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Sectoral Trade Effects of Heterogeneous Environmental Provisions in Trade Agreements: Exploring the Margins

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Abstract

The ubiquity of environmental provisions in trade agreements is well documented, but their economic effects are largely inconclusive. This article analyzes whether environmental provisions in preferential trade agreements (PTAs) have differential effects on sectoral trade. It further examines whether these effects depend on the heterogeneity of environmental provisions and exporters' level of development and quality of regulation. We exploit two fine-grained panel datasets on product-level bilateral trade flows for nearly 200 countries and 300 different types of environmental provisions contained in 775 PTAs for the period 1996 to 2021. We use a theory-consistent industry-level structural gravity model and Pseudo Maximum Likelihood estimator to estimate the trade effects of PTAs with environmental provisions. We use a three-way fixed effects approach to control for unobserved heterogeneity and potential reverse causality. Overall, we find that environmental provisions do not reduce export values and volumes, but their effects are heterogenous across sectors and exporters' income levels and regulatory quality. These effects also depend on the number and types of environmental provisions included in PTAs (i.e., design of PTAs). We also find that exporters' level of income and quality of regulation moderate the trade effects of environmental provisions. We show that the trade effects of environmental provisions are more pronounced in developing exporting countries and/or those that have weak regulatory quality. Moreover, environmental provisions affect export values through their relatively larger effects on the intensive export margin. We show that environmental provisions in PTAs can be used as targeted trade policy strategy to jointly promote economic and environmental sustainability. Our results demonstrate the importance of assessing the effects of targeted trade policies at disaggregated level to capture heterogeneity and enhance formulation of trade policies and achieve sustainable development.

Keywords: International trade; trade agreements; environmental provisions; structural gravity model; environment; trade margins

JEL Classification: F14; Q56; F18; F13

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1 Introduction

The environment features highly in recent policy discourse. This is driven by the existential threats posed by the climate crisis and other environmental problems. Currently, between 3.3 and 3.6 billion people live in areas that are extremely vulnerable to climate change and its effects (IPCC, 2022). Climate-related risks are increasing in frequency, intensity and geographic spread, yet fundamental disagreements persist—both within and between governments—on the use of trade policy and/or environmental policy to address the climate crisis. Without effective trade policies that address environmental concerns, trade can worsen climate change and other environmental problems. Trade contributes to emissions of greenhouse gases and other pollutants (Cristea et al., 2013). However, effective trade and trade policy can also be potent tools for addressing environmental challenges and promoting sustainable economic growth. Countries continue to liberalize trade to increase aggregate welfare for their citizens (Berthou et al., 2019; Busse & Koeniger, 2012; Frankel & Romer, 1999; Ramondo & Rodríguez-Clare, 2013). A widely used trade policy is the ratification of preferential trade agreements (PTAs) to deeply integrate into the world economy to enhance economic growth and reduce poverty (Blümer et al., 2020; Brandi et al., 2020; Kolcava et al., 2019). Moreover, many countries are increasingly using PTAs to address non-trade issues such as environmental protection, social and economic rights (Hofmann et al., 2017; Lechner, 2016; Morin et al., 2018). As a result, we have seen in recent times a rise of environmental provisions (EPs)[1] in preferential trade agreements (Brandi et al., 2020; Morin et al., 2018) to promote economic and environmental sustainability.

Although the ubiquity of environmental provisions in PTAs is well documented, their economic effects are contested. The inclusion of environmental provisions in PTAs is often justified as a targeted trade policy tool that promotes sustainable development, yet there is still much to be learned about the specific trade effects. Do environmental provisions in trade agreements affect a country's exports? Are these effects homogenous across sectors? Do the trade effects depend on the types of environmental provisions included in a PTA? Do these effects depend on the strength of the enforcement mechanisms included in the PTAs? Are the trade effects homogenous with respect to the exporting country's level of development or regulatory quality? How do extensive- and intensive export margins respond to the different types of environmental provisions included in PTAs? This article addresses these questions by analyzing whether environmental provisions in preferential trade agreements have differential effects on sectoral trade. It further analyzes whether these effects depend on the heterogeneity of environmental provisions included in the PTA, the strength of the PTA's dispute settlement mechanisms, the level of development and regulatory quality of the exporting country.

It is important to address these questions because the contribution of different sectors to economic growth varies across countries. Hence, targeted trade policies such as environmental provisions in PTAs might have heterogenous economic effects depending on how different sectors respond to the environmental components of the policy. It is particularly crucial in the

[1] Environmental provisions (EPs) are norms, rules, or clauses that are included in trade agreements to address or govern environment-related issues.

formulation of trade policies that promote inclusive economic growth and development as empirical evidence shows that protectionist interests can spur the inclusion of environmental provisions in PTAs (Bastiaens & Postnikov, 2017; Bechtel et al., 2012; Lechner, 2016).

While extensive empirical evidence on the environmental effects of environmental provisions in PTAs exists (e.g., Baghdadi et al., 2013; Bastiaens & Postnikov, 2017; Brandi et al., 2019; Brandi et al., 2020; Lechner, 2018; Martínez-Zarzoso & Oueslati, 2018; Sorgho & Tharakan, 2022), empirical evidence on their economic effects remains scant and mixed. On the one hand, recent research shows that including environmental provisions in PTAs affects the sectoral composition of trade flows (Brandi et al., 2020), reduces trade flows between trading partners (Berger et al., 2020), and increases investments in environmentally-friendly sectors, but reduce investments in polluting sectors (Lechner, 2018). On the other hand, Mattoo et al. (2022) find that 'deep trade agreements'[2] have larger trade-creating effects and smaller trade-diversion effects compared to shallow trade agreements.

We contribute several novelties to the existing literature. First, most previous studies examine the aggregate trade effects of environmental provisions at country-level. Although Brandi et al. (2020) analyzed the trade effects using sectoral-level merchandise data, their main focus was on composition of trade flows and did not estimate the sector-specific trade effects of environmental provisions. In contrast, we provide more nuanced empirical evidence on how different 2-digit harmonized system (HS2) sectors respond to different types of environmental provisions included in PTAs.

Second, the effects of environmental provisions in PTAs on trade outcomes are likely to be heterogeneous along different dimensions. For instance, different policies will influence trade differently. Countries at different levels of development may also be affected differently given that production and specialization patterns vary as countries develop. However, most previous studies do not examine how the heterogeneity of environmental provisions in PTAs affect trade flows. To analyze how different types of environmental provisions affect sectoral trade composition, Brandi et al. (2020) introduce a distinction between trade-restrictive and liberal environmental provisions. While trade-restrictive environmental provisions are likely to hinder trade, liberal provisions have the potential to promote trade. We adopt this classification and add a separate distinction between defensive and offensive environmental provisions.[3] Defensive provisions seek to protect nations' policy space for adopting environmental regulation whereas offensive provisions prescribe specific environmental policies and strive to harmonize environmental regulation (Blümer et al., 2020). This allows us to provide more nuanced evidence on the linkages between heterogeneity of environmental provisions in PTAs and bilateral trade flows and shed light on strategies that can enhance synergies and manage trade-offs between economic and environmental sustainability.

[2] Deep trade agreements have provisions that address a broad range of issues such as elimination of tariffs, services trade, investments, standards, public procurement, competition and intellectual property rights.

[3] See Table C1 in Appendix. It provides a list of environmental provisions and their classification into defensive, offensive, trade-restrictive, liberal, and neutral environmental provisions.

Third, different types of environmental provisions are likely to affect trade costs (i.e., fixed and variables costs) differently. Different types of environmental provisions can have distinct effects on trade margins depending on their effects on production costs, market access, and competitiveness. Extensive- and intensive margins of trade may also be affected differently by different types of environmental provisions included in PTAs. However, there are no previous studies that examine how heterogeneity of environmental provisions in PTAs affect the extensive- and intensive trade margins and how each of the two margins drives the changes in total trade values.

We exploit a consistently constructed panel dataset of bilateral trade flows at the exporter-importer-product level for around 5000 products and 200 countries from 1995 to 2022. We combine the trade dataset with an updated fine-grained dataset that contains information on almost 300 different types of environmental provisions in 775 preferential trade agreements for the period 1947 to 2021. Methodologically, we apply a theory-consistent industry-level structural gravity model to estimate the trade effects of preferential trade agreements with environmental provisions. We address endogeneity of the trade policy variables (i.e., trade agreements and the environmental provisions therein) using high-dimensional fixed effects estimation techniques for panel data. Specifically, we use three-way fixed effects approach to control for unobserved heterogeneity and potential reverse causality. In all our estimations, we use a Poisson Pseudo Maximum Likelihood (PPML) estimator to address potential inconsistencies due to heteroskedasticity in trade data. We explicitly allow for heterogenous trade effects with respect to: sector, types of environmental provisions in PTAs, strength of PTA's dispute settlement mechanisms (i.e., enforcement), and the exporting country's level of development and regulatory quality. Our identification strategy compares the change in level of exports between two trading partners due to a trade agreement that has more environmental provisions to the change in level of exports between trading partners induced by a trade agreement that has less environmental provisions.

We find that different environmental provisions have heterogenous effects across sectors and exporting country's level of development and quality of regulation. Offensive and liberal environmental provisions are associated with significant reductions in export values in the agri-food and extractive sectors while defensive and trade-restrictive environmental provisions boost export performance in the same sectors. We show that the trade effects of environmental provisions in PTA depends on the number and types of the included environmental provisions. For instance, we find that offensive environmental provisions have smaller export-reducing effects—in absolute terms—than the export-creation effect of defensive provisions. Nevertheless, the export-reducing effects induced by liberal environmental provisions outweigh the export-promoting effects induced by trade-restrictive environmental provisions. We also find that exporters' level of income and quality of regulation moderate the trade effects of environmental provisions. We show that the trade effects of environmental provisions are more pronounced in developing exporting countries and/or those that have weak governance structures. Moreover, our results show that environmental provisions affect export values by increasing more the variable costs of exporting relative to the fixed costs and that different

types of environmental provisions affect the extensive- and intensive export margins differently. For instance, we find that defensive and liberal environmental provisions are associated with significant reductions in extensive export margins while trade-restrictive provisions significantly reduce intensive export margins. Besides, we find that offensive environmental provisions are associated with significant increases and reductions in extensive- and intensive export margin, respectively.

Our findings do not support the public concerns or arguments that increased economic integration induces the 'race to the bottom', turning developing countries into 'pollution havens'. Similarly, concerns that environmental provisions in PTAs serve protectionists interests and hinder economic interests for developing countries are not supported by our findings. Instead, our results suggest that the inclusion of environmental provisions in PTAs can be used as a targeted trade policy strategy to jointly promote economic and environmental sustainability.

The remainder of this paper is organized as follows. Section 2 explains the channels or mechanisms through which environmental provisions in PTAs affect trade flows and provides necessary empirical evidence. Section 3 describes the data used and then explains our estimation and identification strategies. Section 4 presents and discusses the empirical findings. Next, it explains the robustness checks used. Section 5 details our conclusions.

2 Environmental provisions and trade: Theory and empirics

Disentangling the effects of environmental provisions in PTAs on trade is rather complex. While empirical evidence shows that, on average, PTAs increase trade among their respective members (e.g., Baier & Bergstrand, 2007; Baier et al., 2014; Egger et al., 2011; Fugazza & Nicita, 2013), the evidence is particularly scant and inconclusive for environmental provisions. Conceptually, environmental provisions in PTAs can affect trade either positively or negatively depending on the magnitudes and directions of several mechanisms that operate concurrently as well as country-specific characteristics (Anderson et al., 2018; Di Ubaldo & Gasiorek, 2022; Timini et al., 2022). In this section, we discuss the different mechanisms and how they guide the interpretation of our findings.

Environmental provisions in trade agreements can affect trade through three main channels. First, environmental provisions can diminish a country's comparative advantage emanating from either resource endowments (i.e., Factor endowment hypothesis[4]) or environmental regulations (Pollution haven hypothesis[5] (Copeland & Taylor, 1994)). Environmental provisions can reduce these sources of comparative advantage by either directly restricting

[4] Factor endowment hypothesis posits that countries where capital is relatively abundant will export capital-intensive (i.e., mostly environmentally harmful) goods. It predicts that pollution is likely to increase in relatively capital-intensive countries and decrease in countries where capital is relatively scarce.

[5] If comparative advantage arises from lax environmental regulation, Pollution haven hypothesis predicts that, as countries liberalize trade, the production of environmentally harmful goods will be relocated from countries with high income and more stringent environmental regulations to those that have low incomes and lax environmental regulation.

trade in concerned goods or increasing production costs leading to reduced competitiveness. Indeed, environmental provisions in PTAs are used as instruments for enhancing environmental diplomacy and improving environmental standards (Jinnah & Lindsay, 2016; Johnson, 2015). However, countries that have higher incomes and higher environmental standards can also use environmental provisions in PTAs to reduce foreign competition in the global economy by minimizing differences in environmental regulations (Bechtel et al., 2012; Bhagwati, 1995; George, 2014; Krugman, 1997).

Second, environmental provisions in PTAs can affect trade flows by influencing both foreign demand for and domestic supply of goods. Empirical evidence shows that, in many high-income countries, public support for addressing environmental issues in PTAs is high (Bernauer & Nguyen, 2015; Blümer et al., 2020; Esty, 2001) and countries' access to foreign markets can be restricted if they do not comply with environmental standards. Countries that sign PTAs with environmental provisions and comply with set environmental standards are viewed favorably by environment-conscious consumers in foreign markets (Limão, 2007). Thus, compliance with environmental provisions in PTAs might lead to increased trade, particularly for developing countries. On domestic supply, the Porter hypothesis asserts that environmental regulation does not undermine competitiveness but incentivizes firms to innovate resulting in improved productivity (Porter, 1991; Porter & van der Linde, 1995). Moreover, the hypothesis further posits that stringent environmental regulation can induce changes in competitive specialization (Ambec et al., 2013; Lanoie et al., 2008). As environmental provisions enhance domestic environmental regulation (Brandi et al., 2019), they can boost firm-level performance, change the compositions of goods they produce (Brandi et al., 2020), and increase exports. Indeed, Mealy and Teytelboym (2022) show that countries that have more stringent environmental policies export an extensive range and more sophisticated environmentally-friendly goods.

Third, environmental provisions can foster trade by reducing uncertainty over the government's environmental policy direction. A stable and predictable environmental regulation framework provides a conducive business environment and might attract foreign direct investments, leading to enhanced productivity and competitiveness (Miroudot & Rigo, 2022).

It is difficult to predict, a priori, the net effect of environmental provisions in preferential trade agreements on trade because it not only depends on the intricate interactions among the three impact channels or mechanisms described above, but also country- and sector-specific characteristics. The effect of environmental provisions on trade partly depends on countries' level of development. Research has shown that environmental provisions (and other non-trade provisions) have larger effects in developing than in developed countries because developing countries have lower environmental standards to begin with (Anderson et al., 2018; Brandi et al., 2020; Di Ubaldo & Gasiorek, 2022; Limão, 2007; Miroudot & Rigo, 2022; Timini et al., 2022; Urata & Okabe, 2014). Thus, the returns to meeting higher standards is higher for them. Besides, policymakers and producers in developing countries view the inclusion of environmental provisions in PTAs as disguised forms of protectionism and/or "green

imperialism" (Bastiaens & Postnikov, 2017; Bechtel et al., 2012; Bernauer & Nguyen, 2015; Blümer et al., 2020; Esty, 2001). Moreover, the contribution of different sectors (e.g., Agriculture, Manufacturing, Mining and Energy, and Services) to economic growth varies greatly across countries (Nayyar et al., 2021). While primary and secondary sectors (e.g., Agriculture, Mining and Energy) continue to drive economic growth in many developing countries, economic growth is driven by tertiary (e.g., services) and downstream secondary sector (e.g., advanced manufacturing) in most developed countries (Nayyar et al., 2021). Worse still, the Mining and Energy, Agriculture, and upstream Manufacturing sectors have some of the most polluting industries (Kanashiro, 2020) whereas the Services sector comprises industries that are generally environmentally-friendly (Nayyar et al., 2021). This implies that trade effects of environmental provisions might be heterogenous with respect to both sector and the exporting country's level of development. In the end, the size and direction of the effect remains an empirical question.

Although analyzing the general trade effects of environmental provisions is important, both economically and politically, for effective trade policy formulation, it is crucial that the governments or policymakers understand how trade in different sectors respond to different types of PTAs and the environmental provisions therein. This is even more important now because PTAs have, over time, become more complex and have rapidly increased in the number and types of environmental provisions (see Figure 1). Indeed, empirical evidence demonstrates that heterogeneity of both trade agreements (Baier et al., 2014; Brandi et al., 2020; Kohl et al., 2016; Kohl & Trojanowska, 2015; Laget et al., 2020) and environmental provision therein (Brandi et al., 2020) are also important determinants of trade effects across sectors. Therefore, we categorize environmental provisions on two fronts. First, we follow Blümer et al. (2020) and distinguish between offensive, defensive, and neutral environmental provisions. Offensive environmental provisions focus on promoting environmental standards and practices by prescribing specific environmental policies to harmonize environmental regulation to enhance competitiveness and market access[6]. Offensive environmental provisions may include such issues as: commitments to sustainable production methods, renewable energy, or specific emissions reduction targets. Defensive environmental provisions are aimed at preventing environmental degradation by imposing regulations or restrictions on certain practices and/or trade activities that degrade the environment (e.g., pollution or deforestation)[7]. cause by trade activities, such as deforestation or pollution. Good examples of such provisions include prohibiting/restricting trade of endangered species, requirements to conduct environmental impact assessments or biodiversity protection. We define neutral environmental provisions as those that are neither defensive nor offensive. For instance, the PTA signed in 2012 between the EU, Colombia, and Peru explicitly state that *"The Parties reiterate their*

[6] For instance, Article 11 of the PTA signed between the EU and Bosnia and Herzegovina in 2008 prescribes standards on *"pollution caused by heavy goods vehicles"*. Similarly, Annex 1 of the PTA signed between the USA and Jordan in the year 2000 prescribes standards for protecting the *"fragile coral reef ecosystems in the Gulf of Aqaba"*.

[7] E.g., in 2019 Bosnia and Herzegovina and Turkey signed a PTA that provides measures that allow for the *"protection of the environment as a general exception for trade in goods"*.

commitment to address global environmental challenges, in accordance with the principle of common but differentiated responsibilities".

Thereafter, we further re-categorize the environmental provisions into three distinct types: trade-restrictive, liberal, and neutral environmental provisions (Brandi et al., 2020). On the one hand, trade-restrictive environmental provisions prescribe specific measures that seek to directly prohibit/restrict trade flows that are harmful to the environment. For example, in 1996 Canada and Chile signed a trade agreement in which the two countries agreed to *"restrict exportation, importation, or transportation of hazardous waste"*. On the other hand, liberal environmental provisions prescribe specific measures to promote trade in environmentally-friendly sectors. For instance, the PTA that was signed in 2020 between United Kingdom and Kenya demands the parties *"to encourage the production of environmental goods and services"*. Again, we define neutral environmental provisions as those that are neither trade-restrictive nor liberal.

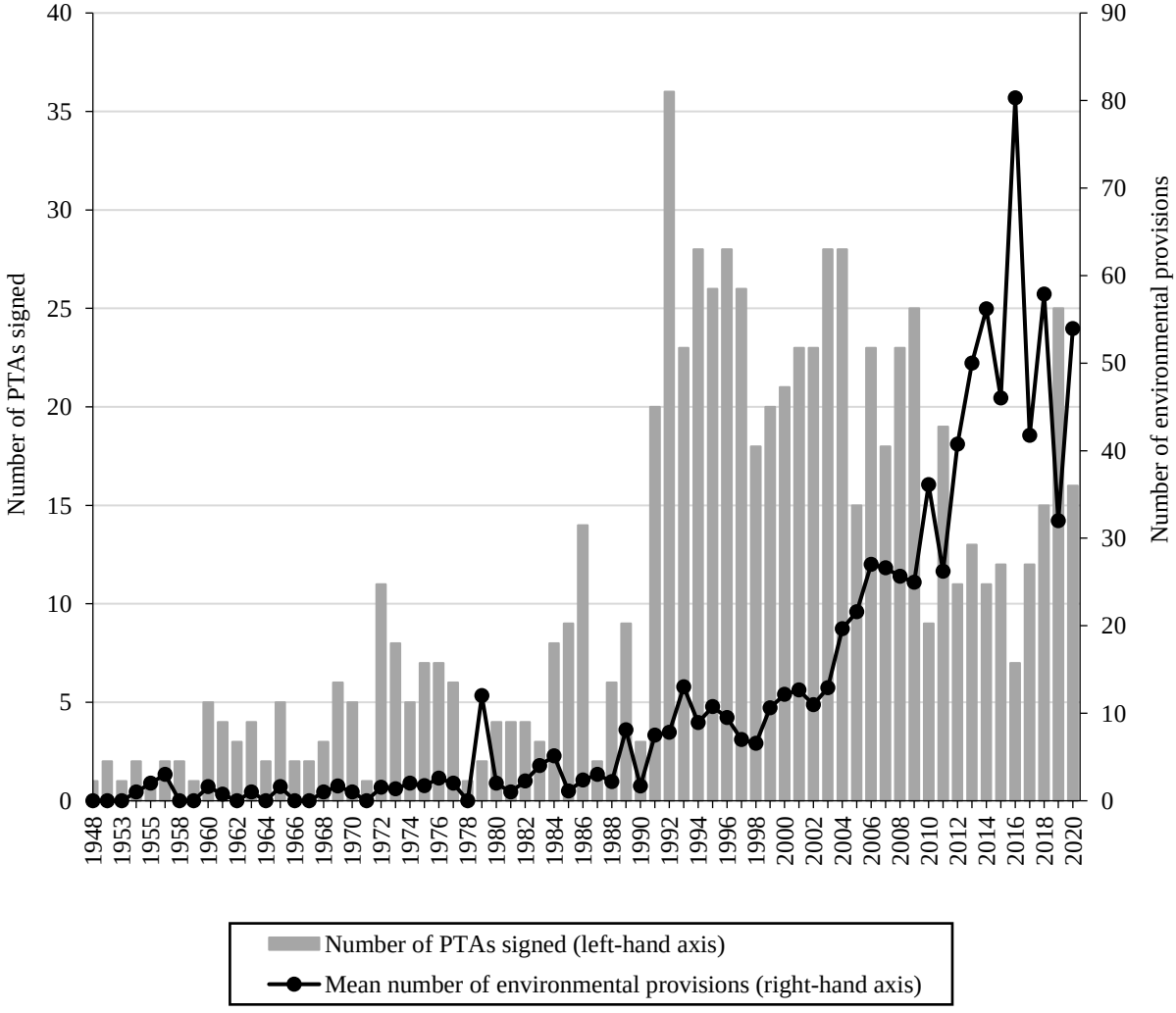

Figure 1. Trends in the average number of environmental provisions in PTAs. *Source:* Authors' elaborations based on data from TRade and ENvironment Database (TREND).

Offensive environmental provisions can affect trade in two ways. First, they can directly restrict trade flows of environmentally harmful goods. Second, offensive environmental provisions can be used to erode comparative and competitive advantages enjoyed by countries with lower environmental regulation. Offensive provisions are likely to reduce trade in polluting sectors and induce countries to shift their focus from primary and secondary sectors to tertiary sector. We believe that trade-restrictive environmental provisions are likely to have similar effects as offensive environmental provisions. We expect liberal environmental provisions to foster trade in environmentally-friendly sectors. The effects of defensive environmental provisions on trade are likely to depend on the global trade and environmental politics. Defensive provisions might provide opportunities for countries to gradually build their capacity to achieve high environmental standards without incurring huge and abrupt changes to production processes and capabilities, which might foster trade flows. However, defensive provisions might hinder trade if they are used by countries with lower environmental standards to avoid complying with offensive environmental provisions. This might trigger countries with higher environmental standards to restrict access to their markets. The net effects of the different types of environmental provisions will depend on how they influence production costs, market access, and competitiveness.

3 Data and Methods

In this section, we present our empirical approach and the data we use in our analyses. We begin by describing the datasets used the empirical analyses in section 3.1. Thereafter, we describe our empirical framework in sections 3.2 and 3.2 where we describe our estimation strategy and identification strategy, respectively.

3.1 Data

To analyze the effects of environmental provisions in preferential trade agreements on export outcomes, we exploit a panel dataset of product-level bilateral export values and volumes from the Base pour l'Analyse du Commerce International (BACI). BACI is maintained by the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) and provides consistently constructed bilateral flows data at the exporter-importer-product level for around 5000 6-digit harmonized system (HS6) products and 200 countries from 1995 to 2022 (Gaulier & Zignago, 2010). Unlike other databases (e.g., UNCOMTRADE, ITPD-E) that provide bilateral trade flows data, BACI provides consistent data because all inconsistencies in the bilateral trade flows between free on board (FOB) export values and cost, insurance, and freight (CIF) import values are reconciled and at relatively disaggregated level (i.e. 6-digit Harmonized System (HS) product-level) (Gaulier & Zignago, 2010). We aggregate bilateral exports data to the 4-digit HS industry-level. A list of all countries included in our sample as exporters or importers and their classification into either 'developed' or 'developing' countries is provided in Table A1 in the Appendix. The classification of countries into 'developed' or 'developing' and their level of regulatory quality comes from the World Bank's World Development Indicators. We classify exporting countries in our sample into 'high-income or developed' and 'low-middle-income or developing' countries based on the 2008 World Development Indicators of the

World Bank.[8] In this article, we use the high-income and low-income or developed and developing countries interchangeably. We use the regulatory quality indicator (Kaufmann et al., 2011), from the World Bank's Worldwide Governance Indicators, to proxy a country's ability to formulate, implement and regulate sound policies. The indicator ranges from -2.5 and 2.5 which we normalize[9] to range from 0 to 1 and these values indicate weak and strong governance, respectively. The mean regulatory quality in our sample is 0.656 (see Table B1 in the Appendix).

We combine the industry-level exports data with information on trade agreements signed between trading partners and the environmental provisions included in these agreements. Data on environmental provisions in trade agreements are taken from the TRade and ENvironment Database (TREND). TREND is a new fine-grained database that identifies about 300 different types of environmental provisions in 775 trade agreements signed between 1947 and 2021 (Morin et al., 2018). The main variable of interest is the maximum number of environmental provisions included in a trade agreement. The number of environmental provisions in a trade agreements reflects the concerns among partner countries regarding environmental issues (Brandi et al., 2020). The number of environmental provisions vary extensively in the sampled PTAs[10], with a median of 5 and a maximum of 134 environmental provisions. On average, the trade agreements have 16 environmental provisions (Table B1).

We also categorize environmental provisions found in the trade agreements into different types and analyze their respective trade effects. Table C1 in the Appendix contains a list of environmental provisions and their classification into different categories—i.e., defensive, offensive, trade-restrictive, liberal or neutral. First, we distinguish between defensive and offensive environmental provisions. PTAs have 4.48 defensive and 3.76 offensive environmental provisions on average (Table B1). Second, we further identify the environmental provisions that are likely to hinder trade (i.e., trade-restrictive EPs) and those that are likely to promote trade (i.e., liberal EPs) (Brandi et al., 2020). The number of both trade-restrictive and liberal environmental provisions vary widely, with a mean of 3.33 and 0.85, respectively (Table B1).

Whenever a particular country dyad has more than one trade agreement enforced in a specific year, we assume that the trade agreement that has the highest number of environmental provisions has the strongest effect and that the other trade agreements with lower numbers of

[8] Our sample covers the period between 1996 to 2020 and the year 2008 is roughly the median so we chose it to act as a basis for classifying the exporting countries into "high-income" and "low-middle-income" groups as defined by the 2008 World Development Indicators of the World Bank. Our "high-income" group comprises exporting countries that were classified as high-income countries whereas the "low-middle-income" group consists of those exporting countries that were classified as either low-income, lower-middle-income or upper-middle-income.

[9] We used the following min-max formula: $\big(\text{Observed value} - (-2.5)\big)/\big(2.5 - (-2.5)\big)$

[10] We exclude all World Trade Organization (WTO) agreements from our analyses because they include almost all countries in our trade flows sample. We assume that any trade agreement where the European Union or European Commission is party to involves all member states and the respective signatory country.

environmental provisions do not have additional effects (Brandi et al., 2020)[11]. Therefore, we use the maximum number of a particular type of environmental provisions (i.e., overall EPs, defensive, offensive, trade-restrictive, or liberal) found in a trade agreement between a specific country-pair in particular year as the main explanatory variables in our analyses.

Data on indices for depth and enforceability of trade agreements are from the Design of Trade Agreements (DESTA) database. Specifically, we exploit the 'Depth Index' that is derived using the Rasch model (Dür et al., 2014). This index relies on latent trait analysis and is derived from 49 variables (e.g., standards, liberalization of services, intellectual property rights, investment measures) that are theoretically related to the depth of a PTA. We prefer this index because it "accounts for the fact that not all variables are of equal importance in establishing the extent of countries' commitments" (Dür et al., 2014). We use maximum depth of any trade agreement between a county dyad as the measure of depth of the trade agreements between the trading partners. PTAs in our sample have a depth index ranging from -1.50 to 2.09, which we normalized[12] to range from 0 to 3.59. A lower value of the index implies that a trade agreement addresses fewer issues while a higher value indicates that more or diverse issues are concurrently addressed. We use the normalized depth index as a covariate in all estimations to ensure that we do not falsely capture the effect of depth of PTAs as the effect of environmental provisions in PTAs. In robustness checks, we use a standardized enforceability index[13] to measure the strength of dispute settlement mechanisms included in the trade agreements (Allee & Elsig, 2016; Dür et al., 2014). Again, we use the maximum enforceability index of any trade agreement between a county dyad as the measure of strength of dispute settlement mechanisms of the trade agreements. The enforceability index in our sample ranges from 0 to 5.75, with a mean of 1.95.

3.2 Estimation strategy

To assess the heterogenous trade effects of PTAs with environmental provisions, we follow Anderson and van Wincoop (2004) and Bergstrand and Egger (2007) and estimate a theory-

[11] For example, consider three countries: New Zealand, Malaysia, and Philippines. These three countries were parties to the *"Association of Southeast Asian Nations—Australia—New Zealand FTA"*, a free trade agreement (FTA) that was signed in the year 2009. This agreement contained a total of forty-five (45) environmental provisions (EPs) out of which twenty-one (21) were neutral, eleven (11) were defensive and thirteen (13) were offensive EPs. In the same year, New Zealand and Malaysia signed another bilateral FTA, the *"Malaysia—New Zealand FTA"*, which had sixty-two (62) environmental provisions that comprised twenty-nine (29) neutral EPs, thirteen (13) defensive EPs, and twenty (20) offensive EPs. In this case, we use the higher numbers (i.e., 62, 29, 13, and 20) of environmental provisions found in the *"Malaysia—New Zealand FTA"* as the representative of the New Zealand-Malaysia dyad for the year 2009. However, we use the lower numbers (i.e., 45, 21, 11, and 13) of environmental provisions found in the *"Association of Southeast Asian Nations—Australia—New Zealand FTA"* as the representative of the New Zealand-Philippines dyad in the year 2009 because this was the only trade agreement that was signed between New Zealand and the Philippines in 2009.

[12] This was accomplished by subtracting the minimum depth index value in our sample (i.e., -1.50) from each observed depth index value.

[13] The standardized enforceability index has a range of 0 to 6, inclusive. We do not use this variable in our core estimation but only as a robustness check.

consistent industry-level structural gravity model. Our core specification of the industry-level gravity equation to be estimated in this paper is:

$$Y^{h}_{ij,t} = \exp[\alpha^{h}_{0} + \alpha^{h}_{1}EP_{ij,t} + \alpha^{h}_{2}PTA_{ij,t} + \alpha^{h}_{3}Depth_{ij,t} + \pi^{h}_{i,t} + \mu^{h}_{j,t} + \omega^{h}_{ij}] \times \varepsilon^{h}_{ij,t} \quad [1]$$

where i, j, h, and t, denote exporter, importer, 4-digit HS industry category, and year, respectively; $Y^{h}_{ij,t}$ is, alternatively, annual levels of (i) export values, (ii) export volumes, (iii) extensive- and (iv) intensive export margins. $EP_{ij,t}$ captures the total number of environmental provisions in a given PTA and is the variable of interest; $PTA_{ij,t} = 1$ if countries i and j signed a trade agreement in year t and $PTA_{ij,t} = 0$ otherwise. $Depth_{ij,t}$ is the normalized depth index of a PTA. $\pi^{h}_{i,t}$, $\mu^{h}_{j,t}$, and ω^{h}_{ij} are the exporter-industry-year, importer-industry-year, and directional country-pair-industry fixed effects, respectively. $\pi^{h}_{i,t}$ and $\mu^{h}_{j,t}$ control for all country-industry-year specific variables (e.g., production, business cycles) that affect bilateral trade. These fixed effects also control for the theoretical outward and inward multilateral resistance terms which capture the fact that trade depends not only on bilateral trade barriers but also on average trade barriers across all trade partners (Anderson & van Wincoop, 2003; Bergstrand & Egger, 2007). ω^{h}_{ij} controls for the time-invariant country-pair-industry specific factors that affect bilateral trade (e.g., similarity in political or economic institutions that regulate an industry, relative production costs) or the signing of a PTA and the number of environmental provisions[14] therein (Brandi et al., 2020). Besides, the country-pair-industry fixed effects are a better measure of bilateral trade costs than a set of standard gravity variables (Bergstrand & Egger, 2007; Egger & Nigai, 2015). Moreover, the directional country-pair-industry fixed effects help address the endogeneity of trade policy variables such as PTAs and the number of environmental provisions they contain (Bergstrand & Egger, 2007). $\varepsilon^{h}_{ij,t}$ is an error term with mean zero. We cluster the errors at the exporter-importer-year level.

We gradually disentangle the 'average treatment effect' of environmental provisions in PTAs by categorizing them into different types: (i) defensive, offensive, and neutral environmental provisions; (ii) trade-restrictive, liberal, and neutral environmental provisions. Thereafter, we analyze whether the trade effects of the environmental provisions vary across (iii) two-digit harmonized system (HS2) sectors and (iv) level of development of the exporting country (i.e., 'high-income or developed' versus 'low-income or developing'). We use equation [1] as a foundation and allow for heterogenous trade effects of the different types of environmental provisions that are included in PTAs along the five dimensions. First, we count the number of defensive, offensive, and neutral environmental provisions (Blümer et al., 2020) in a trade agreement and jointly add them to equation [1] to derive estimating equation [2]:[15]

[14] Once a PTA has been signed, the number of environmental provisions does not change until the PTA is amended and ratified. The exogenous variation in the number of environmental provisions that we exploit in our identification strategy is between PTAs and not within a specific PTA over time.

[15] For a specific trade agreement and country pair in a specific year,
$Defensive\_EP_{ij,t} + Offensive\_EP_{ij,t} + Neutral\_EP_{ij,t} = EP_{ij,t}$.

$$Y_{ij,t}^{h} = \exp[\beta_0^h + \beta_1^h \text{Defensive\_EP}_{ij,t} + \beta_2^h \text{Offensive\_EP}_{ij,t} + \beta_3^h \text{Neutral\_EP}_{ij,t} + \beta_4^h \text{PTA}_{ij,t}] \times \exp[\beta_5^h \text{Depth}_{ij,t} + \pi_{i,t}^h + \mu_{j,t}^h + \omega_{ij}^h] \times \varepsilon_{ij,t}^h \quad [2]$$

$\text{Defensive\_EP}_{ij,t}$, $\text{Offensive\_EP}_{ij,t}$, and $\text{Neutral\_EP}_{ij,t}$ are the numbers of defensive, offensive, and neutral environmental provisions in a given PTA, respectively. All other variables and indices are defined as in equation [1].

We further categorize environmental provisions into those that neither hinder nor promote trade (i.e., neutral EPs), those that hinder trade (i.e., trade-restrictive EPs) and those that promote trade (i.e., liberal EPs) (Brandi et al., 2020). We then assess how the inclusion of these types of environmental provisions in trade agreements affect trade outcomes. Again, we count the number of each type of environmental provisions in a trade agreement and jointly add them to equation [1] to derive estimating equation [3]:[16]

$$Y_{ij,t}^{h} = \exp[\gamma_0^h + \gamma_1^h \text{Restrictive\_EP}_{ij,t} + \gamma_2^h \text{Liberal\_EP}_{ij,t} + \gamma_3^h \text{Neutral\_EP}_{ij,t} + \gamma_4^h \text{PTA}_{ij,t}] \times \exp[\gamma_5^h \text{Depth}_{ij,t} + \pi_{i,t}^h + \mu_{j,t}^h + \omega_{ij}^h] \times \varepsilon_{ij,t}^h \quad [3]$$

Here, $\text{Restrictive\_EP}_{ij,t}$ is the number of trade-restrictive environmental provisions while $\text{Liberal\_EP}_{ij,t}$ is the number of liberal environmental provisions in a particular PTA. All the remaining variables and indices are defined as in equation [1].

We then investigate whether the trade effects of environmental provisions in trade agreements vary across two-digit harmonized system (HS2) sectors. To do this, we group the ninety-six HS2 sectors into twenty-one sectors following the standard section naming developed by the World Trade Organization[17] (see Table D1 in the Appendix) and then re-estimate equations [1] to [3] based on data for the 4-digit HS industries within each sector.

We further investigate whether the trade effects of environmental provisions in trade agreements depend on the level of development of the exporting country. Here, we create a dummy variable (Dev_i) that take a value of 1 for all exporting countries that are classified as 'high-income or developed' and a value of zero for all exporting countries that were categorized as either low-income, lower-middle-income or upper-middle-income (see Section 3.1). We then interact this dummy variable (i.e., Dev_i) with each of the environmental provisions-related variables (i.e., $\text{EP}_{ij,t}$, $\text{Defensive\_EP}_{ij,t}$, $\text{Offensive\_EP}_{ij,t}$ $\text{Neutral\_EP}_{ij,t}$, $\text{Restrictive\_EP}_{ij,t}$, and $\text{Liberal\_EP}_{ij,t}$) and add the relevant interaction variables to equations [1] to [3] and re-estimate them on our full sample.

[16] Similarly, for a specific trade agreement and country pair in a specific year, $\text{Restrictive\_EP}_{ij,t} + \text{Liberal\_EP}_{ij,t} + \text{Neutral\_EP}_{ij,t} = \text{EP}_{ij,t}$. However, it does not mean that $\text{Neutral\_EP}_{ij,t}$ in equation [3] equals $\text{Neutral\_EP}_{ij,t}$ in equation [2] because, by definition, the two variables capture different types of environmental provisions.

[17] Accessible at https://www.wto.org/english/tratop_e/safeg_e/safeg_statindex_e.htm

Theoretically, raising the standard of regulations can boost a country's productivity and export performance by improving product quality and reducing production costs (Cebula & Clark, 2014; Iwanow & Kirkpatrick, 2007). Conversely, if more regulation is required due to higher regulatory quality, it could make compliance more expensive. Thus, it is an empirical question to determine whether increased regulatory quality results in a net increase or decrease in trade performance. Therefore, we examine whether the trade effects of environmental provisions depend on the quality of regulation in an exporting country. To achieve this, we interact the regulatory quality variable (i.e., Reg_i) with each of the environmental provisions-related variables and add the relevant interaction variables to equations [1] to [3] and re-estimate them on our full sample.

After examining the heterogenous trade effects of environmental provisions in PTAs, we analyze whether environmental provisions in trade agreements affect the extensive- and intensive margins of trade. We theorize that the inclusion of environmental provisions in trade agreements may increase both the fixed and variable costs of traders in the exporting countries, hence negatively affecting both the extensive- and intensive margins (Scoppola et al., 2018). We follow the decomposition of trade into extensive- and intensive margins that was proposed by Feenstra (1994) and further developed by Hummels and Klenow (2005) and Feenstra and Kee (2008). This decomposition has two key advantages. First, the two indices are theoretically-grounded and are not only consistent with the consumer price theory but can also be derived by exploiting the property of constant elasticity of substitution utility function (Feenstra, 1994; Scoppola et al., 2018). Second, the decomposition factors in the economic weight of the products.[18] We calculate the sectoral-level bilateral extensive export margin using equation [4] below:

$$EM_{ijh,t} = \frac{\sum_{h \in P^{s}_{ij,t}} \overline{V}^{s}_{jW,h}}{\sum_{h \in P^{s}_{jW}} \overline{V}^{s}_{jW,h}} \qquad [4]$$

where i, j, s, t, and h denote, respectively, exporter, importer, 2-digit HS sector group, year, and 4-digit HS industry category within sector s. $P^{s}_{ij,t}$ is the exporting country i's set of categories, within sector s, exported to importing country j in year t. P^{s}_{jW} is the world's (W) set of industry categories exported to country j over all the years under consideration within the same sector s, whereas $\overline{V}^{s}_{jW,h}$ is the mean value of all world's exports to country j of the 4-digit HS category h over all the years under consideration.

We further calculate the sectoral-level bilateral intensive export margin as follows:

$$IM_{ijh,t} = \frac{\sum_{h \in P^{s}_{ij,t}} \overline{V}^{s}_{ijh,t}}{\sum_{h \in P^{s}_{ij,t}} \overline{V}^{s}_{jW,h}} \qquad [5]$$

[18] Although simple direct approaches to decomposing trade margins (e.g., counting number of products exported within a specific industry/sector as a measure of the extensive margin) are transparent, they implicitly assume that products have equal economic weight and this could be flawed.

Here, $\overline{V}^{s}_{ijh,t}$ is the value of country i's exports of 4-digit HS industry category h to importing country j in year t. All other variables and indices are defined as in equation [4].

After calculating the extensive- and intensive margins using equations [4] and [5], we re-estimate equation [1] to equation [3] using the extensive- and intensive margins as the outcome variables, respectively. As a robustness check, we follow Bernard et al. (2007) and Fiankor et al. (2023) and decompose country i's total exports value to importing country j in sector s and year t as a product of (i) the number of six-digit HS (HS6) product categories exported per sector, and (ii) the average export value per sector. In this case, we define the extensive margin as the number HS6 product categories exported per sector while the intensive margin is measured as average export value per sector. In all our estimations related to export margins, the fixed effects are of the form: (i) exporter-sector-year, (ii) importer-sector-year, and (iii) exporter-importer-sector.

We estimate equation [1] to equation [3] using Poisson Pseudo Maximum Likelihood (PPML) estimator to address potential inconsistencies due to heteroskedasticity (Borchert et al., 2022; Larch et al., 2019; Silva & Tenreyro, 2006). Moreover, we cluster all standard errors at exporter-importer-year level to account for the possibility that country pairs are subject to idiosyncratic, correlated shocks (Brandi et al., 2020) and potential intertemporal dependence due to strong inertia in bilateral trade relationships (Egger & Pfaffermayr, 2011; Egger & Tarlea, 2015).

3.3 Identification strategy

Estimating equation [1] to equation [3] would pose no particular problem if the error terms were orthogonal to the included regressors in each equation. In practice, however, endogeneity problems plague the analysis of the effects of trade policies using the gravity models. A well-known problem in the international trade literature is the endogenous selection into signing of trade agreements and the inclusion of environmental provisions (Brandi et al., 2020; Martínez-Zarzoso & Oueslati, 2018). In this context, an endogenous matching problem could arise because countries that have existing trade relationships are more likely to sign trade agreements. Besides, the signing of trade agreements that contain environmental provisions is more likely to occur among trading partners that have environmental concerns.

We exploit the dyadic panel structure of our data and use three-way fixed effects approach to address several sources of endogeneity. We use the exporter-industry- and importer-industry-time fixed effects to control for all time-varying country- industry-specific factors (e.g., sectoral value added) that are correlated with both trade levels and environmental provisions (Brandi et al., 2020). We also use directional country-pair-industry fixed effects to capture all time-invariant country-pair-industry specific factors (e.g., comparative advantage, similarity in political or economic institutions) that affect countries' propensity to sign a trade agreement and the inclusion of environmental provisions which also influences the intensity of trade between the trading partners. Indeed, empirical international trade literature shows that directional country-pair-industry fixed effects help address the endogeneity of trade policy

variables such as membership to preferential trade agreements (Bergstrand & Egger, 2007; Yotov et al., 2016). Our identification strategy compares the change in level of exports between two trading partners in a given industry due to a trade agreement that has more environmental provisions to the change in level of exports between trading partners induced by a trade agreement that has less environmental provisions.

4 Results and discussion

We present and discuss the results of our empirical analysis in this section. We begin by discussing our baseline findings in section 4.1, before analyzing whether environmental provisions have heterogenous effects across 2-digit HS sectors, exporting countries' income levels, and regulatory quality in sections 4.2, 4.3 and 4.4, respectively. In section 4.5, we offer further insights into our main findings by decomposing the effects of environmental provisions on export values into extensive- and intensive export margins. We then subject our main findings to a series of robustness checks in section 4.6.

4.1 Effects of environmental provisions on export values and volumes

Table 1 presents our main results of estimating the trade effects of including environmental provisions in PTAs and the core findings are presented in columns (1) and (2). We find that environmental provisions are associated with small decreases in export values and increases in export volumes, although the coefficients present high standard errors and are not statistically significant at conventional levels. Specifically, an additional environmental provision in a PTA is associated with a 0.01% decrease in export values and a 0.01% increase in export volumes.[19] Thus, the annual trade losses associated with an additional environmental provision ranges from a mean of US$400 to a maximum of US$8.5 million in export values; whereas the gains range from a mean of 0.3 metric tons to a maximum of 72,000 metric tons in export volumes.[20]

The positive direct effect of environmental provisions on export volumes implies that the demand effect it induces outweighs the supply effect. A likely explanation is that countries that sign PTAs with environmental provisions and comply with set environmental standards benefit from positive reputation effects (Pal & Hilbe, 2022). Countries that sign PTAs with environmental provisions and comply with the set environmental standards are viewed favorably by environment-conscious consumers in foreign markets (Bernauer & Nguyen, 2015; Blümer et al., 2020; Esty, 2001; Limão, 2007) which might lead to increased trade. These results could also be suggestive of the Porter hypothesis that increased environmental regulation through environmental provisions incentives firms in exporting countries to innovate and improve productivity (Porter, 1991; Porter & van der Linde, 1995) and export more in all sectors.

[19] $[\exp(-0.0001) - 1] \times 100\% = -0.01\%$

[20] Using the summary statistics in Table B1 in the Appendix, we calculate annual reductions in export values as: 0.0001 × US$0.004 billion = US$400 and 0.0001 × US$85 billion = US$8.5 million; (ii) export volumes 0.0001 × US$0.003 million metric tons = 0.3 metric tons and 0.0001 × US$720 million metric tons = 72,000 metric tons.

The effects of environmental provisions on trade flows partly depend on the different types of environmental provisions included in PTAs (Blümer et al., 2020; Brandi et al., 2020). To assess whether heterogeneity of environmental provisions in PTAs matters for trade flows, we categorize the environmental provisions included in a PTA into defensive, offensive, and neutral. The results are presented in columns (3) and (4) in Table 1. We find that different types of environmental provisions have different trade effects and that the effects of defensive and offensive environmental provisions on export performance go in the opposite directions. While defensive environmental provisions significantly increase both export values and volumes, offensive environmental provisions significantly reduce them. A possible explanation is that meeting higher levels of environmental standards imposed by offensive environmental provisions increases production costs more compared to defensive environmental provisions. Thus, the negative supply effect induced by offensive environmental provisions outweighs the positive demand effect and the opposite holds for defensive environmental provisions. We further observe that defensive environmental provisions have larger effects (in absolute terms) than offensive environmental provisions regardless of the trade outcome. On average, increasing the mean number of offensive environmental provisions in PTAs from 4 to 5 is associated with reductions in export values and volumes of 0.57% and 0.77%, respectively while the same increment in the mean number of defensive provisions increases export values and volumes by 0.64% and 0.97%, respectively.

We further categorize the environmental provisions included in PTAs based on whether they restrict trade in environmentally harmful products (i.e., trade-restrictive), promote trade in environmentally friendly products (i.e., liberal) or neither hinder nor foster trade (i.e., neutral). The results are presented in columns (5) and (6) in Table 1. We find that trade-restrictive environmental provisions are associated with statistically and economically significant increases in both export values and export volumes. Specifically, increasing the mean number of trade-restrictive environmental provisions in PTAs from 3 to 4 increases export values and volumes by 1% to 1.68%, respectively. We further observe that liberal environmental provisions significantly reduce export values (2.61%) and volumes (2.56%) while neutral environmental provisions have neither statistically nor economically significant effect on both export values and volumes. Our results are consistent with the findings of Brandi et al. (2020) who found that trade-restrictive environmental provisions increase exports but significantly reduce the share of dirty goods in exports from developing countries. They also show that both liberal and neutral environmental provisions have trade-reducing effects but these effects are neither statistically nor economically significant.

As expected, we find that PTAs have economically and statistically significant trade-creation effects. On average, PTAs increase export values by 3.07% – 3.63% (columns (1), (3), and (5) in Table 1) and export volumes by 3.90% – 4.61% (columns (2), (4), and (6) in Table 1). Consistent with Brandi et al. (2020), we find that deep PTAs significantly reduce both export values and volumes. However, other studies (e.g., Baier et al., 2014; Dür et al., 2014; Martínez-Zarzoso & Chelala, 2021; Mattoo et al., 2022) show that deep trade agreements have more trade-creation and less trade-diversion effects than shallow agreements.

Table 1: Effects of environmental provisions on export values and volumes

Dependent variable	Specification 1		Specification 2		Specification 3	
	Values	Volumes	Values	Volumes	Values	Volumes
	(1)	(2)	(3)	(4)	(5)	(6)
$EP_{ij,t}$	-0.0001	0.0001				
	(0.0001)	(0.0003)				
$Neutral\_EP_{ij,t}$			0.0015*	0.0019	-0.0007	-0.0024
			(0.0009)	(0.0024)	(0.0006)	(0.0015)
$Defensive\_EP_{ij,t}$			0.0064***	0.0097***		
			(0.0013)	(0.0031)		
$Offensive\_EP_{ij,t}$			-0.0057***	-0.0077**		
			(0.0011)	(0.0030)		
$Restrictive\_EP_{ij,t}$					0.0100***	0.0168***
					(0.0020)	(0.0055)
$Liberal\_EP_{ij,t}$					-0.0261***	-0.0256**
					(0.0050)	(0.0109)
$PTA_{ij,t}$	0.0363***	0.0461**	0.0307***	0.0390**	0.0356***	0.0452**
	(0.0096)	(0.0196)	(0.0096)	(0.0198)	(0.0096)	(0.0197)
$Depth_{ij,t}$	-0.0129***	-0.0247**	-0.0205***	-0.0362***	-0.0095**	-0.0264**
	(0.0043)	(0.0107)	(0.0046)	(0.0111)	(0.0043)	(0.0108)
Exporter-industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer- industry-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-importer-industry FE	Yes	Yes	Yes	Yes	Yes	Yes
N	42,400,661	42,400,661	42,400,661	42,400,661	42,400,661	42,400,661

Notes: The dependent variable in columns (1), (3), and (5) is the industry-level annual export values while in columns (2), (4), and (6) is the industry-level annual export volumes. $PTA_{ij,t}$ is a dummy variable that indicates the presence or absence of a preferential trade agreement (PTA) between exporting country i and importing country j in in year t. $PTA_{ij,t} = 1$ if countries i and j signed a trade agreement in year t and $PTA_{ij,t} = 0$ otherwise. $EP_{ij,t}$ is the total number of environmental provisions in the PTA. $Neutral\_EP_{ij,t}$, $Defensive\_EP_{ij,t}$, $Offensive\_EP_{ij,t}$, $Restrictive\_EP_{ij,t}$, and $Liberal\_EP_{ij,t}$ are, respectively, the numbers of neutral, defensive, offensive, trade-restrictive, and liberal environmental provisions included in the PTA. $Depth_{ij,t}$ is the normalized depth index. Robust standard errors are in parentheses. The standard errors are clustered at the exporter-importer-year level. ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercepts and fixed effects (FE) included but not reported for brevity. All models are estimated using Poisson Pseudo Maximum Likelihood (PPML).

Overall, our results in Table 1 indicate that the inclusion of environmental provisions in PTAs does not undermine the trade-creation effects of PTAs. This is consistent with the findings of Brandi et al. (2020) who find neither statistically nor economically significant effect of environmental provisions on trade based on gravity estimations using annual country-level exports data. These results are also similar to those of Santeramo et al. (2023) who find that the effects of environmental measures on trade values and volumes tend to be positive. Moreover, these results demonstrate that the design of trade agreements (i.e., heterogeneity of environmental provisions) matters for the achievement of the desired policy objectives. Given that different types of environmental provisions have different trade outcomes and that the overall average trade effect depends on the size and direction of the trade effects of the different types of environmental in PTAs, we focus the rest of our discussion on the heterogenous trade effects of environmental provisions on export values and relegate the results on export volumes to Appendix F.

4.2 Sector-specific effects

The overall trade effects of environmental provisions in an exporting country also depend on how different sectors respond to the heterogeneity of environmental provisions in PTAs. Countries that are service-based (e.g., Switzerland, United Kingdom) are likely to respond differently to different types of environmental provisions compared to agrarian countries (e.g., Ethiopia, Laos). To analyze how different sectors respond to different types of environmental provisions included in PTAs, we re-estimate equations [1] and [3] on sector-specific subsamples in our dataset. The HS2 sector-specific findings are presented in Tables 2 and 3. The estimates in column (1), Table 2, show that the overall effect of environmental provisions on export values varies across sectors. We observe that environmental provisions promote export performance in sectors such as leather, paper, textile, footwear, and metals and hinder exports in minerals.

We find that different sectors are affected differently by the different types of environmental provisions. The results in Table 2, columns (5) and (7), show that defensive environmental provisions are associated with export-increasing effects across most HS2 sector groups while offensive environmental provisions reduce exports. Specifically, we observe that defensive environmental provisions significantly increase export values in HS2 sector groups such as animals, fats, minerals, plastics, paper, textile, stone cement, metals, and machinery and reduce export values in vegetables. Moreover, we observe that most of these sectors are also negatively affected by offensive environmental provisions. Our findings on export-reducing effects of offensive environmental provisions in the agri-food sectors are consistent with those of Fontagné et al. (2005) who found negative effects of environmental measures on food trade. On the one hand, this implies that the inclusion of offensive environmental provisions in PTAs might have detrimental effects on trade in the agri-food and extractive sectors hence countries that largely trade in products from these sectors are likely to be negatively affected. On the other hand, the results suggest that the inclusion of offensive environmental provisions in PTAs can be used as a targeted trade policy strategy to promote environmental sustainability in cases where trade in primary and secondary sectors (e.g., agriculture, mining and energy, and manufacturing) produces harmful environmental outcomes.

Table 2: Sector-specific effects of defensive and offensive environmental provisions on export values

2-digit HS group	$EP_{ij,t}$		Neutral_$EP_{ij,t}$		Defensive_$EP_{ij,t}$		Offensive_$EP_{ij,t}$		N
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Animals	0.0003	0.0003	0.0038	0.0024	0.0083**	0.0035	-0.0086***	0.0032	865,791
Vegetables	0.0000	0.0003	0.0054***	0.0021	-0.0079**	0.0031	-0.0021	0.0026	1,935,085
Fats	-0.0003	0.0007	-0.0048	0.0050	0.0152**	0.0076	-0.0037	0.0067	348,697
Prepared foods	0.0003*	0.0002	0.0030**	0.0013	0.0008	0.0022	-0.0033*	0.0017	2,067,097
Minerals	-0.0014***	0.0005	-0.0034	0.0043	0.0139***	0.0047	-0.0076	0.0058	878,902
Chemicals	0.0001	0.0002	0.0014	0.0018	0.0029	0.0022	-0.0032	0.0022	5,030,791
Plastics	-0.0003*	0.0002	0.0023*	0.0013	0.0066**	0.0026	-0.0076***	0.0016	2,257,644
Leather	0.0012***	0.0005	0.0041	0.0029	0.0003	0.0053	-0.0021	0.0040	522,977
Wood	-0.0002	0.0003	0.0049*	0.0026	0.0005	0.0045	-0.0070**	0.0032	872,579
Paper	0.0005**	0.0002	0.0024	0.0016	0.0139***	0.0024	-0.0095***	0.0021	1,618,924
Textile	0.0012***	0.0003	-0.0026	0.0022	0.0104***	0.0037	0.0004	0.0027	5,271,774
Footwear	0.0038***	0.0007	0.0016	0.0051	0.0001	0.0081	0.0088	0.0055	782,580
Stone cement	0.0002	0.0002	0.0043***	0.0015	0.0068**	0.0029	-0.0089***	0.0019	1,731,542
Precious	-0.0004	0.0009	-0.0213***	0.0071	-0.0013	0.0139	0.0246***	0.0094	293,063
Metals	0.0007***	0.0002	-0.0017	0.0014	0.0110***	0.0024	-0.0025	0.0018	5,028,544
Machinery	0.0001	0.0002	0.0047***	0.0013	0.0053**	0.0025	-0.0086***	0.0017	7,713,111
Vehicles	-0.0004	0.0003	0.0073**	0.0028	0.0049	0.0034	-0.0127***	0.0035	1,089,668
Instruments	0.0000	0.0002	0.0008	0.0014	-0.0013	0.0023	-0.0001	0.0019	2,278,597
Arms	-0.0014*	0.0008	-0.0180**	0.0075	-0.0120	0.0118	0.0257***	0.0094	104,547
Miscellaneous	0.0002	0.0003	0.0022	0.0022	0.0006	0.0050	-0.0025	0.0029	1,579,322
Art	-0.0005	0.0008	0.0130*	0.007	-0.0010	0.013	-0.0164	0.0109	129,426

Notes: The dependent variable is sectoral-level annual bilateral export values. All models are estimated using Poisson Pseudo Maximum Likelihood (PPML). ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercepts and fixed effects (FE) included but not reported for brevity. Neutral_$EP_{ij,t}$, Defensive_$EP_{ij,t}$, and Offensive_$EP_{ij,t}$, are, respectively, the numbers of neutral, defensive and offensive environmental provisions included in a PTA. $EP_{ij,t}$, is the total number of all environmental provisions in a PTA. SE are robust standard errors—clustered at the exporter-importer-year level. All other controls are included but not reported for brevity. Animals comprises HS:01, HS:02, HS:03, HS:04, HS:05; Vegetables comprises HS:06, HS:07, HS:08, HS:09, HS:10, HS:11, HS:12, HS:13, HS:14; Fats comprises HS:15; Prepared foods comprises HS:16, HS:17, HS:18, HS:19, HS:20, HS:21, HS:22, HS:23, HS:24; Minerals comprises HS:25, HS:26, HS:27; Chemicals comprises HS:28, HS:29, HS:30, HS:31, HS:32, HS:33, HS:34, HS:35, HS:36, HS:37, HS:38; Plastics comprises HS:39, HS:40; Leather comprises HS:41, HS:42, HS:43; Wood comprises HS:44, HS:45, HS:46; Paper comprises HS:47, HS:48, HS:49; Textile comprises HS:50, HS:51, HS:52, HS:53, HS:54, HS:55, HS:56, HS:57, HS:58, HS:59, HS:60, HS:61, HS:62, HS:63; Footwear comprises HS:64, HS:65, HS:66, HS:67; Stone cement comprises HS:68, HS:69, HS:70; Precious comprises HS:71; Metals comprises HS:72, HS:73, HS:74, HS:75, HS:76, HS:78, HS:79, HS:80, HS:81, HS:82, HS:83; Machinery comprises HS:84, HS:85; Vehicles comprises HS:86, HS:87, HS:88, HS:89; Instruments comprises HS:90, HS:91, HS:92; Arms comprises HS:93; Miscellaneous comprises HS:94, HS:95, HS:96; and Art comprises HS:97.

In Table 3, column (3) we observe that trade-restrictive environmental provisions have export-promotion effects in several sectors. Export values in sectors such as minerals, chemicals, plastics, paper, textile, metals, and vehicles are significantly positively affected by trade-restrictive environmental provisions. Moreover, trade-restrictive environmental provisions are associated with reductions in export values in vegetable and leather sectors. We further find that liberal environmental provisions are associated with reduced export performance in the mineral, paper, precious metals, and vehicles sectors and increase export values in the leather sector (Table 3, column (5)). Our results on the export-reducing effects of trade-restrictive and liberal environmental provisions could be worrisome to the governments or policymakers in developing countries whose export baskets are dominated by agri-food products and/or products from extractive sectors. Such countries are likely to be negatively affected by trade-restrictive and liberal environmental provisions. However, given that the inclusion of trade-restrictive environmental provisions in PTAs seeks to hinder trade in the environmentally-unfriendly sectors/products while liberal environmental provisions promote trade in environmentally-friendly sectors/products, these results demonstrate the potential of using such targeted policy instruments to promote environmental sustainability in specific sectors of concern.

Put together, our findings presented in Tables 2 and 3 consistently demonstrate that offensive, trade-restrictive, and liberal environmental provisions have export-reducing effects in agri-food and extractive sectors. This is likely to be of concern to the governments or policymakers in developing countries who strive to grow their economies to reduce food insecurity and poverty without increasing their environmental footprints. This may heighten the arguments or public concerns in developing economies that the inclusion of environmental provisions in PTAs is a disguised form of protectionism and/or green imperialism (Bastiaens & Postnikov, 2017; Bechtel et al., 2012; Bernauer & Nguyen, 2015; Esty, 2001). However, given that the inclusion environmental provisions in PTAs aims at mitigating the negative effects of trade on the environment and promoting environmental sustainability, these results reaffirm the potential of using targeted trade policy to address non-trade issues such as environmental degradation. Environmental provisions can counter the ‘race to the bottom’ and prevent ‘pollution havens’ in developing countries.

Table 3: Sector-specific effects of trade-restrictive and liberal environmental provisions on export values

2-digit HS group	Neutral_EP$_{ij,t}$		Restrictive_EP$_{ij,t}$		Liberal_EP$_{ij,t}$		N
	Coefficient	SE	Coefficient	SE	Coefficient	SE	
	(1)	(2)	(3)	(4)	(5)	(6)	
Animals	-0.0010	0.0015	0.0061	0.0054	-0.0049	0.0125	865,791
Vegetables	0.0014	0.0014	-0.0091**	0.0042	0.0149	0.0123	1,935,085
Fats	-0.0075*	0.0043	0.0194*	0.0106	0.0159	0.0333	348,697
Prepared foods	0.0001	0.0009	0.0028	0.0029	-0.0058	0.0078	2,067,097
Minerals	-0.0036*	0.0022	0.0251***	0.0063	-0.0607***	0.0167	878,902
Chemicals	-0.0009	0.0011	0.0064**	0.0031	-0.0103	0.0092	5,030,791
Plastics	-0.0033***	0.0011	0.0130***	0.0035	-0.0102	0.0078	2,257,644
Leather	0.0033	0.0024	-0.0244**	0.0102	0.0670***	0.0230	522,977
Wood	-0.0016	0.0019	0.0068	0.0068	-0.0075	0.016	872,579
Paper	-0.0011	0.0011	0.0122***	0.0034	-0.0205**	0.0100	1,618,924
Textile	-0.0021	0.0015	0.0139***	0.0051	-0.0031	0.0127	5,271,774
Footwear	0.0009	0.0032	0.0081	0.0121	0.0244	0.0327	782,580
Stone cement	-0.0005	0.0012	0.0058	0.0036	-0.0114	0.0093	1,731,542
Precious	0.0048	0.0061	0.0058	0.0202	-0.0837**	0.0374	293,063
Metals	-0.0036***	0.0011	0.0192***	0.0039	-0.0127	0.0082	5,028,544
Machinery	0.0012	0.0011	0.0010	0.0036	-0.0149*	0.0090	7,713,111
Vehicles	-0.0001	0.0019	0.0154**	0.0060	-0.0558***	0.0159	1,089,668
Instruments	-0.0012	0.0013	-0.0010	0.0040	0.0178*	0.0092	2,278,597
Arms	-0.0009	0.0052	0.0108	0.0179	-0.0479	0.0418	104,547
Miscellaneous	0.0003	0.0019	-0.0009	0.0073	0.0031	0.0138	1,579,322
Art	0.0062	0.0058	-0.0428**	0.0216	0.0695*	0.0396	129,426

Notes: The dependent variable is sectoral-level annual bilateral export values and the model is estimated using Poisson Pseudo Maximum Likelihood (PPML). ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercept and fixed effects (FE) included but not reported for brevity. Neutral_EP$_{ij,t}$, Restrictive_EP$_{ij,t}$ and Liberal_EP$_{ij,t}$ are, respectively, the numbers of neutral, trade-restrictive and liberal environmental provisions included in a PTA. SE are robust standard errors—clustered at the exporter-importer-year level. All other controls are included but not reported for brevity. Animals comprises HS:01, HS:02, HS:03, HS:04, HS:05; Vegetables comprises HS:06, HS:07, HS:08, HS:09, HS:10, HS:11, HS:12, HS:13, HS:14; Fats comprises HS:15; Prepared foods comprises HS:16, HS:17, HS:18, HS:19, HS:20, HS:21, HS:22, HS:23, HS:24; Minerals comprises HS:25, HS:26, HS:27; Chemicals comprises HS:28, HS:29, HS:30, HS:31, HS:32, HS:33, HS:34, HS:35, HS:36, HS:37, HS:38; Plastics comprises HS:39, HS:40; Leather comprises HS:41, HS:42, HS:43; Wood comprises HS:44, HS:45, HS:46; Paper comprises HS:47, HS:48, HS:49; Textile comprises HS:50, HS:51, HS:52, HS:53, HS:54, HS:55, HS:56, HS:57, HS:58, HS:59, HS:60, HS:61, HS:62, HS:63; Footwear comprises HS:64, HS:65, HS:66, HS:67; Stone cement comprises HS:68, HS:69, HS:70; Precious comprises HS:71; Metals comprises HS:72, HS:73, HS:74, HS:75, HS:76, HS:78, HS:79, HS:80, HS:81, HS:82, HS:83; Machinery comprises HS:84, HS:85; Vehicles comprises HS:86, HS:87, HS:88, HS:89; Instruments comprises HS:90, HS:91, HS:92; Arms comprises HS:93; Miscellaneous comprises HS:94, HS:95, HS:96; and Art comprises HS:97.

4.3 Environmental provisions and exporters' income levels

Bao and Qiu (2012) show that the demand for clean products and greener technologies correlates with a country's level of income. These products and technologies are viewed favorably by the environment-conscious consumers in high-income countries (Bernauer & Nguyen, 2015; Blümer et al., 2020; Esty, 2001; Limão, 2007). Moreover, the high environmental standards imposed by the inclusion of environmental provisions in PTAs may increase both the fixed and variable costs of firms/producers in the exporting countries. This is likely to be more challenging for exporting firms from developing countries where environmental standards are low and the investments required to meet the introduced high environmental standards may be substantial. Therefore, we examine whether the different types of environmental provisions have differential effects on export values depending on the level of development of the exporting countries and the results are presented in Table 4.

The coefficients on all the interaction terms in Table 4 are neither statistically or economically significant except for defensive and trade-restrictive environmental provisions. We find that exporters' income level moderates the trade effects of environmental provisions. We observe that the trade-creation effects associated with defensive and trade-restrictive environmental provisions and the export-reducing effects associated with neutral, offensive and liberal environmental provisions are lower in high-income than in low-income exporting countries. This suggests that the trade effects of the different types of environmental provisions are more pronounced in developing than developed exporting countries. Thus, developing exporting countries are likely to gain or lose more from the inclusion of environmental provisions in PTAs than developed exporting countries.

Table 4: Effects of environmental provisions on export values across different levels of exporters' incomes

	Specification 1		Specification 2		Specification 3	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
	(1)	(2)	(3)	(4)	(5)	(6)
$EP_{ij,t}$	0.0001	0.0003				
$EP_{ij,t} \times Dev_i$	-0.0002	0.0003				
$Neutral\_EP_{ij,t}$			-0.0001	0.0026	-0.0036***	0.0014
$Neutral\_EP_{ij,t} \times Dev_i$			0.0022	0.0027	0.0043***	0.0015
$Defensive\_EP_{ij,t}$			0.0136***	0.0026		
$Defensive\_EP_{ij,t} \times Dev_i$			-0.0114***	0.0030		
$Offensive\_EP_{ij,t}$			-0.0078**	0.0032		
$Offensive\_EP_{ij,t} \times Dev_i$			0.0037	0.0032		
$Restrictive\_EP_{ij,t}$					0.0228***	0.0042
$Restrictive\_EP_{ij,t} \times Dev_i$					-0.0190***	0.0049
$Liberal\_EP_{ij,t}$					-0.0312***	0.0097
$Liberal\_EP_{ij,t} \times Dev_i$					0.0086	0.0110
$PTA_{ij,t}$	0.0245	0.0170	0.0152	0.0169	0.0231	0.0171
$PTA_{ij,t} \times Dev_i$	0.0185	0.0199	0.0242	0.0199	0.0193	0.0200
$Depth_{ij,t}$	-0.0097	0.0089	-0.0201**	0.0097	-0.0118	0.0088
$Depth_{ij,t} \times Dev_i$	-0.0053	0.0099	-0.0014	0.0105	0.0012	0.0099
Exporter-industry-year FE	Yes		Yes		Yes	
Importer- industry-year FE	Yes		Yes		Yes	
Exporter-importer-industry FE	Yes		Yes		Yes	
N	42,358,224		42,358,224		42,358,224	

Notes: $PTA_{ij,t}$ is a dummy variable that indicates the presence or absence of a preferential trade agreement (PTA) between exporting country i and importing country j in in year t. $PTA_{ij,t} = 1$ if countries i and j signed a trade agreement in year t and $PTA_{ij,t} = 0$ otherwise. Dev_i is a dummy variable that takes a value of 1 if an exporting country was classified as 'high-income or developed' in the 2008 World Development Indicators of the World Bank and a value of zero, otherwise. $EP_{ij,t}$ is the total number of environmental provisions in the PTA. $Neutral\_EP_{ij,t}$, $Defensive\_EP_{ij,t}$, $Offensive\_EP_{ij,t}$, $Restrictive\_EP_{ij,t}$, and $Liberal\_EP_{ij,t}$ are, respectively, the numbers of neutral, defensive, offensive, trade-restrictive, and liberal environmental provisions included in the PTA. $Depth_{ij,t}$ is the normalized depth index. SE are robust standard errors that are clustered at the exporter-importer-year level. ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercepts and fixed effects (FE) included but not reported for brevity. All models are estimated using Poisson Pseudo Maximum Likelihood (PPML).

4.4 Environmental provisions and quality of regulation in the exporting countries

We now examine whether the trade effects of environmental provisions vary with strength of governance practices, systems and structures (i.e., regulatory quality) in the exporting countries. Quality of regulation may have different moderating effects on environmental provisions depending on the exporting country's circumstances. On the one hand, exporters that good governance practices and institutions are more likely to stringently regulate standards on different issues including the environment. These countries have higher and more stringent environmental standards such that the compliance demands emanating from the inclusion of environmental provisions in PTAs would neither significantly increase the production costs nor the regulation costs to ensure compliance. Thus, exporters that have higher regulatory quality and environmental standards are likely to be affected less by the inclusion of environmental provisions in PTAs. On the other hand, if the quality of regulation is weak in the exporting countries resulting in lower environmental standards, the inclusion of environmental provisions in PTAs might significantly increase both production and regulation costs. Depending on the magnitudes and interactions between the demand and supply effects induced by the environmental provisions, exporters that have weak regulatory quality are likely to be affected more by the environmental provisions.

Table 5 shows that regulatory quality moderates the effects of environmental provisions on export values. We observe that coefficients on the interaction terms related to the overall number of environmental provisions (i.e., $EP_{ij,t}$), defensive ($Defensive\_EP_{ij,t}$) and trade-restrictive ($Restrictive\_EP_{ij,t}$) environmental provisions are economically and statistically significant. We find that the overall export value-promoting effect associated with environmental provisions in PTA is higher for exporting countries where regulatory quality is weak than those with strong regulatory quality. We also find that the export-reducing effects associated with offensive and liberal environmental provisions and the export-increasing effects associated with defensive and trade-restrictive environmental provisions are lower for exporting countries where regulatory quality is stronger than those with weak regulatory quality. For instance, in column 5 of Table 5, we observe that the reduction in export values associated with liberal environmental provisions is 3.69 percentage points lower for exporting countries with strong regulatory quality than those with weak regulatory quality. Our results in Table 5 consistently show that the trade effects of the different types of environmental provisions are more pronounced in economies that have weak governance architecture. These results suggest that low-income exporting countries—which are usually characterized by weak or lax governance systems—are likely to gain or lose more from the inclusion of different types environmental provisions in PTAs than high-income exporting countries should they be able to meet the higher environmental standards.

Table 5: Heterogenous effects of environmental provisions on export values across different levels of regulatory quality

	Specification 1		Specification 2		Specification 3	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
	(1)	(2)	(3)	(4)	(5)	(6)
$EP_{ij,t}$	0.0011*	0.0006				
$EP_{ij,t} \times Reg_i$	-0.0015**	0.0008				
$Neutral\_EP_{ij,t}$			-0.0034	0.0051	-0.0098***	0.0034
$Neutral\_EP_{ij,t} \times Reg_i$			0.0071	0.0067	0.0132***	0.0046
$Defensive\_EP_{ij,t}$			0.0305***	0.0068		
$Defensive\_EP_{ij,t} \times Reg_i$			-0.0360***	0.0097		
$Offensive\_EP_{ij,t}$			-0.0112*	0.0066		
$Offensive\_EP_{ij,t} \times Reg_i$			0.0087	0.0085		
$Restrictive\_EP_{ij,t}$					0.0538***	0.0122
$Restrictive\_EP_{ij,t} \times Reg_i$					-0.0632***	0.0169
$Liberal\_EP_{ij,t}$					-0.0488**	0.0233
$Liberal\_EP_{ij,t} \times Reg_i$					0.0325	0.0319
$PTA_{ij,t}$	-0.0282	0.0389	-0.0370	0.0386	-0.0280	0.0391
$PTA_{ij,t} \times Reg_i$	0.0947*	0.0550	0.1004*	0.0549	0.0930*	0.0553
$Depth_{ij,t}$	-0.0210	0.0231	-0.0355	0.0252	-0.0262	0.0231
$Depth_{ij,t} \times Reg_i$	0.0094	0.0312	0.0209	0.0338	0.0232	0.0314
Exporter-industry-year FE	Yes		Yes		Yes	
Importer- industry-year FE	Yes		Yes		Yes	
Exporter-importer-industry FE	Yes		Yes		Yes	
N	42,306,138		42,306,138		42,306,138	

Notes: The dependent variable in columns (1), (3), and (5) is the industry-level annual export values. $PTA_{ij,t}$ is a dummy variable that indicates the presence or absence of a preferential trade agreement (PTA) between exporting country i and importing country j in in year t. $PTA_{ij,t} = 1$ if countries i and j signed a trade agreement in year t and $PTA_{ij,t} = 0$ otherwise. Reg_i captures quality of governance (i.e., regulatory quality) in the exporting country and its value ranges from 0 to 1. A value of 0 indicates weak governance while 1 indicates strong governance. $EP_{ij,t}$ is the total number of environmental provisions in the PTA. $Neutral\_EP_{ij,t}$, $Defensive\_EP_{ij,t}$, $Offensive\_EP_{ij,t}$, $Restrictive\_EP_{ij,t}$, and $Liberal\_EP_{ij,t}$ are, respectively, the numbers of neutral, defensive, offensive, trade-restrictive, and liberal environmental provisions included in the PTA. $Depth_{ij,t}$ is the normalized depth index. SE are robust standard errors that are clustered at the exporter-importer-year level. ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercepts and fixed effects (FE) included but not reported for brevity. All models are estimated using Poisson Pseudo Maximum Likelihood (PPML).

Overall, our findings in Tables 4 and 5 could be worrisome to the policymakers in developing countries who strive to promote economic growth to reduce poverty and food insecurity without increasing their environmental footprints. Moreover, these results might heighten concerns, particularly in developing countries, that the inclusion of environmental provisions in PTAs is motivated by protectionists interest or green imperialism (Bastiaens & Postnikov, 2017; Bechtel et al., 2012; Lechner, 2016). This could derail the potential gains that arise from using targeted trade policy instruments to address critical non-trade issues such as environmental degradation in order to achieve sustainable economic growth and development.

4.5 Decomposing the trade effects of environmental provisions

The total export value per country is determined by both price and quantity components. To gain further insights into the effects of environmental provisions on export values, we decompose the total export values into extensive- and intensive export margins following Hummels and Klenow (2005) and Feenstra and Kee (2008). We report the estimation results in Table 6. We observe that the effects of environmental provisions on extensive- and intensive export margins counteract each other. The results in columns (1) and (2) show that, overall, environmental provisions have a negative and significant effect on extensive export margin and a significant positive effect on intensive export margin. Moreover, environmental provisions affect total export values primarily through their effect on the intensive export margin as evidenced by the larger (in absolute terms) effect on intensive- than extensive export margin. One the one hand, this means that the inclusion of environmental provisions in PTAs is associated with a reduction in the number of exported 6-digit harmonized system (HS6) product varieties within a particular 4-digit harmonized system (HS4) industry category. On the other hand, it also suggests that the environmental provisions increase the average export value for the exported HS6 product varieties within a particular HS4 industry category.

The results in columns (3) and (4) show that defensive environmental provisions have a significant negative effect and a non-significant positive effect on extensive- and intensive export margins, respectively. We further observe that offensive environmental provisions are associated with a positive and significant effect on extensive export margin and a significant negative effect on intensive export margin. Moreover, we find that trade-restrictive provisions significantly reduce the intensive export margin but have non-significant positive effect on extensive export margin. On the contrary, liberal environmental provisions have a significant negative effect and a non-significant positive effect on the extensive- and intensive export margins respectively (Table 6, columns (5) and (6)). The respective significant negative effect of trade-restrictive and liberal environmental provisions on intensive- and extensive export margin could be indicative of the efficacy of these types of environmental provisions in altering the mix of products in export baskets to promote environmental objectives. For example, the negative effect of liberal provisions could be suggestive of substitution effects whereby exporting countries orient their export baskets towards environmentally-friendly products and drop out products that are harmful to the environment.

Table 6: Effects of environmental provisions on extensive and intensive export margins

	Specification 1		Specification 2		Specification 3	
Dependent variable	Extensive	Intensive	Extensive	Intensive	Extensive	Intensive
	(1)	(2)	(3)	(4)	(5)	(6)
$EP_{ij,t}$	-0.0005***	0.0010***				
	(0.0001)	(0.0001)				
$Neutral\_EP_{ij,t}$			-0.0021***	0.0059***	-0.0005*	0.0029***
			(0.0004)	(0.0008)	(0.0003)	(0.0006)
$Defensive\_EP_{ij,t}$			-0.0035***	0.0014		
			(0.0007)	(0.0013)		
$Offensive\_EP_{ij,t}$			0.0035***	-0.0059***		
			(0.0006)	(0.0012)		
$Restrictive\_EP_{ij,t}$					0.0014	-0.0059***
					(0.0009)	(0.0018)
$Liberal\_EP_{ij,t}$					-0.0062**	0.0031
					(0.0028)	(0.0051)
$PTA_{ij,t}$	-0.0156***	0.0163***	-0.0133***	0.0111*	-0.0155***	0.0155**
	(0.0042)	(0.0062)	(0.0042)	(0.0063)	(0.0042)	(0.0062)
$Depth_{ij,t}$	0.0197***	-0.0268***	0.0253***	-0.0335***	0.0206***	-0.0270***
	(0.0024)	(0.0050)	(0.0026)	(0.0051)	(0.0025)	(0.0051)
Exporter-sector-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer-sector-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Exporter-importer-sector FE	Yes	Yes	Yes	Yes	Yes	Yes
N	3,336,260	3,336,260	3,336,260	3,336,260	3,336,260	3,336,260

Notes: The dependent variable in columns (1), (3), and (5) is the extensive export margin while in columns (2), (4), and (6) is the intensive export margin. All models include a dummy variable ($PTA_{ij,t}$) that indicates the presence or absence of a preferential trade agreement (PTA) between exporting country i and importing country j in in year t. $PTA_{ij,t} = 1$ if countries i and j signed a trade agreement in year t and $PTA_{ij,t} = 0$ otherwise. $EP_{ij,t}$ is the total number of environmental provisions in the PTA. $Neutral\_EP_{ij,t}$, $Defensive\_EP_{ij,t}$, $Offensive\_EP_{ij,t}$, $Restrictive\_EP_{ij,t}$, and $Liberal\_EP_{ij,t}$ are, respectively, the numbers of neutral, defensive, offensive, trade-restrictive, and liberal environmental provisions included in the PTA. $Depth_{ij,t}$ is the normalized depth index and measures depth of the PTA. Robust standard errors, clustered at the exporter-importer-year level, are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercepts and fixed effects (FE) are included but not reported. All models are estimated using Poisson Pseudo Maximum Likelihood (PPML).

Overall, the results in Table 6 consistently show that the variations in the total export values associated with different types of environmental provisions in PTAs are mostly driven by changes in the intensive export margin. The smaller extensive margin effects we find relative to the intensive margins suggest that the different types of environmental provisions in PTAs affect export values by increasing more the variable costs of exporting than the fixed costs. This is inconsistent with the empirical evidence (e.g., Curzi et al., 2020; Fiankor et al., 2021; Fontagné et al., 2015) that show that the extensive margin drive more the export-reducing effects of technical regulations than the intensive margin. These results reinforce the importance of more disaggregated empirical evidence for effective trade policy formulation. It is crucial that the governments or policymakers understand how trade in different products/industries/sectors respond to different types of PTAs and the environmental provisions therein. This is even more important now because PTAs have, over time, become more complex and have rapidly increased in the number and types of environmental provisions they contain.

4.6 Robustness checks

We conduct several robustness checks to ascertain that our main findings do not critically hinge on the specific model we use or on how we capture the number of environmental provisions in PTAs. We do not jointly implement these robustness tests. Rather, they are conducted one at a time and the results are reported in Tables E1a to E4c in the Appendix. First, we analyze whether the strength of enforcement mechanisms of environmental provision in PTAs affect their trade effects. We create a dummy indicating the whether a particular PTA has weak or strong enforcement mechanism. We then interact this dummy with all environmental provisions-related variables and re-estimate equations [1] to [3] by including the relevant interaction terms. The results are presented in Tables E1a and E1b in the Appendix. We find that strong enforcement of environmental provisions moderates their effects on export values particularly for defensive and offensive environmental provisions. Overall, the results show that enforcement mechanisms included in PTAs do not significantly drive our core findings.

Second, we test whether our results are driven by the European Union (EU[21]) enlargement effects. We do this by excluding, from our sample, all trade relations between the EU member countries and then re-estimate equations [1] to [3]. The results are reported in Table E2. We find that the EU enlargement effects do not critically undermine our main results. Instead, we find that the heterogenous trade effects of the different types of environmental provisions not only persist without the intra-EU trade relations but also become more significant, both economically and statistically. This suggests that the inclusion of environmental provisions in PTAs is unlikely to significantly affect intra-EU trade because the EU members generally have relatively high levels of environmental standards and strict environmental regulations.

[21] We classify United Kingdom, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden as EU members. Despite Brexit, we include the United Kingdom as part of the EU because the country was part of the EU within our sample period (i.e., between 1996 and 2020).

Third, we use a different decomposition approach to test whether our results on export margins are robust to the choice of the approach used. To do this, we follow Bernard et al. (2007) and Fiankor et al. (2023) and decompose total exports value into price and quantity elements. We define the extensive margin as the number HS6 product categories exported per sector while the intensive margin is captured as the average export value per sector. We then re-estimate equations [1] to [3]. The regression results are presented in Table E3. We find that our main findings remain stable and in most cases are comparable in terms of both direction and magnitudes of the effect sizes. This implies that our results are robust to the choice of the approach used to decompose the export margins.

Lastly, we use different estimating equations to check whether our main results are robust to the analytical approach used. Instead of analyzing how the number and different types of environmental provisions in PTAs affect export flows, we analyze how the presence or absence of environmental provisions in PTAs affect trade and whether the effects vary depending on the strength of enforcement mechanisms included in the PTAs, and/or on the level of development of the trading partners. The estimation results are reported in Tables E4a to E4c. Again, we find that, overall, the direction of our main results to not change. To summarize, our main results remain stable across different specifications, subsamples, and measures of environmental provisions in PTAs.

5 Conclusion

The prevalence of environmental provisions in PTAs is well documented but their economic effects are not well-understood. Environmental provisions can affect trade through several intricate mechanisms and disentangling these effects can be challenging. In this paper, we analyze the effects of environmental provisions on sectoral trade flows. We further investigate whether these effects depend on the heterogeneity of environmental provisions included in the PTAs, strength of the PTAs' dispute settlement mechanisms, and the exporting countries' level of development and quality of regulation. We also assess how the extensive and intensive export margins are affected by different types of environmental provisions. It is important to address these issues because the contribution of different sectors to economic growth varies across countries hence targeted trade polices such as environmental provisions in PTAs might have heterogenous economic effects depending on how different sectors respond to the policy.

We use a theory-consistent industry-level structural gravity model to estimate the trade effects of trade agreements with environmental provisions. We use a three-way fixed effects approach to control for unobserved heterogeneity and potential reverse causality. We find that environmental provisions have heterogenous effects not only across sectors but also across the exporting country's income levels and quality of regulation. While offensive and liberal environmental provisions are associated with significant reductions in export values in the agri-food and extractive sectors, defensive and trade-restrictive environmental provisions boost export performance in the same sectors. This could be worrisome for developing countries since their economies are largely dominated by agri-food and extractive sectors which are considered relatively more harmful to the environment. Concerns that environmental

provisions in PTAs serve protectionists interests and that they hinder economic interests for developing countries are not supported by our findings. Instead, it appears that environmental provisions can help developing countries to concurrently increase economic growth and reduce their environmental footprints. Exporters' income levels and quality of regulation moderate the trade effects of environmental provisions such that developing exporting countries are likely to gain or lose more from the inclusion of environmental provisions in PTAs than developed exporting countries.

Moreover, we find that the effects of environmental provisions in PTA depends on the number and types of the included environmental provisions. We find that offensive environmental provisions have smaller (in absolute terms) export-reducing effects than the export-creation effect of defensive provisions. The export-creation effects associated with trade-restrictive environmental provisions are outweighed by the export-reducing effects induced by liberal environmental provisions. We find that the environmental provisions in PTAs affect export values by increasing more the variable cost costs of exporting relative to the fixed costs. However, these effects are heterogenous across sectors.

Our results are interesting on two fronts. First, they provide industry level evidence that can stimulate academic research on the relationship between increased economic integration and environmental policy. Our findings do not broadly support the public concerns or arguments that increased economic integration induces the 'race to the bottom', turning developing countries into 'pollution havens' as postulated by the Pollution haven hypothesis. On the contrary, our results suggest that the inclusion of environmental provisions in PTAs can be used as a targeted trade policy strategy to jointly promote economic and environmental sustainability. Second, our findings also suggest that policymakers should critically analyze the design of PTAs in order to achieve the desired outcomes and impact. Our empirical evidence shows that offensive, trade-restrictive, and liberal environmental provisions can reduce trade in potentially environmentally harmful sectors such as animals, plastics, wood, minerals, paper, leather, stone cement, machinery, and vehicles.

We contribute to the contentious debate on international trade and trade policy and their implications for environmental and economic sustainability. Our results also inform the design of future deep PTAs, or modification of the existing PTAs, that seek to address specific issues of environmental concerns through targeted trade policies in a multilateral setting. Although our findings have important implications for trade and environmental policy, and are invaluable to academicians, and the general public, we recognise that they could be limited. We conducted partial equilibrium analyses and do not capture the general equilibrium effects of environmental provisions on trade outcomes. We control for third-party effects through the theoretical outward and inward multilateral resistance terms but do not directly address these effects. Hence, for further research it would be interesting to estimate the general equilibrium effects of the environmental provisions in PTAs to enhance evidence-based policy formulation and debates.

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