Trade in environmental goods and sustainable development: What learning from the transition economies' experience?

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Abstract

We investigate the causal effects of trade intensity in environmental goods (EGs) on air and water pollution by treating trade, environmental policy and income as endogenous. After estimating a structural equation model on extensive data for transition economies*, from 1995 to 2003, we cannot univocally support a global and uniform EGs' trade liberalization in a sustainable development perspective. Indeed, our empirical results show that trade intensity in EGs (pooled list) reduces CO_2 emissions mainly through an indirect income effect, but raises BOD emissions, since the income induced effect doesn't offset the direct harmful scale-composition effect. No significant effect is found for SO_2 emissions for the aggregated EGs list. In addition to diverging effects across pollutants, we show that results are sensitive to the EGs' classification. A double profit: environmental and economic, is found only for "*cleaner technologies & products*" in the models explaining GHG emissions. On the contrary, these EGs' trade is found to increase SO_2 and BOD emissions since the indirect income effect does not compensate their detrimental indirect effect on the environmental regulation. As for trade intensity in "*end-of-the-pipe products*", its direct harmful, prevailing scale-composition, effect on pollution is found to be offset by a positive impact on the stringency of the environmental regulation. Trade intensity in "*environmentally preferable products*", having no indirect technique effect, is found to reduce air pollution through negative scale-composition effects. Other interesting findings are discussed for trade intensity, imports and exports of different EGs classifications.

Keywords: trade liberalization; environmental goods; environmental policy; pollution; transition countries.
JEL classification: F13, F14, F18, Q56.

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* We consider in this study the ***transition economies*** from *Central and Eastern Europe (CEE)* and the *Commonwealth of Independent States (CIS)* having emerged from a socialist-type command economy towards a market-based economy during the last decade of the 20th century (see Appendix A).

1. Introduction

At the beginning of the 21th century, one could not clearly validate the double gains, economic and environmental, of the countries' economic openness. Today, this can always be possible for trade in environmental goods (EGs), which can play an important role in the diffusion of ecological technologies. All increase in the availability of environmental goods and services (EGS) through trade openness represents an opportunity for a "win-win-win" relationship between trade, environment and development (Yu, 2007). First, trade should be facilitated through the reduction or elimination of tariff and non-tariff barriers (NTBs). Environmental technologies could thus be acquired on the local markets at lower costs, which should in turn stimulate innovation and further technology transfer. Second, the offered opportunity of obtaining high quality EGs could also directly improve the quality of life for citizens by providing a cleaner environment. Finally, the liberalization of trade in EGs should be beneficial for development by helping countries achieve the necessary tools to address key environmental priorities as part of their development strategies. Hence, taking into account this triple win scenario and thus considering that EGs could play an essential role in sustainable development, the Paragraph 31(iii) of the Doha mandate, agreed by all WTO Members in 2001, calls for a reduction or, as appropriate, elimination of tariffs and non-tariff barriers on environmental goods and services. According to the WTO, the EGs' trade liberalization would benefit to developed countries as well as to developing countries; it would allow simultaneously environmental protection improvement and economic development. On the one hand, polluting firms in the developing countries, mainly EGs importers, should probably increase their pollution abatement efforts because of the reduced prices resulting from import tariffs cut (ICTSD, 2008). Alternatively, this reduction in environmental compliance costs would encourage the local governments to set more ambitious environmental standards. On the other hand, it is expected that EGs exporters would draw benefit from getting new markets because of tariff reductions; that would contribute to economic development through creating more employment and income in eco-industrial activities. However, the debate concerning potential advantages of EGs' trade liberalization lacks a consensus. For instance, since tariffs applied to EGs are lower in the developed countries than in the developing countries, one can suppose that this trade liberalization could *economically* benefit especially to the first country group. A note of Hamwey *et al.* (2003) on the liberalization of the international trade in EGS illustrates well this intuition. The authors affirm that direct commercial profits of EGS' trade liberalization return mainly to the most advanced WTO member countries, which benefit from a better access to EGS markets in the developing countries. Furthermore, the EGs import tariffs can play at least two roles in the EGs non-manufacturing countries or non-competitive producers. First, import tariffs can contribute to welfare improvement since they permit to the importing country to retain a part of international eco-industrial firms' revenues. Secondly, according to the literature on foreign direct investments (FDI) determinants[1], the tariffs can lead to technology transfer via FDI aiming eco-industrial activities. However, empirics suggest that international projects are more likely to be accompanied by technology transfers when tariffs are low

[1] Corden (1974), Svedberg (1979), etc.

in the host countries. For instance, Schmid (2012) shows that a 10% increase in EGs' tariff rate is associated with a 3 percentage point decrease in the likelihood of technology transfer in Clean Development Mechanism project.

A number of studies have highlighted the potential trade gains from liberalization of EGs. For instance, World Bank (2007) estimated that the removal of tariffs for wind, solar, clean coal and efficient lighting technologies in 18 top GHG emitting developing countries would result in trade gains of up to 7% and, if simultaneously accompanied by the removal of non-tariff barriers, it could increase trade by 13%. Similarly, Hufbauer and Kim (2010) suggest that tariff elimination on EGs would increase the world imports of EGs by about $56 billion. Balineau and de Melo (2011) show, though, a lack of significant EGs import response to tariff reduction during the last decade. It should however be noted that the impacts of EGs liberalization vary across products and countries, and depend on the existing tariff levels and the import elasticity of demand. If trade gains from tariff reduction/removal are more or less appraised, to our knowledge, there is no empirical study on both economic and environmental effects of EGs' trade openness. Feess and Muehlheusser (1999, 2002), Copeland (2005), Canton (2007), Greaker and Rosendahl (2006), Nimubona (2012) study the impact of the international trade in EGs on the environmental policy design. For instance, by developing a theoretical framework to investigate the effectiveness EGs' trade liberalisation in a developing country dependent on EGs imports, Nimubona (2012) shows that reduction of trade tariffs on EGs might in fact reduce stringency of pollution taxes, which can result in increased pollution levels. The author suggests that, when an import tariff on EGs cannot sufficiently extract rents generated by stringent environmental regulation for an imperfectly competitive eco-industry, the "*government regulator in an EG-importing country strategically lessens the stringency of environmental regulation to maximize domestic social welfare*". However, none of these studies addresses problems related to the impact of trade in EGs on the sustainable development, considering socio-economic issues in addition to the environmental concerns.

The novelty of this study is that it evaluates the simultaneous impact of trade in EGs on two pillars of the sustainable development: environmental and economic. More specifically, we estimate the impact on pollution of trade intensity in EGs by simultaneously identifying direct and indirect effects. First, we note that an indirect effect may pass through the environmental policy, since governments are known to be sensitive to international issues while establishing their domestic policies. Second, apart from its role as a pillar of the sustainable development, income is worth to be investigated as an indirect channel of EGs' trade impact on pollution because it is supposed to induce together with, and also via, the environmental regulation a technique effect[2] leading to the environmental quality improvement.[3] Hence, another contribution of this study is to highlight some political implications (e.g. in terms

[2] See definition in section 3, page 9.

[3] Income can perform a technique effect on the environmental quality through two channels: first, directly, via consumers' richness and their willingness to pay for environment, reducing thus pollution during consumption processes; and second, indirectly, by means of the environmental policy, i.e., by requiring more environmental protection and thus more severe environmental standards. We should, though, mention that removal of tariff barriers in a EGs *net importing* country can lead to a loss of income and thus to a lower demand for the environmental quality.

of EGS' trade liberalization) as it should permit to see the good (or bad) of EGs' trade intensity by investigating its overall environmental effect, as well as each of the scale-composition or technique direct effects[2], and environmental regulation and income indirect effects.

Although the OECD Member States count for the main part of EGS' market, the fastest growth rates currently occur in the developing and the transition economies (Kennett and Steenblik, 2005). Studying economic and environmental consequences of increasing trade in EGs, and particularly through trade liberalization, becomes of strategic importance for the last country groups, for which empirical studies are still scarce, if not non-existent. In particular, examining transition economies from the Central and Eastern Europe (CEE) and the Commonwealth of Independent States (CIS) should allow to properly identify the effects of trade liberalization, since these countries opened their economies quickly and consistently during the studied period (1995-2003). In addition, with the adhesion of a number of CEE countries (CEECs) to the European Union in 2004 and 2007, trade became increasingly intense on the West part of the European continent at the beginning of the last decade. Consequently, and more precisely, this study seeks to investigate the economic and environmental impacts of EGs' trade openness in the transition economies between 1995 and 2003, by using instrumental variables for trade intensity in EGs[4] in a system of three simultaneous equations, explaining pollution, environmental regulation stringency and per capita income, respectively. We employ a theoretical framework inspired from Grossman (1995) and Antweiler, Copeland and Taylor (2001) for *pollution* equation, the main theoretical assumptions of some recent studies on *environmental policy* design (Fredriksson *et al.,* 2005; Damania, Fredriksson and List, 2003, amongst others), and the endogenous growth literature (see, for example, Mankiw *et al.*, 1992; Frankel and Romer, 1999) for *income* equation.

This paper is structured as follows. After having introduced our research objectives and the literature on trade in EGs, we present in section 2 some definitions of EGs and stylized facts for our country sample. Section 3 specifies the model to be estimated, while section 4 presents the estimation strategy and data. We discuss the basic empirical results, some robustness tests and extended empirical findings in sections 5 and 6. The last section daws some conclusions and policy implications.

2. EGs definition and some stylized facts

The concept of EGs recovers intellectually *all products and all technologies favourable to the environment*. But, the lack of a universally accepted definition of EGs has slowed down agreement on product coverage in the negotiations on EGs. Various suggestions were made concerning criteria of EGs identification. Criterion of final use or prevalent final use can be applied to the selection of equipment used in the environmental activities, such as pollution control and waste management. In theory, there is broad support for this criterion, which distinguishes the 'traditional environmental' goods having the main purpose of addressing or remedying an environmental problem (e.g., carbon

[4] We compute instrumental variables for EGs trade intensity following the methodology proposed by Frankel and Rose (2005), i.e. we predict trade using gravity model estimations.

capture and storage technologies). The lists drawn up by OECD and the member economies of Asia-Pacific Economic Co-operation forum (APEC) have been the references so far, even if other international organizations work on this classification criterion.[5] If EGs were to be limited to the narrow lists of OECD and APEC, only few advanced developing countries would benefit from trade in EGs. The most of developing countries do not have yet well developed markets of such products. Other criteria could be applied to also identify the environmentally preferable products (EPPs). EPPs lists (e.g. UNCTAD list) include products that cause less damage to the environment at one of their life cycle stages, because of the manner they are manufactured, collected, used, destroyed or recovered. Developing countries have in particular suggested that negotiations should not be limited to the industrial products (of interest to developed countries) but should also include agricultural goods (of particular interest to developing countries) since they generally have negative trade balances in traditional environmental goods but considerable export opportunities in EPPs, which often include natural resource-based, raw and processed commodities (UNESCWA, 2007). However, to identify EPPs, one has generally recourse to labelling and certification. Because EPPs lead to differentiate the seemingly similar products, or 'like products', WTO did not considered so far these products in the negotiations on EGs' trade liberalization. Several members, including developing countries, fear that EPPs' liberalization would lead to discrimination against their own products based on other than environmental concerns, e.g. social concerns (de Melo and Vijil, 2014). Finally, criteria of performance were also proposed, such as energy efficiency during the use. However, it can be difficult to apply these last continuous criteria because of the technological progress and innovation.

Several negotiated lists were proposed so far, ranging from the apparently non-debatable 'core list' of 26 products (agreed by Australia, Colombia, Hong Kong, Norway and Singapore in 2011) to the large so-called "WTO list" of 408 products (a combined list including many of the OECD and APEC goods and most of products from "Friends of the Environment list"). Many problems explain current difficulties in defining EGs: e.g. (i) inadequacy of HS descriptors, (ii) products' multiple end-use, (iii) relativism and attribute disclosure, as a same good may be used and disposed of in different ways (e.g. doubt on bio-fuels to save energy, expressed in Steenblik, 2007 and Hufbauer et al. 2009).[6] In addition, Balineau and de Melo (2013) suggest that countries are mostly submitting goods in which they have a revealed comparative advantage and are respectively excluding from their submission list goods with high tariffs (thus revealing a mercantilistic behaviour: i.e., countries do not propose highly protected goods).

In this study, we aim investigating relevant EGs categories for a proper interpretation of empirical results, without restricting the analysis to the shortest list of EGs, neither too broadening our approach by investigating aggregate lists of highly heterogeneous EGs. More specifically, we choose considering explicit types of EGs derived from the quite comprehensible EGs' categorization proposed by UNCTAD (see Appendix C and Hamwey, 2005, for

[5] See Steenblik (2005) for more details about the genesis, description and comparison of OECD and APEC lists, which were compiled in the late 1990s.

[6] See Hamwey (2005), de Melo and Vijil (2014) for more discussion on these issues.

more details), which suggests two broad classes of EGs, further decomposed into 10 homogeneous groups: (1) **Class A EGs** (or traditional EGs; most of them under discussion in WTO negotiations, in particular the content of the OECD and APEC lists), which includes manufactured goods and chemicals used directly in the provision of environmental services; and (2) **Class B EGs** (less supported in the WTO negotiations, in particular the EPPs), which includes industrial and consumer goods not primarily used for environmental purposes but whose production, end-use and/or disposal have positive environmental characteristics relative to similar substitute goods. Could also be considered here the less polluting and energy saving technologies, the facilities of electrical production using renewable energy, and recycled materials (the so-called Class B Clean Technologies).

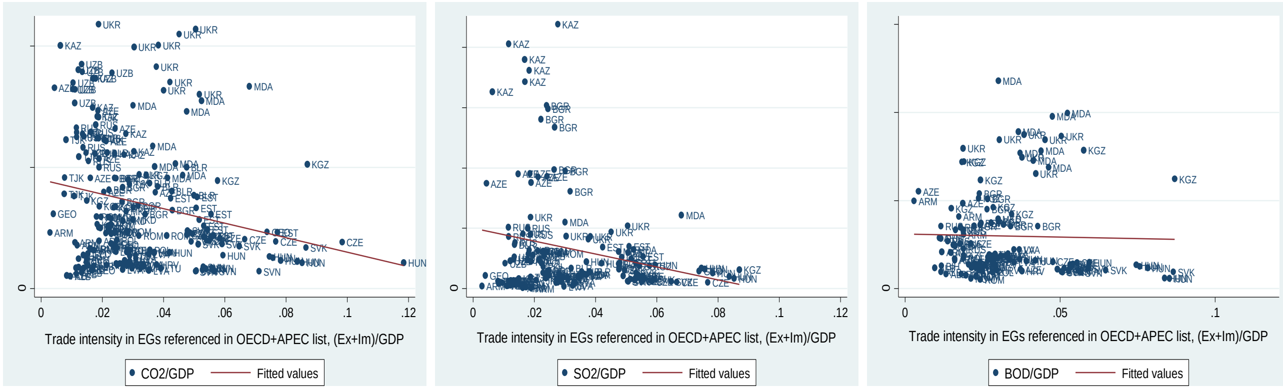
Since the OECD and APEC lists were the most discussed and remain relatively the most commonly accepted lists under the Doha Round negotiations, our core empirical analysis is focused on these EGs. Although we choose to particularly investigate two homogeneous EGs' sub-groups from OECD+APEC list: [*end-of-the-pipe] pollution control products* and [*beginning-of-the-pipe] pollution prevention* / *resource management products*, we also extend our empirical analysis to other EGs sub-categories from the aforementioned UNCTAD classification[7].

To get an idea of the importance of trade in EGs in the transition economies, we provide some stylized facts for trade in EGs, as defined by OECD and APEC. During the studied period 1995-2003, EGs trade in the transition economies was at its beginning stage of development, counting in 2005 for only 3% in their total exports and approximately 6% in their total imports. We note though big differences across the countries. Concerning imports, a rather similar figure (5-6%) characterized the two groups of transition economies: CEECs and CIS. As for EGs exports, the first country group had definitely higher advantages: 4.5% in total exports in 2005, compared to the second group, where EGs counted only for 1.3% in total exports. In 2005, the imports of traditional EGs, as well as of EPPs, were two times higher than the exports of these products. Between 1995 and 2004, the trade intensity ((exports + imports) /GDP) in EGs referenced in OCDE+APEC list increased by 150% in the transition economies (same trend for CEE and CIS countries). As for the EPPs, trade intensity increased by 33% during the same period, with the average annual growth rate of 5% in the case of CEECs and of only 1% in the CIS countries. Most spectacular annual growth rates were registered for trade intensity in Class B clean technologies: 11% for CEECs and 23% for CIS. Trade of these products represented 1.75% in the total exports and 3% in the total imports of transition economies in 2005.

Before engaging a more complex econometric analysis, it is of interest to take a look on the primary data and observe correlations. Figure 1 shows an apparent negative relationship between trade intensity in EGs (OECD+APEC list) and [air] pollution in the transition economies.

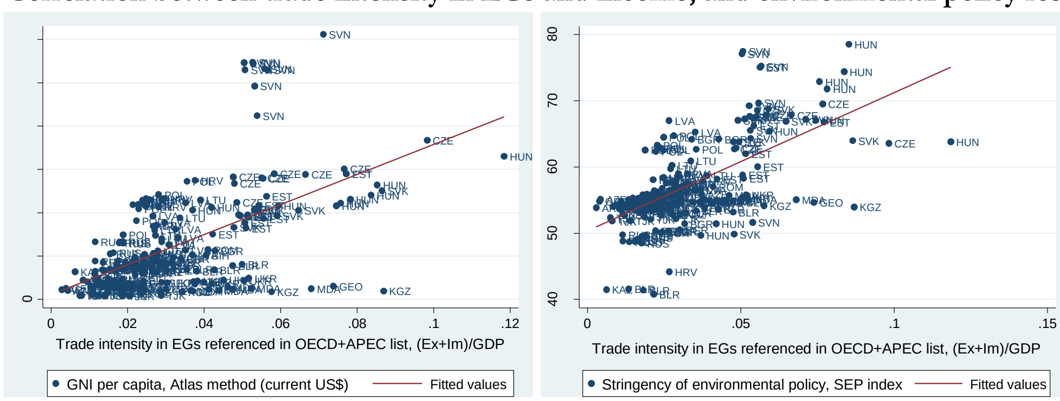
[7] See section 4.1 for more information about the EGs categories considered in the empirical analysis.

Figure 1: Correlation between pollution and trade intensity in EGs



We can also observe in Figure 2 a positive correlation between EGs' trade openness and economic development, as well as between EGs' trade openness and severity of the environmental policy (SEP index[8]).

Figure 2 Correlation between trade intensity in EGs and income, and environmental policy respectively



Following the above figures, we would be willing to support the EGs' trade liberalization in a sustainable development perspective. We should however mention that the observed correlations could be due to endogeneity issues, rather than causality. It's largely proven, through Environmental Kuznets Curve, that income growth has a positive impact on the environmental quality. At the same time, increasing income and democracy stimulate trade. The endogeneity of trade is a familiar problem in the empirical literature on whether openness promotes growth. Harrison (1995) concludes that "existing literature is still unresolved on the issue of causality". Other causality may be identified while analysing the environmental regulation, which imposes firms to use performing technologies and environment management products, usually imported by transition economies from developed countries. Thus, stringency of environmental regulation may raise EGs trade intensity and environmental quality simultaneously. Consequently, aiming to answer the question on the need for liberalizing EGs' trade in the transition economies in order to meet sustainable development goals, we think important to develop a structural equation model investigating indirect effects by controlling for endogeneity issues. As regards the later, we pay particular attention

[8] See definition in section 4.1.

to the endogeneity of trade variables, which are instrumented in our empirical analysis.

3. Theoretical assumptions and econometric specifications

In this section, we examine the direct and indirect determinants of pollution.

Pollution specification

Following the decomposition proposed by Grossman (1995), total emissions of a country can be expressed as:

$$E_{it} = Y_{it}\sum_{j=1}^{n} e_{ijt}\gamma_{ijt} \quad (1)$$

where E are total emissions; i represents countries, t – years and $j = 1, 2, ..., n$ are the various economy sectors. Y_{it} is the total GDP (scale of the economy) of country i in year t, it can also be presented by the sum of the n sectors' added-values, i.e., $Y_{it} = \sum_{j=1}^{n} Y_{ijt}$ · $\gamma_{ijt} = Y_{ijt} / Y_{it}$ represents the ratio of the sector's j added-value in the total GDP of country i in year t. We consider parameter e_{ijt} to be the '*effective'* emission intensity (or net emissions), i.e., the average quantity of pollution actually emitted in the atmosphere/water for each unit of added-value in the j sectors of country i in year t. According to this equation, total annual emissions of a country can be regarded as the product of the economy's total added-value (Y_{it}) and the average sectorial pollution intensity, weighted by the ratio of each sector's added-value in the total GDP ($\sum_{j=1}^{n} e_{ijt}\gamma_{ijt}$).

Total differentiating and dividing all Equation's (1) terms by E, we can rewrite it as follows:

$$\hat{E}_i = \hat{Y}_i + \sum_{j}^{n} \hat{\gamma}_{ij} + \sum_{j}^{n} \hat{e}_{ij} \quad (2)$$

This decomposition defines the famous three pollution determinants. $\hat{Y}$ indicates the *scale effect*, supposed to be a growth factor of pollution. Everything else equal, any production increase means quasi-proportional increase in pollution. The *composition effect* is represented by $\hat{\gamma}$. Dynamic changes in $\hat{\gamma}$ represent the impact on pollution of any change in the economic activities' structure. The third term represents the *technique effect*. The use of clean technologies, more efficient production techniques and abatement efforts can lead to a pollution reduction for the same level of economic growth and industrial structure.

Furthermore, we consider the average "*net"* emission intensity of polluting sectors of country i in year t is given by the following additively separable function: $e_{it} = \theta_{it} - g(a_{it})$, where θ is the average "*gross"* emission intensity of polluting activities depending on the technology used (i.e., when no "end-of-the-pipe" pollution abatement occurs, but it could result from "cleaner production" or "beginning-of-the-pipe" technique), and a is the total demand for products used in the "end-of-the-pipe" pollution abatement process.[9]

The third term of Equation (2) is the most complex one, needing more discussion:

- First, the term $\hat{e}_1$ is supposed here to be function of EGs' trade intensity, in particular of trade in

[9] With $0 \le g(a) \le \theta$; $g'(a) > 0$, that is abatement effort reduces pollution, and $g''(a) < 0$, meaning decreasing returns to abatement.

"beginning-of-the-pipe" or *cleaner technologies & products* (CTP) affecting the parameter θ (pollution prevention), and of trade in *end-of-the-pipe products* (EOP) influencing the parameter *a* (pollution abatement). Indeed, trade openness is supposed to reduce the local price of EGs, mainly imported in the transition economies, and to induce thus an increased demand for these goods, characterized by a negative own price elasticity. Thus, at the same levels of production and environmental regulation, any reduction in import tariffs would increase demand for imported EGs. Since abatement and cleaner technologies become less expensive and more available, one can anticipate a pollution reduction. Therefore, *trade intensity in EGs* (CTP and EOP) is assumed to perform a direct negative (technique) effect on pollution, as long as it doesn't affect economic structure or production levels. Otherwise, since traditional EGs' production is generally pollution-intensive or as a result of a "rebound effect" – i.e., at the same level of environmental regulation, and in spite of the marginal abatement cost reduction due to EGs trade liberalization, one can be incited to produce more by keeping the same total initial level of abatement costs, raising thus total pollution –, EGs trade openness performs also a direct positive scale-composition effect on pollution. The sign of *trade intensity in EGs* variables should indicate us the dominant direct effect on pollution: either technique (if negative) or scale-composition (if positive).

- Second, we assume the technique effect $\hat{e}_1$ to be also function of the *environmental policy stringency*, τ, since regulation acts directly on firms' production technology used (θ) and pollution abatement efforts (*a*).
- Third, considering in this study total polluting emissions in a country, consumer behaviour in respect to environment should also be taken into account since environmental regulation cannot systematically affect the abatement efforts and technology used in the consumption processes, such as household heating, transport, etc. Households are not usually asked to make capital investments for controlling pollution; they are rather asked to alter their behaviour. Hence, consumer *willingness to pay to reduce pollution* – i.e., how much is the consumer willing to pay for a particular level of an environmental good? – is an important measure here, generating a technique effect together with *environmental regulation* and *trade intensity in EGs*. Moreover, when formal regulation is weak or perceived to be insufficient, communities strongly concerned by environmental quality may informally regulate firms indirectly or directly through bargaining, petitioning and lobbying.

Consequently, how much abatement is undertaken, i.e. g(a), depends on abatement costs, efficiency of environmental regulation and willingness-to-pay for abatement. The same assumption is made for the demand for cleaner production technologies (influencing parameter θ): i.e., moving to cleaner technologies and products depends on their costs, environmental regulation and willingness-to-pay for environmental quality.

Finally, a number of works, like: Lucas, Wheeler and Hettige (1992), Harbaugh, Levinson and Wilson (2002), Dean (2002), Copeland and Taylor (2001, 2004), Antweiler, Copeland and Taylor (2001), Frankel and Rose (2005) show that scale, composition and technique effects are endogenous and often determined by country's overall trade openness. The later can have a direct impact on the environmental quality, in the sense that tariff reduction increases trade intensity and thus influences economic growth (first term in Equation (2)), or simply shifts production from pollution intensive goods to more ecological ones, or vice-versa (second term in the same equation). Finally, trade openness can have a direct impact on the technologies used and abatement efforts. Dean (2002), for example, using pooled provincial data on Chinese water pollution, studies the relationship between international trade and industrial pollution. Its simultaneous-equations system estimation suggests that international trade increases pollution through the effect of pollution havens, but it also contributes to China's economic growth, which reduces in its turn pollution since a higher income reinforces the public demand for a better environmental quality. Thus, trade openness is an economic determinant of pollution to be considered together with all variables representing the scale, composition and technique effects.

Following the above discussed assumptions, we can write the specification explaining total pollution in a country:

$$E_{it} = e(Y_{it},\ \gamma_{it},\ \theta_{it},\ a_{it},\ Open_{\ it}) \tag{3}$$

with: $\gamma_{it} = f(K_{it}/L_{it}),\ \theta_{it} = f(CTP_{it}, \tau_{it}, R_{it}),\ a_{it} = f(EOP_{it}, \tau_{it}, R_{it})$

where: *Y* is the scale of economy (total GDP); $\gamma = f\left(K / L\right)$ - the composition effect supposed to be function of capital (*K*, stock of capital) to labour (*L*, active population) relative endowments (Antweiler, Copeland and Taylor, 2001, solve for the share of polluting production in total output as a function of the capital-to-labour ratio); *CTP* – trade intensity in "beginning-of-the-pipe" or cleaner technologies and products; *EOP* – trade intensity in "end-of-the-pipe" EGs; τ is the stringency of the environmental regulation; *R* – per capita income supposed to capture the willingness-to-pay for environmental goods, since it is commonly assumed that environmental quality is a normal good; *Open* – instrumented variable of overall trade openness.

Everything else equal, we expect positive coefficients for the scale and composition effects, and negative coefficients for variables capturing the technique effect. The coefficients of our trade intensity variables are supposed to represent the prevailing direct impact on emissions (the counterbalance between a positive scale - composition effect and a negative technique effect).

Environmental Regulation and Economic Development specifications

Besides a direct impact on pollution, we also suppose that trade intensity in EGs can affect the severity of the environmental regulation and the economic development (per capita income). Besides controlling for endogeneity, estimating a structural equation model (also called simultaneous equations model) would allow us identifying indirect channels of influence of trade intensity in EGs on the environmental quality.

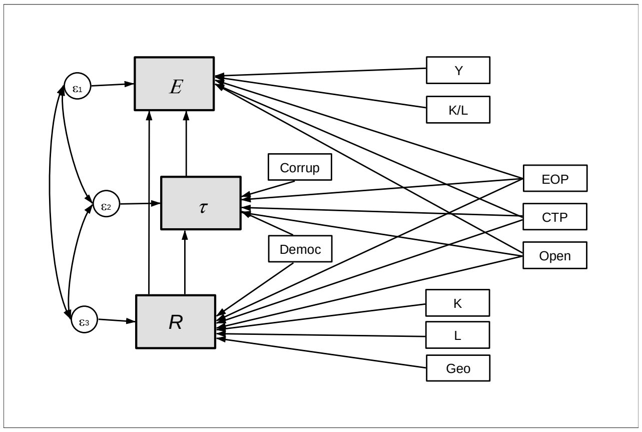
First, we derive ***Environmental Regulation*** specification from recent studies on environmental policy design. Both theoretical and empirical studies have shown that *trade*, *democracy* and *corruption* have substantial influence on environmental policy. Damania, Fredriksson and List (2003) develop a theoretical model producing several testable predictions: i) *trade liberalization* raises the stringency of environmental policy; ii) *corruption* reduces environmental policy stringency; and iii) the effect of trade liberalization (corruption) on environmental policy is conditional on the level of corruption (trade openness). All these predictions are validated empirically using data from a mix of 30 developed and developing countries from 1982-1992. Trade may directly influence stringency of the environmental regulation via "race to the bottom" (negative effect) or "race to the top" (positive effect) phenomena that are said to occur when competition between nations or states (over investment capital, for example) leads to the progressive dismantling or, respectively, increase of regulatory standards. Based on predictions generated by a lobby group model and empirical findings, Fredriksson *et al.* (2005) suggest that environmental *lobby* groups tend to positively affect the stringency of environmental policy. Moreover, political competition tends to raise policy stringency, in particular where citizens' participation in the democratic process is widespread. Pellegrini and Gerlagh (2006) find that corruption stands out as an important determinant of environmental policies, while democracy has a very limited impact. Zugravu, Millock and Duchene (2008), using a common agency model of government for environmental policy creation, find empirically that stringency of environmental regulation depends on the *consumers' preferences for environmental quality*, represented by per capita revenues. Indeed, higher revenues induce more preferences for better environmental quality on behalf of the population and thus more stringent environmental regulation. Finally, some works highlight endogeneity of environmental policy design in respect to EGs supply. Greaker and Rosendahl (2006) conclude that an especially stringent environmental regulation may be well founded, as it increases the competition between technology suppliers, and lead to lower domestic abatement costs. Consequently, if *liberalization of EGs* takes place, this phenomenon may amplify. Thus, import tariffs' cut-off would induce the government to raise its environmental standards, anticipating firms' ability to comply easier with them as EGs become more available. However, as stated in Greaker and Rosendahl (2006), "an especially stringent environmental policy is not a particularly good industrial policy with respect to developing successful new export sectors based on abatement technology". Moreover, theory suggests that (1) strict environmental standards weaken a country's competitive position in pollution-intensive industries and (2) enforcement cause firms active in the pollution intensive industry to relocate their activities to less regulated countries. Hence, depending on the competitiveness of local industries, *trade intensity in EGs* (*EOP* and *CTP*, respectively) can have an ambiguous effect on the environmental regulation stringency.

We can thus write the following specification for the stringency of the environmental policy:

$$\tau_{it} = z(R_{it}, Democ_{it}, Corrup_{it}, Open_{it}, EOP_{it}, CTP_{it}) \tag{4}$$

with *Democ* for democracy and *Corrup* for corruption level, the other variables being specified in Equation (3).

Next, we specify ***Income function*** following the endogenous growth literature. As Rodrik, Subramanian and Trebbi (2004) point out, labour, physical and human capital, while affecting economic development, are in turn determined by deeper and more fundamental factors which fall into three broad categories: geography, institutions and trade (see Acemoglu *et al.*, 2001; Frankel and Romer, 1999; Sachs, 2003; among others). Easterly and Levine (2003) provide a good overview of how each of these three determinants has been treated in the literature with the aim of explaining the vast differences in growth and levels of income amongst countries. The quality of institutions is widely considered one of the most important source of economic growth and development, while geography acting indirectly, through the channel of institutions. However, a recent study (Hibbs and Olsson, 2004) demonstrates the importance of the biogeographic initial conditions 12,000 years ago - which allowed for the transition from hunting-gathering to agriculture - as a nearly ultimate source of contemporary prosperity. Even if institutional conditions are considered, biogeography and geography remain significant explanatory variables for the differences in the level of economic development across the world. Gallup, Sachs and Mellinger (1999) state that geography plays a fundamental role in economic productivity through four main channels (direct and indirect): human health, agricultural productivity, physical location, and proximity and ownership of natural resources. Regarding the relative importance of the three deep determinants, Rodrik, Subramanian and Trebbi (2004) report that institutions matter most for economic development once the endogeneity of intuitions and trade has been properly accounted for, leaving a negligible role for geography and trade. Sachs (2003), on the other hand, finds that geographical factors are the most important deep determinants of income and output, while Frankel and Romer (1999) underscore the importance of international trade. The authors suggest that trade has a quantitatively large and robust significant, positive effect on income. However, while considering here transition economies, the impact of trade liberalization on development may be different according to some adjustment costs. The most serious adjustment costs associated with trade liberalization and the transition process from centralized to market economies are social costs reflected in different indicators of poverty or measured by the level of unemployment. Recent experience of CEEC/CIS countries also confirms the importance of better public and private governance and a favourable business climate for reducing poverty. Trade liberalization is often made responsible for the deterioration in the trade balance of these countries and fiscal problems stemming from the contraction of foreign trade related taxes in budget revenues. Income specification may be written as follows:



$$R_{it} = \varphi(K_{it}, L_{it}, Geo_i, Inst_{it}, Open_{it}, EOP_{it}, CTP_{it}) \quad (5)$$

where *Geo* represents geography/settlement characteristics; *Inst* - institutional quality represented here by civil liberties and political rights, namely *Democ* variable.

In order to estimate our structural equation model, we build the following system of three simultaneous equations: the first one identifying the *direct effect* on pollution of trade intensity in EGs, while the last two ones capturing the *indirect effects* of trade intensity in EGs, passing through environmental regulation and income, respectively.

$$
\begin{cases}
E_{it} = e(Y_{it}, K_{it} / L_{it}, \tau_{it}, R_{it}, EOP_{it}, CTP_{it}, Open_{it}) \\
\tau_{it} = z(R_{it}, Democ_{it}, Corrup_{it}, EOP_{it}, CTP_{it}, Open_{it}) \\
R_{it} = \varphi(K_{it}, L_{it}, Democ_{it}, Geo_{i}, EOP_{it}, CTP_{it}, Open_{it})
\end{cases}
\qquad (6)
$$

We distinguish three endogenous variables in our System: E, τ and R, and nine explanatory variables (Y, K, L, *Democ*, *Corrup*, *Geo*, *Open*, *EOP*, and *CTP*) – the system is thus over identified and may be estimated. However, it is often argued that the correlation between trade and income makes it difficult to identify the causality direction between the two. Similarly, double causality may be revealed between trade and environmental regulation, as mentioned in the previous section. Consequently, trade should also be considered endogenous and thus instrumented, by controlling for all variables in the system affecting it, in order to assess its proper effects. We follow the methodology proposed by Frankel and Rose (2005) to instrument trade by predicting bilateral "natural" flows in a gravity equation, which is one of the most used tools for such purpose for at least the following reasons: very good empirical explanation of trade flows; a theoretical base well understood (monopolistic competition model with transport costs or HO model with trade costs); a crucial role given to the geography, which took all its place in the international economics.

4. Empirical strategy

4.1. Data

In our empirical study, we make use of both country-specific and bilateral data from various sources (see the Appendix B for definitions and sources of all variables).[10] Besides trade variables, which are instrumented in our study, we have three endogenous variables in our structural equation model:

- *Pollution* (CO_2, SO_2, and BOD in order to encompass at least two dimensions: air and water pollution, as EGs may have multiple uses and impacts on the overall environmental quality). Data on total CO_2 emissions comes from IEA and cover 24 CEE/CIS countries from 1995 to 2003, while data on SO_2 emissions is available for 22 countries for 1995-2002 period (with some missing points for 2001 and 2002 years).[11] The data source of

[10] Gross domestic product for exporting and importing countries in trade variables' instrumentation are examples of country-specific variables that we include in the analysis. Geographical distance, adjacency, and main language, amongst others, are examples of other characteristics that we take into account for each pair of countries in the gravity model.

[11] See the list of countries in Appendix A.

SO_2 variable is an exhaustive data set of worldwide emissions of sulphur dioxide, carefully constructed by Stern (2006) from his own econometric estimates. SO_2 (anthropogenic) emissions have characteristics that make them suitable to study the effects of trade on the environment: a by-product of goods production; strong local effects; regulation across many countries; and available abatement technologies. Note that the focus of the paper is on positive analysis, i.e., we are interested in linking pollution to potentially traded production. That is why we use data on emissions rather than on concentration, even though the latter would be more appropriate to address welfare issues. As for organic water pollution (BOD in kg per day), we use data from the World Bank, which covers in our study 18 countries for 1995-2003 years, with some year/country missing points. Finally, we consider total greenhouse gas (GHG) emissions for comparison, but since this data is available only for 2 years (1995 and 2000) in the time period considered (1995-2003), we analyse this pollutant only in the first part of our empirical work. Data on GHG comes from *Climate Analysis Indicators Tool*, World Resources Institute.

- *Stringency of environmental policy* (SEP) – our proxy for environmental regulation –, is one of the most difficult variables to measure since comparable data do not exist for all countries in the world and over time. We use in this study the *SEP* index constructed by Zugravu, Millock and Duchene (2008). This index comprises at the same time variables of environmental policy and of industries' and the population's capacity to organize in lobbies (nongovernmental organizations, etc.) in order to put pressure on government's behaviour towards a more environmentally-friendly direction. *SEP* index is computed following the technique of Z-score applied to five indicators: number of signed multilateral environmental agreements (MEAs), existence of a regulation on air pollution, density of international nongovernmental organizations (INGOs), number of ISO 14001 certified companies, and adhesion to the Responsible Care® Program. Aware of potential limits of this measure, we perform robustness tests by employing an alternative proxy for the stringency of environmental regulations (*SER* index) computed using, besides INGOs, MEAs and ISO 14001, an output indicator – GDP per unit of energy used, climate netted out – which is a real measure of the impact of the former component variables in the aggregated index. This should allow distinguishing countries that apply effective environmental measures from the ones adopting a "theoretical" environmental policy, with no compliance assurance efforts.
- *Income/Economic development* is represented in our study by per capita Gross National Income (*GNI/cap*), data coming from WDI (World Bank). We follow the strategy of Antweiler, Copeland and Taylor (2001), which consists in considering the difference between *GDP* (measuring the intensity of the economic activity in a given country) and *GNI/cap* (capturing here the richness of country's habitants, and namely their willingness-to-pay for environmental goods). Hence, we do not use GDP per capita for this indicator in order to make distinction between the scale of economy (*GDP*) and income (*GNI*), which enter simultaneously our pollution equation.

As explanatory variables in our structural equation model, we list: GDP, relative factor endowments, geographic and institutional factors, instrumented variables for overall trade openness and EGs trade intensity[12]. We use the variable *Lat* (latitude) as a proxy for geographic factors. Latitude gives the location of a place on Earth north or south of the equator and it is one of the most important factors determining location's climate. The institutional factors are represented by two variables: *Corrup* and *Democ*, which mean corruption level and democracy, respectively. The first variable comes from the database constructed by Kaufmann *et al.* (2005), namely, it is the opposite of the *Corruption Control* index.[13] Kaufmann *et al.* (2005) indicators are highly positively correlated. For that reason, we use a different data source for our democracy variable, which is represented in our study by the *Freedom House democracy* index. *Freedom in the World* published by Freedom House ranks countries by political rights and civil liberties that are derived in large measure from the Universal Declaration of Human Rights.[14] In our study, we use a variable *Democ* computed by taking the inverse of the mean of political rights and civil liberties indicators. Thus, higher values of *Democ* correspond to higher democracy levels.

Finally, trade openness is proxied in our study by trade intensity, and namely (Exports+Imports)/GDP, and is instrumented using a gravity equation. Bilateral trade values come from UN COMTRADE database, the World trade database reporting flows at a high level of product disaggregation. We combine this database with the EGs' classification lists[15] specified at HS 6 digit level, and obtain a new dataset for trade in EGs. Hence, we have several EGs trade variables:

- *Trade_EGs* and *TradeInt_EGs*: trade flows (*Trade*) and trade intensity (*TradeInt*) in EGs (pooled lists);
- *TradeA_OA* and *TradeIntA_OA*: trade flows and trade intensity in Class A EGs, OECD + APEC (OA) list. **OA list** covers three groups: A) pollution management (mainly end-of-the-pipe products), B) cleaner technologies and products, and C) resources management group. Combining the two last groups in a same EGs category of goods designed to prevent environmental degradation, we obtain the following sub-groups of EGs referenced in OA list:
    - *TradeA_EOP* and *TradeIntA_EOP*: trade flows and trade intensity in end-of-the-pipe products from OA list, making distinction between air and water pollution (although these variables have the same name in our regressions, they involve different products while explaining air or water pollution);
    - *TradeA_CTP* and *TradeIntA_CTP*: trade flows and trade intensity in products preventing environmental degradation, here called cleaner technologies & products from OA list;

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[12] See Appendix B for data definition and sources.

[13] This index measures the extent to which governments fight corruption and it takes values ranging between -2.5 and +2.5, the maximum values signifying less corruption. The change of sign that we do thus yields an indicator that varies directly with the degree of corruption of the country.

[14] Countries are assessed as free, partly free, or unfree. The political rights and civil liberties categories contain numerical ratings between 1 and 7 for each country or territory, with 1 representing the most free and 7 the least free.

[15] See Appendix C for definitions.

- *TradeA_OtherEGs* and *TradeIntA_ OtherEGs*: trade flows and trade intensity in Other type Class A EGs not included in OA list;
- *TradeB_CT* and *TradeIntB_CT*: trade flows and trade intensity in Clean Technologies, Class B EGs;
- *TradeB_EPP* and *TradeIntB_EPP*: trade flows and trade intensity in Environmentally Preferable Products, Class B EGs.

  There are other class B EGs, very particular classifications reported in the Appendix C, which are not considered in this study. We focus here on the most discussed EGs categories.

4.2. Estimation technique

Before estimating our structural equation model, we test exogeneity of our explanatory variables. The Durbin-Wu-Hausman test reports endogeneity for *GNI/cap*, *SEP*, *trade intensity in EGs* and *GDP*. As the same test shows that one year lagged GDP is exogenous for this model, we use in our estimations the variable GDP_{t-1}. As *GNI/cap* and *SEP* are endogenous in our theoretical specifications (being thus estimated through separate equations), we need only to instrument trade flows. For this purpose, we run panel fixed-effects gravity equations in order to get valid instruments for our trade variables.[16]

Our system of three simultaneous equations is estimated by using a three-stage least squares (3SLS) procedure[17]. To do that, we need to check for correctness of the specification and for the internal consistency of the entire system. Hence, we run Hausman Test for Misspecification, which does not reject the null hypothesis of no systematic difference between the 3SLS and the 2SLS estimates, meaning that 3SLS estimators are consistent and efficient.[18] Moreover, the underidentification test (Anderson LM statistic: 19.481, with Chi-sq(3) P-val=0.0002) indicates that the matrix is full column rank, i.e., the model is identified, whereas the Sargan-Hansen test of overidentifying restrictions (Chi-sq(2) P-val =0.5014) does not allow us to reject the null hypothesis of instruments' validity, i.e., the instruments are uncorrelated with the error term and the excluded instruments are correctly excluded from the estimated equation.

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[16] Using the estimated coefficients, we obtain the fitted values of bilateral trade. We then take the exponent of the fitted values and finally sum across bilateral trading partners. By this means, we obtain instrumental variables for different EGs classifications' trade flows, which appear to be exogenous in our structural equation model, as also reported by the Durbin-Wu-Hausman test. Moreover, the statistic (chi2=6.51; Prob>chi2 = 0.1642) of the Hausman specification test does not allow us to reject its null hypothesis, indicating that model with instrumented trade openness variable performs better than with its real value, i.e. in the first case coefficients are consistent and efficient.

[17] Three stages are necessary to get 3SLS coefficients: we first regress the right-hand side endogenous variables on all exogenous variables from the model; next, we regress the endogenous variables on the fitted values from the first stage and the exogenous variables of the model; and finally, we apply Feasible Generalized Least Squares to get structural parameters.

[18] Under the null hypothesis of no misspecification, the 3SLS results are efficient and consistent, whereas the 2SLS coefficients are consistent but not efficient. We should note that, if any equation from the structural model is misspecified, only this single equation is affected while estimating with the 2SLS technique; on the contrary, any single misspecification is transmitted to all equations under 3SLS estimation, due to using an inconsistently estimated covariance matrix in the third stage.

For our panel data we need to conduct panel 3SLS. A way of doing this is using country dummies in each equation of our system in order to capture the unobserved country-specific effects. But fixed effects/country-dummies models have some weaknesses. Too many dummy variables can significantly reduce the degrees of freedom needed for powerful statistical tests. In addition, a model with too many dummies may suffer from multicollinearity, which increases the standard errors. Consequently, the panel was resolved in this study by using Stata's command `*xtdata*', which transforms data set of all the variables: `*xtdata, fe*' for fixed effects (within) estimation (for each cross-sectional unit, the average over time is subtracted from the data in each time period - time-demeaned data) and `*xtdata, re*' for random effects, allowing for simultaneously explaining changes over time and among units. We opt here for random effects estimation for four reasons. First, descriptive statistics for our core variables (in particular, trade intensity in EGs) indicate clearly that standard deviation *between* is higher than *within*. Second, some variables of interest for this study are mostly time-invariant or fluctuate moderately, like institutional variables for example. Third, for each specification, we run a Breusch Pagan Lagrange-multiplier test. In all our specifications random-effects are significant. Finally, the random effects assumption is that the individual specific effects are uncorrelated with the independent variables. The fixed effect assumption is that the individual specific effect is correlated with the independent variables. If the random effects' assumption holds, the random effects model is more efficient than the fixed effects model. In our regressions, the residuals are supposed to be orthogonal to the predetermined variables, since the model is estimated through 3SLS, which corrects estimators for endogeneity and cross-equation error correlations. Consequently, random effects estimations are assumed to perform better.

5. Empirical results

Empirical results from the estimation of the structural equation models for CO_2 emissions (model 1), SO_2 (model 2), BOD (model 3) and total GHG emissions (model 4) are reported in Table 1. In these models we first investigate trade in EGs classified following OECD and APEC lists.

In our regressions, *SEP* represents the technique effect engendered by the environmental regulation, which is estimated separately from a technique effect induced by the consumers' willingness-to-pay for environmental quality, *GNI/cap*. As for the composition effect, it is estimated in a flexible way, by authorizing its sign and size to be dependent on the relative capital endowments. Our empirical results confirm the theoretical assumptions: *GDP* (models 1 to 4) and, in a lesser extent, physical capital endowments (model 4) tend to increase pollution, while *SEP* (all models) and per capita income (except for SO_2 emissions) reduce it.

Table 1 Impact on pollution of trade intensity in EGs (OA list)

	(1)	(2)	(3)	(4)
Pollution	ln*CO2*	ln*SO2*	ln*BOD*	ln*GHG*
ln*GDP_1*	1.3085***	1.4177***	0.8465***	1.3117***
ln*K/L*	0.0845	-0.2390	-0.1389*	0.3461**
ln*GNI/cap*	-0.5593***	0.0672	-0.4619***	-1.0327***
ln*SEP*	-4.6132***	-5.0351***	-1.8951***	-6.2267***
ln*TradeIntA_EOP*	0.1173**	-0.2277*	0.1026*	0.3034**

ln*TradeIntA_CTP*	-0.1208**	0.0394	-0.0358	-0.2194**
ln*Open*	0.3472***	0.6151***	0.1451	0.2628
ln*SEP*				
ln*GNI/cap*	0.0604***	-0.0017	0.0652**	0.0030
ln*Democ*	-0.0125	-0.0078	0.0337	0.0095
ln*Corrup*	-0.0478	-0.1320**	-0.1153	-0.0298
ln*TradeIntA_EOP*	0.0336***	0.0437***	0.0207	0.0492**
ln*TradeIntA_CTP*	-0.0225**	-0.0207*	-0.0273*	-0.0232
ln*Open*	0.0189	0.0061	0.0295	-0.0174
constant	3.2909***	3.8435***	3.7715***	3.4565***
ln*GNI/cap*				
ln*K*	0.5754***	0.5651***	0.5633***	0.6483***
ln*L*	-0.6453***	-0.5825***	-0.6951***	-0.7079***
ln*Democ*	0.0731	0.0668	-0.0525	0.0844
ln*Lat*	0.5524**	0.9060***	0.7999**	0.5600
ln*TradeIntA_EOP*	-0.0140	0.0285	0.0414	-0.0097
ln*TradeIntA_CTP*	0.0858***	0.0512*	0.0638**	0.0692
ln*Open*	-0.0599	-0.0698	-0.1227**	-0.0628
constant	1.1472	-1.2546	0.8363	0.6682
N. of obs.	216	148	128	48

* p<0.1, ** p<0.05, *** p<0.01

Trade openness in general appears to increase CO_2 and SO_2 emissions. Regarding trade intensity in *end-of-the-pipe EGs*, it is found to increase CO_2, BOD and total GHG emissions and to decrease SO_2 emissions. Abatement processes thus seem to be most efficient in the SO_2 polluting activities in the transition economies, since the direct technique effect of trade in end-of-the-pipe products dominates over its scale-composition effect for this pollutant. As for trade in *cleaner technologies & products*, we find a direct negative and statistically significant effect on GHG emissions, and namely on CO_2 (models 1 and 4). We don't find any direct impact of trade intensity in this kind of EGs on SO_2 and BOD emissions (models 2 and 3). To conclude in terms of climate change issues, we would qualify trade in *end-of-the-pipe EGs* to be harmful for the environment (a beneficial role is however found for SO_2 reduction). On the opposite, trade in *cleaner technologies & products* appears to contribute to climate change mitigation. Nonetheless, this conclusion would be very partial without considering the indirect effects.

The estimation results for ***Environmental policy equation*** show a positive effect of *GNI/cap* in our CO_2 and BOD models. Corruption is found to reduce stringency of the environmental policy in the SO_2 model. With regard to trade openness (*Open*), we don't find any support for "race to the bottom" or "race to the top" phenomena. As expected, trade intensity in *end-of-the-pipe products* raises environmental regulation's stringency (models 1, 2 and 3). Increased availability of end-of-the-pipe abatement technologies and products allows governments to set more rigorous environmental standards, since compliance becomes effortless. On the contrary, we find a negative impact of trade intensity in *cleaner technologies & products* on the severity of the environmental policy (models 1 to 3). We can suppose, based on Greaker and Rosendahl (2006) findings, that stringent environmental regulation was not the optimal strategy for transition economies seeking to promote this new industry (they were mostly net importers of such products during the investigated time period), taking also into account that cleaner technologies and products' production is generally pollution intensive and severe environmental policy may hurts their international competitiveness. This last finding gives some support to the "race to the bottom" hypothesis while considering trade in cleaner technologies and products; similar finding is also found by Nimubona (2012) in a theoretical model for EGs-import dependent countries facing imperfectly competitive foreign eco-industries.

Income equation's estimates confirm the predictions of the endogenous growth literature. We find that relative capital abundance and distance from equator raise per capita income. These results are robust (similar results for models explaining pollutants of different nature) and highly significant. As regards the trade intensity in EGs, we find that only trade intensity in *cleaner technologies & products* has a positive statistically significant impact on income in our CO_2, SO_2 and BOD models. Finally, trade openness has no impact on income in air pollution models, but appears to reduce GNI/cap in the model explaining BOD emissions. Large trade deficit and related high unemployment rates in CEECs/CIS could partially explain this finding. Hence, our results are in some contradiction with theoretical assumptions, i.e., trade raises income (see Frankel and Romer, 1999). However, Rigobon and Rodrik (2004) suggest that the Frankel and Romer (1999) finding is not robust to the inclusion of institutional quality. The authors conclude that "openness (trade/GDP) has a negative impact on income levels after we control for geography and institutions". We thus confirm this finding, after having controlled for geography (distance from equator) and institutions (civil liberties and political rights).

To summarize the findings explored in Table 1 and draw some conclusions, we compute the overall impact on pollution of trade intensity in EGs (Table 2 below), in order to see if its indirect effects, via *SEP* and *GNI/cap*, amplify, reduce or even offset its direct impact on pollution (prevailing scale-composition or technique effect).

Table 2 Overall environmental impact of trade intensity in EGs, as defined by OECD&APEC

	CO_2	SO_2	BOD	GHG
trade intensity in class A (O+A) end-of-the-pipe products	-	-	+	-
trade intensity in class A (O+A) cleaner technologies & products	-	+	+	-

- For ***trade intensity in end-of-the-pipe products***, we find that the direct positive (prevailing scale-composition) effect on CO_2, and GHG emissions in general, is offset by the indirect negative technique effect via *SEP*, generating thus a negative net impact on these pollutants (see Table 2). In other words, if trade in end-of-the-pipe EGs appears to reduce the country's total GHG emissions, it is not because of its direct, final use, technique effect but due to an induced technique effect on the overall economic activity through the environmental regulation's upgrading. The same net impact is found for SO_2 emissions, with the difference that the negative indirect effect via *SEP* comes to amplify their direct technique effect, found to prevail over the scale-composition effect. As for BOD emissions, besides its positive, prevailing direct scale-composition effect, trade intensity in end-of-the-pipe products doesn't perform any indirect technique effect on this kind of emissions, resulting thus in a harmful overall impact on water pollution. No impact on income is found for trade intensity in these products. In conclusion, *trade intensity in end-of-the-pipe products was found to increase pollution in the transition economies via a direct positive, prevailing scale-composition, effect* (CO_2, BOD and GHG models). Fortunately, this harmful effect *is offset* (CO_2, SO_2 and GHG models) *by a positive impact on the stringency of the environmental regulation*. Although environmental benefits are found for air pollution, our empirical results do not support the double profit: economic and environmental, of trade in end-of-the-pipe EGs in the transition economies.

- Our empirical results underscore a negative direct impact of ***trade intensity in cleaner technologies & products*** on CO_2, and GHG emissions in general, strengthened by a *negative indirect effect* (the harmful impact via *SEP* being offset by a beneficial effect via income) in the case of CO_2 pollution. Regarding *SO_2 and BOD models*, where no direct impact is found, *the indirect effect via income doesn't compensate the detrimental effect induced through SEP, producing thus a positive (or harmful) net impact* on these pollutants. For this kind of EGs' trade intensity, the double profit (environmental and economic) is found only in the model explaining CO_2 emissions. These products' trade liberalization could thus be particularly supported while targeting climate change mitigation.

We thus identify different transmission channels for these two EGs categories: direct technique effects for both of them but on different pollutants, even a prevailing harmful scale-composition direct effect for end-of-the-pipe products; and favourable indirect effects passing through environmental regulation in the case of end-of-the-pipe products, and via income in the case of cleaner technologies & products.

6. Robustness checks and extended empirical analysis

6.1. Tests for environmental regulation variable

First, we aim to perform a robustness test for *SEP* variable. We run models (1) to (4) by replacing *SEP* variable by a new proxy, the Stringency of Environmental Regulation (SER) index. The last differs from the former by using as components, additionally to the density of international nongovernmental organizations (INGO) and the number of ISO 14001 certified companies, the number of *ratified multilateral environmental agreements* (MEAs) instead of signed MEAs, and *energy efficiency* instead of existence of a regulation on air pollution and adhesion to the Responsible Care® Program. Countries ratifying more MEAs prove their governments' concern about the environmental protection. We think it is important to consider MEA's ratification in robustness tests since it is often argued that it is the ratification, and not the year of signature, that imposes compliance to international environmental treaties. Moreover, since no definition of composite variables does really exist, we also suppose important to have an index with consistent but different component variables. Moreover, since *SEP* variable is created using Z-score method, we decide to discuss here empirical estimators for the *SER* index computed using the technique of the principal component analysis (PCA), in order to highlight robustness for both: component variables and computation technique. Table 7 in Appendix E reports comparative estimates for our structural equation models (CO_2, SO_2, BOD and GHG) using *SER* index as proxy for the stringency of the environmental regulation. The empirical results confirm robustness of our previous findings, namely for *EGs' trade intensity* estimates. Other core variables, like environmental regulation and income, keep sign and significance levels, having very similar coefficients.

6.2. Alternative EGs classifications

In this subsection, we extend our empirical analysis by considering alternative EGs classifications. We investigate environmental impact of trade intensity in other Class A EGs not included in the OECD+APEC list (*TrInA_OtherEGs*), and the mostly discussed Class B EGs: clean technologies used for power generation and environmentally preferable products (*TradeIntB_CT* and *TradeIntB_EPP*, respectively). Many developing countries wish these products to be included in the EGs list for WTO negotiations on trade liberalization.

Table 3 displays results for alternative EGs classifications. On the whole, our control variables keep sign and significance compared to our benchmark estimations (models 1 to 3). Concerning EGs, only *trade intensity in environmentally preferable products* has a direct negative effect on CO_2 emissions and it has no technique indirect effects. This result is in some way obvious, as *environmentally preferable products*' production, consumption, and/or disposal are less pollutant (suggesting a negative scale-composition direct effect), and their uses are not pollution abatement processes (so no technique effect expected). No significant effect is found for SO_2 emissions, which are industrial by-products and thus not directly linked to consumer products. On the contrary, trade intensity in *environmentally preferable products* seems to raise water pollution through an induced reduction in income.

As regarding Other Class A EGs not included in the OA list, trade intensity in *other type A EGs* appears to reduce only water pollution through the indirect income channel, which offsets its surprisingly negative impact on the stringency of the environmental policy. Seemingly to *environmentally preferable products*, no significant effect is found for SO_2 emissions, but a harmful impact is found on CO_2 emissions.

Table 3 Environmental impact of trade intensity in EGs, alternative classifications

EnvQual	(5) ln*CO₂*	(6) ln*SO₂*	(7) ln*BOD*
ln*GDP_1*	1.2480***	1.4638***	0.7953***
ln*K/L*	0.1260	-0.2679	-0.1330*
ln*GNI/cap*	-0.6199***	-0.0805	-0.5104***
ln*SEP*	-3.7811***	-5.5621***	-1.4967***
ln*TradeIntA_OtherEGs*	0.0516	-0.0338	0.0152
ln*TradeIntB_CT*	0.0064	-0.0791	0.0993**
ln*TradeIntB_EPP*	-0.1177**	0.0154	-0.0773
ln*Open*	0.3316***	0.5972***	0.1885*
ln*SEP*			
ln*GNI/cap*	0.0612***	0.0244	0.0681**
ln*Democ*	0.0078	0.0195	0.0405
ln*Corrup*	-0.0639	-0.1213*	-0.1695*
ln*TradeIntA_OtherEGs*	-0.0246**	-0.0227	-0.0281**
ln*TradeIntB_CT*	0.0185**	0.0231**	0.0104
ln*TradeIntB_EPP*	0.0076	0.0040	0.0014
ln*Open*	0.0302	0.0220	0.0602**
constant	3.4487***	3.8749***	3.9520***
ln*GNI/cap*			
ln*K*	0.5609***	0.5593***	0.5296***
ln*L*	-0.6192***	-0.5472***	-0.6605***

ln*Democ*	0.0314	0.0471	-0.0289
ln*Lat*	0.7146***	1.1746***	0.8202**
ln*TradeIntA_OtherEGs*	0.0369	0.0608**	0.0756***
ln*TradeIntB_CT*	0.0427**	0.0153	0.0672***
ln*TradeIntB_EPP*	0.0092	0.0124	-0.0586**
ln*Open*	-0.0866*	-0.1251**	-0.1216**
constant	0.0172	-2.3917**	1.1094
N. of obs.	216	148	128

* p<0.1, ** p<0.05, *** p<0.01

Finally, *trade intensity in Class B clean technologies* reduces CO_2 and SO_2 emissions through indirect channels, mainly through environmental regulation (CO_2 and SO_2) and also through the income effect (CO_2). The opposite effect is found for BOD emissions that increase with trade intensity in *Class B clean technologies* via its direct positive scale-composition effect, which is reduced by not offset by the negative indirect income effect (see Table 4 for overall impacts).

Table 4 Overall environmental impact of trade intensity in alternative EGs classifications

	CO_2	SO_2	BOD
trade intensity in other class A EGs	+	no effect	-
trade intensity in class B clean technologies	-	-	+
trade intensity in class B environmentally preferable products	-	no effect	+

Finally, we run in this sub-section some additional regressions on the aggregated EGs lists (see Table 8 in Appendix E). The first three models regress pollution on trade intensity in all EGs referenced in OA list (EOP and/or CTP), while the last three ones consider any environmental good, included in class A or class B. The six estimation models underline similar findings: while considering pooled/large lists, trade intensity in EGs is found to have an overall negative impact on CO_2 emissions, resulting from the only significant indirect income effect. Considering BOD emissions, the indirect income effect doesn't offset the direct positive scale-composition effect, inducing thus a global harmful effect on water quality. No impact is found for SO_2 emissions. The last finding may be explained by divergent effects found on SO_2 emissions for trade intensity in the two OA list's sub-categories: end-of-the-pipe products and cleaner technologies & products; from where the interest to separately study specific and accurate EGs classifications, which allow identifying homogeneous EGs sub-categories having different transmission channels. As for the overall trade openness, we find in all the regressions a global harmful impact on the environmental quality: i.e. higher trade intensity generates more pollution in the transition economies, either directly by the means of the scale/composition effects, or indirectly through its negative effect on the levels of per capita income. Contrary to Antweiler, Copeland and Taylor (2001), and Dean (2002), and after having controlled for trade in goods designed to improve environmental quality, i.e. EGs, we do not find any technique effect on pollution for trade openness in the transition countries.

6.3. Environmental impact of EGs imports and exports

Subsequently, we investigate environmental impact of EGs exports and imports separately, instead of examining trade intensity in EGs. This aspect seems to be very important for CEE/CIS countries as they were net importers of EGs during the analysed period, and the overall impact (economic and environmental) of these products' liberalization would mainly depend on the effect of EGs imports on income, environmental policy and pollution. Consequently, we rewrite Table 1 models (1) to (3) by replacing trade intensity (*TradeInt*) variables by imports (*Im*) and exports (*Ex*), respectively. Table 5 displays estimation results, which are rather similar to those found in Table 1, and are quite robust (except for *K/L* and *Open* variables, changing statistical significance).

As regards the EGs, we can draw some interesting conclusions. Examining the direct impact on pollution, we find that ***imports*** of *end-of-the-pipe products* reduce CO_2, SO_2 and BOD emissions, while imports of *cleaner technologies & products* raise air pollution (CO_2 and SO_2). These results show a prevailing direct technique effect for imports of end-of-the-pipe products and a dominating direct scale-composition effect for imports of cleaner technologies & products (the later generating usually productivity gains, may lead, through abound effects, to more production and hence more pollution). Examining further indirect effects, we found for the imports of end-of-the-pipe products a negative impact on *SEP*, which induces a global positive impact on BOD emissions but doesn't offset the direct negative effects on CO_2 and SO_2 emissions. Our empirical results underscore negative indirect effects on pollution of cleaner technologies & products' imports, passing through both income rise and environmental standards strengthening, and thus generating a negative net impact of these imports on BOD and CO_2 emissions. However, since no indirect technique effect is found on SO_2 emissions, the global impact on sulphur dioxide pollution remains positive. To conclude, focusing on negative overall effects on pollution, we show that imports of end-of-the-pipe products contribute to environmental quality improvement through a direct technique effect, while imports in cleaner technologies & products – though indirect effects via environmental regulation and income.

Table 5 Environmental impact of EGs imports and exports

	(12)	(13)	(14)
EnvQual	ln*CO₂*	ln*SO₂*	ln*BOD*
ln*GDP_1*	1.5600***	1.5946***	1.0243***
ln*K/L*	0.1548*	-0.2048	-0.1345
ln*GNI/cap*	-0.4352***	0.0711	-0.4066***
ln*SEP*	-7.0137***	-6.6030***	-3.2374***
ln*ImA_EOP*	-0.3503***	-0.2843**	-0.3049**
ln*ExA_EOP*	0.2123***	-0.0956	0.1338*
ln*ImA_CTP*	0.2843***	0.3704**	0.2244
ln*ExA_CTP*	-0.0634	0.0070	0.0230
ln*Open*	0.2910**	0.2637	0.1717
ln*SEP*			
ln*GNI/cap*	0.0712***	0.0291	0.0582**
ln*Democ*	-0.0099	-0.0072	-0.0211
ln*Corrup*	0.0090	-0.0923	-0.0201
ln*ImA_EOP*	-0.0331***	-0.0265*	-0.1001***
ln*ExA_EOP*	0.0375***	0.0375**	0.0379***
ln*ImA_CTP*	0.0315***	0.0252	0.0973***
ln*ExA_CTP*	-0.0148	-0.0142	0.0000
ln*Open*	0.0022	-0.0050	-0.0443
constant	2.7834***	3.4894***	3.0502***
ln*GNI/cap*			
ln*K*	0.3555***	0.3146***	0.4225***
ln*L*	-0.7032***	-0.6346***	-0.7259***

ln*Democ*	-0.0333	-0.0334	-0.1009
ln*Lat*	0.9862***	1.2095***	0.7897**
ln*ImA_EOP*	0.0298	0.0262	-0.0255
ln*ExA_EOP*	0.0721***	0.1149***	0.0766**
ln*ImA_CTP*	0.0690***	0.0824***	0.0811*
ln*ExA_CTP*	-0.0175	-0.0559**	0.0189
ln*Open*	-0.2340***	-0.2403***	-0.2262***
constant	4.5488***	3.1061***	3.9627***
N. of obs.	216	148	128

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Concerning ***exports***, no effect (direct or indirect) is found for cleaner technologies & products, whereas a global negative impact on our three pollutants is revealed for exports of end-of-the-pipe products. Concerning the last, despite a direct positive scale-composition effect, our results underline a prevailing negative indirect effect, i.e. end-of-the-pipe products' exports raise income and severity of the environmental regulation, inducing thus an overall beneficial effect on the environment. These findings may be explained by a relatively higher propensity to export end-of-the-pipe products than cleaner technologies & products in the CEE/CIS countries, and highlight the role of exports in raising income and the capacity to comply with regulation.

Finally, we perform additional regressions aiming to identify the environmental impact of environmentally preferable products' imports and exports (see Table 9 in Appendix E). Our results confirm some practical intuitions. We found an overall negative impact on pollution (CO_2 and BOD emissions) for environmentally preferable products' imports mainly due to a negative direct scale-composition effect, since these products are recognized to be more environment-friendly than their substitutes during consumption and disposal processes, and an indirect income effect (CO_2). On the contrary, our results suggest that environmentally preferable products' exports increase BOD emissions (positive net impact), mainly through a harmful effect on the environmental regulation's stringency. Similar to trade intensity, no significant effect on SO_2 emissions is found for environmentally preferable products' imports and exports.

Table 6 Overall environmental impact of EGs imports and exports

		CO_2	SO_2	BOD
Imports	*end-of-the-pipe products*	-	-	+
	cleaner technologies & products	-	+	-
	environmentally preferable products	-	no effect	-
Exports	*end-of-the-pipe products*	-	-	-
	cleaner technologies & products	no effect	no effect	no effect
	environmentally preferable products	-	no effect	+

7. Conclusion

Should transition countries open their markets to EGs? The answer is much more complex than it would seem to be, since different aspects: EGs classifications, countries' priorities concerning specific pollutants, role of tariff revenues in total income, etc., should be considered before concluding.

Our study finds support for the existing concerns of developing countries regarding EGs classifications and their double profit: economic and environmental. Trade intensity in the most discussed EGs for liberalization (e.g. OECD and APEC lists) doesn't have univocal beneficial effect on environment. After having considered the main transmission channels and different pollutants, we found an overall negative impact of trade intensity in EGs on CO_2 and a positive impact on BOD emissions. No significant effect is found for SO_2 emissions. However, we underline importance of making distinction between *end-of-the-pipe products*, used in abatement processes, and *cleaner technologies & products* designed to improve production techniques with respect to environment. Trade intensity in end-of-the-pipe products has a negative direct technique effect only on SO_2 emissions, while trade intensity in cleaner technologies & products performs such effect on CO_2 and total GHG emissions. On the overall, we find that trade intensity in end-of-the-pipe products reduces air pollution (CO_2, total GHG and SO_2 emissions) mainly *through an indirect impact on environmental regulation*, but increases water pollution (BOD). Concerning cleaner technologies & products, our empirical results underscore a negative net impact on GHG (in particular on CO_2) emissions, the direct negative effect being amplified by an *induced indirect income effect*; and a positive overall impact on SO_2 and BOD emissions because of a harmful effect on environmental regulation. Moreover, some EGs, most of which are not currently under WTO negotiations on trade liberalization (*other class A EGs products* not included in OECD+APEC list and *the environmentally preferable products*) are found to reduce some pollutant emissions in the transition economies. Hence, CEE/CIS countries suffering mainly from *air pollution* should be interested in opening their markets to *OECD+APEC EGs* lists (especially *end-of-the-pipe products*) and some *Class B EGs* (namely *clean technologies* for power generation and *environmentally preferable products*), while those essentially concerned by ***water pollution*** would oppose to liberalization of the former EGs, and prefer *other Class A EGs* that are found to reduce BOD emissions.

Our empirical results suggest some particular considerations to be taken into account for EGs net importers. Opening trade in EGs would have an "immediate" net effect on pollution mainly depending on EGs imports' effect: generally, results indicate for CO_2 reduction and divergent effects on SO_2 and BOD emissions according to EGs sub-categories considered. Concerning negative overall effects on pollution, we show that imports of end-of-the-pipe products contribute to environmental quality improvement through a direct technique effect, while imports in cleaner technologies & products – through indirect effects via environmental regulation and income. Hence, our study highlights importance of considering *indirect effects*, since while estimating EGs' trade impact on pollution we often found an indirect negative (technique) effect compensating a direct positive (scale-composition) impact, such as for cleaner technologies & products' imports for example. The indirect income effect is particularly important for CEE/CIS countries and two circumstances should be considered. If the indirect income effect is mainly due to some technological progress, liberalizing EGs trade may be interesting even if the direct harmful scale-composition effect remains dominant. In fact, transition economies might stake on the beneficial indirect effects (via *income* and/or *SEP*) during negotiations on EGs liberalization, in order to benefit, in the short-term, from a technique effect ensuring them, in the long-term, better environmental performances. On the contrary, if the positive effect on income is mainly due to import tariffs, their cut off could only harm the environment. In that case, the transition economies should be incited to integrate the global market by promoting their own exports. That would accelerate economic development and improve thus environmental quality, since our empirical results reveal a positive effect on income and global negative impact on pollution for exports of end-of-the-pipe products and cleaner technologies & products, for which CEE/CIS countries have yet some relative comparative advantage. Without exports' promotion, EGs' trade liberalization might not be an economically interesting issue for a net importing country with significant import tariffs' revenues.

To conclude, we cannot state for a global and uniform EGs' trade liberalization. Since countries differ in their industrialization level and market size and don't have the same initial conditions while integrating a trading-bloc, regional or bilateral trade agreements could act as building blocks towards a global, sequentially achieved, liberalization of EGs. Our empirical findings encourage further investigations on the determinants of trade in EGs, allowing to evaluate the trade liberalization's marginal effect compared with other potential barriers, like institutional factors and user/consumer preferences, allowing to boost trade in EGs without threating income levels in the net importing countries.

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Appendices

A. List of countries

Country		CO_2 models *	SO_2 models **	BOD models ***
Albania	*CEEC*	+	+	+
Armenia	*CIS*	+	+	+
Azerbaijan	*CIS*	+	+	+
Belarus	*CIS*	+	+	-
Bulgaria	*CEEC*	+	+	+
Croatia	*CEEC*	+	-	+
Czech Republic	*CEEC*	+	+	+
Estonia	*CEEC*	+	+	-
Georgia	*CIS*	+	+	-
Hungary	*CEEC*	+	+	+
Kazakhstan	*CIS*	+	+	-
Kyrgyzstan	*CIS*	+	+	+
Latvia	*CEEC*	+	+	+
Lithuania	*CEEC*	+	+	+
Poland	*CEEC*	+	+	+
Republic of Moldova	*CIS*	+	+	+
Romania	*CEEC*	+	+	+
Russian Federation	*CIS*	+	+	+
Slovakia	*CEEC*	+	+	+
Slovenia	*CEEC*	+	+	+
Tajikistan	*CIS*	+	+	-
The former Yugoslav Rep.	*CEEC*	+	-	+
Ukraine	*CIS*	+	+	+
Uzbekistan	*CIS*	+	+	-
Total		*24*	*22*	*18*

* 216 observations: 24 countries for 9 years (1995-2003).
** 148 observations: 22 countries for 8 years (1995-2002); some data are missing for 2001 and 2002 years.
*** 128 observations: 18 countries for 9 years (1995-2003) with many missing points.

B. Data summary

Variable	Definition	Source
CO_2	Carbon dioxide emissions, in kT	International Energy Agency
SO_2	Sulfur Emissions, in TgS	David Stern (2006)
BOD	Organic water pollutant (BOD) emissions (kg per day)	WDI 2007, World Bank
GHG	Greenhouse Gas emissions (CO_2, CH4, N_2O, PFCs, HFCs, SF6)	CAIT (WRI)
GDP	GDP in constant 2000 US$	WDI 2007, World Bank
GNI/cap	GNI: Atlas method, current US$- Net per capita income	WDI 2007, World Bank
K	Capital stock calculated by using the following formula: Creation of fixed assets $_t$ +0.95*Capital stock $_{t-1}$	WDI 2007, World Bank + author's calculation
L	Active population (the labour)	WDI 2007, World Bank
K/L	Capital stock to Labour ratio	Author's calculation
SEP	*Stringency of Environmental Policy* Index	Zugravu N., Millock K. and Duchene G. (2008)
SER	*Stringency of Environmental Regulation* Index	Author's calculation
Corrup	Corruption index	Kaufmann *et al.* (2005)
Democ	The average of the two variables of Freedom House : « Political Rights » and « Civil Liberties »	Freedom House
Lat	Technically, latitude is an angular measurement in degrees ranging from 0° at the equator to 90° at the poles	CEPII's database Distances
Trade	Bilateral trade (all products)	UN Comtrade database
TradeA_OA	Bilateral trade in class A EGs, aggregated OECD and APEC list (OA)	Author's database (using UN Comtrade database & EGs lists)
TradeA_EOP	Bilateral trade in OA list's end-of-the-pipe / pollution control products; involve different products while explaining air or water pollution	Author's database (using UN Comtrade database & EGs lists)
TradeA_CTP	Bilateral trade in OA list's cleaner technologies & products /beginning-of-the-pipe products (pollution prevention / resource management products)	Author's database (using UN Comtrade database & EGs lists)
Open	Openness /Total trade intensity: (Export+Import)/GDP	Author's calculation
TradeIntEGs	Trade intensity in EGs (all classifications confused)	Author's calculation
TradeIntA_OA	Trade intensity in class A EGs, OA list	Author's calculation
TradeIntA_EOP	Trade intensity in OA list's end-of-the-pipe / pollution control products; involve different products while explaining air or water pollution	Author's calculation
TradeIntA_CTP	Trade intensity in OA list's cleaner technologies & products /beginning-of-the-pipe products (pollution prevention / resource management products)	Author's calculation
TradeIntA_OtherEGs	Trade intensity in other class A EGs not included in the OA list	Author's calculation
TradeIntB_CT	Trade intensity in class B EGs: Clean Technologies (used for power generation)	Author's calculation
TradeIntB_EPP	Trade intensity in class B EGs: Environmentally Preferable Products	Author's calculation
Ex…/Im…	Exports and imports, respectively, for different EGs classifications	Author's calculation
…_1	One year lagged variable	

C. EGs classifications

UNCTAD has identified two types of environmental goods for analytical purposes:

- **Class A EGs**, which include all chemicals and manufactured goods used directly in the provision of environmental services.
- **Class B EGs**, which include all industrial and consumer goods not primarily used for environmental purposes but whose production, end-use and/or disposal have positive environmental characteristics relative to similar substitute goods.

In order to analyse environmental good trade flows, these two broad sets of EGs have been further decomposed into 10 homogeneous groups of EGs:

Class A EGs have been subdivided into 2 groups:

- **OA list** comprised of the group of all EGs included on the OECD and APEC lists while avoiding double-counting of goods appearing on both lists. **OA list** covers three groups: A) pollution management, B) cleaner technologies and products, and C) resources management group. The first group includes mainly end-of-pipe products, while the two last ones generally cover clean technologies and products used to prevent environmental degradation.
- **Oth-TypeA-EGs list** comprised of several goods used to provide environmental services which have not been captured by the OECD and APEC lists. This list contains, for example, plastic gloves and protective eyewear which are used in environmental clean-up and remediation activities.

Class B EGs that have been subdivided into 8 groups:

- **CT list** comprised of clean technologies used for power generation. This list includes energy efficient natural gas based power generation and renewable energy technologies and their components.
- **EPP-core** list comprised of consumer and industrial non-durable and semi-durable EPP goods. Goods on the EPP list have been selected based on environmentally superior end-use and disposal characteristics only (i.e., not based on PPMs). This list includes a wide variety of goods including natural fibres for industrial uses and in the form of textiles; natural rubber; natural vegetable derivatives, colourings and dyes.
- **CT-fuel list** including fuels for CT, and some conventional (i.e., fuel-switching), power generation technology applications. This list includes natural gas, propane and butane, as well as ethanol and a range of agricultural feedstocks – bagasse and oilseeds – used respectively to produce ethanol and biodiesel fuels.
- **EPP-RCY** list comprised of recoverable materials that are reintegrated into the production cycle. This list includes scrap and waste paper, wood, plastics, rubber and various scrap metals.
- **EPP-WOOD** list comprised of wood and wood-based products including building supplies and furniture.
- **EPP-WSA** list comprised of apparel manufactured from natural wool and silk fibres.
- **EPP-CM** list comprised of raw cotton materials and cotton textiles.
- **EPP-CA** list comprised of apparel manufactured from natural cotton fibres.

Source: Hamwey (2005)

D. Composition of EGs group lists examined in this paper, by HS-96 6-digit code[1]

Class A, OECD+APEC list for '*end-of-the-pipe products*'
230210, 252100, 252220, 281410, 281511, 281512, 281610, 281830, 282010, 282090, 282410, 283210, 283220, 283510, 283521, 283523, 283524, 283525, 283526, 283529, 283822, 380210, 392020, 392490, 392690, 560314, 580190, 591190, 681099, 690210, 690220, 690290, 690310, 690320, 690390, 690919, 701710, 701720, 701790, 730900, **731010**, 731021, 731029, 732510, 780600, **840410**, 840510, 840991, 841000, 841320, **841350**, **841360**, **841370**, 841410, 841430, 841440, 841459, 841480, 841490, 841780, 841790, 841940, 841960, 841989, 842119, 842121, **842129**, **842139**, 842191, **842199**, 842220, 842381, 842382, 842389, 842490, **842833**, 846291, 847290, 847410, 847432, 847439, 847982, 847989, 847990, **848110**, **848130**, **848140**, **848180**, **850590**, 851410, 851420, 851430, 851490, 851629, **870892**, 890710, 890790, 901320, 901540, 901580, 901590, 902229, 902290 , 902511, 902519, 902580, 902590, 902610, 902620, 902680, 902690, 902710, 902720, 902730, 902740, 902750, 902780, 902790, 902830, 902890, 903010, 903020, 903031, 903039, 903083, 903089, 903090, 903110, 903120, 903130, 903149, 903180, 903190, 903220, 903281, 903289, 903290, 903300, **960310**, 960350, 980390 ***– 142 items***

Class A, OECD+APEC list for '*cleaner technologies & products*' (including resource management products)

220100, 220710, 280110, 284700, 285100, 290511, **320910**, 320990, 381500, 391400, **460120**, 700800, 701990, **840420**, 840999, **841011**, 841012, **841013**, **841090**, **841381**, **841911**, **841919**, **841950**, **841990**, 843680, **850231**, 853931, **854140**, 854389, 902810, 902820, 903210 ***– 32 items***

Other type Class A EGs (Oth-TypeA-EGs)
284700, 392321, 392329, 392620, 401519, 440130, 441700, 611610, 630533, 630611, 630612, 630619, 640110, 640191, 640192, 640199, 691010, 691090, 820110, 820120, 820130, 820140, 820150, 820160, 820190, 820210, 842820, 842832, **842833**, 842839, 842890, 842959, 847490, 850530, **850590**, 850810, 850820, 850880, 850890, 850910, 850930, 853949, 870490, **870892**, 900490, 902000 ***– 46 items***

Class B, *Clean Technologies* (CT)
392510, **731010**, 731100, 732211, 732219, 732290, 761100, 761300, 830249, 840211, 840212, 840219, 840220, 840290, 840310, 840390, **840410**, **840420**, 840490, 840681, 840682, 840690, 840890, **841011**, **841012**, **841013**, **841090**, 841181, 841182, 841199, **841350**, **841360**, **841370**, **841381**, 841391, 841620, 841630, 841869, **841911**, **841919**, **841950**, **841990**, **842129**, **842139**, **842199**, 847960, **848110**, **848130**, **848140**, **848180**, 848190, 848310, 848360, 848410, 848490, 850131, 850132, 850133, 850134, 850161, 850162, 850163, 850164, 850211, 850212, 850213, 850220, **850231**, 850239, 850240, 850300, 850421, 850422, 850423, 850431, 850432, 850433, 850434, 850440, 850490, 851150, 851610, 851621, **854140**, 900190, 900290 ***– 86 items***

Class B, *Environmentally Preferable Products* (EPP-core)
050900, 121110, 121120, 121190, 130110, 130120, 130190, 130219, 140190, 140310, 140390, 140410, 150510, 150590, 152110, 152190, 230690, 230890, 310100, 320190, 320300, **320910**, 321000, 400110, 400121, 400122, 400129, 400280, 450110, 450200, 450310, 450390, **460120**, 460191, 460210, 480610, 500200, 500400, 500600, 500710, 500720, 500790, 510111, 510119, 510121, 510129, 510130, 510310, 510320, 510400, 510510, 510521, 510529, 510610, 510710, 510910, 510910, 511111, 511119, 511190, 511211, 511219, 511290, 511290, 530110, 530121, 530129, 530210, 530290, 530310, 530410, 530521, 530591, 530710, 530720, 530810, 530890, 531010, 531090, 531100, 531100, 560710, 560721, 560729, 560750, 560890, 570110, 570220, 570231, 570241, 570251, 570291, 570310, 580110, 581099, 600129, 600199, 600241, 600291, 630120, 630510, 670100, 680800, 850680, 850780, **960310** ***– 106 items***

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[1] In total we have 377 products: 161 are present in the current WTO408 list (of which 106 are from O+A list) and 20 in the WTO26 list (with 14 codes from OA). With the exception of the Oth-TypeA-EGs and EPP-core lists, which generally contain unique products not present in the other lists (with a few exceptions), the O+A and CT lists share some common goods (see codes in blue and violet colors).

E. Alternative empirical estimations

Table 7 Robustness tests for environmental regulation variable

	(15)	(16)	(17)	(18)
EnvQual	lnCO_2	lnSO_2	ln*BOD*	ln*GHG*
ln*GDP_1*	1.3173***	1.3928***	0.9170***	1.2379***
ln*K/L*	0.2251***	-0.0902	-0.1660**	0.3976***
ln*GNI/cap*	-0.4011***	0.1995	-0.3270***	-0.4993***
ln*SER(pca)*	-5.3192***	-5.5440***	-2.5800***	-6.2782***
ln*TradeIntA_EOP*	0.1587***	-0.1937*	0.1161**	0.0688
ln*TradeIntA_CTP*	-0.2091***	0.0085	-0.0881	-0.1389**
ln*Open*	0.5486***	0.6670***	0.2400**	0.4496***
ln*SER(pca)*				
ln*GNI/cap*	0.1192***	0.0572***	0.1586***	0.0841***
ln*Democ*	-0.0282	0.0103	0.0004	0.0056
ln*Corrup*	-0.0270	-0.1441***	-0.0076	-0.0546
ln*TradeIntA_EOP*	0.0401***	0.0281***	0.0074	0.0153
ln*TradeIntA_CTP*	-0.0412***	-0.0237***	-0.0290**	-0.0145
ln*Open*	0.0561***	0.0223	0.0464**	0.0153
constant	2.6656***	3.6359***	2.8829***	3.2908***
ln*GNI/cap*				
ln*K*	0.5646***	0.5613***	0.5452***	0.6332***
ln*L*	-0.6191***	-0.5843***	-0.6646***	-0.6862***
ln*Democ*	0.0689	0.0338	-0.0540	0.0973
ln*Lat*	0.6782***	0.9624***	0.9544***	0.7633
ln*TradeIntA_EOP*	-0.0056	0.0440	0.0499	-0.0036
ln*TradeIntA_CTP*	0.0848***	0.0449*	0.0636**	0.0639
ln*Open*	-0.0724	-0.0755	-0.1365**	-0.0717
constant	0.3957	-1.5313	0.0488	-0.1190
N. of obs.	195	143	118	43

* p<0.1, ** p<0.05, *** p<0.01

Table 8 Environmental impact of trade intensity in EGs, pooled lists

	(19)	(20)	(21)	(22)	(23)	(24)
EnvQual	lnCO_2	lnSO_2	ln*BOD*	lnCO_2	lnSO_2	ln*BOD*
ln*GDP_1*	1.2850***	1.4363***	0.8131***	1.3003***	1.4618***	0.8319***
ln*K/L*	0.1214	-0.3056	-0.1004	0.1168	-0.2838	-0.1296*
ln*GNI/cap*	-0.5798***	-0.0464	-0.5679***	-0.5817***	-0.0868	-0.5225***
ln*SEP*	-4.1630***	-5.4159***	-1.6520***	-4.2262***	-5.4577***	-1.7760***
ln*TradeIntA_OA*	-0.0111	-0.0991	0.1084***			
ln*TradeInt_EGs*				-0.0136	-0.0985	0.0863**
ln*Open*	0.2783***	0.5864***	0.0796	0.2803***	0.5814***	0.1151
ln*SEP*						
ln*GNI/cap*	0.0702***	0.0323	0.0672**	0.0614***	0.0190	0.0653**
ln*Democ*	0.0023	0.0153	0.0374	-0.0044	0.0061	0.0294
ln*Corrup*	-0.0533	-0.1155*	-0.1058	-0.0517	-0.1184*	-0.1067
ln*TradeIntA_OA*	0.0012	0.0042	-0.0056			
ln*TradeInt_EGs*				0.0068	0.0115	-0.0024
ln*Open*	0.0188	0.0102	0.0242	0.0082	-0.0027	0.0177
constant	3.5721***	4.0368***	3.8767***	3.5525***	4.0331***	3.8693***
ln*GNI/cap*						
ln*K*	0.5610***	0.5640***	0.5614***	0.5537***	0.5677***	0.5446***
ln*L*	-0.6392***	-0.5986***	-0.6816***	-0.6215***	-0.5876***	-0.6647***
ln*Democ*	0.0302	0.0182	-0.0459	0.0763	0.0801	-0.0132
ln*Lat*	0.2061	0.6346**	0.4574	0.4794*	0.8197***	0.7943**
ln*TradeIntA_OA*	0.0880***	0.0860***	0.1070***			
ln*TradeInt_EGs*				0.0714***	0.0650***	0.0956***
ln*Open*	-0.0546	-0.0758	-0.1110**	-0.0277	-0.0378	-0.0945*
constant	1.8589**	-0.3035	1.4918	0.7595	-1.1641	0.2856
N. of obs.	216	148	128	216	148	128

* p<0.1, ** p<0.05, *** p<0.01

Table 9 Environmental impact of EPPs imports and exports

	(25)	(26)	(27)
EnvQual	lnCO_2	lnSO_2	ln*BOD*
ln*GDP_1*	1.4629***	1.4706***	1.0607***
ln*K/L*	0.2995***	-0.1226	-0.0593
ln*GNI/cap*	-0.5435***	-0.2630	-0.2498**
ln*SEP*	-5.3937***	-5.7376***	-3.2307***
ln*ImB_EPP*	-0.1465***	-0.0882	-0.1294***
ln*ExB_EPP*	0.0187	0.0340	0.0270
ln*Open*	0.5916***	0.5648***	0.4952***
ln*SEP*			
ln*GNI/cap*	0.0930***	0.0449	0.1028***
ln*Democ*	0.0051	0.0444	0.0301
ln*Corrup*	-0.0006	-0.1095	-0.0570
ln*ImB_EPP*	-0.0011	0.0017	0.0012
ln*ExB_EPP*	-0.0082	-0.0117	-0.0232**
ln*Open*	0.0393**	0.0366*	0.0509*
constant	3.2970***	4.0367***	3.6058***
ln*GNI/cap*			
ln*K*	0.5213***	0.5420***	0.5664***
ln*L*	-0.6592***	-0.5983***	-0.6619***
ln*Democ*	0.0242	0.0464	0.0197
ln*Lat*	1.3564***	1.5158***	1.2039***
ln*ImB_EPP*	0.0359**	0.0132	0.0148
ln*ExB_EPP*	0.0709***	0.0808***	0.0699***
ln*Open*	-0.1452***	-0.1244***	-0.0986*
constant	-0.6630	-2.6662***	-0.9442
N. of obs.	216	148	128

* p<0.1, ** p<0.05, *** p<0.01