Environmental Goods Trade Liberalization: A Quantitative Modelling Study of Trade and Emission Effects*

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Abstract

Trade liberalization in environmental goods is expected to mitigate climate change by limiting greenhouse gas emissions. In this paper, quantitative modelling is used to generate projections on the trade, GDP, and emission effects of a potential trade liberalization agreement in energy related environmental goods. Two channels reducing greenhouse gas (GHG) emissions are considered: an increase in energy efficiency through the reduction in import prices of energy related environmental goods (EREGs) and a reduction in the costs of intermediate and capital goods used in electricity production from renewable energy sources. We evaluate four scenarios based on combinations of reductions in tariffs and NTMs of EREGs, and environmentally preferable products (EPPs). Simulations with the WTO Global Trade Model project: (i) an increase in exports of EREGs and EPPs both at the global level and in most regions; (ii) a modest increase in GDP in all regions because of falling tariffs, NTMs, and increased energy efficiency; (iii) a modest reduction in global emissions of about 0.3%.

Keywords: Environmental Goods, Trade Liberalization, Emissions

JEL Classification: F18

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1 Introduction

The shift from fossil-fuel energy sources towards low-carbon renewable energy sources is crucial to tackle climate change. The use of environmental goods and services (EGS) is recognised to be an important instrument that helps in improving energy efficiency and reducing emissions. Despite the lack of a formal definition, environmental goods and services are used to measure, prevent, limit, minimize or correct environmental damage to water, air, and soil, as well as problems related to waste, noise and eco-systems. They include cleaner technologies, products and services that reduce environmental risk and minimize pollution and resource use Eurostat (1999). As such, facilitating access to environmental goods (EGs) can help countries increase their energy efficiency and switch from conventional to renewable energy use.

Theoretical and empirical work on the potential effects of liberalizing environmental goods trade is relatively scarce or inconclusive. This is mostly because of difficulties to classify and distinguish EGs and the large number of channels through which trade in EGs can affect economic and environmental outcomes. Nimubona (2012) examines the potential effectiveness of reductions in trade barriers on EGs in a developing country that imports all its consumption of EGs from an imperfectly competitive foreign eco-industry. Findings point out that trade liberalization of EGs might in fact lead to less stringent pollution taxes, which can result in an actual rise in pollution levels. He et al. (2015) study the impact of trade liberalization on EGs exports. They use bilateral trade data from 20 Asia-Pacific Economic Cooperation members and find that tariff reduction in an exporting country has a larger positive impact on its exports of EGs than tariff reduction in an importing country. De Alwis (2014) look at the impact of opening trade of environmental goods and services (EGS) on environmental quality estimating pollution functions of Sulphur Dioxide (SO2), Nitrogen Oxides (NOx) and Carbon Dioxides (CO2) using cross country data for 62 countries. Results show that the elimination of tariffs on EGs trade results in falling SO2 emissions in comparison to increasing SO2 pollution as a result eliminating tariff on non-EGs trade. Furthermore, it seems that such fall of SO2 pollution due to elimination of tariff on EGs is due to differences in countries' capital-labour endowments, favouring capital abundant countries in reducing the pollution emissions.Tamini and Sorgho (2018) use import data of 34 OECD member countries and from a sample of 167 exporting countries, from 1995 to 2012, and look at the trade effect of reducing barriers on EGs, in a trans-log gravity model. They find that removing tariff barriers for EGs will have a modest impact because for the biggest importers and exporters, elasticities of trade costs are very low while for most trading relationships they are very high, making it difficult for exporters to maintain their markets. Wan et al. (2018) show that trade liberalization in EGs may lower each country's welfare when the production of the EGs' intermediate input generates global pollution (e.g., CO2). The authors suggest that global pollution may increase due to the increased demand for EGs' dirty intermediate inputs. In order to deal with rebound effects, EGs' trade liberalization should be combined with rebound mitigation strategies, like economy-wide cap-and-trade systems, energy and carbon taxes, etc. Indeed, several studies (Vikhlyaev (2004); Kalirajan et al. (2016); De Melo and Solleder (2020); Tamini and Sorgho (2018)) point out that EGs' liberalisation is not enough, it should be complemented by Multilateral Environmental Agreements (MEAs), regulatory harmonization between trading partners, investment, government procurement, licensing of intellectual property rights, elimination of non-tariff barriers, etc. Zugravu-Soilita (2018) investigates the causal effects of trade intensity in environmental goods on air and water pollution by treating trade, environmental policy for the period 1995-2003. Results suggest that although trade intensity in EGs reduces CO2 emissions mainly through an indirect income effect, it increases water pollution because the income-induced effect does not offset the direct harmful scale-composition effect. Based on panel data covering 114 countries between 1996 and 2011, **?** investigates the impact on pollution of trade in environmental goods. They show that trade in EGs alone fail to address environmental problems effectively. First this is because of a rebound effect (i.e. increase in trade leads to an increase in production, thus emissions). Second, they mention the fact that EGs could also be used in dirtier sectors leading to a multiple-use problem. Lastly, findings suggest that a quick liberalization of EGs with high tariff levels, and for which there is no sufficient local demand with adequate technical skills, could worsen environmental, thus a uniform trade liberalisation would not be optimal. Among few works that quantify the effect of trade liberalization in EGs using a simulation exercise, Hu et al. (2020) show that lowering the cost of EGs inputs compared to the use of conventional technology inputs is expected to induce a transition from dirtier to cleaner energy sectors reducing emissions. However, they show that such a reduction in production costs can also generate an increase in economic activity leading to more emissions. Despite several existing studies on the impact of trade liberalization in EGs, understanding the mechanisms and effects at play of trade liberalization in environmental goods remains crucial in tackling climate change issues.

This paper reports on research work undertaken by the secretariat, combining econometric estimations with quantitative modelling to generate projections on the trade, GDP, and emission effects following trade liberalization in a list of EGs. To this purpose, we explore four scenarios combining reductions in tariffs and non-tariff measures (NTMs) of Energy Related Environmental Goods (EREGs) and environmentally preferable products (EPPs). Both EREGs and EPPs are EGs sub-categories. We focus on the former to explore the potential impact on emissions and we complement our analysis by the latter to turn the focus towards developing countries, seemingly having a comparative advantage in EPPs ((Tothova, 2005); (De Melo and Solleder, 2020)). Two effects of EREGs liberalization on emissions are considered: an increase in energy efficiency through the reduction in import prices of products instrumental in raising energy efficiency and a reduction in the costs of intermediate and capital goods used in the production of electricity from renewable sources. The impact of trade liberalization in EPPs on emissions is not considered in this study, since emission data at the detailed product level are not available and so it is not feasible to model the potential substitution in consumption and production towards EPPs.

The rest of the paper is organized as follows. Section 2 starts with a background of discussions on environmental goods and the different channels through which more trade in the considered environmental goods could affect the environment. Section 3 describes the methodology used in the study, followed by a discussion of the results in Section 4. Section 5 concludes.

2 Trade liberalization in Environmental Goods

Attempts to define and create a scope of environmental goods have started since the early 1990s. The OECD created a list to illustrate, primarily for analytical purposes, the scope of the "environment industry". The categories of goods could therefore be broad, because adding products to the list would have no specific policy consequences. Such list was a result of joint OECD and Eurostat work on a manual for national statisticians to assist them in measuring their national environmental industries Eurostat (1999). Despite an existing definition of environmental goods and services, negotiating tariff reductions on environmental goods requires agreement between countries towards common criteria in terms of product coverage. At the same period, in a meeting in Osaka, Japan in November 1995, APEC Leaders agreed to identify industries in which the progressive reduction of tariffs could have a positive impact on trade and on economic growth in the Asia-Pacific region, or for which there was regional industry support for early liberalisation. As stated in Steenblik (2005) both the OECD and APEC products lists were interlinked and informed each other, though the purpose was different. The OECD list contained broader categories of goods because there were no specific policy consequences of adding products to the list, whereas since the APEC list's aim was to obtain more favourable tariff treatment for environmental goods, APEC member economies limited themselves to considering only those specific goods that could be readily distinguished by customs agents and treated differently for tariff purposes. These two lists served as basis for the upcoming initiatives in putting forward negotiations for enviromental goods trade liberalization.

In November 2001, during the Doha round, negotiating members adopted a list-based approach under which each member would propose a set of potential environmental goods (defined at the 6th digit level of the harmonized system, HS6) on which trade barriers should be reduced or eliminated. Since then, there are several lists commonly referred to, in the literature and in the different negotiation processes. The first list is the so-called WTO combined list (411 HS6 lines), which aggregates all submissions made under the Doha negotiations until 2011.[1] Thirteen members participated in the process.[2] Then a core list of 26 products, derived from the WTO combined list, identified as "clear environmental goods". It had the objective of serving as a basis for negotiations under the Doha Development Agenda (DDA) in 2010 (Balineau and De Melo, 2013). A subset of 153 HS6 lines of the WTO combined list, published in 2009 by a group of WTO members called the "Friends of environmental goods" is also another commonly used list.[3] While the Doha negotiations on environmental goods did not conclude, another initiative by the Asia Pacific Economic Cooperation (APEC) reached an agreement, which introduced yet another list. At the Vladivostok Ministerial meeting in 2012, APEC members agreed to reduce applied tariffs on a list of 54 HS codes below 5%. This is commonly referred to as "the APEC list". In July 2014, a group of 46 WTO members launched a negotiation to establish an Environmental Goods Agreement (EGA), with the aim of eliminating tariffs on a number of important environmental goods.[4] The APEC list served as a starting point for the EGA negotiations. Table 1 provides a concise overview of the main lists discussed in this paragraph, which may have overlapped HS6 lines. However, while the lists included in Table 1 are the most referred to, the table is not exhaustive.

It is important to note that partners that decided to participate in submission processes consist mostly of developed countries. This is mainly because developing economy members did not have an Environmental Technology sector. The goods on those different lists, and thus on the Doha negotiations' list, are therefore likely to represent the comparative advantage of high-income economies.[6] That said, such lists contained goods that also overlapped with EPPs, that concerned also developing countries. As early as 1995, UNCTAD was advocating the use of EPPs defined as products that are inherently more environmental friendly in their production, use, or disposal, as an opportunity for

[1]JOB/TE/3/Rev. 1 (2011), see: `https://docs.wto.org/dol2fe/Pages/SS/directdoc.aspx?filename=Q:/TN/TE/20.pdf&Open=True`

[2]Saudi Arabia (262 HS6 lines), Japan (57), Philippines (17), Qatar (20), Singapore (72), and the Friends' list (164), a merger of lists by Canada, the European Union, Japan, Korea, New Zealand, Switzerland, Taiwan, the United Sates, and Norway (De Melo and Solleder, 2020).

[3]Countries that are included are Canada, the European Union, Japan, Korea, New Zealand, Norway, Switzerland, Chinese Taipei, and the United States.

[4]Participating countries were Australia, Canada, China, Costa-Rica, European Union, Hong Kong, China, Iceland, Israel, Japan, Korea, New-Zealand, Norway, Singapore, Switzerland, Chinese Taipei, Turkey, and the United States.

[6]See De Melo and Solleder (2020) for a discussion.

Table 1: Lists of Environmental goods for trade negotiation

List	Number of HS6 codes	Assembling parties
Early lists		
OECD list	164	OECD
APEC list	109	APEC
Trade Negotiation lists		
Friends' list (2009)	154	Subset of WTO list containing submissions by Canada, the European Union, Japan, Korea, New Zealand, Norway, Switzerland, Chinese Taipei, and the United States
Doha negotiations list (2011)	411	13 WTO members[5]
Core list (2011)	26	Subset of WTO list selected by Australia, Colombia, Hong Kong, Norway and Singapore
APEC list (2012)	54	APEC members

Source: Steenblik (2005), JOB(09)132; JOB/TE/3/Rev. 1; TN/TE/20; Leader's declaration, APEC ministerial 2012.

developing countries. The work by UNCTAD was later extended by the OECD and a list of EPPs, representative of the comparative advantage of developing countries, was established Tothova (2005).

In what follows, we first discuss different environmental goods categories and then introduce the channels through which trade in these goods is expected to positively affect the environment.

2.1 An overview of environmental goods categories

Environmental goods included in the various lists mentioned above serve several environmental purposes. In general, they can be classified in two main groups: Goods for Environmental Management (GEMs) and EPPs. As mentioned before, EPPs are products inherently more environmental friendly in their production, use, or disposal. GEMs can be further divided in 9 sub-categories, as listed in Table 2. Among the list of GEMs, this study will only concentrate on energy efficiency (EE), resource efficiency (RE), and clean and renewable energy (CRE) categories that we define as Energy Related Environmental Goods (EREGs). It is nevertheless important to underline that some EREGs serve various environmental purposes, and can thus fall under several sub-categories. For example, HS6 8541.40 can be considered a CRE, RE, and EE, depending on its final use.

HS 8541.40 is defined as ”Photosensitive semiconductor devices, including photo-voltaic cells whether or not assembled in modules or made up into panels; light-emitting diodes (LED)”.These diodes can be part of a solar panel and thus help produce renewable energy (CRE) or be used to build lamps and reduce energy consumption (EE, RE). .

Table 2: List of Goods for Environmental Management (GEMs) sub-categories

Abbreviation	Corresponding environmental good category
Energy Related Environmental Goods (EREGs)	
CRE	Clean and Renewable Energy
EE	Energy Efficiency
RE	Resource Efficiency
Other GEMs	
APC	Air Pollution Control
EMAA	Environmental monitoring, analysis and assessment
ERC	Environmental remediation and clean-up
NVA	Noise and vibration abatement
SHWM	Solid and Hazardous Waste Management
WMWT	Wastewater management and water treatment

Note: The EREG consists of a list of climate or energy related goods put together for analytical and research purposes.

Clean and renewable energy (CRE) goods include all products required for the generation of electricity by methods that are environmentally preferable to conventional alternatives. To provide an example, products under HS6 code 85.0231, corresponding to ”Wind-powered electric generating sets” are important inputs to wind power generation. Some goods in the CRE category and in other categories in general are however harder to identify at the HS6 level. Indeed, most EGs are defined at the 8- or 10-digit tariff lines (even in some cases with ex-outs), making the distinction of EGs at the HS6 complex. As a result, any analysis at the HS6 level provides upper-bound estimates. The HS6 code 84.7990, corresponding to ”Machines and mechanical appliances having individual functions, not specified or included elsewhere” is also part of EG lists as it contains parts and equipment used in machines considered as EG, but it has a broader definition. As goods in these HS lines are also used in a broad range of other applications, including non-environmentally friendly applications, there is a so called ”multiple end-use problem”. That is, goods from the same HS line can have clean and dirty uses from an environmental perspective.

Energy efficiency (EE) goods help managing and restraining the growth in energy consumption. For example, using LED light (corresponding to HS6 8541.40 code on APEC's list) instead of filament lamps would reduce energy consumption as the former is more energy efficient.

Resource Efficiency (RE) goods are, in nature, close to EE and CRE as they operate through the same channel and aim at reducing energy consumption. Resource efficiency denotes the efficiency with which resources are used in an economy or in a production process. In addition, RE goods, as many other environmental goods, are often used in conjunction with environmental services[7] and are mostly concerned with the resource consumption in the life cycle of a product.

The three above mentioned types of GEMs will be at the centre of our analysis. To ease the reading, hereafter, we will refer to these categories together as EREGs.

As mentioned before, EREGs might fall under several additional GEMs sub-categories, depending on their final uses. Turning to these other categories of GEMs, air pollution control goods (APC) serve to remove the air pollution particles that have been emitted from industrial sites. Environmental monitoring, analysis, and assessment (EMAA) goods are used to perform monitoring and detection on the state of air quality, water quality, or other environmental damages. Environmental Remediation and Clean-Up (ERC) goods are used to mitigate environmental damages. Noise and Vibration Abatement (NVA) goods concentrate on a very different type of pollution: noise. This category contains mostly noise isolation materials as well as noise measuring instruments. Solid and Hazardous Waste Management (SHWMT) goods are used in waste management processes. Wastewater Management and Water Treatment (WMWT) goods comprise goods used to purify water as well as goods helping to put proper sewage in place.

As already mentioned in the introduction, the literature on the effect of EGs trade focuses on different environmental outcome variables and results are often inconclusive in terms of their impact on the environment. However, it must be noted that environmental goods are often considered as a monolithic bloc geared towards a common outcome. In practice, that is not the case as each of the categories presented above may have different effects on different variables of interest. Using one of the common lists introduced in

[7]Discussions on Environmental Services (ES) have been left out of the negotiation agenda.

Section 2 (APEC or WTO list, for example) would inevitably lead to mixing goods that may have an impact on carbon emissions and goods that are used to clean water. To circumvent this issue, our analysis will concentrate on a list of 177 HS6 codes of EREGs containing mainly intermediate and capital goods related to clean and renewable technology and energy efficiency. It is a list of climate or energy related goods that has been put together for analytical and research purposes.

As most of the goods on the list used in this study (EREGs) are technological goods and appear less likely to be in the trade interest of developing countries, we supplement our analysis with the list of environmentally preferable products (EPPs) developed by Tothova (2005). The term EPPs was first defined at the international level by UNCTAD in 1995 as "products which cause significantly less environmental harm at some stage of their life cycle (production, processing, consumption, or waste disposal) than alternative products that serve the same purpose, or products the production and sales of which contribute significantly to the preservation of the environment". Such list builds on the list of EPPs from UNCTAD (1995) and suggests a long number of possible qualifying products. As explained in Tothova (2005), it divides the illustrative additions into seven broad categories: environmentally preferable (EP) , transportation, energy, pollution control, life-cycle extension, EP alternatives, and waste and scrap. Each category includes several sub-categories, including complements, parts, and infrastructure, where applicable.

2.2 Channels and expected effects of trade liberalization in environmental goods

There are several channels through which trade liberalization in environmental goods may contribute to less emissions.

First, trade liberalization in EREGs leads to a reduction in input prices that serve to produce renewable energy. Lowering the cost of clean technology inputs compared to conventional technology inputs is expected to induce a transition from dirtier to cleaner energy sectors, similar to what the literature refers to as a composition effect, reducing emissions (Copeland and Taylor 2003).[8] However, such a reduction in production costs also generates an increase in economic activity (what is commonly known as a scale effect)[9], leading to more emissions (Hu et al. 2020). For instance, trade liberalization in EREGs may result in an increase of overall economic activity and, thus, in an increase in demand for energy, including coal and oil in some countries (e.g., Russia, Saudi Arabia). This is also known as a rebound effect. Another worth mentioning issue that affects the overall effect of trade liberalization in EGs on emissions is the ”multiple end-use problem” (see subsection 2.2). In that situation, trade liberalization in EREGs can lead to a reduction of production costs in conventional technologies (Hu et al. 2020), thus limiting the reduction in emissions.

Second, using more EREGs leads to changes (improvements) in energy efficiency, which reduces emissions from production through a more efficient use of energy (similar to a technique effect).[10] The energy efficiency can be reflected in production and consumption. An increase in energy efficiency in production implies that the same output can be produced with less energy inputs and an increase in energy efficiency in consumption implies that the same amount of a final good can be consumed with less energy inputs. For instance, trade liberalization in EPPs induces the use of products that cause significantly less *environmental harm* at some stage of their life cycle compared to alternative products serving the same purpose (Tothova, 2005). The use of such goods can bring environmental benefits from production, consumption, and disposal.

Finally, trade liberalization in EGs also allows countries to achieve domestic environmental goals and access new destination markets with stringent environmental requirements regarding their imports. Nevertheless, it is important to note that the abovementioned channels do not affect countries equally. Countries with a high level of emissions and high trade barriers on EREGs are expected to have higher emission reductions from the liberalization of EREGs, as shown in the case of China by Francois and Baugh-

[8]The composition effect measures the changes in environmental degradation due to changes in the range of goods produced, assuming constant scale and technique of production.

[9]Econometric studies find support for both competing effects (e.g., Zugravu 2018, 2019).

[10]The technique effect measures the change in aggregate pollution (or environmental degradation) arising from a switch to more environmentally sustainable production techniques, assuming constant scale and composition effects (Copeland and Taylor 2003).

man (2016). Again, these effects interplay at the aggregate level and are heterogeneous among countries. However, GHGs are global pollutants whose impact transcends borders, thus reducing emissions is a global concern rather than a regional one. Indeed, less emissions at the aggregate level are key in fighting climate change.

3 Quantitative modelling

3.1 Data

3.2 Model - Methodology

To model the potential impact of trade liberalization in EREGs on emissions, the energy and electricity version of the WTO Global Trade Model is used, a recursive dynamic computable general equilibrium (CGE) model. A baseline projection until 2030 for the global economy is generated employing the model with the path for global CO2 emissions close to the emissions projected by the International Energy Agency (IEA) as reported in Böhringer et al. (2021).

We show that trade liberalization in EREGs has an impact on CO2 emissions along three different channels in the model.

First, trade liberalization in EREGs is projected to raise trade and income which will raise the demand for energy and thus emissions (scale effect). This channel emerges endogenously in the model.

Second, increased imports of EE and CRE goods are projected to increase the energy efficiency of both production - the same amount of energy generates more output - and consumption –the same amount of goods can be consumed using less energy inputs -, which will reduce the consumption of energy and thus emissions (technique effect). To model this channel, energy efficiency of both production and consumption is a function of the output price of EREGs. The elasticity of energy efficiency with respect to the price of EREGs is calibrated based on econometric estimates of the impact of EE/RE trade on CO2 emissions in a global panel of emissions and trade.[11] More details about the econometric

[11] The elasticity of energy efficiency with respect to (wrt) the price of gross output of EREGs is calibrated

estimations are provided in Annex A. Results suggest a decrease of 0.2% of CO2 emissions for a 1% increase in EREGs trade.

Third, increased imports of clean and renewable energy (CRE) goods, a subset of EREGs, are projected to reduce the costs of production in renewable energy sectors, leading to a substitution from the use of fossil fuels to renewable energy in electricity generation, which will reduce CO2 emissions (composition effect). The costs of producing renewable energy are affected in two different ways by the price of CRE goods: through the price of intermediates used in production and through the price of capital goods. The latter channel is most important since the renewable energy sector tends to be very capital intensive Chepeliev (2020) [12] As found in Hu et al. (2020), there is a possibility that lower prices of CRE goods also lead to lower costs in the production of electricity with non-renewable sources of energy (coal, oil, gas). Hence, a distinction is made between a scenario with end use control (i.e. only the costs of capital inputs in renewable energy sources of electricity is falling) and a scenario without end use control (i.e. the costs of capital inputs in all energy sources of electricity is falling).

3.3 Scenarios and descriptive evidence

To run the different scenarios, the bilateral tariff rates are obtained from the Market Access Map (MAcMap) database, provided by the International Trade Centre (ITC). As discussed in Section 2.2 we work with a list of 177 HS6 tariff lines representing trade in EREGs. Ad valorem equivalents of non-tariff measures (NTMs) are taken from Cadot et al. (2018) which are based on count data on NTMs from the UNCTAD TRAINS Data Base. The scenarios assume a 25% reduction in iceberg trade costs associated with NTMs based on the fact that many NTMs serve domestic policy objectives and can thus not be reduced and

by simulating step-wise (from 1% to 10%) reductions in iceberg trade costs country-by-country, controlling for changes in GDP, for various levels of the elasticity. The simulated reductions in emissions are regressed on the simulated changes in real imports for various levels of the elasticity of energy efficiency with respect to the price of gross output, searching for the elasticity generating an elasticity of emissions wrt trade equal to the empirically estimated elasticity. This calibration exercise generates an elasticity of energy efficiency wrt the gross output price of EREGs of 0.4.

[12]The capital goods price channel does not emerge endogenously in the model, because investment is not sector specific in the employed model. Therefore, the reduction in the price of EREG investment goods is mapped into a productivity shifter of capital in the different electricity source sectors. With end use control only the productivity of renewable energy sources of electricity is affected, without end use control the productivity of all sources of electricity is affected.

the fact that some NTMs are not trade restrictive.[13] as well as the literature on regulatory convergence (Vanzetti et al. (2018)).

Four cumulative trade liberalization scenarios are considered: [14]

1. Elimination of tariffs on EREGs
2. As (1) and a 25% reduction in NTMs on EREGs
3. As (2) and elimination of tariffs on the additional EPPs
4. As (3) and elimination of NTMs on the additional EPPs

Table 3 displays respectively per importer and per exporter the assumed percentage point changes in ad-valorem tariffs and trade costs associated with NTMs for Scenario 4 (full liberalization).[15] The table makes clear that initial tariffs (and thus tariff cuts) are lowest for developed countries as importer, followed by developing and least developed countries. For NTMs the pattern is opposite: they are cut most for developed economies, although the differences are smaller than for tariffs. Globally, the reductions in NTMs and tariffs are similar in the trade liberalization scenarios. On the exporter side least-developed countries would face the smallest reduction in tariffs, which is related to the existence of preferential tariff rates already in place.

Table 4 displays the value of trade (in 2021 according to our projections) in EREGs and EPPs per region, as well as the revealed comparative advantage (RCA) of regions in these goods. The table makes clear that China is both in absolute (trade share) and relative terms (RCA) an important player in EREGs. The table shows that comparative advantage in EREGs is concentrated in Asia: Japan, Korea, Other Asia (OAS), and South-East Asia (SEA) all have an RCA larger than 1 in these goods. Low-income regions

[13] A 25% reduction in NTMs is in line with empirical estimates of the effect of an FTA on NTMs (Porto (2018), Francois et al. (2015))

[14] A thorny though important detail is that baseline tariffs between the US and China are also for EREGs and EPPs much higher since the 2018/2019 trade conflict between the two countries. The simulations presented do not take these tariffs into account, which means that results can be interpreted is if they are either projecting the change in trade flows compared to the situation before the US-China trade conflict or they are assuming that the US-China tariff increases from 2018-2019 stay in place. In future robustness checks a scenario will be included in which the 2018-2019 US-China tariffs are included in the baseline and cut to zero in the EREGs and EPPs policy experiments.

[15] The percentage point tariff and NTM changes for all regions are in Annex Tables A.1 and A.2.

Table 3: Percentage point changes in the ad valorem equivalent tariffs and NTMs for EREGs and EPPs for groups of countries

Region	Commodity: EGA		Commodity: EPP	
	AVE Tariff Cut	AVE NTM Cut	AVE Tariff Cut	AVE NTM Cut
Importer				
Developed	0.71%	1.96%	1.41%	2.58%
Developing	2.77%	1.51%	4.08%	1.87%
Least-developed	6.68%	1.11%	7.68%	2.20%
Global (WLD)	1.61%	1.74%	2.93%	2.24%
Exporter				
Developed	1.67%	1.73%	1.96%	2.24%
Developing	1.70%	1.78%	3.14%	2.28%
Least-developed	0.81%	1.66%	2.21%	2.51%

Notes: the table displays the percentage point changes in the tariff rates and ad valorem rates of NTMs in the EREG and EPP liberalization scenarios per exporter and importer for three groups of countries. Developing is exclusive of the least-developed economies.
Source: MacMap ITC and GTAP Data Base

such Asia Least-Developed (ASL), Sub-Saharan Africa Least Developed (SSL) and Sub-Saharan Africa Other (SSO) instead have a very low RCA in EREGs. For EPPs the picture is different: most low-income regions have a comparative advantage in these products (ASL, Indonesia, India, SSL, and SSO), although also SEA is an important player in these products. Finally, Table 2 shows that trade in EREGs is an order of magnitude larger than trade in EPPs, respectively 2 trillion and 67 billion dollars.

Table 4: The share of exports to different regions in global trade of EREG and EPP and the revealed comparative advantage in EREGs and EPPs

Regions	Share of exports in global trade		RCA	
	EREG	EPP	EREG	EPP
ASL	0.1%	1.4%	0.10	2.75
AUS	0.3%	5.0%	0.21	3.19
BRA	0.5%	0.8%	0.30	0.51
CAN	1.6%	1.1%	0.60	0.44
CHN	23.8%	15.1%	1.82	1.15
E27	24.4%	22.5%	0.86	0.80
EFT	1.7%	0.9%	0.65	0.35
GBR	1.5%	1.6%	0.56	0.57
IDN	0.7%	6.9%	0.59	5.59
IND	1.0%	2.3%	0.52	1.20
JPN	7.6%	2.3%	1.90	0.57
KOR	7.5%	1.3%	2.26	0.39
LAC	0.8%	3.8%	0.27	1.36
MEX	2.3%	0.4%	1.21	0.22
MIN	1.6%	1.5%	0.25	0.23
OAS	4.7%	2.3%	1.27	0.61
ROW	0.6%	0.7%	0.37	0.45
RUS	0.5%	0.4%	0.19	0.14
SEA	10.3%	23.2%	1.70	3.84
SSL	0.0%	0.8%	0.05	1.01
SSO	0.2%	1.1%	0.16	1.21
TUR	0.5%	0.8%	0.61	0.96
USA	7.6%	2.7%	0.93	0.33
ZAF	0.2%	0.8%	0.43	1.56
WLD	2,030,952	67,476		

Source: MacMap ITC and GTAP Data Base

4 Simulation results

In this section the projected medium run effects of trade liberalization in EREGs and EPPs on trade, GDP and emissions by 2030 are presented. [16] The projections are based on the four scenarios defined in the previous section.

4.1 Trade Effects

The projected per cent changes in real exports of EREGs (upper panel) and EPPs (lower panel) in different regions are displayed in Figure 1, whereas Table 4 contains the projected changes in the quantity of exports in millions of dollars. There are four takeaways from these results. First, global exports of both EREGs and EPPs are projected to increase respectively by 5% and 14% (Region WLD in the figure) under the trade liberalization scenario. Second, the projected per cent change in exports is larger for EPPs than for EREGs, although the value of trade of the latter is much larger. Table 5 shows that at the global level the projected expansion of trade in EREGs in millions of dollars is an order of magnitude larger than the increase in trade of EPPs. However, behind these aggregate numbers there are substantial shifts in bilateral market shares. Third, total exports are projected to rise for all regions. The reason is that the fall in trade costs of EREGs and EPPs and the implied increase in energy efficiency both raise GDP leading to an increase in import demand. This positive effect dominates the negative effect of trade diversion for EREGs in some regions.

Fourth, exports of EPPs from most regions are expected to increase, whereas exports of EREGs are projected to rise only in slightly more than half of the regions. Low-income regions are projected to expand trade of EPPs, whereas trade gains of EREGs are concentrated in the high-income and Asian regions. Table 5 shows that more than 80% of the projected increase in the quantity exported by 2030 in millions of dollars occurs in three countries: China, Japan, and South-Korea. The concentration of export gains in these three regions can also explain why some regions are projected to see their exports of EREGs decrease. The source of imports into big markets like to EU for example is pro-

[16] As discussed in the introduction, emission effects of substitution towards EPP are not modelled because of a lack of data on emissions at the detailed product level.

Table 5: The projected change in the quantity of exports of EREGs, EPPs, and total exports by 2030 in millions of dollars

Region	EREG	EPP	Total
ASL	-111	11	494
AUS	426	-316	1262
BRA	615	81	6982
CAN	849	105	1199
CHN	61008	4003	47697
E27	9415	1239	6606
EFT	600	267	103
GBR	867	96	422
IDN	-225	496	550
IND	2976	324	8991
JPN	15186	465	4637
KOR	16847	256	11844
LAC	-1367	42	2886
MEX	-291	100	104
MIN	-334	130	10991
OAS	3620	123	1890
ROW	-507	88	955
RUS	-87	4	3353
SEA	-5665	2162	2325
SSL	-39	82	926
SSO	-412	85	1839
TUR	1630	65	279
USA	4658	448	10810
ZAF	-225	-27	622
WLD	**109436**	**10328**	**127764**

Source: simulations GTM

jected to shift to China, leading to trade diversion away from other regions. We analyze three countries into more detail. Table A.5 displays the initial value of exports, the simulated tariff reductions, and the projected changes in exports from Southeast Asia to other regions. Southeast Asia is selling a large share of its exports to China (26%). At the same time the initial tariffs in EREGs is 0%. Given that other regions would see tariffs into China fall under the liberalization scenario (see Table A.7) , trade diversion away from goods coming from Southeast Asia would be the result. Exports from Southeast Asia to some other regions are projected to increase somewhat (particularly to Japan and the USA), but this increase is insufficient to compensate the projected loss of sales in China. Southeast Asia's exports would also fall to some other destinations, particularly Southeast Asia itself, which can again be attributed to trade diversion.

Table A.6 shows the projected changes in China's exports. The largest increases in exports are expected to the large destination markets E27, USA, and also Korea. Also exports to Brazil are projected to rise substantially, because of relatively high initial tariffs. Table A.7 shows the projected changes in trade for China as importer. The table shows that the bulk of the projected increase in imports into China will come from the EU, Japan and Korea, both because these regions have a substantial market share and because tariffs would fall substantially (3%-5%) for exports into China from these regions. As analyzed above the increase in imports from these regions would be at the expense of exports from Southeast Asia. Finally, Table A.8 displays the projected change in imports of EREGs into the EU. The table makes clear that changes here are dominated by shift in intra-EU trade to imports from China. Imports from China are projected to increase by 148% of the total increase in imports into the EU, whereas imports from within the EU (intra-EU trade) will fall by 82% of the total change in EU imports.

4.2 Macroeconomic Effects

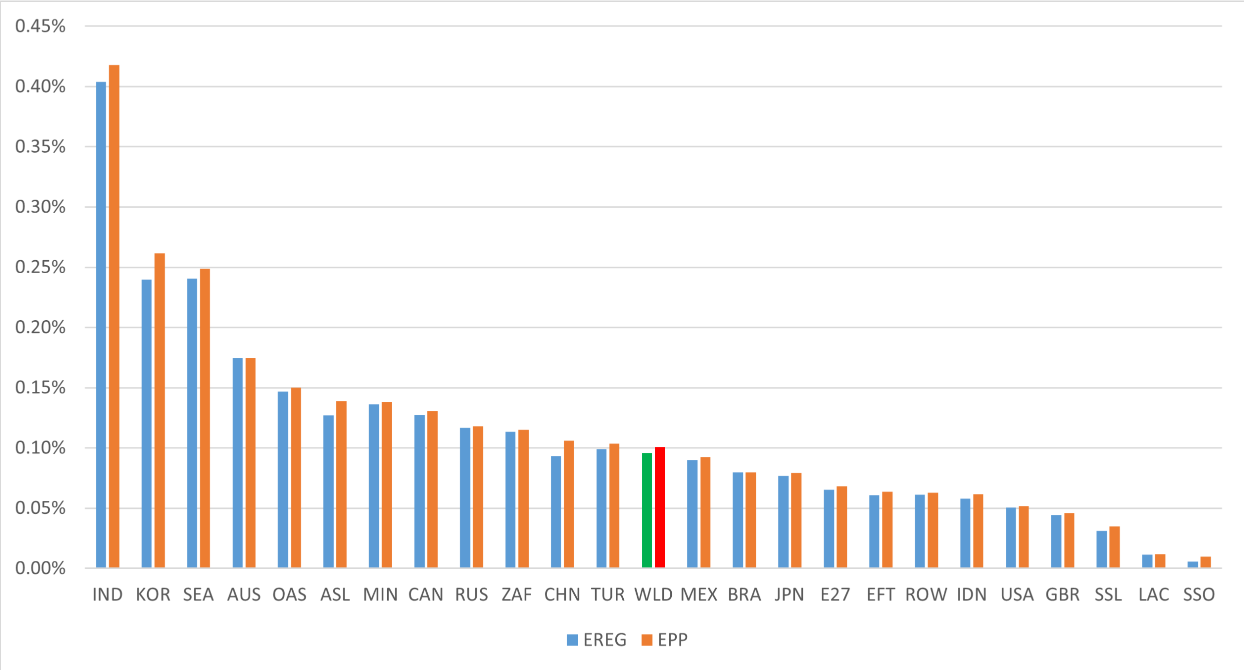
The projected per cent changes in real GDP for each of the regions in the simulations are displayed in Figure 2. The figure suggests that even the regions projected to face a fall in real exports of EREGs and EPPs because of trade diversion (as shown in Figure 1 and discussed in the previous subsection) are expected to see their real GDP increase,

Figure 1: Projected per cent change in real exports of EREG (upper panel) and EPP (lower panel) in 2030

Notes: The figure displays the projected per cent changes with the WTO Global Trade Model in exports of EREGs (upper panel) and EPPs (lower panel) with only a reduction in tariffs (blue bars) and a reduction in both tariffs and NTMs (red bars), based on the reductions displayed in Annex Tables **??** and **??**

which can be explained by three forces. First, the reduction in tariffs and NTMs reduces distortions in the economy and thus raises output. Second, NTMs are resource-wasting

Figure 2: Projected per cent change in real GDP by region



Notes: The figure displays the projected per cent changes with the WTO Global Trade Model in GDP with only tariff and NTM reductions of EREGs and both EREGs and EPPs.

regulations (modelled as iceberg trade costs) implying that reductions in NTMs operate like an increase in productivity: the costs of exporting fall because of a reduction in the resources exporters need to spend to be able to export.[17] This contributes to positive GDP effects. Third, the reduction in the price of EE/RE goods leads to an increase in energy efficiency, constituting a second positive productivity effect. The three features imply that resource efficiency and productivity are projected to increase as a result of trade liberalization in EPPs (through lower tariffs and NTMs) and in particular EREGs (through both lower iceberg trade costs and higher energy efficiency), which in turn leads to a rise in GDP.

Figure 2 makes clear that most of the projected increase in real GDP is driven by trade liberalization of EREGs with EPPs trade liberalization only contributing little. The reason is that the projected change in trade in EPPs is an order of magnitude smaller than the projected trade change of EREGs.

[17]For the products and NTMs modelled it is reasonable to assume that they are resource-wasting, because they concern mostly technical barriers to trade (TBT) type of measures which requires firms to spend extra resources to comply with them.

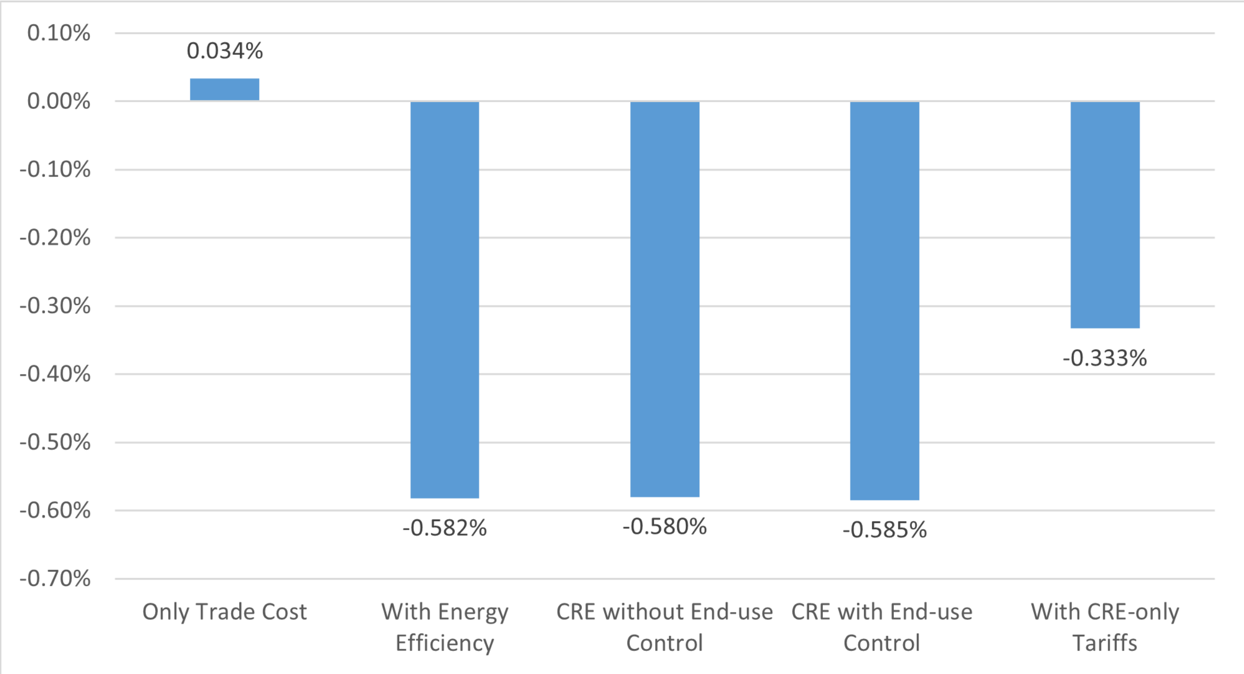
4.3 Emissions Effects

We now turn the analysis towards the projected change in emissions in the various scenarios. Figure 3 displays the projected reduction in global CO2 emissions depending on the inclusion of the channels discussed in Section 3.1. The first bar considers only the trade and GDP effects, neglecting the impact on energy efficiency and the reduced price of investment goods used in the production of electricity. As expected, this channel is projected to lead to an increase in global emissions, because lower trade costs will raise income and thus increase the demand for energy.[18] The second bar includes the energy efficiency channel, turning the effect of a potential trade liberalization in EREGs on CO2 emissions negative. The simulations indicate that emissions would fall by about 0.3% globally by 2030. Indeed, higher energy efficiency because of cheaper availability of goods employed to raise energy efficiency will reduce the use of energy by both firms and households. However, the impact on the reduction of emissions is tempered by the so-called rebound effect: higher energy efficiency will reduce the price of energy and thus increase the demand for energy leading to more emissions. The third and fourth bar include the effect of a lower price of investment goods of clean and renewable energy (CRE) goods used in the electricity sectors (captured by a productivity increase of capital use in these sectors). The third bar displays the effects without end use control and the fourth with end use control. Without end use control the productivity of capital in all electricity generating sectors rises, whereas with end use control only the productivity of electricity sectors generating electricity from renewable sources is increasing.

The simulations indicate that the last channel leads as expected to a smaller reduction in emissions without end use control and a larger reduction with end use control. With end use control, the production of electricity from renewable energy sources becomes cheaper, leading to a substitution from electricity generated from fossil fuel to electricity generated from renewable sources, thus reducing emissions. Without end use control, the production of electricity based on all sources becomes cheaper, leading to higher emissions. However, the size of this channel as well as the effect of end-use control are small.

[18]Part of the effect is also driven by increased demand for transportation services, which will generate additional emissions.

Figure 3: Projected per cent change in global CO2 emissions with different channels



Notes: The figure displays the projected per cent changes in global CO2 emissions with the WTO Global Trade Model in GDP according to the different channels included. The first bar includes only the impact of trade cost reductions. The second bar includes the energy efficiency channel. The third and fourth bar include the impact of a reduction in the price of investment goods used in electricity generating sectors because of increased imports of CRE goods. The fifth bar includes all channels (CRE with end use control), but only models a reduction in tariffs.

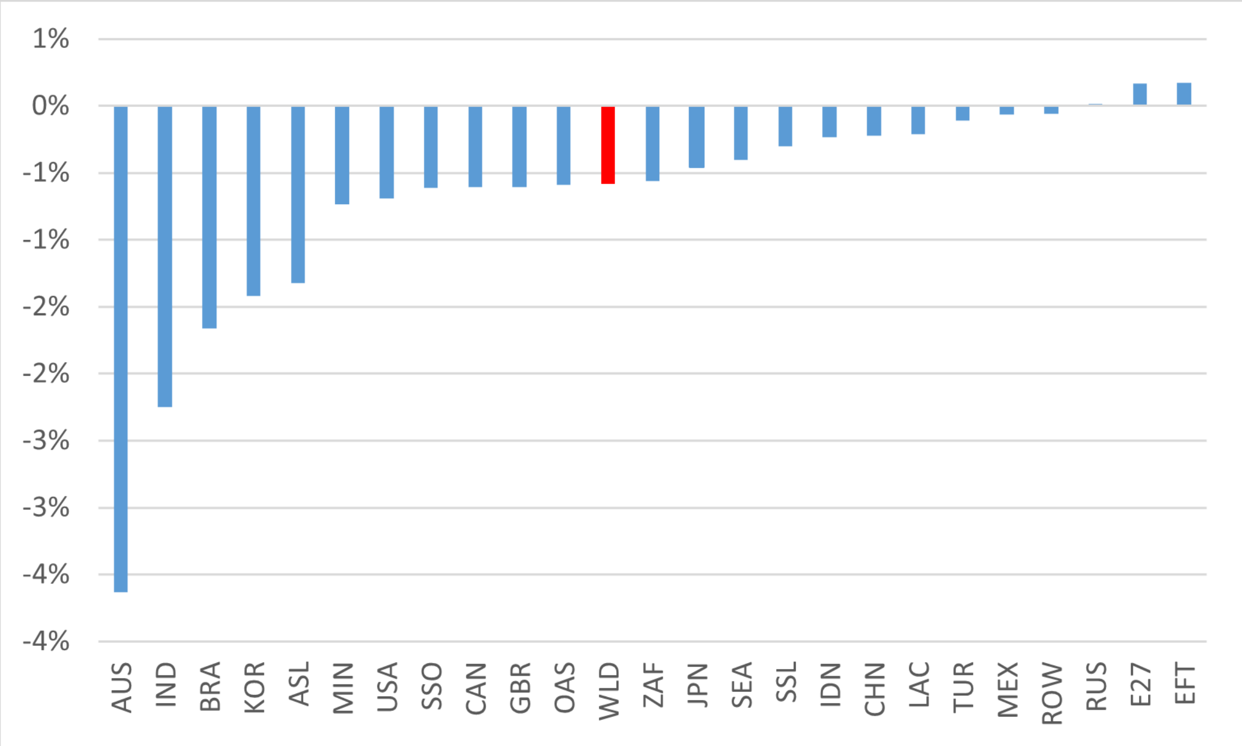
Emissions with end use control fall by about 0.003% more and without end use control they fall by about 0.003% less.[19] The fifth bar displays the effect considering all channels (i.e. lower prices of CRE goods with end-use control), but only based on tariff liberalization. The projected reduction in emissions in this scenario is about half the reduction compared to the scenario with a reduction in both tariffs and NTMs.

Finally, Figure 4 displays the projected change in emissions in the different regions in the scenario with both tariff and NTM reductions (Scenario 4). Emissions in all regions except for EFTA are projected to fall.[20] However, rather than the geographical pattern of

[19]Compared with Hu et al. (2020) the CRE channel in this study is about an order of magnitude smaller, since the projected reduction in emissions in their study is 0.12%. This can be explained by three main differences between the two approaches. First, in Hu et al. the reduction in the price of CRE goods is based on an external PE model. Second, it is assumed that the same price reduction applies for domestic goods, whereas in the current study the domestic price of CRE goods follows from simulations with the model. Second, in the current study a recursive dynamic CGE model is employed to simulate the impact on CO2 emissions, whereas Hu et al. (2020) use an energy model.

[20]The reason for the projected increase in emissions in EFTA is that in EFTA Norway is exporting a substantial share of its electricity. This implies that an improvement in energy efficiency will raise the demand for electricity thus raising emissions from production of electricity in the EFTA region. However, such inter-country substitution effects in the demand for electricity do not significantly affect the projected

Figure 4: Projected per cent change in emissions per region in tariff and NTM scenario



Notes: The figure displays the projected per cent changes in regional CO2 emissions with the WTO Global Trade Model with all the channels included (CRE with end use control).

changes in emissions, what matters for climate change mitigation is the global change in emissions.

5 Conclusion

In this paper we discussed the potential impact of trade liberalization in environmental goods on trade patterns, GDP, and emissions. Reductions in both tariffs and NTMs on two types of environmental goods, energy related environmental goods (EREGs) and environmentally preferable products (EPPs) have been simulated with the power version of the WTO Global Trade Model. The simulations project:

(i) an increase in exports of EREGs and EPPs in most regions as well as an increase in aggregate exports in all regions. (ii) a modest increase in GDP in all regions as a result of falling tariffs, NTMs, and increased energy efficiency. (iii) a modest reduction in global emissions of about 0.3

global reduction in emissions.

Emissions are expected to be affected through three different channels by a potential EGA: (1) through an increase in energy efficiency because of the increased availability and reduced prices of energy and resource efficiency goods, emissions are projected to fall; (2) through a reduction in the price of clean and renewable energy goods reducing the costs to produce electricity from renewable energy sources, emissions are expected to fall; (3) through rising income and trade, emissions are expected to increase because of a rising demand for energy. The first two effects drive down emissions and the third raises emissions. The simulations show that the first effect is much larger than the second effect and that the negative effects dominate the positive effects implying a projected reduction in emissions. The fact that the second channel is small in our projections also implies that end-use control is less important for guaranteeing a reduction in emissions because of trade liberalization in environmental goods.

However, this study comes with some limitations. Two ways in which emissions could be affected are not incorporated in the simulations. First, increased trade in environmental goods can promote the diffusion of green innovation, and second, liberalization of EPPs can lead to a shift of consumption to environmentally preferable goods with lower emissions. For the diffusion of green innovation channel end use control could be important, since technology also diffuses with trade for fossil fuel technologies. However, both channels are hard to quantify. In particular, a lack of emissions data at the detailed sectoral level makes it difficult to evaluate the emissions effects of trade in EPPs.

References

BALINEAU, G. AND J. DE MELO (2013): "Removing barriers to trade on environmental goods: an appraisal," *World Trade Review*, 12, 693–718.

BÖHRINGER, C., S. PETERSON, T. F. RUTHERFORD, J. SCHNEIDER, AND M. WINKLER (2021): "Climate policies after Paris: Pledge, Trade and Recycle: Insights from the 36th Energy Modeling Forum Study (EMF36)," *Energy Economics*, 103, 105471.

CHEPELIEV, M. (2020): "GTAP-power data base: Version 10," *Journal of Global Economic Analysis*, 5, 110–137.

DE ALWIS, J. (2014): "Environmental consequence of trade openness for environmental goods," *Sri Lankan Journal of Agricultural Economics*, 16, 79–98.

DE MELO, J. AND J.-M. SOLLEDER (2020): "Barriers to Trade in Environmental Goods: How Important they are and what should developing countries expect from their removal," *World Development*, 130, 104910.

EUROSTAT, O. (1999): "The environmental goods and services industry: Manual for data collection and analysis," .

FRANCOIS, J., M. MANCHIN, H. NORBERG, O. PINDYUK, AND P. TOMBERGER (2015): "Reducing transatlantic barriers to trade and investment: An economic assessment," Tech. rep., Working Paper.

HE, Q., H. FANG, M. WANG, AND B. PENG (2015): "Trade liberalization and trade performance of environmental goods: evidence from Asia-Pacific economic cooperation members," *Applied Economics*, 47, 3021–3039.

HU, X., H. POLLITT, J. PIRIE, J.-F. MERCURE, J. LIU, J. MENG, AND S. TAO (2020): "The impacts of the trade liberalization of environmental goods on power system and CO2 emissions," *Energy Policy*, 140, 111173.

KALIRAJAN, K. ET AL. (2016): "Export of environmental goods: India's potential and constraints," *Environment and Development Economics*, 21, 158–179.

NIMUBONA, A.-D. (2012): "Pollution policy and trade liberalization of environmental goods," *Environmental and Resource Economics*, 53, 323–346.

PORTO, M. (2018): "Free Trade Agreements and import-import substitution effect Evidence from a CGE analysis: the case of EU-Korea and EU-Japan FTAs," .

STEENBLIK, R. (2005): "Environmental goods: A comparison of the APEC and OECD lists," Tech. rep., OECD Publishing.

TAMINI, L. D. AND Z. SORGHO (2018): "Trade in environmental goods: evidences from an analysis using elasticities of trade costs," *Environmental and Resource Economics*, 70, 53–75.

TOTHOVA, M. (2005): "Liberalisation of trade in environmentally preferable products," .

VANZETTI, D., C. KNEBEL, AND R. PETERS (2018): "Non-tariff measures and regional integration in ASEAN," .

VIKHLYAEV, A. (2004): "Environmental goods and services: Defining negotiations or negotiating definitions," *J. World Trade*, 38, 93.

WAN, R., M. NAKADA, AND Y. TAKARADA (2018): "Trade liberalization in environmental goods," *Resource and Energy Economics*, 51, 44–66.

ZUGRAVU-SOILITA, N. (2018): "The impact of trade in environmental goods on pollution: what are we learning from the transition economies' experience?" *Environmental Economics and Policy Studies*, 20, 785–827.

Figures and Tables

Appendix A

1 Additional Tables

Table A-1: Percentage point changes in trade barriers full liberalization scenario (per importer)

Region	Commodity: EGA		Commodity: EPP	
	AVE Tariff Cut	AVE NTM Cut	AVE Tariff Cut	AVE NTM Cut
ASL	0.33%	1.75%	2.42%	2.50%
AUS	2.28%	1.64%	1.39%	1.63%
BRA	2.41%	1.61%	2.19%	2.35%
CAN	0.91%	1.95%	1.40%	2.23%
CHN	2.31%	1.81%	5.72%	2.34%
E27	1.10%	1.80%	1.61%	2.25%
EFT	1.24%	1.76%	2.69%	2.39%
GBR	1.35%	1.82%	2.35%	2.38%
IDN	0.86%	1.87%	2.15%	2.58%
IND	2.70%	1.75%	4.58%	2.58%
JPN	2.70%	1.59%	5.17%	2.03%
KOR	2.33%	1.57%	4.19%	2.11%
LAC	0.52%	1.67%	1.31%	2.20%
MEX	0.24%	2.02%	1.26%	2.91%
MIN	1.40%	1.76%	2.51%	2.50%
OAS	1.34%	1.62%	2.63%	2.20%
ROW	0.92%	1.71%	3.16%	2.14%
RUS	1.79%	1.56%	1.69%	1.89%
SEA	0.51%	1.69%	3.14%	2.07%
SSL	1.16%	1.55%	2.48%	2.56%
SSO	1.67%	1.43%	2.12%	2.32%
TUR	3.29%	1.70%	2.72%	2.34%
USA	1.64%	1.74%	3.24%	2.84%
ZAF	1.42%	1.58%	1.56%	1.84%
WLD	1.61%	1.74%	2.93%	2.24%

Note:

Table A-2: Percentage point changes in trade barriers full liberalization scenario (per exporter)

Region	Commodity: EGA		Commodity: EPP	
	AVE Tariff Cut	AVE NTM Cut	AVE Tariff Cut	AVE NTM Cut
ASL	5.96%	1.40%	4.58%	2.87%
AUS	2.01%	2.83%	1.30%	2.78%
BRA	11.15%	3.03%	6.17%	2.36%
CAN	0.46%	2.27%	1.06%	6.08%
CHN	2.59%	1.33%	4.82%	1.05%
E27	0.64%	1.78%	0.58%	2.24%
EFT	0.03%	1.72%	0.20%	2.46%
GBR	0.86%	2.13%	0.84%	2.48%
IDN	1.66%	0.85%	1.73%	1.82%
IND	5.90%	1.99%	15.41%	3.31%
JPN	0.12%	2.34%	1.75%	2.23%
KOR	2.36%	1.72%	12.56%	2.46%
LAC	4.27%	0.91%	2.41%	2.00%
MEX	0.59%	1.38%	1.06%	2.26%
MIN	4.32%	1.72%	3.81%	2.46%
OAS	0.91%	1.50%	1.33%	1.60%
ROW	2.81%	1.09%	2.71%	1.26%
RUS	3.27%	1.72%	4.21%	2.46%
SEA	0.90%	1.56%	1.05%	1.79%
SSL	7.14%	0.93%	12.55%	0.88%
SSO	8.64%	0.63%	7.20%	3.13%
TUR	0.37%	2.70%	1.01%	3.46%
USA	0.66%	2.10%	1.06%	3.05%
ZAF	2.04%	1.72%	1.80%	2.46%
WLD	1.61%	1.74%	2.93%	2.24%

Note:

Table A-3: Overview of region names in the model

Name	Region	Name	Region	Name	Region
ASL	Asia LDC	IDN	Indonesia	ROW	Rest of World
AUS	Australia	IND	India	RUS	Russia
BRA	Brazil	JPN	Japan	SEA	Southeast Asia
CAN	Canada	KOR	Korea	SSL	Sub-Saharan Africa LDC
CHN	China	LAC	Latin America	SSO	Sub-Saharan Africa other
E27	European Union 27	MEX	Mexico	TUR	Turkey
EFT	EFTA	MIN	Middle East and North Africa	USA	United States
GBR	Great Britain	OAS	Other Asian countries	ZAF	South Africa

Note:

Table A-4: The initial value of exports, simulated tariff reduction, and projected change in exports from Southeast Asia

Region	Exports value	Exports share	Tariff reduction	Change exports value	Change exports share
ASL	2254	1%	2%	-564	10%
AUS	2384	1%	0%	-281	5%
BRA	1846	1%	8%	-8	0%
CAN	2337	1%	0%	-31	1%
CHN	65546	26%	0%	-5231	93%
E27	27475	11%	1%	477	-8%
EFT	1082	0%	0%	1	0%
GBR	2410	1%	1%	17	0%
IDN	6347	3%	0%	-478	8%
IND	6170	2%	4%	385	-7%
JPN	10591	4%	0%	550	-10%
KOR	8789	3%	0%	-898	16%
LAC	2176	1%	5%	312	-6%
MEX	5374	2%	0%	-103	2%
MIN	7436	3%	4%	376	-7%
OAS	13325	5%	0%	-191	3%
ROW	357	0%	4%	45	-1%
RUS	910	0%	3%	67	-1%
SEA	41407	16%	0%	-1039	18%
SSL	372	0%	8%	24	0%
SSO	574	0%	9%	122	-2%
TUR	1182	0%	1%	61	-1%
USA	42171	17%	0%	704	-12%
ZAF	1026	0%	2%	30	-1%
Total	253541	100%		-5653	100%

Note: The table displays the exports by destination, the share of exports by destination, the tariff reduction in the policy experiments, and the projected change in exports by destination, in value and as a share of the total change in exports.

Table A-5: The initial value of exports, simulated tariff reduction, and projected change in exports from China

Region	Exports value	Exports share	Tariff reduction	Change exports value	Change exports share
ASL	4038	1%	6%	124	0%
AUS	14705	2%	3%	1034	2%
BRA	14067	2%	12%	5138	8%
CAN	23551	3%	1%	1476	2%
CHN	0	0%	0%	0	0%
E27	129131	18%	2%	15997	26%
EFT	6819	1%	0%	72	0%
GBR	19686	3%	2%	2018	3%
IDN	11785	2%	0%	-760	-1%
IND	25310	4%	6%	4786	8%
JPN	45916	7%	0%	1659	3%
KOR	51951	7%	3%	6809	11%
LAC	31340	4%	5%	3922	6%
MEX	36717	5%	1%	1872	3%
MIN	40824	6%	6%	6927	11%
OAS	42800	6%	0%	-1316	-2%
ROW	6994	1%	4%	894	1%
RUS	11312	2%	4%	1544	3%
SEA	83141	12%	1%	-655	-1%
SSL	5705	1%	9%	834	1%
SSO	4386	1%	10%	1149	2%
TUR	12044	2%	0%	-76	0%
USA	72456	10%	1%	6899	11%
ZAF	5766	1%	4%	895	1%
Total	700443	100%		61240	100%

Note: The table displays the exports by destination, the share of exports by destination, the tariff reduction in the policy experiments, and the projected change in exports by destination, in value and as a share of the total change in exports.

Table A-6: The initial value of imports, simulated tariff reduction, and projected change in imports to China

Region	Imports value	Imports share	Tariff reduction	Change imports value	Change imports share
ASL	318	0%	0%	-20	0%
AUS	1784	1%	4%	334	1%
BRA	934	0%	7%	494	2%
CAN	2179	1%	3%	299	1%
CHN	0	0%	0%	0	0%
E27	33509	11%	5%	9743	30%
EFT	3298	1%	4%	753	2%
GBR	1764	1%	4%	504	2%
IDN	1568	0%	0%	-155	0%
IND	1908	1%	5%	655	2%
JPN	51574	16%	4%	11060	34%
KOR	91432	29%	3%	14434	44%
LAC	1512	0%	0%	-141	0%
MEX	904	0%	3%	117	0%
MIN	2675	1%	1%	-14	0%
OAS	46156	15%	1%	-1888	-6%
ROW	706	0%	5%	209	1%
RUS	762	0%	4%	170	1%
SEA	65546	21%	0%	-5231	-16%
SSL	128	0%	0%	-12	0%
SSO	55	0%	3%	9	0%
TUR	291	0%	8%	180	1%
USA	8458	3%	3%	1106	3%
ZAF	245	0%	6%	112	0%
Total	317707	100%	0%	32721	100%

Note: The table displays the imports by source, the share of imports by source, the tariff reduction in the policy experiments, and the projected change in imports by source, in value and as a share of the total change in imports.

Table A-7: The initial value of imports, simulated tariff reduction, and projected change in imports to the EU

Region	Imports value	Imports share	Tariff reduction	Change imports value	Change imports share
ASL	179	0%	0	-8	0%
AUS	464	0%	0	54	0%
BRA	999	0%	0	211	2%
CAN	2125	0%	0	266	2%
CHN	129131	28%	0	15997	148%
E27	211887	45%	0	-8874	-82%
EFT	11784	3%	0	-523	-5%
GBR	10160	2%	0	-434	-4%
IDN	1962	0%	0	-60	-1%
IND	4492	1%	0	236	2%
JPN	10185	2%	0	1011	9%
KOR	10695	2%	0	-461	-4%
LAC	1640	0%	0	-30	0%
MEX	1156	0%	0	-41	0%
MIN	5343	1%	0	171	2%
OAS	5539	1%	0	300	3%
ROW	4895	1%	0	-149	-1%
RUS	2906	1%	0	195	2%
SEA	27475	6%	0	477	4%
SSL	165	0%	0	-7	0%
SSO	506	0%	0	-19	0%
TUR	3837	1%	0	-179	-2%
USA	18877	4%	0	2714	25%
ZAF	902	0%	0	-27	0%
Total	467303	100%		10820	100%

Note: The table displays the imports by source, the share of imports by source, the tariff reduction in the policy experiments, and the projected change in imports by source, in value and as a share of the total change in imports.

2 Econometric estimations

To obtain the elasticity of emissions with respect to trade in environmental goods, we follow the approach pioneered by Baghdadi et al. (2013). It consists in regressing the logarithm of CO2 emissions, sourced from EDGAR database, on the logarithm of the import value of environmental goods. Following Baghdadi et al. (2013) and Zugravu (2018, 2019), we use a set of control variables such as the GDP, the capital-labour ratio (K/L), the gross national income (GNI) per capita, and trade openness. Despite the combination of fixed effects and several control variables, endogeneity issues might still be present due to unobserved characteristics at country level that affect the level of emissions, other than trade in environmental goods, leading to an upward bias. Another source of endogeneity could be the reverse causality, in which case the level of emissions could affect trade in environmental goods. To deal with such issues, we instrument the GNI per capita trade in environmental goods, and trade openness by their lagged variable. Results of both OLS (column 1) and IV (column 2) regressions are presented in Table A.4. All control variables have the expected sign and are statistically significant. The coefficient of environmental goods' imports is statistically significant, negative, and close in magnitude for both regressions.

Table A-8: Estimation results EG imports on CO2 emissions

Dependant variable	ln(CO2) (OLS)	ln(CO2) (IV)
Ln(GDP)	1.313***	1.352***
	(0.043)	(0.062)
Ln(K/L)	0.565***	0.961***
	(0.036)	(0.076)
Ln(GNI per capita)	-0.805***	-1.220***
	(0.033)	(0.079)
Ln(Openness)	1.320***	1.371***
	(0.033)	(0.063)
Ln(Import EG)	-0.225***	-0.232***
	(0.039)	(0.058)
Obs	1898	1742
Adj. R2	0.895	0.885

Note:

Appendix B