0	14	2
55. Jordan	0	16	0	16	0	16
56. Kazakhstan	0	16	1	15	5	11
57. Kenya	0	16	0	16	0	16
58. Kyrgyzstan	0	16	0	16	0	16
59. Kuwait	0	15	0	15	15	0
60. Lebanon	1	15	0	16	0	16

Country	APEC54 Net Exporter	APEC54 Net Importer	WTO26 Net Exporter	WTO26 Net Importer	WTO408 Net Exporter	WTO408 Net Importer
61. Libyan Arab Jamahiriya	0	7	0	7	4	3
62. Lithuania	1	15	0	16	12	4
63. Latvia	0	16	0	16	1	15
64. Morocco	0	16	0	16	0	16
65. Mexico	1	15	7	9	10	6
66. Malta	0	15	5	10	1	14
67. Mongolia	0	16	0	16	0	16
68. Mozambique	0	16	0	16	0	16
69. Malaysia	14	2	16	0	16	0
70. Nicaragua	0	16	0	16	0	16
71. Netherlands	11	5	7	9	2	14
72. Norway	14	2	15	1	16	0
73. Nepal	0	16	0	16	0	16
74. New Zealand	8	7	8	7	0	15
75. Oman	0	6	0	6	0	6
76. Pakistan	0	16	0	16	0	16
77. Panama	0	16	0	16	0	16
78. Peru	1	15	0	16	1	15
79. Philippines	16	0	16	0	16	0
80. Poland	7	8	11	4	6	9
81. Portugal	3	13	8	8	9	7
82. Paraguay	0	16	0	16	0	16
83. Republic of Korea	16	0	11	5	16	0
84. Republic of Moldova	2	14	0	16	0	16
85. Romania	5	11	10	6	8	8
86. Russian Federation	5	11	6	10	16	0
87. Saudi Arabia	1	15	1	15	15	1
88. Senegal	0	16	0	16	0	16
89. Sri Lanka	5	11	1	15	0	16
90. Sudan	0	16	0	16	5	11
91. Slovakia	7	9	11	5	16	0
92. Slovenia	16	0	12	4	11	5
93. South Africa	16	0	7	9	2	14
94. Spain	0	16	1	15	0	16
95. Sweden	16	0	16	0	16	0
96. Switzerland	16	0	16	0	3	13
97. Togo	0	16	0	16	0	16
98. Thailand	9	7	7	9	16	0
99. Tajikistan	0	16	0	16	0	16
100. Turkmenistan	0	16	0	16	14	2
101. Tunisia	4	12	7	9	0	16
102. Turkey	0	16	4	12	0	16
103. United Republic of Tanzania	0	16	0	16	0	16
104. Ukraine	13	3	15	1	4	12
105. Uruguay	0	16	0	16	1	15
106. United Arab Emirates	0	10	0	10	3	7
107. United Kingdom	6	10	0	16	1	15
108. United States of America	6	10	5	11	0	16
109. Uzbekistan	0	16	0	16	7	9
110. Venezuela	0	16	2	14	16	0
111. Viet Nam	4	12	10	6	4	12
112. Yemen	0	15	0	15	1	14
113. Zambia	0	16	1	15	0	16
114. Zimbabwe	0	16	0	16	0	16
Nb. of observations (total 1767 obs. with non-missing data)	438 (25%)	1329 (75%)	465 (26%)	1302 (74%)	533 (30%)	1234 (70%)

B. Data summary and descriptive statistics

Table B.1 Definitions and sources of variables

Variable	Definition	Source
Dep. Var. CO_2 SO_2	 CO_2 total emissions (tons, metric) SO_2 total emissions (tons, metric)	 EDGAR database EDGAR database
GDP	GDP in constant 2000 US dollars	WDI, World Bank
GNI/cap	GNI: Atlas method, current US dollars – net per capita income	WDI, World Bank
K	Capital stock calculated by using the following formula: Creation of fixed assets $_t$ +0.95*Capital stock $_{t-1}$	Author using WDI, World Bank
L	Active population (the labour)	WDI, World Bank
K/L	Capital stock to Labour ratio	Author's calculation
ER	***Environmental Regulation* Index**, an average z-score of (i) Ratification of a selection of Multilateral Environmental Agreements and Protocols; (ii) International NGOs' members per million of population; (iii) Energy efficiency (GDP/unit of energy used), corrected for latitude; (iv) Number of companies certified ISO 14001, weighted by GDP	Author's calculation
Corrup	**Corruption** index: ***the inverse of*** the original Kaufmann/World Bank's Governance indicator ***Control of Corruption***, which reflects the control of corruption in states. A higher value means a worse governance outcome	World Bank's Governance indicators
Inst.Qual	***Institutional Quality* Index**, calculated as the sum of the World Bank's Governance indicators (increasing value for higher quality): Control of Corruption, Government Effectiveness, Political Stability and Absence of Violence, Regulatory Quality, Rule of Law, Voice and Accountability	Author's calculation using World Bank's Governance indicators
Geo	Geography represented by the Latitude – an angular measurement in degrees ranging from 0 degrees at the equator to 90 degrees at the poles; should account for geological and climatic specificities	CEPII's database Distances
Open	Openness/Total trade intensity: (Export+Import)/GDP	Author calculation using WDI, World Bank
Trade/GDP_EGs	EGs' trade intensity: (EGs export + EGs impot)/GDP	Author's calculation, using UN CONTRADE + WDI data
Trade_EGs	**Trade in EGs**: EGs export + EGs import (EGs representing different goods, following the specified group: ***APEC54***, ***WTO26***, or ***WTO408***, the latter being further split into four categories: WTO_{RE} - Renewable Energy, WTO_{ET} - Environmental Technologies, WTO_{WMWT} – Waste Management and Water Treatment, and WTO_{APC} – Air Pollution Control)	Author's calculation, using UN CONTRADE data
Net_ImEGs	A dummy taking value 1 if a country is a 'net importer' of specific EGs categories	Author's calculation
…t-1	One year lagged variable	

Table B.2 Descriptive statistics in the CO2 models

VARIABLES *(all variables in logarithm)*	(1) N	(2) mean	(3) sd	(4) min	(5) max	(6) p25	(7) p50	(8) p75	(9) skewness	(10) kurtosis
year				**1997**	**2011**					
CO_2	1,653	22.23	1.810	17.82	27.58	20.82	22.24	23.38	0.293	2.731
GDP	1,653	24.40	1.976	20.27	30.09	22.86	24.06	25.80	0.379	2.604
K/L	1,653	9.422	1.605	5.745	12.53	8.175	9.382	10.83	-0.0731	1.980
Open	1,653	4.155	0.498	2.692	6.309	3.838	4.137	4.485	0.0170	3.087
GNI/cap	1,653	8.189	1.607	4.248	11.39	6.877	8.129	9.620	0.0336	1.902
GNI/cap, $_{t-1}$	1,653	8.124	1.613	4.248	11.37	6.791	8.061	9.576	0.0624	1.890
ER	1,653	3.904	0.200	3.376	4.567	3.758	3.854	4.035	0.693	2.911
ER, $_{t-1}$	1,653	3.903	0.199	3.376	4.585	3.760	3.855	4.033	0.702	3.015
Trade/GDP_EGs$_{APEC54}$	1,653	0.475	0.346	0.0311	2.204	0.215	0.404	0.624	1.433	5.640
Trade_EGs$_{APEC54}$	1,653	19.31	2.161	13.67	25.84	17.73	19.05	20.85	0.342	2.667
Trade_EGs$_{APEC54, t-1}$	1,653	19.15	2.113	13.67	25.71	17.58	18.91	20.69	0.340	2.683
Trade_EGs$_{WTO26}$	1,653	18.82	2.108	12.89	25.20	17.24	18.61	20.27	0.304	2.769
Trade_EGs$_{WTO26, t-1}$	1,653	18.65	2.057	12.89	25.02	17.16	18.49	20.09	0.293	2.780
Trade_EGs$_{WTO408}$	1,653	22.27	1.933	16.95	27.67	20.84	22.16	23.66	0.201	2.549
Trade_EGs$_{WTO408, t-1}$	1,653	22.13	1.912	16.95	27.58	20.68	21.99	23.51	0.210	2.536
InstQual	1,653	2.664	0.376	1.610	3.293	2.406	2.628	2.983	-0.193	2.336
Corrup	1,653	6.402	0.0560	4.468	7.188	6.401	6.402	6.405	-22.75	891.4
Geo	1,653	4.484	0.339	3.166	4.884	4.316	4.622	4.722	-1.514	5.209
Number of countries	114	114	114	114	114	114	114	114	114	114

Table B.3 Descriptive statistics in the SO2 models

VARIABLES *(all variables in logarithm)*	(1) N	(2) mean	(3) sd	(4) min	(5) max	(6) p25	(7) p50	(8) p75	(9) skewness	(10) kurtosis
year				**1997**	**2008**					
SO2	1,335	16.61	1.839	12.61	22.11	15.37	16.37	18.05	0.238	2.597
GDP	1,335	24.34	1.984	20.27	30.09	22.80	24.01	25.77	0.378	2.603
K/L	1,335	9.286	1.601	5.745	12.29	8.039	9.254	10.71	-0.0382	1.940
Open	1,335	4.143	0.499	2.692	6.309	3.836	4.128	4.470	0.0121	3.156
GNI/cap	1,335	8.065	1.619	4.248	11.36	6.697	7.986	9.525	0.0848	1.876
GNI/cap, $_{t-1}$	1,335	7.995	1.618	4.248	11.25	6.620	7.867	9.496	0.112	1.866
ER	1,335	3.902	0.196	3.376	4.567	3.766	3.854	4.030	0.736	3.126
ER, $_{t-1}$	1,335	3.902	0.195	3.376	4.585	3.768	3.856	4.024	0.745	3.265
Trade/GDP_EGs$_{APEC54}$	1,335	0.414	0.301	0.0311	2.028	0.182	0.348	0.552	1.428	5.742
Trade_EGs$_{APEC54}$	1,335	19.00	2.034	13.67	25.36	17.46	18.78	20.57	0.288	2.609
Trade_EGs$_{APEC54, t-1}$	1,335	18.82	1.953	13.67	25.10	17.33	18.62	20.41	0.220	2.463
Trade_EGs$_{WTO26}$	1,335	18.51	1.975	12.89	24.78	17.08	18.36	19.99	0.227	2.712
Trade_EGs$_{WTO26, t-1}$	1,335	18.32	1.892	12.89	24.52	16.93	18.17	19.87	0.145	2.554
Trade_EGs$_{WTO408}$	1,335	22.02	1.874	16.95	27.58	20.59	21.86	23.40	0.188	2.493
Trade_EGs$_{WTO408, t-1}$	1,335	21.85	1.829	16.95	27.36	20.44	21.70	23.28	0.172	2.415
InstQual	1,335	2.663	0.377	1.610	3.293	2.396	2.628	2.983	-0.182	2.324
Corrup	1,335	6.402	0.0603	4.468	7.188	6.401	6.402	6.405	-22.69	816.7
Geo	1,335	4.483	0.339	3.166	4.884	4.316	4.622	4.722	-1.528	5.279
Number of countries	114	114	114	114	114	114	114	114	114	114

Figure B.1 Partial correlations

CO2																
0.852	SO2															
0.865	0.801	GDP														
0.461	0.316	0.664	K/L													
-0.276	-0.345	-0.338	0.067	Open												
0.019	0.003	0.034	0.040	-0.053	Corrup											
0.285	0.225	0.529	0.793	0.048	0.018	InstQual										
0.183	0.068	0.161	0.265	0.149	-0.007	0.178	Geo									
0.438	0.297	0.656	0.981	0.038	0.049	0.824	0.269	GNI/cap								
0.438	0.300	0.660	0.980	0.031	0.045	0.829	0.262	0.998	GNI/cap,t-1							
0.214	0.119	0.407	0.677	0.037	0.033	0.749	0.395	0.697	0.697	ER						
0.222	0.128	0.423	0.686	0.024	0.042	0.757	0.378	0.705	0.705	0.981	ER,t-1					
-0.104	-0.204	-0.142	0.186	0.544	0.009	0.141	0.228	0.161	0.154	0.201	0.181	APEC54(X+M/GDP)				
0.769	0.652	0.865	0.730	-0.038	0.031	0.568	0.289	0.718	0.712	0.489	0.496	0.325	APEC54(X+M)			
0.780	0.663	0.877	0.736	-0.057	0.025	0.583	0.293	0.723	0.719	0.502	0.509	0.247	0.966	APEC54(X+M)t-1		
0.759	0.652	0.860	0.710	-0.035	0.021	0.549	0.292	0.698	0.690	0.474	0.482	0.292	0.980	0.950	WTO26(X+M)	
0.786	0.653	0.875	0.736	-0.006	0.021	0.532	0.290	0.725	0.717	0.449	0.457	0.198	0.952	0.933	0.951	WTO408(X+M)

C. Empirical strategy

Table C.1 OLS and GLS regressions for CO2 emissions

Independent VARIABLES \ MODELS / Explained variable	(1) OLS-robust CO_2	(2) OLS-robust CO_2	(3) OLS-robust CO_2	(4) OLS-robust CO_2	(5) FE CO_2	(6) RE CO_2
GDP	0.813***	0.805***	0.801***	0.728***	0.601***	0.836***
	(0.0253)	(0.0265)	(0.0257)	(0.0300)	(0.142)	(0.0420)
K/L	0.0590	0.145**	0.160**	0.255***	0.0896	0.0340
	(0.0670)	(0.0736)	(0.0727)	(0.0762)	(0.103)	(0.0840)
GNI/cap $_t$	-0.326***	0.368				
	(0.0637)	(0.226)				
GNI/cap $_{t-1}$		-0.770***	-0.416***	-0.489***	-0.0482	-0.165**
		(0.226)	(0.0683)	(0.0707)	(0.0836)	(0.0748)
ER $_t$	-0.720***	1.094*				
	(0.125)	(0.599)				
ER $_{t-1}$		-1.897***	-0.842***	-1.034***	-0.627***	-0.707***
		(0.606)	(0.128)	(0.135)	(0.225)	(0.203)
Open	0.160***	0.126**	0.129**	0.0935	0.0111	0.00518
	(0.0569)	(0.0582)	(0.0574)	(0.0588)	(0.0746)	(0.0638)
Trade_EGs $_t$	0.169***	0.0249				
	(0.0207)	(0.0456)				
Trade_EGs $_{t-1}$		0.157***	0.185***	0.264***	0.0209	0.0568***
		(0.0457)	(0.0212)	(0.0263)	(0.0232)	(0.0220)
Trend				-0.0362***	-0.00745	-0.00921
				(0.0064)	(0.00835)	(0.00565)
Constant	3.408***	3.595***	3.764***	4.973***	9.184***	4.598***
	(0.643)	(0.660)	(0.650)	(0.708)	(3.063)	(1.069)
Observations	1,767	1,653	1,657	1,657	1,657	1,657
R-squared	0.785	0.793	0.792	0.797	0.071	
Robust st.err.	YES	YES	YES	YES		
Number of country_id					114	114
Random fixed-effects						YES
Country fixed-effects					YES	

Legend: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table C.2 IV-GMM regressions for CO2 emissions

MODELS / Explained variable / Independent VARIABLES	(1) IV-GMM: Second-stage regression CO_2	(2) IV-GMM: Second-stage regression CO_2	(3) IV-GMM: Second-stage regression CO_2	(3) First-stage regreesion ER	(3) First-stage regreesion GNI/cap	(3) First-stage regreesion Trade_EGs
ER_t	-1.054** (0.410)	-1.054** (0.410)	-1.012** (0.407)			
GNI/cap_t	-0.530*** (0.157)	-0.530*** (0.157)	-0.516*** (0.156)			
$Trade\_EGs_t$	0.341*** (0.0780)	0.341*** (0.0780)	0.345*** (0.0779)			
ER_{t-1}				0.979*** (0.00749)	0.0524*** (0.0180)	0.145* (0.0786)
GNI/cap_{t-1}				0.00311 (0.00293)	0.955*** (0.00967)	0.0419 (0.0385)
$Trade\_EGs_{t-1}$				0.0038*** (0.00116)	-0.0081* (0.00487)	0.773*** (0.0164)
GDP	0.648*** (0.0924)	0.648*** (0.0924)	0.637*** (0.0916)	-0.0048*** (0.00130)	0.0076 (0.00549)	0.235*** (0.0163)
K/L	0.288* (0.157)	0.289* (0.157)	0.276* (0.156)	-0.00121 (0.00299)	0.0330*** (0.00985)	-0.0410 (0.0416)
Open	0.0111 (0.167)	0.0116 (0.167)	-0.0199 (0.163)	-0.0004 (0.00209)	0.0096 (0.0114)	0.265*** (0.0336)
Trend	-0.0470*** (0.0117)	-0.0470*** (0.0117)	-0.0464*** (0.0117)	-0.0006** (0.000260)	0.0078*** (0.000801)	0.0419*** (0.00315)
Corrup		0.102 (0.115)		-0.0261*** (0.00755)	0.0969* (0.0561)	0.124 (0.0920)
Constant	5.984*** (2.113)	5.327** (2.303)	6.150*** (2.105)	0.289*** (0.0611)	-0.852** (0.377)	-4.060*** (0.735)
Observations	1,653	1,653	1,653	1,653	1,653	1,653
R-squared	0.792	0.792	0.792			
Instruments	**Lags of ER+GNI+EGs**	**Lags of ER+GNI+EGs**	**Lags of ER+GNI+EGs & Corrup**			
Robust estimation	YES	YES	YES			
Country clustering	YES	YES	YES			

Legend: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

D. Estimation results

Table D.1 System-GMM regressions on trade in EGs from the APEC 54 list (pooled simple of countries)

MODELS / Explained variable / Independent VARIABLES	(1) APEC54			(2) APEC54		
	CO_2	ER – channel	GNI/cap – channel	**SO_2**	ER – channel	GNI/cap – channel
ER	-1.360*** (0.334)			-1.956*** (0.514)		
GNI/cap	-0.574*** (0.149)	0.0822*** (0.0130)		-0.651*** (0.243)	0.0737*** (0.0150)	
Trade_EGs $_{t-1}$	**0.233***** (0.0546)	**0.0529***** (0.0132)	**0.0609***** (0.0193)	**0.230***** (0.0676)	**0.0458***** (0.0146)	**0.0444*** (0.0232)
GDP	0.772*** (0.0720)			0.731*** (0.0798)		
K/L	0.374** (0.152)			0.382* (0.231)		
Open	0.278* (0.147)	0.000168 (0.0269)	-0.111*** (0.0383)	-0.00784 (0.140)	-0.0496 (0.0367)	-0.0818** (0.0402)
Trend	-0.0381*** (0.00802)	-0.0142*** (0.00169)	0.00672** (0.00323)	-0.0560*** (0.00950)	-0.00980*** (0.00185)	0.00301 (0.00398)
Pollution		0.378*** (0.0525)			0.675*** (0.195)	
Pollution^2		-0.0101*** (0.00119)			-0.0221*** (0.00586)	
Corrup		-0.158* (0.0893)			-0.358 (0.237)	
K			0.799*** (0.0317)			0.821*** (0.0351)
L			-0.826*** (0.0284)			-0.824*** (0.0301)
InstQual			0.652*** (0.0776)			0.589*** (0.0801)
Geo			0.0216 (0.0506)			-0.0143 (0.0500)
Observations	1,653	1,653	1,653	1,335	1,335	1,335
Robust estimation	YES	YES	YES	YES	YES	YES
Country clustering	YES	YES	YES	YES	YES	YES

Legend: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D.2 System-GMM regressions on trade in EGs from the APEC 54 list, net importers compared to net exporters

MODELS / Explained variable / Independent VARIABLES	(1) APEC54			(2) APEC54		
	CO_2	ER – channel	GNI/cap – channel	**SO_2**	ER – channel	GNI/cap – channel
ER	-1.280*** (0.331)			-1.830*** (0.511)		
GNI/cap	-0.581*** (0.144)	0.0788*** (0.0131)		-0.638*** (0.244)	0.0703*** (0.0150)	
Trade_EGs $_{t-1}$	**0.122*** (0.0645)	**0.0452***** (0.0129)	**0.0990***** (0.0244)	**0.0461** (0.0925)	**0.0310**** (0.0154)	**0.0795***** (0.0291)
Net_ImEGs x Trade_EGs $_{t-1}$	***0.167****** (0.0492)	*0.00592* (0.00852)	***-0.0442****** (0.0165)	***0.261****** (0.0664)	*0.0105* (0.0115)	***-0.0409**** (0.0193)
GDP	0.761*** (0.0708)			0.722*** (0.0798)		
K/L	0.378*** (0.145)			0.355 (0.229)		
Open	0.270* (0.140)	-0.00135 (0.0274)	-0.127*** (0.0369)	-0.0162 (0.143)	-0.0435 (0.0372)	-0.116*** (0.0373)
Trend	-0.0383*** (0.00848)	-0.0132*** (0.00170)	0.00551* (0.00332)	-0.0539*** (0.0103)	-0.0086*** (0.00202)	0.00285 (0.00405)
Pollution		0.374*** (0.0575)			0.686*** (0.178)	
Pollution^2		-0.0099*** (0.00131)			-0.0222*** (0.00541)	
Corrup		-0.124 (0.0915)			-0.338 (0.219)	
K			0.807*** (0.0308)			0.830*** (0.0348)
L			-0.852*** (0.0271)			-0.852*** (0.0284)
InstQual			0.569*** (0.0860)			0.524*** (0.0871)
Geo			-0.0313 (0.0596)			-0.0402 (0.0628)
Net_ImEGs	-3.274*** (1.037)	-0.153 (0.174)	0.849*** (0.326)	-5.098*** (1.353)	-0.246 (0.228)	0.772** (0.376)
Observations	1,653	1,653	1,653	1,335	1,335	1,335
Robust estimation	YES	YES	YES	YES	YES	YES
Country clustering	YES	YES	YES	YES	YES	YES

Legend: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D.3 System-GMM regressions on trade in EGs from the WTO lists (pooled simple of countries)

MODELS / Explained variable / VARIABLES	(1) WTO-408			(2) WTO-26			(3) WTO-408			(4) WTO-26		
	CO_2	ER	GNI/cap	**CO_2**	ER	GNI/cap	**SO_2**	ER	GNI/cap	**SO_2**	ER	GNI/cap
ER	-1.120***			-1.256***			-1.386***			-1.858***		
	(0.294)			(0.335)			(0.520)			(0.507)		
GNI/cap	-0.653***	0.0790***		-0.578***	0.0881***		-0.759***	0.0786***		-0.659***	0.0792***	
	(0.161)	(0.0157)		(0.156)	(0.0126)		(0.246)	(0.0173)		(0.244)	(0.0145)	
$Trade\_EGs_{t-1}$	**0.398*** **	**0.0770*** **	**0.173*** **	**0.177*** **	**0.0446*** **	**0.0540*** **	**0.150**	**0.0427** **	**0.165*** **	**0.207*** **	**0.0380** **	**0.0253**
	(0.0779)	(0.0246)	(0.0318)	(0.0508)	(0.0131)	(0.0158)	(0.112)	(0.0211)	(0.0365)	(0.0566)	(0.0149)	(0.0197)
GDP	0.650***			0.829***			0.816***			0.755***		
	(0.0753)			(0.0688)			(0.108)			(0.0720)		
K/L	0.409***			0.382**			0.457*			0.398*		
	(0.158)			(0.159)			(0.235)			(0.233)		
Open	0.0886	-0.0288	-0.204***	0.319**	0.00277	-0.107***	-0.00710	-0.0638	-0.189***	0.0135	-0.0402	-0.0707*
	(0.146)	(0.0320)	(0.0383)	(0.147)	(0.0268)	(0.0397)	(0.178)	(0.0413)	(0.0424)	(0.140)	(0.0354)	(0.0416)
Trend	-0.052***	-0.0163***	0.00100	-0.033***	-0.0137***	0.00677**	-0.0502***	-0.0102***	0.000329	-0.0561***	-0.0095***	0.00366
	(0.00878)	(0.00252)	(0.00358)	(0.00774)	(0.00176)	(0.00339)	(0.0116)	(0.00222)	(0.00387)	(0.00949)	(0.00190)	(0.00416)
Pollution		0.352***			0.382***			0.704***			0.637***	
		(0.0389)			(0.0456)			(0.224)			(0.191)	
$Pollution^2$		-0.0099***			-0.010***			-0.0229***			-0.0207***	
		(0.00083)			(0.00105)			(0.00677)			(0.00573)	
Corrup		-0.160***			-0.161**			-0.409			-0.308	
		(0.0566)			(0.0768)			(0.282)			(0.234)	
K			0.688***			0.806***			0.704***			0.838***
			(0.0373)			(0.0270)			(0.0424)			(0.0293)
L			-0.808***			-0.828***			-0.809***			-0.827***
			(0.0263)			(0.0275)			(0.0276)			(0.0289)
InstQual			0.711***			0.656***			0.663***			0.591***
			(0.0740)			(0.0764)			(0.0807)			(0.0788)
Geo			-0.00106			0.0209			-0.0228			-0.0178
			(0.0528)			(0.0506)			(0.0520)			(0.0500)
Observations	1,653	1,653	1,653	1,653	1,653	1,653	1,335	1,335	1,335	1,335	1,335	1,335
Robust estimation	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country clustering	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Legend: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D.4 System-GMM regressions on trade in EGs from WTO lists, net importers vs net exporters

MODELS / Explained variable / VARIABLES	(1) WTO-408			(2) WTO-26			(3) WTO-408			(4) WTO-26		
	CO2	ER	GNI/cap	**CO2**	ER	GNI/cap	**SO2**	ER	GNI/cap	**SO2**	ER	GNI/cap
ER	-1.126***			-1.257***			-1.411***			-1.882***		
	(0.296)			(0.330)			(0.519)			(0.498)		
GNI/cap	-0.682***	0.0817***		-0.588***	0.0827***		-0.772***	0.0806***		-0.661***	0.0744***	
	(0.162)	(0.0154)		(0.154)	(0.0122)		(0.253)	(0.0163)		(0.248)	(0.0140)	
Trade_EGs $_{t-1}$	0.318***	0.0648***	0.187***	0.0527	0.0425***	0.0895***	0.122	0.0364	0.180***	-0.0129	0.0333**	0.0594**
	(0.0904)	(0.0232)	(0.0414)	(0.0585)	(0.0139)	(0.0213)	(0.118)	(0.0227)	(0.0461)	(0.0768)	(0.0169)	(0.0266)
Net_ImEGs x Trade_EGs $_{t-1}$	0.103*	-0.000720	-0.00504	0.160***	-0.00119	-0.0398**	0.0352	-0.000736	-0.00774	0.252***	-0.00197	-0.0342
	(0.0620)	(0.0132)	(0.0181)	(0.0493)	(0.0106)	(0.0186)	(0.0931)	(0.0144)	(0.0200)	(0.0691)	(0.0169)	(0.0222)
GDP	0.631***			0.836***			0.822***			0.767***		
	(0.0726)			(0.0656)			(0.107)			(0.0709)		
K/L	0.454***			0.367**			0.471**			0.388*		
	(0.159)			(0.157)			(0.240)			(0.234)		
Open	0.0503	-0.0273	-0.213***	0.313**	0.00194	-0.120***	0.0149	-0.0576	-0.201***	0.00169	-0.0369	-0.0988**
	(0.143)	(0.0339)	(0.0389)	(0.138)	(0.0265)	(0.0386)	(0.183)	(0.0411)	(0.0433)	(0.132)	(0.0357)	(0.0402)
Trend	-0.0519***	-0.0144***	-8.73e-05	-0.0292***	-0.0124***	0.00576*	-0.0509***	-0.00928***	-0.000420	-0.0490***	-0.00799***	0.00298
	(0.00910)	(0.00235)	(0.00372)	(0.00779)	(0.00174)	(0.00350)	(0.0121)	(0.00224)	(0.00378)	(0.00977)	(0.00195)	(0.00430)
Pollution		0.397***			0.387***			0.743***			0.672***	
		(0.0492)			(0.0518)			(0.224)			(0.179)	
Pollution^2		-0.0108***			-0.0100***			-0.0239***			-0.0215***	
		(0.00117)			(0.00121)			(0.00680)			(0.00538)	
Corrup		-0.218***			-0.160**			-0.451			-0.344	
		(0.0704)			(0.0805)			(0.289)			(0.222)	
K			0.687***			0.812***			0.703***			0.845***
			(0.0393)			(0.0263)			(0.0447)			(0.0284)
L			-0.818***			-0.854***			-0.819***			-0.855***
			(0.0258)			(0.0259)			(0.0270)			(0.0268)
InstQual			0.677***			0.585***			0.643***			0.534***
			(0.0759)			(0.0840)			(0.0815)			(0.0829)
Geo			-0.00150			-0.0165			-0.0310			-0.0351
			(0.0629)			(0.0582)			(0.0637)			(0.0608)
Net_ImEGs	-2.417*	-0.0105	0.125	-3.233***	-0.0231	0.743**	-0.765	0.00303	0.184	-5.069***	-0.0177	0.625
	(1.420)	(0.306)	(0.419)	(0.989)	(0.207)	(0.358)	(2.092)	(0.324)	(0.458)	(1.334)	(0.323)	(0.422)
Observations	1,653	1,653	1,653	1,653	1,653	1,653	1,335	1,335	1,335	1,335	1,335	1,335
Robust estimation	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Country clustering	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Legend: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D.5 System-GMM regressions on trade in EGs from different categories of WTO408 list (pooled simple of countries)

VARIABLES \ MODELS / Explained variable	(1) Different WTO classifications			(2) Different WTO classifications		
	CO2	ER	GNI/cap	**SO2**	ER	GNI/cap
ER	-1.341*** (0.294)			-2.203*** (0.481)		
GNI/cap	-0.614*** (0.155)	0.0653*** (0.0164)		-0.699*** (0.233)	0.0495*** (0.0191)	
$Trade\_EGs_{APC,t-1}$	**-0.0180** (0.0706)	**-0.0294*** (0.0156)	**0.0728**** (0.0313)	**0.0532** (0.0845)	**-0.0364*** (0.0194)	**0.0777**** (0.0330)
$Trade\_EGs_{WMWT,t-1}$	**0.381***** (0.120)	**0.0720**** (0.0286)	**0.0193** (0.0374)	**0.728***** (0.140)	**0.0994***** (0.0303)	**0.0188** (0.0388)
$Trade\_EGs_{ET,t-1}$	**0.299***** (0.0728)	**0.0290** (0.0238)	**0.0829**** (0.0353)	**-0.110** (0.120)	**0.0177** (0.0186)	**0.0811**** (0.0361)
$Trade\_EGs_{RE,t-1}$	**-0.264**** (0.118)	**0.00832** (0.0219)	**-0.0159** (0.0319)	**-0.318***** (0.107)	**-0.00466** (0.0210)	**-0.0364** (0.0314)
GDP	0.660*** (0.0619)			0.741*** (0.0846)		
K/L	0.332** (0.147)			0.344 (0.219)		
Open	0.114 (0.135)	-0.0226 (0.0293)	-0.166*** (0.0373)	0.0146 (0.163)	-0.0815** (0.0367)	-0.144*** (0.0393)
Trend	-0.0451*** (0.00835)	-0.0159*** (0.00216)	0.000385 (0.00352)	-0.0669*** (0.0110)	-0.0109*** (0.00222)	-0.00106 (0.00362)
Pollution		0.386*** (0.0482)			0.730*** (0.156)	
$Pollution^2$		-0.0106*** (0.00106)			-0.0241*** (0.00467)	
Corrup		-0.192** (0.0762)			-0.452** (0.185)	
K			0.706*** (0.0409)			0.736*** (0.0476)
L			-0.811*** (0.0290)			-0.816*** (0.0308)
InstQual			0.646*** (0.0827)			0.616*** (0.0860)
Geo			0.0386 (0.0512)			-0.0205 (0.0505)
Observations	1,653	1,653	1,653	1,335	1,335	1,335
Robust estimation	YES	YES	YES	YES	YES	YES
Country clustering	YES	YES	YES	YES	YES	YES

Legend: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table D.6 System-GMM regressions on trade in EGs from different categories of WTO408 list, net importers compared to net exporters

VARIABLES (MODELS / Explained variable)	(1) Different WTO classifications			(2) Different WTO classifications		
	CO2	ER	GNI/cap	**SO2**	ER	GNI/cap
ER	-1.387*** (0.278)			-2.095*** (0.459)		
GNI/cap	-0.579*** (0.143)	0.0694*** (0.0155)		-0.683*** (0.219)	0.0535*** (0.0177)	
$Trade\_EGs_{APC,t-1}$	-0.108 (0.0739)	**-0.0373**** (0.0164)	**0.0748**** (0.0331)	-0.0548 (0.0715)	**-0.0464**** (0.0209)	**0.0798**** (0.0352)
Net_ImEGs_{APC} x **$Trade\_EGs_{APC,t-1}$**	***0.106**** (0.0521)	*0.000477* (0.0107)	*0.00237* (0.0201)	***0.225***** (0.0746)	*0.00349* (0.0148)	*-9.38e-06* (0.0255)
$Trade\_EGs_{WMWT,t-1}$	**0.302**** (0.128)	**0.0759***** (0.0294)	0.0280 (0.0371)	**0.667***** (0.149)	**0.113***** (0.0349)	0.0200 (0.0385)
Net_ImEGs_{WMWT} x **$Trade\_EGs_{WMWT,t-1}$**	*0.0278* (0.0476)	*-0.0171* (0.0117)	***-0.0306**** (0.0135)	*0.0527* (0.0716)	***-0.0274**** (0.0158)	*-0.0265* (0.0214)
$Trade\_EGs_{ET,t-1}$	**0.253***** (0.0785)	0.0168 (0.0207)	**0.0886**** (0.0391)	-0.0737 (0.113)	0.0120 (0.0202)	0.0766* (0.0411)
Net_ImEGs_{ET} x **$Trade\_EGs_{ET,t-1}$**	*0.0684* (0.0646)	*0.0141* (0.0145)	*0.0242* (0.0187)	*-0.153** (0.0878)	*0.00414* (0.0164)	*0.0295* (0.0238)
$Trade\_EGs_{RE,t-1}$	**-0.270**** (0.128)	0.00740 (0.0237)	-0.0168 (0.0306)	**-0.414***** (0.121)	-0.0165 (0.0258)	-0.0330 (0.0348)
Net_ImEGs_{RE} x **$Trade\_EGs_{RE,t-1}$**	*0.0739* (0.0478)	*0.00852* (0.0113)	*-0.00572* (0.0157)	*0.109* (0.0806)	*0.0183* (0.0174)	*-0.00409* (0.0221)
GDP	0.617*** (0.0566)			0.740*** (0.0810)		
K/L	0.319** (0.136)			0.338* (0.205)		
Open	0.0589 (0.123)	-0.0238 (0.0275)	-0.169*** (0.0387)	-0.0528 (0.153)	-0.0832** (0.0361)	-0.143*** (0.0409)
Trend	-0.0426*** (0.00858)	-0.0136*** (0.00201)	-0.00160 (0.00353)	-0.0583*** (0.0118)	-0.00861*** (0.00219)	-0.00272 (0.00369)
Pollution		0.398*** (0.0476)			0.750*** (0.185)	
$Pollution^2$		-0.0109*** (0.00117)			-0.0247*** (0.00571)	
Corrup		-0.155** (0.0627)			-0.434* (0.225)	
K			0.712*** (0.0399)			0.744*** (0.0476)
L			-0.828*** (0.0294)			-0.831*** (0.0314)
InstQual			0.602*** (0.0911)			0.609*** (0.0929)
Geo			0.0169 (0.0608)			-0.0272 (0.0636)
Observations	1,653	1,653	1,653	1,335	1,335	1,335
Robust estimation	YES	YES	YES	YES	YES	YES
Country clustering	YES	YES	YES	YES	YES	YES

Legend: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI
Fondazione Eni Enrico Mattei Working Paper Series

Our Working Papers are available on the Internet at the following addresses:
http://www.feem.it/getpage.aspx?id=73&sez=Publications&padre=20&tab=1

NOTE DI LAVORO PUBLISHED IN 2017

1.2017, SAS Series, Anna Alberini, Milan Ščasný, The Benefits of Avoiding Cancer (or Dying from Cancer): Evidence from a Four-country Study

2. 2017, ET Series, Cesare Dosi, Michele Moretto, Cost Uncertainty and Time Overruns in Public Procurement: a Scoring Auction for a Contract with Delay Penalties

3.2017, SAS Series, Gianni Guastella, Stefano Pareglio, Paolo Sckokai, A Spatial Econometric Analysis of Land Use Efficiency in Large and Small Municipalities

4.2017, ESP Series, Sara Brzuszkiewicz, The Social Contract in the MENA Region and the Energy Sector Reforms

5.2017, ET Series, Berno Buechel, Lydia Mechtenberg, The Swing Voter's Curse in Social Networks

6.2017, ET Series, Andrea Bastianin, Marzio Galeotti, Matteo Manera, Statistical and Economic Evaluation of Time Series Models for Forecasting Arrivals at Call Centers

7.2017, MITP Series, Robert C. Pietzcker, Falko Ueckerdt, Samuel Carrara, Harmen Sytze de Boer, Jacques Després, Shinichiro Fujimori, Nils Johnson, Alban Kitous, Yvonne Scholz, Patrick Sullivan, Gunnar Luderer, System Integration of Wind and Solar Power in Integrated Assessment

8.2017, MITP Series, Samuel Carrara, Thomas Longden, Freight Futures: The Potential Impact of Road Freight on Climate Policy

9.2017, ET Series, Claudio Morana, Giacomo Sbrana, Temperature Anomalies, Radiative Forcing and ENSO

10.2017, ESP Series, Valeria Di Cosmo, Laura Malaguzzi Valeri, Wind, Storage, Interconnection and the Cost of Electricity Generation

11.2017, EIA Series, Elisa Delpiazzo, Ramiro Parrado, Gabriele Standardi, Extending the Public Sector in the ICES Model with an Explicit Government Institution

12.2017, MITP Series, Bai-Chen Xie, Jie Gao, Shuang Zhang, ZhongXiang Zhang, What Factors Affect the Competiveness of Power Generation Sector in China? An Analysis Based on Game Cross-efficiency

13.2017, MITP Series, Stergios Athanasoglou, Valentina Bosetti, Laurent Drouet, A Simple Framework for Climate-Change Policy under Model Uncertainty

14.2017, MITP Series, Loïc Berger and Johannes Emmerling, Welfare as Simple(x) Equity Equivalents

15.2017, ET Series, Christoph M. Rheinberger, Felix Schläpfer, Michael Lobsiger , A Novel Approach to Estimating the Demand Value of Road Safety

16.2017, MITP Series, Giacomo Marangoni, Gauthier De Maere, Valentina Bosetti, Optimal Clean Energy R&D Investments Under Uncertainty

17.2017, SAS Series, Daniele Crotti, Elena Maggi, Urban Distribution Centres and Competition among Logistics Providers: a Hotelling Approach

18.2017, ESP Series, Quentin Perrier, The French Nuclear Bet

19.2017, EIA Series, Gabriele Standardi, Yiyong Cai, Sonia Yeh, Sensitivity of Modeling Results to Technological and Regional Details: The Case of Italy's Carbon Mitigation Policy

20.2017, EIA Series, Gregor Schwerhoff, Johanna Wehkamp, Export Tariffs Combined with Public Investments as a Forest Conservation Policy Instrument

21.2017, MITP Series, Wang Lu, Hao Yu, Wei Yi-Ming, How Do Regional Interactions in Space Affect China's Mitigation Targets and Economic Development?

22.2017, ET Series, Andrea Bastianin, Paolo Castelnovo, Massimo Florio, The Empirics of Regulatory Reforms Proxied by Categorical Variables: Recent Findings and Methodological Issues

23.2017, EIA Series, Martina Bozzola, Emanuele Massetti, Robert Mendelsohn, Fabian Capitanio, A Ricardian Analysis of the Impact of Climate Change on Italian Agriculture

24.2017, MITP Series, Tunç Durmaz, Aude Pommeret, Ian Ridley, Willingness to Pay for Solar Panels and Smart Grids

25.2017, SAS Series, Federica Cappelli, An Analysis of Water Security under Climate Change

26.2017, ET Series, Thomas Demuynck, P. Jean-Jacques Herings, Riccardo D. Saulle, Christian Seel, The Myopic Stable Set for Social Environments

27.2017, ET Series, Joosung Lee, Mechanisms with Referrals: VCG Mechanisms and Multilevel Mechanism

28.2017, ET Series, Sareh Vosooghi, Information Design In Coalition Formation Games

29.2017, ET Series, Marco A. Marini, Collusive Agreements in Vertically Differentiated Markets

30.2017, ET Series, Sonja Brangewitz, Behnud Mir Djawadi, Angelika Endres, Britta Hoyer, Network Formation and Disruption - An Experiment - Are Efficient Networks too Complex?

31.2017, ET Series, Francis Bloch, Anne van den Nouweland, Farsighted Stability with Heterogeneous Expectations

32.2017, ET Series, Lionel Richefort, Warm-Glow Giving in Networks with Multiple Public Goods

33.2017, SAS Series, Fabio Moliterni, Analysis of Public Subsidies to the Solar Energy Sector: Corruption and the Role of Institutions

34.2017, ET Series, P. Jean-Jacques Herings, Ana Mauleon, Vincent Vannetelbosch, Matching with Myopic and Farsighted Players

35.2017, ET Series, Jorge Marco, Renan Goetz, Tragedy of the Commons and Evolutionary Games in Social Networks: The Economics of Social Punishment

36.2017, ET Series, Xavier Pautrel, Environment, Health and Labor Market

37.2017, ESP Series, Valeria Di Cosmo, Sean Collins, and Paul Deane, The Effect of Increased Transmission and Storage in an Interconnected Europe: an Application to France and Ireland

38.2017, MITP Series, Massimo Tavoni, Valentina Bosetti, Soheil Shayegh, Laurent Drouet, Johannes Emmerling, Sabine Fuss, Timo Goeschl, Celine Guivarch, Thomas S. Lontzek, Vassiliki Manoussi, Juan Moreno-Cruz, Helene Muri, Martin Quaas, Wilfried Rickels, Challenges and Opportunities for Integrated Modeling of Climate Engineering

39.2017, ESP Series, Lucia de Strasser, Calling for Nexus Thinking in Africa's Energy Planning

40.2017, EIA Series, Alice Favero, Robert Mendelsohn and Brent Sohngen, Can the global forest sector survive 11°C warming?

41.2017, EIA Series, Malcolm N. Mistry, Ian Sue Wing, Enrica De Cian, Simulated vs. Empirical Weather Responsiveness of Crop Yields: U.S. Evidence and Implications for the Agricultural Impacts of Climate Change

42.2017, ET Series, Carlo Drago, Interval Based Composite Indicators

43.2017, EIA Series, Emanuele Massetti and Robert Mendelsohn, Do Temperature Thresholds Threaten American Farmland?

44.2017, EIA Series, Shouro Dasgupta, Burden of Climate Change on Malaria Mortality

45.2017, SAS Series, Fabio Moliterni, Sustainability-oriented Business Model Innovation: Context and Drivers

46.2017, MITP Series, Enrica De Cian, Shouro Dasgupta, Andries F. Hof, Mariësse A.E. van Sluisveld, Jonathan Köhler, Benjamin Pfluger, Detlef P. van Vuuren, Actors, Decision-making, and Institutions in Quantitative System Modelling

47.2017, MITP Series, Jacopo Bonan, Pietro Battiston, Jaimie Bleck, Philippe LeMay-Boucher, Stefano Pareglio, Bassirou Sarr, Massimo Tavoni, Social Interaction and Technology Adoption: Experimental Evidence from Improved Cookstoves in Mali

48.2017, EIA Series, Lorenza Campagnolo, Marinella Davide, Can the Paris Deal Boost SDGs Achievement? An Assessment of Climate Mitigation Co-benefits or Side-effects on Poverty and Inequality

49.2017, ET Series, Sebastian Dengler, Reyer Gerlagh, Stefan T. Trautmann, Gijs van de Kuilen, Climate Policy Commitment Devices

50.2017, ET Series, Spiros Bougheas, Contagion in Stable Networks

51.2017, MITP Series, Michael A. Mehling, Gilbert E. Metcalf, Robert N. Stavins, Linking Heterogeneous Climate Policies (Consistent with the Paris Agreement)

52.2017, ET Series, Lucia Rotaris, Ready for a Carbon Tax? An Explorative Analysis of University Students' Preferences

53.2017, ESP Series, Giovanni Marin, Francesco Vona, The Impact of Energy Prices on Employment and Environmental Performance: Evidence from French Manufacturing Establishments

54.2017, MITP Series, Adriano Vinca, Marianna Rottoli, Giacomo Marangoni and Massimo Tavoni, The Role of Carbon Capture and Storage Electricity in Attaining 1.5 and 2°C

55.2017, MITP Series, Soheil Shayegh and Greg P. Casey, To Go or not to Go: Migration Alleviates Climate Damages even for Those Who Stay Behind

56.2017, EIA Series, Natalia Zugravu-Soilita, Trade in Environmental Goods: Empirical Exploration of Direct and Indirect Effects on Pollution by Country's Trade Status

Fondazione Eni Enrico Mattei
Corso Magenta 63, Milano – Italia

Tel. +39 02.520.36934
Fax. +39.02.520.36946

E-mail: letter@feem.it
www.feem.it

FONDAZIONE ENI
ENRICO MATTEI