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Targeted Trade Policy Instruments and Climate Change Mitigation: The Case of Environmental Provisions in Trade Agreements

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Abstract

This article explores the effects of including environmental provisions (EPs) in preferential trade agreements (PTAs) on climate change mitigation. It further examines whether the effects depend on the heterogeneity of the EPs. We exploit a panel dataset of the climate change performance index (CCPI) from 2006 to 2019 and the environmental performance index (EPI) from 2000 to 2020 for multiple countries. We combine these datasets with the TREND database that contains information on almost 300 different types of EPs in 775 PTAs. Empirically, we use an autoregressive panel data model with an exponential fractional regression framework and a two-step system generalized method of moments (GMM) estimator. Potential endogeneity issues are addressed with suitable instrumentation and panel estimation techniques. Our results shows that the inclusion of EPs in PTAs significantly improves climate change mitigation. The effectiveness of these provisions, however, depends on their diversity. Key benefits include reduced greenhouse gas emissions, increased renewable energy use, and enhanced climate policies. Furthermore, PTAs with direct CPs yield greater improvements in climate change mitigation outcomes compared to those addressing environmental issues more generally or indirectly. Finally, we show that PTAs with climate change provisions are an effective tool for climate change mitigation, regardless of the development status of the signatories. However, the effects are more pronounced for North-South PTAs compared to North-North and South-South PTAs.

Keywords: Trade agreements; environmental provisions; climate change; environmental health; environmental policy; climate change performance index

JEL Classification: F13; F18; Q54; Q56

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1 Introduction

Globalization has increased interactions between firms across countries, even over long distances, often with drastic consequences for social, economic, and environmental sustainability. For instance, bilateral trade flows between developing economies have increased by nearly 15 percentage points in recent decades[1] as food systems have become more globalized and increasingly integrated through the proliferation of preferential trade agreements. As trade grows, however, so does the coupling of consumer choices in one part of the world to resource use elsewhere in production areas. This relationship is a key driver of climate change.[2] As a result, we are seeing increasing attempts to use trade, trade policy and international cooperation to address climate change.[3] But how effective are these policy measures in supporting climate change mitigation and adaptation strategies? This paper addresses this question by investigating whether the inclusion of environmental provisions (EPs[4]) and climate change provisions (CPs) in preferential trade agreements (PTAs) affects climate change mitigation at the country level.

The last decade has seen a proliferation of 'deep PTAs' that extend provisions beyond liberalizing tariffs to substantially cover a broad range of issues including services trade, investments, standards, public procurement, competition and intellectual property rights (Dür et al., 2014). This is often credited for the concurrent proliferation of global and regional value chains (Fan et al., 2024; Laget et al., 2020; Zhang et al., 2021). Since 1990, the number of PTAs with an EP has increased from 111 to 680 in 2021. Whereas this increase is noteworthy,

[1] D'Andrea et al. (2024) show that trade between developing countries grew at a rate of 9.7 per cent per year, surging from 9.8% to 24.6% of global trade between 1995 and 2022, while trade between developed and developing economies expanded modestly from 35.8% to 36.9% of global trade in the same period.

[2] International trade can exacerbate climate change by increasing deforestation rates (Abman & Lundberg, 2020; DeFries et al., 2010; Leblois et al., 2017), biodiversity loss (Bjelle et al., 2021; Chaudhary & Brooks, 2019; Lenzen et al., 2012; Marques et al., 2019), and emissions of carbon and GHGs (Ermgassen et al., 2020; Johansson et al., 2020; Karstensen et al., 2013; Saikku et al., 2012). On the positive side, international trade and trade policies increase the worldwide diffusion and deployment of lower-emission goods and services, capital equipment and know-how (Busse & Koeniger, 2012; Frankel & Romer, 1999; World Trade Organization, 2022) and reduce the costs of these products through efficiency improvements, economies of scale and learning-by-doing (Berthou et al., 2019; De Loecker & Warzynski, 2012; Lyn & Rodríguez-Clare, 2013; Young, 1991). Concurrently, climate change also negatively affects international trade by increasing trade costs, and disrupting production and supply chains (World Trade Organization, 2022). It could also cause 250,000 additional deaths per year between 2030 and 2050 due to malnutrition, malaria, diarrhea, and heat stress alone (WHO, 2018).

[3] An example is the attempt by trade ministers of the EU and 59 other countries who, recognizing that international trade can and must make a positive contribution to driving down greenhouse gas emissions, and enable a just transition to climate neutral, resilient, and sustainable economies by mid-century, established the Coalition of Trade Ministers on Climate https://www.tradeministersonclimate.org/. See also https://www.washingtonpost.com/opinions/2023/11/15/global-trade-climate-change-benefits/

[4] EPs are defined as rules that are incorporated in an international treaty that address or govern environment-related issues (Blümer et al., 2020).

there may be different rationales for incorporating EPs in PTAs. It could be a strategic move to garner the support of sections of society that oppose economic liberalization (Blümer et al., 2020; Martínez-Zarzoso, 2018). This is because EPs are considered as more effective instruments to promote higher environmental standards (Jinnah & Lindsay, 2016; Johnson, 2015) as they help diffuse cleaner technologies worldwide and contribute to global climate governance (George & Yamaguchi, 2018). Including EPs in PTAs can, however, also be disguised forms of protectionism and/or "green imperialism" (Bastiaens & Postnikov, 2017; Blümer et al., 2020), for instance, if they target cheap imports. Despite the ubiquity and heterogeneity of EPs in PTAs, empirical evidence on their effects on climate change mitigation and environmental health is scant (Morin & Jinnah, 2018; Sorgho & Tharakan, 2022). Yet, the parallel development of trade liberalization and climate change policies calls their interplay into question (Himics et al., 2018). Our work contributes to extending this literature.

We assess how the inclusion of EPs in PTAs affects climate change mitigation using a combination of data on environmental quality outcomes from Germanwatch e.V. and the Socioeconomic Data and Applications Center, and data on PTAs from the TRade and ENvironment Database (TREND). The databases on environmental quality contain various indicators of environmental performance, from which we compute two indices that proxy for climate change mitigation: a Climate Protection Performance Index (CCPI) and an Environmental Performance Index (EPI). The CCPI measures a country's performance in protecting its environment from climate change through improvements in climate policy, energy use, renewable energy and GHG emissions. Similarly, the EPI measures broader environmental protection efforts, focusing on environmental health, ecosystem vitality, and climate change. We combine these indices with data on 775 PTAs that include about 300 EPs. Empirically, we estimate an autoregressive panel data model in an exponential fractional regression framework using two-step system generalized method of moments on a sample of 57 countries from 2000 to 2020.[5] We address the endogeneity of trade policy variables using instrumental variables and panel data estimation techniques.

Our initial descriptive evidence shows that over the study period, global climate change mitigation performance has been modest, with average CCPI and EPI scores of 0.52 and 0.56, respectively. This means that, countries, on average, have met just over half of their climate

[5] Our main analysis is conducted using the CCPI from Germanwatch e.V. This database, however, only cover 57 countries over the period 2006 to 2019. To ensure the external validity of our findings we extend the analysis using the EPI which covers 180 countries over the period 2000 to 2020.

change mitigation targets. Moreover, this performance is not entirely determined by a country's development status or income level as some developing countries such as Morocco outperform developed ones such as Australia and USA. Our empirical estimates show that PTAs with EPs improve climate change mitigation efforts, while PTAs without EPs reduce them. The effects of the latter are, however, not statistically significant. Specifically, a unit increase in the number of PTAs with EPs is associated with a 0.017 percentage point increase in the CCPI and a 0.007 percentage point increase in the EPI. Furthermore, the overall increase in climate change mitigation performance is driven by reductions in GHGs emissions and improvements in climate policy. Finally, the positive climate change mitigation effects of PTAs with EPs outweigh the negative impact of PTAs without EPs.

Further heterogeneous analyses reveal that whereas PTAs with climate change provisions that address climate change issues either directly and/or indirectly enhance environmental performance, PTAs that directly tackle climate change achieve greater environmental benefits. Finally, we show that PTAs with climate change provisions are an effective tool for climate change mitigation, regardless of the development status of the signatories, however, the effects are more pronounced for North-South PTAs compared to North-North and South-South PTAs.

Our work and its findings fit into a literature on trade relationships and environmental sustainability. For instance, Ghosh and Yamarik (2006) investigated both the direct and indirect effects of PTAs on the environment. They found no direct effects of PTAs on the environment but established that PTAs had an indirect positive effect on environmental quality. Baghdadi et al. (2013) investigated the effects of including EPs in PTAs on carbon dioxide (CO_2) emissions as a proxy for environmental quality. They found that PTAs with EPs significantly reduced CO_2 emissions, while those without EPs significantly increased CO_2 emissions. Similarly, Zhou et al. (2017) investigated the effects of PTAs and EPs on particulate matter less than 2.5 microns (i.e., $PM_{2.5}$). They also established that PTAs with EPs significantly reduced $PM_{2.5}$ concentrations, highlighting their positive environmental impacts. Martínez-Zarzoso and Oueslati (2018) explored the impact of PTAs with EPs on environmental quality, using indicators like Sulphur dioxide (SO_2), nitrogen dioxide (NO_2), nitrogen oxide (NO_x), CO_2 and $PM_{2.5}$. Their findings revealed that PTAs with EPs significantly reduced $PM_{2.5}$, SO_2, CO_2 and NO_x emissions, whereas PTAs without EPs had a significant positive impact on emissions. More recently, Sorgho and Tharakan (2022) assessed the effectiveness of EPs in PTAs on climate change mitigation. They distinguish between EPs and climate-related provisions and use methane (CH_4), CO_2 and NO_2 as proxies for climate change. They found that PTAs with climate change-related provisions significantly reduced emissions while PTAs with EPs related to other environmental issues had an insignificant negative effect on GHGs emissions. Abman et al. (2024) investigated the effectiveness of EPs in limiting deforestation. They find that reginal trade agreements (RTAs) with *"specific provisions aimed at protecting forests and/or biodiversity almost entirely offsets the net increases in forest loss observed in similar RTAs without such provisions"*. These existing works share one commonality; they measure climate change mitigation using only the emissions of one more GHGs.

Our work extends this literature by providing two key innovations. First, unlike previous studies that primarily focus on GHG emissions, we capture climate protection performance in a more comprehensive manner. While GHGs emissions are central to global warming and climate change, they are by themselves unlikely to reflect how well a country is performing in areas such as climate policy, renewable energy or energy efficiency. We use the Climate Change Performance Index (CCPI), which is a comprehensive, independent monitoring tool for climate protection performance based on 14 indicators that fall into four broad sub-components, namely GHG emissions, renewable energy, energy use, and climate policy (Burck et al., 2023). The CCPI evaluates climate protection efforts across 57 countries responsible for over 90% of global emissions and enhances transparency in international climate politics. This allows us to comprehensively capture and compare cross-country performance in climate change mitigating efforts. We complement the CCPI with analyses based on the Environmental Performance Index which is available for 180 countries. Together, these indices allow us to provide a more complete view of global efforts in reducing emissions, advancing renewable energy, and enhancing environmental health and ecosystem vitality.

Second, we categorize PTAs based on whether they contain EPs that specifically address climate change, allowing us to distinguish the effects of general EPs from those of climate-specific provisions. In a pioneering contribution to the field, Sorgho and Tharakan (2022) proposed a similar classification. Our approach, however, is distinctive in that we focus exclusively on PTAs with direct climate change provisions, excluding those that address climate change in an indirect manner. We argue that, by joining PTAs that make direct climate change provisions, countries signal their willingness to consciously address climate change issues and so we isolate this extra effect in our estimations. This distinction ensures that we accurately capture the intentionality of signatories in addressing climate change, reflecting their genuine commitment to mitigating its effects. Our results also show why this distinction is important; in most cases we find that the positive effects of EPs on climate change mitigation efforts are larger when the provisions directly address climate change than when the provisions are more general.

Our work also contributes to the literature that assesses the effectiveness of PTAs on the agricultural and food sector. The majority of these efforts have focused on how these preferences influence export performance (Afesorgbor et al., 2024; Jafari et al., 2023; Scoppola et al., 2018) and food security (Ritzel & Fiankor, 2024) ignoring in large part how they interact with climate change. Agriculture is, however, a major contributor to climate change, while also remaining one of the economic sectors most exposed to the increasing risks from climate variability and change (e.g., crop losses and negative yield shocks). As global trade in the past three decades has lifted millions out of poverty, keeping food markets open to trade remains crucial for global food security (K. Anderson, 2022; Brown et al., 2017). The role of PTAs in this achievement cannot be underestimated. In this regard, our work is novel is showing that, in order to guarantee the continued sustainability of food systems, it is imperative that these PTAs are deep enough to address environmental concerns.

Overall, our results suggest that the inclusion of environmental provisions in PTAs can be a potent targeted policy instrument to dampen the negative environmental effects of trade and address climate change and other environmental issues. What is crucial, however, is the effective designing of PTAs. In terms of policy advise, our work shows that if PTAs with EPs are to contribute effectively to climate change mitigation and adaptation efforts, they must directly address climate change issues.

The rest of the article is organized as follows. Section 2 briefly describes the theoretical framework linking PTAs and environmental provisions to trade and environmental quality indicators. We describe our analytical framework and econometric procedure in Section 3 and present key data sources in Section 4. We present and discuss our main results in Section 5 and draw our conclusions in Section 6.

2 Theoretical framework

While trade liberalization and environmental outcomes are deeply intertwined, empirical evidence shows that the way in which they affect each other is rather complex. Increased trade openness can benefit or destroy a country’s environment and natural resources depending on the size and interactions among the so-called scale, composition, and technique effects (Grossman & Krueger, 1991). The pioneering work of Grossman and Krueger (1991) has been used many times in the literature to assess how international trade interacts with the environments (Copeland & Taylor, 2004; Grossman & Krueger, 1991; Managi et al., 2009). This section presents a review of the theoretical literature that forms the basis for our analysis and provides the theoretical predictions that inform the interpretation of our findings.

As trade increases global economic activity, it can lead to more environmental pollution and degradation. This is the *scale effect* Although this is the general expectation, there is also empirical evidence suggesting that higher incomes—often resulting from increased trade—can improve environmental quality (Antweiler et al., 2001; Copeland & Taylor, 2004; Grossman & Krueger, 1991), potentially reflecting the Environmental Kuznets Curve, which posits that environmental quality improves as a country's income increases.[6]. Second, the *technique effect* indicates that trade liberalization positively impacts the environment by promoting the diffusion of improved knowledge and production technologies, resulting in the extensive adoption and use of cleaner technologies which contributes to reducing pollution. It is commonly agreed that trade is the primary conduit for technology transfers and improved technologies benefit the environment if they reduce emission intensities. Finally, it is argued that trade liberalization alters comparative advantage and the mix of goods produced by economies and this affects environmental quality. This is the so-called *composition effect.* Based on economic theory, it is difficult to predict, *a priori*, the net impact of the composition effect of trade liberalization on the environment because it depends on the specific sectors in which a particular economy has comparative advantage. In the end, the direction of the effect is an empirical question.

Moreover, comparative advantage can arise from cross-country differences in both resource endowments and environmental regulations. On the one hand, if an economy’s comparative advantage is mainly determined by its relative factor endowment, such as capital relative to labour, the Factor Endowment Hypothesis (FEH) postulates that economies in which capital is relatively abundant are likely to export capital-intensive (and therefore often pollution-intensive) goods. Thus, the FEH predicts that pollution should increase in capital-intensive countries and decrease in countries where capital is scarce. Alternatively, if a country’s comparative advantage emanates from lax environmental regulations, the Pollution Haven Hypothesis (PHH) suggests that *“trade liberalisation in goods will lead to the relocation of pollution-intensive production from countries with high income and more stringent*

[6] An inverted U-shaped relationship between environmental quality and income per capita which implies that environmental quality first deteriorates up to a point, and then improve with rising per capita income.

environmental regulations to countries with low income and less stringent environmental regulations" (Martínez-Zarzoso, 2018, p. 13). The PHH predicts that environmental damage could increase in developing countries because their lax environmental regulations could make them pollution havens. A number of researchers (e.g., Cherniwchan et al., 2017; Millimet & Roy, 2016; Wilting et al., 2021) have provided evidence to support the existence of the PHH. Overall, numerous scientific studies that directly investigate the impact of PTAs on the environment conclude that PTAs, generally, improve environmental quality outcomes by increasing trade, quality of traded goods, and income per capita (Baghdadi et al., 2013; Bastiaens & Postnikov, 2017; Brandi et al., 2020; Ghosh & Yamarik, 2006; Martínez-Zarzoso, 2018).

3 Analytical framework and econometric strategy

This section sets out the analytical framework and econometric estimation strategy that we use to test the theoretical predictions set out in Section 2.

3.1 Empirical strategy

We follow Martínez-Zarzoso and Oueslati (2018) and Sorgho and Tharakan (2022) and estimate the effects of environmental provisions in PTAs on climate change mitigation using the following empirical model:

$$CPP^{\rho}_{i,t} = \alpha_1 PTAwoEP_{i,t} + \alpha_2 PTAwEP_{i,t} + \alpha_3 CPP^{\rho}_{i,t-1} + \alpha_4 lnOpenness_{i,t} + \alpha_5 lnGDPcap_{i,t} + \alpha_6 lnPopdensity_{i,t} + \alpha_7 Demoindex_{i,t} + \tau_i + \delta_t + \mu_{i,t} \quad [1]$$

where $CPP^{\rho}_{i,t}$ is measure ρ for the climate change mitigation performance of country i in year t. ρ denotes the two indicators of climate change mitigation performance, i.e., the climate change performance index and its components (i.e., GHGs emissions, climate policy, energy use, and renewable energy) as well as the environmental performance index and its components (i.e., environmental health, and climate and energy). We measure a country's willingness to deal with climate change by the number of the different types of PTAs that it has in year t. $PTAwoEP_{i,t}$ is the number of PTAs that do not include environmental provisions while $PTAwEP_{i,t}$ is the number of PTAs that include such provisions. $PTAwoEP_{i,t}$ and $PTAwEP_{i,t}$ are our key variables of interest. In further heterogeneous analyses, we would assess the effects of PTAs with general climate change provisions (PTAwCPs) and those with direct climate change provisions (PTAwDCPs).

To control for the scale, technique and composition effects that feature in our theoretical framework, we include further controls in Equation [1]. We define $\text{Openness}_{i,t}$ as a ratio of total trade to gross domestic product (GDP) and use it as a control for the direct effect of trade intensity on climate change mitigation. Trade intensity proxies the *composition effect* (e.g., Antweiler et al., 2001; Baghdadi et al., 2013; Cherniwchan et al., 2017; Copeland & Taylor, 2004; Frankel & Rose, 2005; Ghosh & Yamarik, 2006; Martínez-Zarzoso & Oueslati, 2018; Zhou et al., 2017). GDP per capita ($\text{GDPcap}_{i,t}$) in constant 2017 US dollars is our proxy for the *technique effect* and captures the direct effect of income on climate protection performance. We proxy the *scale effect* using population density ($\text{Popdensity}_{i,t}$) defined as the average number of people inhabiting a square kilometre of land area in country i in year t.[7] $\text{Demoindex}_{i,t}$ captures a country's political structure, offering a measure of how democratic or autocratic its governance structures are. This accounts for the role of political institutions in shaping environmental quality outcomes by addressing market failures such as environmental externalities (Frankel & Rose, 2005). Time-fixed effects (δ_t) capture linear time trend effects that are common to all countries such as global economic downturns while the country-fixed effects (τ_i) control for time-invariant, country-specific factors that affect a country's climate change mitigation efforts. $\mu_{i,t}$ is the random error term with mean zero, which we cluster at the country level.

3.2 Addressing endogeneity of trade and climate protection performance relationship

Equation [1] may suffer from several sources of endogeneity that could affect identification. First, there is potential endogeneity stemming from omitted variable biases due to observed and unobserved confounding factors (e.g., country-specific quality of economic and environmental institutions) that we cannot control for. We address this concern using country and time fixed effects. Second, there is potential reverse causality of the PTA and environmental quality performance relationship. For instance, while having more PTAs with EPs may improve environmental performance, the severity of environmental concerns in a country may induce it to sign up to PTAs with EPs (Martínez-Zarzoso, 2018). We use dynamic panel data estimation techniques to address this concern (Arellano & Bond, 1991). Third is the endogeneity of the relationship between income (GDP) and trade. This is a common problem in the trade openness and economic growth literature (Baghdadi et al., 2013; Frankel & Rose, 2005; Managi et al., 2009; Martínez-Zarzoso & Oueslati, 2018; Sorgho & Tharakan, 2022;

[7] *A priori*, we expect population density to have a negative effect on environmental quality (Antweiler et al., 2001; Martínez-Zarzoso & Oueslati, 2018; Sorgho & Tharakan, 2022). However, the empirical evidence on this relationship is mixed (Sorgho & Tharakan, 2022).

Zhou et al., 2017). We address this using instrumental variable (IV) techniques. But this requires that we find appropriate instruments for the trade openness and GDP variables in our estimation equation.

We instrument for trade flows using the theory and empirics of the gravity model of trade (J. E. Anderson & van Wincoop, 2003)[8] and estimate the following theory-consistent structural gravity model:

$$X_{ij,t} = \exp[Z_{ij}\beta + \pi_{i,t} + \omega_{j,t}] \times \varepsilon_{ij,t} \quad [2]$$

where total bilateral trade values between countries i and j in year t, $X_{ij,t}$, is regressed on a vector Z_{ij} of country-pair variables (including controls for bilateral distance, contiguity, linguistic similarity and colonial ties), and a host of time-varying exporting country ($\pi_{i,t}$) and importing country ($\omega_{j,t}$) fixed effects.[9] $\varepsilon_{ij,t}$ is the random error term, which we cluster at the exporter-importer-year level. We estimate equation [2] using the Poisson Pseudo-Maximum Likelihood (PPML) estimator to address potential inconsistencies due to heteroskedasticity of trade data (Silva & Tenreyro, 2006). The estimates of the gravity model are reported in Table A1 in the online supplementary material. All estimated coefficients have the expected signs and are statistically significant. In a follow-up step, we predict total bilateral trade and aggregate it across all bilateral trading partners for each country (i.e., $\sum_{j\neq i}\widehat{X}_{ij,t}$) to get predicted total trade for country i in year t. We then use the predicted trade values as an instrument for observed trade (Frankel & Romer, 1999; Frankel & Rose, 2005; Millimet & Roy, 2016; Sorgho & Tharakan, 2022; Zhou et al., 2017).

To instrument the income effect, we estimate the following income equation based on the theories and empirics on income growth (Baghdadi et al., 2013; Frankel & Rose, 2005):

[8] The gravity model postulates that trade between two countries is influenced, positively, by their sizes (e.g., GDP, population, and land area) and, negatively, by the bilateral distance between them (e.g., physical distance, cultural distance). This is the work horse model for studying how trade-related policies such as food standards, trade agreements or global shocks affect agricultural trade (Curzi & Huysmans, 2022; Fiankor et al., 2023; Scoppola et al., 2018).

[9] The country-time fixed effects control for all country-time specific variables (e.g., GDP, production, institutional quality, population). 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 (J. E. Anderson & van Wincoop, 2003).

$$\ln GDPpc_{i,t} = \theta_1 \ln GDPpc_{i,t-1} + \theta_2 \ln Pop_{i,t} + \theta_3 \ln Invest_{i,t} + \theta_4 \ln Tradecap_{i,t} + \theta_5 \ln HCI_{i,t} + \theta_6 Popgrowth_{i,t} + \varphi_i + \sigma_t + u_{i,t} \quad [3]$$

where we regress GDP per capita ($GDPpc_{i,t}$) for country i in year t on its lag ($GDPpc_{i,t-1}$), population ($Pop_{i,t}$), investment rate ($Invest_{i,t}$) proxied by gross capital formation, trade per capita ($Tradecap_{i,t}$) defined as the ratio of total trade to population, human capital proxied by the human capital index ($HCI_{i,t}$), population growth rate ($Popgrowth_{i,t}$), country-fixed effects (φ_i), and year-fixed effects (σ_t). The term $u_{i,t}$ is random error with mean zero, which we cluster at the country level. We estimate the income equation [5] using ordinary least squares (OLS) and present the results in Table A2 of the online supplementary material. Thereafter, we predict income per capita (i.e., $\widehat{GDPcap}_{i,t}$) and use it to instrument for the observed GDP per capita. In addition, we calculate predicted trade openness as the ratio of predicted total trade we obtained from Equation 2 to predicted GDP per capita (i.e., $\widehat{Openness}_{i,t} = \sum_{j \neq i} \widehat{X}_{ij,t} / \widehat{GDPcap}_{i,t}$) and use it to instrument for observed trade openness in equation [1].

3.3 Empirical estimation

We model our estimation equation [1] as autoregressive panel data models because the indicators of climate change mitigation (i.e., the outcome variables in equation [1]) exhibit state/path dependence (Blundell & Bond, 1998; Managi et al., 2009; Sorgho & Tharakan, 2022). This implies that a country's current climate change mitigation performance depends on its past performance. Thus, in the absence of a large exogenous negative shock, high performing countries are likely to consistently perform high. Econometrically, this time dynamic effects pose estimation challenges because they cause the incidental parameter problem (Neyman & Scott, 1948). As a result, we use the two-step system generalized method of moments (GMM) estimator (Arellano & Bover, 1995; Blundell & Bond, 1998) instead of the difference GMM estimator (Arellano & Bond, 1991) because the former performs well in the presence of heteroscedasticity and time-invariant independent variables (Blundell & Bond, 1998; Windmeijer, 2005). We use $\widehat{Openness}_{i,t}$ and $\widehat{GDPcap}_{i,t}$ as instruments for the endogenous variables $Openness_{i,t}$ and $GDPcap_{i,t}$ respectively. Furthermore, regressors $Popdensity_{i,t}$, $Demoindex_{i,t}$, and δ_t are used as excluded instruments while 'internal instruments' (i.e., differences of the lags of endogenous variables – e.g., $\Delta CPP^{\rho}_{i,t-2}$ and $\Delta PTA^{g}_{i,t}$) were used to address the endogeneity of the lagged regressor ($CPP^{\rho}_{i,t-1}$) and the PTA variables (Blundell & Bond, 1998; Sorgho & Tharakan, 2022). As our dependent variables ($CPP^{\rho}_{i,t-1}$) are bounded between zero and one, we specify our estimation equations as an exponential fractional regression models (EFRM) following Ramalho et al. (2018).[10]

4 Data

Our analyses are based on a combination of data from three main sources. One on environmental provisions in preferential trade agreements and two on measures of climate change mitigation performance. In this section we discuss these data sources and present descriptive statistics.

4.1 PTAs and environmental provisions

We use the TRade and ENvironment Database (TREND) that systematically collects detailed information on PTAs and the different types of environmental provisions (EPs) they contain. TREND identifies close to 300 EPs in 775 trade agreements. Following Morin and Jinnah (2018) and Sorgho and Tharakan (2022), we categorize EPs into those that address climate change (directly and indirectly) and those that address other environmental issues. But, we take our approach a step further and make a stricter distinction between PTAs that directly address climate change from those that do not or only address general environmental concerns. We argue that, by joining PTAs that have direct climate change provisions, countries signal their willingness to consciously address climate change issues. Based on this categorization of EPs, we classify PTAs into six categories as follows: (i) PTAs with EPs (PTAwEPs), (ii) PTAs without EPs (PTAwoEPs), (iii) PTAs with direct climate change provisions (PTAwDCPs), (iv) PTAs without direct climate change provisions (PTAwoDCPs), and (v) PTAs with either direct or indirect climate change provisions (PTAwCPs), (vi) PTAs without climate change provisions (PTAwoCPs).

Figure 1 shows the growth in the number of the different types of PTAs based on the categories outlined above. Overall, the number of PTAs and the share of PTAs with EPs has increased steadily since the early 1990s but most of these PTAs do not directly address climate change issues. In 2021, only 144 out of the 775 PTAs (i.e., around 18.63%) directly addressed climate change. Moreover, it was only in 1979 that PTAs began to include direct provisions on climate change. Our work exploits this variation in the various types of environmental provisions in PTAs over time and across countries to assess how they affect environmental outcomes.

[10] All estimations were carried out using the user-written command 'frmpd' package in R. We use the GMM_{WW} estimator developed by Ramalho et al. (2018) for fractional exponential regression. However, for exponential regression the estimator was originally proposed by Wooldridge (1997) and Windmeijer (2000).

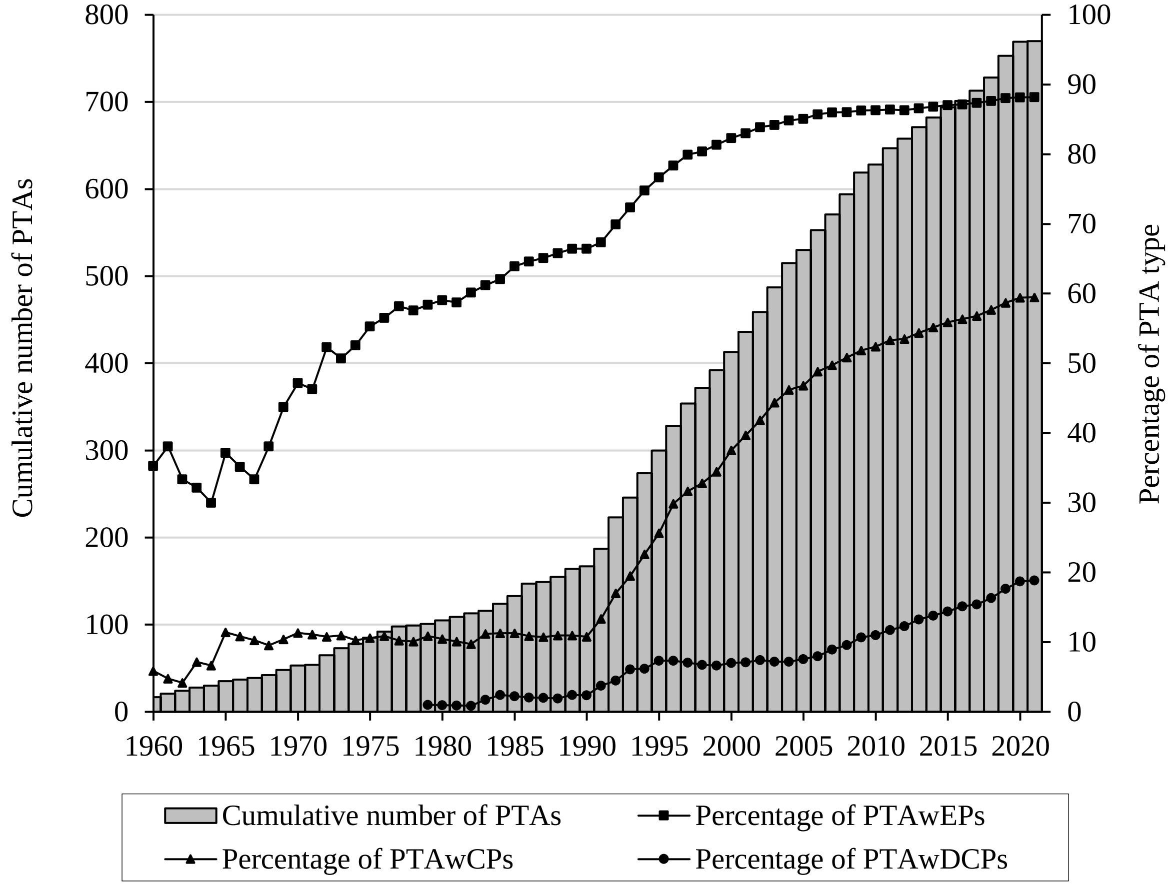

Figure 1. Global evolution of PTAs by type. *Note:* PTAs means preferential trade agreements; PTAwEPs means PTAs with environmental provisions; PTAwCPs means PTAs with climate change provisions that either directly or indirectly address climate change issues; PTAwDCPs means PTAs with climate change provisions that directly address climate change issues. *Source:* Authors' calculations based on data from TRade and ENvironment Database (TREND).

4.2 Measuring environmental performance

The data for our climate protection performance measures (i.e., the CCPI and its components) are provided by Germanwatch e.V. The CCPI is based on 14 indicators that fall into four broad sub-components, namely GHG emissions, renewable energy, energy use, and climate policy.[11] Broadly speaking, the index captures how climate policy, when effective, affects energy use and renewable energy ultimately leading to reductions in GHG emissions over time (Burck et al., 2023) and thus improvements in protecting the environment from climate change. Higher scores on the index (and its components) signify that a country performed better in terms of protecting its environment and climate. The data covers 57 countries over the period 2006 to 2019. Overall, global climate protection performance has been modest with mean CCPI scores

[11] See Figure D1 in the online supplementary material for a detailed description of the components that make up the CCPI.

of around 50% (see Figure 2). The data also show that climate protection performance is not entirely determined by a country's development status (Figure 3 below). For example, Morocco (a developing country) outperforms developed countries such as Australia and the United States of America.

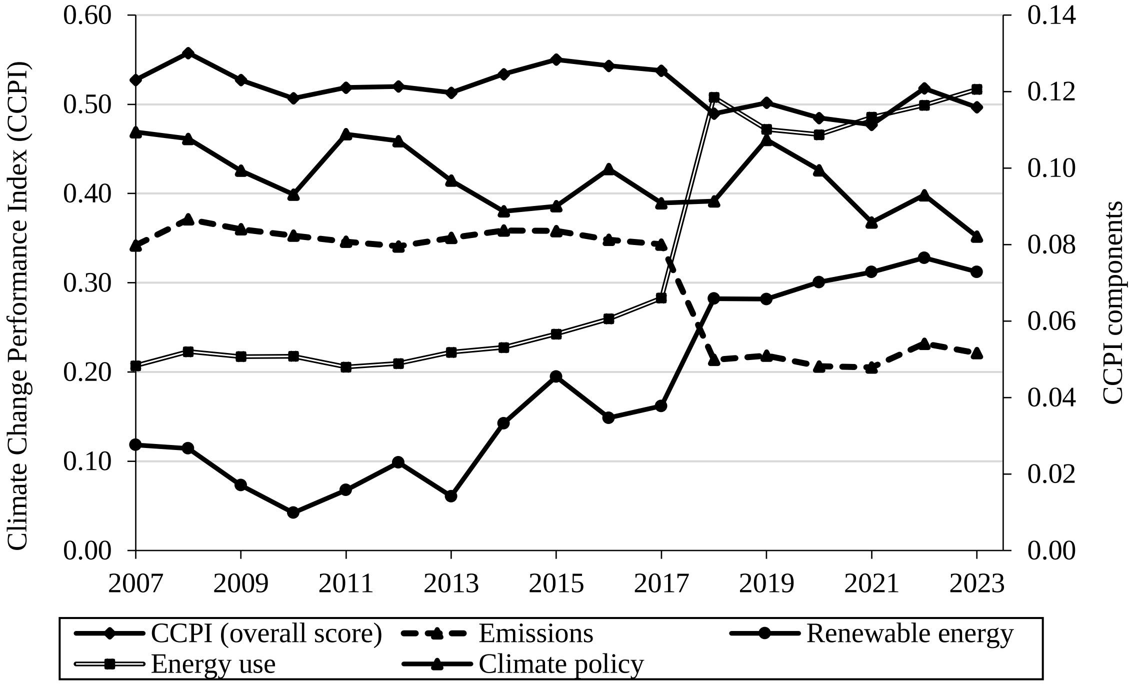

Figure 2. Global trends in climate change performance index and its components from 2007 to 2023. *Note:* The primary vertical axis captures scores for overall CCPI and emissions while scores for climate policy, renewable energy, and energy use are on the secondary y-axis. *Source:* Authors' calculations based on data from Germanwatch e.V.

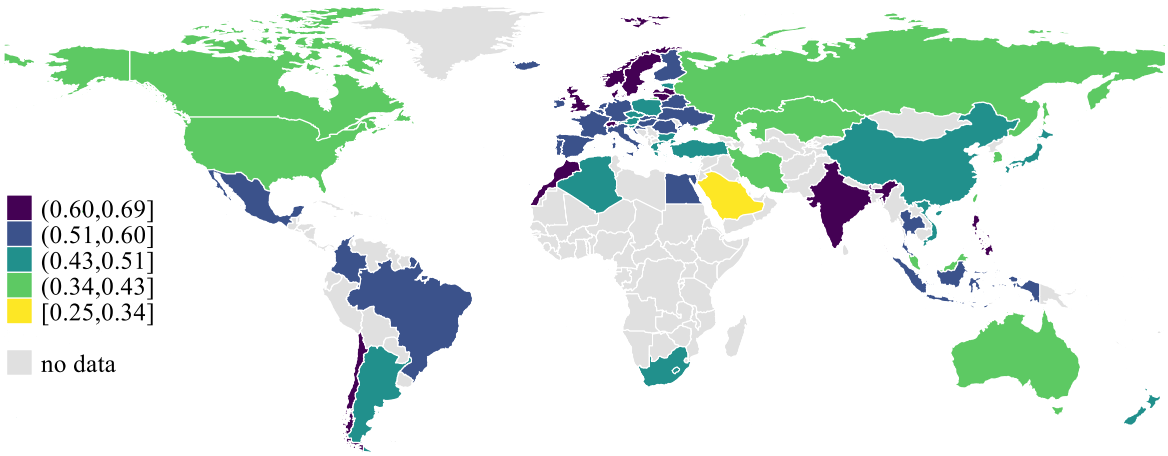

Figure 3. Variations in mean CCPI scores across countries over the sample period. *Note:* The darker shade (from yellow to purple), the larger the average CCPI score. Gray-shaded regions refer to missing data (i.e., where CCPI is not tracked). *Source:* Authors' illustration based on data from Germanwatch e.V.

To provide broader and robust evidence (i.e., based on more countries) on how well countries perform in terms of climate change performance, environmental health, and ecosystem vitality, we complement our analyses on CCPI using data on environmental performance index. These data come from the Socioeconomic Data and Applications Center (SEDAC)[12]. The EPI is constructed using 58 performance indicators across 11 issue categories (for details see Figure D2 in the online supplementary material). The index tracks the progress of 180 countries on three policy objectives: environmental health, ecosystem vitality, and climate change (Block et al., 2024). A higher EPI score indicates that a country is doing a better job of protecting its environment and climate. Overall, EPI scores vary widely, ranging from 0.184 in Mali to 0.935 in Iceland, with a mean of 0.560 (Table C2). For details on the variations in mean EPI scores across countries over the sample period, see Figure D3 in the online supplementary material.

4.3 Other data sources

The rest of the variables used in the empirical analyses come from different sources. Data on GDP per capita, population, investment and population growth rate are from the World Bank's World Development Indicators (WDI) whereas the human capital index comes from the Penn World Table version 10.01 (Feenstra et al., 2015). Bilateral trade flows and gravity variables (i.e., bilateral distance, contiguity, colonial relationship and common language) are from the Base pour l'Analyse du Commerce International (Gaulier & Zignago, 2010). Data on the democracy index comes from the Economic Intelligence Unit. Table C1 defines our key variables and outlines the data and data sources we used in our econometric estimations while Table C2 presents the summary statistics.

5 Results and discussion

This section presents and discusses the results of our analysis. In section 5.1, we discuss our baseline findings. In section 5.2, we analyze whether environmental provisions that address climate change directly or indirectly have different effects on climate change mitigation efforts. In section 5.3, we look at our main findings in more detail using a different measure of climate change mitigation. In Section 5.4, we look at whether the effects depend on which countries – developed or developing – are involved in the agreement.

[12] Data available at https://sedac.ciesin.columbia.edu/data/collection/epi/sets/browse

5.1 The effect of PTAs with environmental provisions on climate change mitigation

Our main results are presented in column (1) of Table 3 and suggest that international trade cooperation through PTAs enhances a country's ability to mitigate and adapt to climate change. The results show that the number of PTAs with EPs is positively associated with a statistically significant increase in the Climate Change Performance Index (CCPI). Specifically, a unit increase in the number of PTAs with EPs is associated with a 0.017 percentage points increase in the CCPI. On the contrary, PTAs without EPs are associated with a reduction in the CCPI, although the coefficient present high standard errors and thus not statistically significant at conventional levels.

To assess the channels through which the PTAs with EPs affect environmental performance, we assess how it affects the different components that make up the CCPI. The results are presented in columns (2) – (5) of Table 1. We find that PTAs with environmental provisions have a positive effect on GHGs emissions reduction and climate policy efficiency and a negative effect on energy use. Moreover, PTAs without environmental provisions significantly undermine performance in areas such as climate policy. These results suggest that the significant positive effect of PTAs with environmental provisions on climate change mitigation is driven by improvements in domestic environmental and climate policy initiatives and reductions in GHGs emissions.

As expected, we find that all coefficients on the lag of the outcome variables (i.e., $CPP^{\rho}_{i,t-1}$) are positive and statistically significant. This implies that a country's capacity to address climate change depends in part on the effectiveness of its past efforts. We further observe that all coefficients on trade openness are positive except for GHGs emissions. On the one hand, the negative and statistically significant effect of trade openness on GHGs emissions (column (2) of Table 1) implies that countries that trade more tend to have higher levels of GHGs emissions. This is consistent with the findings of Sorgho and Tharakan (2022) that trade openness increases emissions of CH_4 and CO_2. On the other hand, the positive effect of trade openness on renewable energy (column (3), Table 1) suggests that countries that are more open use more renewable energy. These results indicate that increased trade openness can benefit or hurt a country's climate change mitigation efforts depending on the size and interactions among the scale, composition, and technique effects (Copeland & Taylor, 2004; Grossman & Krueger, 1991; Managi et al., 2009). Except for energy use, all coefficients on the income variable (i.e., GDP per capita) are positive whenever they are statistically significant. This implies that countries with high income levels have more capacity to reduce GHGs emissions and increase the use of renewable. They can invest in green production technologies to reduce their carbon footprints and/or import more environmental goods. Population density is negatively associated with all our outcome variables. The same is true for the democracy index. As such, climate change mitigation performance decreases with increasing levels of democracy.[13]

Table 1. Effects of environmental provisions in PTAs on climate change mitigation

Dependent variable	CCPI (1)	Emissions reduction (2)	Renewable energy (3)	Energy use (4)	Climate policy (5)
$PTAwoEP_{i,t}$	-0.010	0.080	-0.077	0.323	-0.182***
	(0.037)	(0.169)	(0.132)	(0.268)	(0.050)
$PTAwEP_{i,t}$	0.017***	0.004***	-0.001	-0.031***	0.036***
	(0.005)	(0.001)	(0.009)	(0.011)	(0.009)
$CPP^{\rho}_{i,t-1}$	0.158**	0.501***	0.105***	0.120***	0.534***
	(0.089)	(0.113)	(0.311)	(0.193)	(0.084)
$lnOpenness_{i,t}$	0.079	-0.453***	0.040**	0.668*	0.358
	(0.214)	(0.160)	(0.022)	(0.352)	(0.223)
$lnGDPcap_{i,t}$	0.506	0.807**	0.034**	-0.828	0.797*
	(0.533)	(0.391)	(0.017)	(0.494)	(0.483)
$lnPopdensity_{i,t}$	-0.478*	-0.576***	-0.048	-0.206	-0.493*
	(0.272)	(0.206)	(0.113)	(0.174)	(0.283)
$Demoindex_{i,t}$	-2.853***	-4.633***	-0.399	0.221	-3.422***
	(1.003)	(1.401)	(0.923)	(1.109)	(0.530)
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	727	727	727	727	727
Countries	57	57	57	57	57
Hansen test (prob.)	0.117	0.123	0.128	0.166	0.137

Notes: CCPI means climate change performance index. $PTAwoEP_{i,t}$ is the number of preferential trade agreements (PTAs) that do not have environmental provisions and are in force in country i in year t. $PTAwEP_{i,t}$ is the number of PTAs that have environmental provisions. $CPP^{\rho}_{i,t-1}$ is the first lag of the dependent variable. $lnOpenness_{i,t}$, $lnGDPcap_{i,t}$, and $lnPopdensity_{i,t}$, are, respective, the natural logarithms of trade openness (instrumented), gross domestic product per capita (instrumented), and population density for country i in year t. $Demoindex_{i,t}$ is the democracy index. Standard errors, clustered at the country level, are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercepts, country and year fixed effects included but not reported for brevity. The Hansen test results fail to reject the validity of instruments. All models are estimated using two-step system generalized method of moments (GMM).

[13] Whereas, we find that democracy is negatively associated with environmental quality outcomes, we acknowledge that the empirical evidence on the relationship between democratic governance institutions and environmental quality outcomes is rather mixed. Acheampong et al. (2022) show that high-level democracy indicators moderate energy consumption to increase carbon dioxide emissions in West Africa and Central Eastern Africa but not Sub-Saharan Africa and Southern Africa. Povitkina and Jagers (2022) show that the type of democracy matters for environmental policy outputs. They find that *"democracies with stronger deliberative features adopt more, but not necessarily stricter or more effective, environmental policies. Instead, democracies with stronger social-liberal features adopt both stricter and more effective policies"*.

5.2 The effect of PTAs with environmental provisions on climate change mitigation: accounting for climate-specific provisions

The effects of environmental provisions on environmental quality outcomes also depend on the heterogeneity of the specific environmental provisions included in the trade agreements (Blümer et al., 2020; Brandi et al., 2020). To assess whether this heterogeneity matters for climate change mitigation, we categorize the EPs included in a trade agreement into direct, indirect, and neutral (i.e., neither address climate change issues directly nor indirectly) climate change provisions.[14] Based on this classification, we categorize PTAs into four groups: (i) PTAs with direct climate change provisions (PTAwDCPs), (ii) PTAs without direct climate change provisions (PTAwoDCPs), (iii) PTAs with climate change provisions (PTAwCPs), and (iv) PTAs without climate change provisions (PTAwoCPs). This allows us to assess whether the explicit inclusion of climate change provisions in PTAs matters for climate change mitigation.

We present the results in Table 2. The estimates in column (1) of Table 2, show that PTAs with any form of climate change provisions (i.e., the provisions address climate change issues directly and/or indirectly) are associated with a positive and statistically significant effect on climate change mitigation. Specifically, a one unit increase in the number of such PTAs is associated with a 0.17 percentage points increase in the CCPI. We find, however, that PTAs with environmental provisions that directly address climate change issues are associated with an even larger positive effect on climate protection performance (column (2)) with a unit increase in the number of such PTAs leading to a 0.45 percentage point increase in the CCPI. In essence, to achieve greater climate change mitigation outcomes, the EPs included in the PTAs must address climate change issue precisely.

In terms of channels through which different types of EPs in PTAs influence the overall climate change mitigation performance, we find that PTAs with climate change provisions that address climate change issues more broadly are associated with significant positive effects on GHGs emissions and climate policy (columns (2) and (5)) and significant negative effect on energy use (column (4)). Moreover, PTAs that do not have any climate change provisions are associated with significant negative and positive effects on GHGs emissions reduction efforts

[14] For instance, Article V of the PTA signed between China and Singapore in 2008 prescribes standards on promotion of renewable production of energy and energy efficiency. This is an example of a PTA with direct climate change provisions. An example of a PTA that includes indirect climate change provision is the trade agreements signed between Mexico and Panama in 2014, which, provides measures that call for the conservation of natural resources and the establishment of contact points on environmental matters.

and climate policy, respectively. On climate policy, our findings in column (5) indicate that enhanced international trade collaboration through PTAs can facilitate the adoption and implementation of environmental and climate policies, irrespective of whether the provisions within the agreement specifically address climate change.

The positive direct effect of PTAs with climate change provisions on CCPI, GHGs emissions, and climate policy support the conclusion by Sorgho and Tharakan (2022) that the inclusion of climate change-related provisions in PTAs can have an overall positive effect on environmental quality. Our work is, however, novel in showing that we achieve even larger positive effects when the provisions on climate change are direct and explicit. The results are presented in the even numbered columns of Table 2. We find that PTAs with climate change provisions that directly address climate change issues are associated with an overall significant positive effect on climate change mitigation and GHGs emissions (columns (6) and (4)). We also observe that PTAs without direct climate change provisions are associated with increased GHGs emissions and energy use (columns (4) and (8)).

Table 2. Effects of direct climate change provisions on climate change mitigation

	CCPI		Emissions reduction		Renewable energy		Energy use reduction		Climate policy	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$PTAwoCP_{i,t}$	-0.002		-0.040**		0.014		-0.021		0.004**	
	(0.025)		(0.020)		(0.015)		(0.016)		(0.002)	
$PTAwCP_{i,t}$	0.017***		0.024***		-0.006		-0.019**		0.002**	
	(0.006)		(0.001)		(0.010)		(0.008)		(0.001)	
$PTAwoDCP_{i,t}$		-0.015		-0.050***		0.028		-0.049***		0.061
		(0.043)		(0.017)		(0.029)		(0.016)		(0.057)
$PTAwDCP_{i,t}$		0.045**		0.008**		-0.008		0.004		0.010
		(0.023)		(0.003)		(0.010)		(0.009)		(0.014)
$CPP^{\rho}_{i,t-1}$	0.263***	0.244***	0.436***	0.180***	0.149***	0.137***	0.132***	0.116***	0.445***	0.437***
	(0.040)	(0.041)	(0.050)	(0.067)	(0.522)	(0.045)	(0.152)	(0.013)	(0.148)	(0.100)
$lnOpenness_{i,t}$	0.312	0.269	-0.425	-0.128	0.151**	0.005	0.543**	0.289	0.191	0.232
	(0.236)	(0.247)	(0.348)	(0.349)	(0.009)	(0.296)	(0.229)	(0.227)	(0.457)	(0.221)
$lnGDPcap_{i,t}$	-0.294	-0.127	1.320	0.417	0.048**	0.071	-0.676*	-0.458	-0.044	1.011**
	(0.597)	(0.639)	(0.844)	(1.047)	(0.029)	(0.313)	(0.383)	(0.360)	(0.424)	(0.515)
$lnPopdensity_{i,t}$	0.090	0.117	0.272	-0.789***	-0.065	-0.086	-0.167	-0.192	0.075	-0.213
	(0.167)	(0.212)	(0.187)	(0.220)	(0.121)	(0.129)	(0.130)	(0.146)	(0.132)	(0.259)
$Demoindex_{i,t}$	-0.977	0.324	-0.067	-0.158	-0.971	-0.230	0.118	1.512*	0.914	-2.993***
	(1.133)	(1.065)	(0.435)	(0.958)	(1.102)	(1.071)	(0.850)	(0.775)	(1.363)	(0.838)
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	727	727	727	727	727	727	727	727	727	727
Countries	57	57	57	57	57	57	57	57	57	57
Hansen test (prob.)	0.133	0.107	0.202	0.269	0.264	0.272	0.135	0.101	0.123	0.167

Notes: CCPI means climate change performance index. $PTAwoCP_{i,t}$ is the number of preferential trade agreements (PTAs) that do not have environmental provisions that address climate change-related issues either directly, indirectly, or both and are in force in country i in year t. $PTAwCP_{i,t}$ is the number of PTAs that have environmental provisions that address climate change-related issues either directly, indirectly, or both. $PTAwoDCP_{i,t}$ is the number of PTAs that do not have environmental provisions that directly address climate change-related issues. $PTAwDCP_{i,t}$ is the number of PTAs that have environmental provisions that directly address climate change-related issues. $CPP^{\rho}_{i,t-1}$ is the first lag of the dependent variable. $lnOpenness_{i,t}$, $lnGDPcap_{i,t}$, and $lnPopdensity_{i,t}$, are, respective, the natural logarithms of trade openness (instrumented), gross domestic product per capita (instrumented), and population density for country i in year t. $Demoindex_{i,t}$ is the democracy index. FEs means fixed effects. Standard errors, clustered at the country level, are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercepts, country and year fixed effects included but not reported for brevity. The Hansen test results fail to reject the validity of instruments. All models are estimated using two-step system generalized method of moments (GMM).

5.3 The effect of PTAs with environmental provisions on climate change mitigation: alternative measure of climate performance

Our findings so far confirm the positive effects of PTAs with EPs on climate change mitigation. The use of the CCPI index allows us to capture climate change effects more broadly, but the downside is that the CCPI covers a limited set of countries, which calls into question the generalizability of our findings. To address this concern and provide a broader and more robust evidence on how different types of PTAs affect environmental quality outcomes, we measure climate change mitigation using an alternative indicator: the environmental performance index (EPI) and its components (i.e., environmental health, and climate and energy). The EPI covers 180 countries. Specifically, we estimate equation [1] but replace the outcome variable CCPI with EPI. The results are presented in Table 3. First, we assess whether EPs matter for climate change mitigation and present the results in columns (1), (4), and (7). Consistent with our findings in Table 1, we find that PTAs with environmental provisions have a positive effect on EPI, but also its components—environmental health, and climate and energy. PTAs without EPs, however, have no discernable effects on EPI and climate and energy, but have a negative effect on environmental health. The significant positive direct effect of PTAs with EPs on the three environmental quality indicators reaffirms our main findings and the notion that the inclusion of environmental provisions in trade agreements could be a potent trade policy instrument in the existential fight against climate change and other environmental issues (Abman et al., 2024; Brandi et al., 2020; Sorgho & Tharakan, 2022).

Consistent with Section 5.2, we also examine whether the climate change mitigation effects of PTAs depend on whether the provisions address climate change directly or indirectly. In columns (2), (5) and (8), PTAs with climate change provisions are associated with positive and statistically significant effects on EPI, environmental health, and climate and energy. Moreover, PTAs without climate change provisions are negatively associated with all the three environmental quality indicators. The results in columns (3), (6), and (9) of Table 3 further show that PTAs with direct climate change provisions are associated with an overall significant positive effect on climate protections performance. Here, again the effects of PTAs with direct climate change provisions on climate mitigation performance are larger in magnitude than the effects of PTAs with more broadly defined climate provisions.

Table 3. Effects of different types of environmental provisions in PTAs on environmental quality outcomes

	EPI			Environmental health			Climate and energy		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$PTAwoEP_{i,t}$	0.009			-0.423***			-0.005		
	(0.064)			(0.061)			(0.057)		
$PTAwEP_{i,t}$	0.007**			0.026**			0.015**		
	(0.003)			(0.012)			(0.006)		
$PTAwoCP_{i,t}$		-0.020			-0.074***			-0.002	
		(0.025)			(0.028)			(0.016)	
$PTAwCP_{i,t}$		0.002**			0.057***			0.025***	
		(0.001)			(0.018)			(0.009)	
$PTAwoDCP_{i,t}$			-0.025*			-0.059*			0.013
			(0.015)			(0.031)			(0.012)
$PTAwDCP_{i,t}$			0.003**			0.147***			0.012**
			(0.001)			(0.051)			(0.004)
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	787	787	787	905	905	905	794	794	794
Countries	114	114	114	132	132	132	115	115	115
Hansen test (prob.)	0.162	0.163	0.155	0.148	0.123	0.173	0.141	0.142	0.153

Notes: EPI means environmental performance index. $PTAwoEP_{i,t}$ is the number of preferential trade agreements (PTAs) that do not have environmental provisions and are in force in country i in year t. $PTAwEP_{i,t}$ is the number of PTAs that have environmental provisions. $PTAwoCP_{i,t}$ is the number of PTAs that do not have environmental provisions that address climate change-related issues either directly, indirectly, or both and are in force in country i in year t. $PTAwCP_{i,t}$ is the number of PTAs that have environmental provisions that address climate change-related issues either directly, indirectly, or both. $PTAwoDCP_{i,t}$ is the number of PTAs that do not have environmental provisions that directly address climate change-related issues while $PTAwDCP_{i,t}$ is the number of PTAs that have environmental provisions that directly address climate change-related issues. Other controls included in all the models are (i) $CPP^{\rho}_{i,t-1}$, the first lag of the dependent variable; (ii). $lnOpenness_{i,t}$, (iii) $lnGDPcap_{i,t}$, and (iv) $lnPopdensity_{i,t}$, are, respectively, the natural logarithms of trade openness (instrumented), gross domestic product per capita (instrumented), and population density for country i in year t. Standard errors, clustered at the country level, are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% respectively. Intercepts, country and year fixed effects included but not reported for brevity. The Hansen test results fail to reject the validity of instruments. All models are estimated using two-step system generalized method of moments (GMM).

5.4 Heterogeneous effects across North-North, North-South, and South-South PTAs

The effectiveness of environmental regulations can be mitigated by several factors. For instance, the effectiveness of EPs in PTAs could depend on whether they are signed between developed (North), or developed and developing (South), or developing countries (Bastiaens & Postnikov, 2017). Therefore, we extend our analyses and examine whether the climate change mitigation effects of EPs in PTAs vary between South-South PTAs, North-North PTAs and North-South PTAs. We use the United Nations Conference on Trade and Development (UNCTAD) classification to divide countries into two mutually exclusive and collectively exhaustive groups: North[15] and South (Hoffmeister, 2020). We then split up PTAs based on whether they were signed between South-South, North-North, or North-South countries and-estimate equation [1] on these subsamples. In this section, our analysis is limited to the EPI, rather than the CCPI, due to the former's larger sample size of developed and developing countries, which provides sufficient variation for analysis. The results are presented in Table 4.

The top panel of Table 4 assesses the effects of PTAs with some form of climate provisions on climate change mitigation, while the lower panel assesses the effects of PTAs with direct climate change provisions. Consistent with our findings presented in Table 3, we find that PTAs with climate change provisions are associated with positive and significant effects on EPI, environmental health, and climate and energy irrespective of development status of the signatories. The same is true for PTAs with direct climate change provisions. The magnitudes of the estimated effects are, however, larger for PTAs with direct climate change provisions. We also observe that climate change provisions have larger climate change mitigation effects in North-South PTAs than in either North-North or South-South PTAs. Moreover, North-North PTAs without climate change provisions are negatively associated with all the three environmental quality indicators but the effects are statistically non-significant. On the contrary, North-South and South-South PTAs without climate change provisions are, generally, associated with non-significant positive effects on EPI, environmental health, and climate and energy.

[15] The following countries and territories are categorized as developed (North) under the UNCTAD classification: Åland Islands, Albania, Andorra, Australia, Austria, Belarus, Belgium, Bermuda, Bosnia and Herzegovina, Bulgaria, Canada, Christmas Island, Cocos (Keeling) Islands, Croatia, Cyprus, Czechia, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Greenland, Guernsey, Heard Island and McDonald Islands, Holy See, Hungary, Iceland, Ireland, Isle of Man, Israel, Italy, Japan, Jersey, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Netherlands, New Zealand, Norfolk Island, Macedonia, Norway, Poland, Portugal, Republic of Korea, Republic of Moldova, Romania, Russian Federation, Saint Pierre and Miquelon, San Marino, Serbia, Slovakia, Slovenia, Spain, Svalbard and Jan Mayen Islands, Sweden, Switzerland, Ukraine, United Kingdom, United States of America, United States Minor Outlying Islands.

We further assess whether environmental provisions that directly address climate change related issues have heterogenous environmental quality effects across North-North, North-South, and South-South PTAs and present the results in Table 4b. We find that PTAs with direct climate change provisions are associated with significant positive effects on all environmental quality indicators. This further reaffirms that PTAs with direct climate change provisions can contribute to improving environmental sustainability. We also observe that direct climate change provisions have larger environmental quality-promoting effects in South-South PTAs than in either North-North or North-South PTAs. In addition, North-North PTAs without direct climate change provisions are associated with significant positive effect on climate and energy. Moreover, North-South PTAs and South-South PTAs without direct climate change provisions are, generally, positively associated with all the three environmental quality indicators but the effects are significant for EPI and environmental health.

Table 4. Effects of climate-change related environmental provisions on environmental quality outcomes

	North-North PTAs			North-South PTAs			South-South PTAs		
	EPI	Environmental health	Climate & energy	EPI	Environmental health	Climate & energy	EPI	Environmental health	Climate & energy
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$PTAwoCP_{i,t}$	-0.021	-0.042	-0.043	0.014	-0.018	0.023	0.058	0.018	0.026
	(0.028)	(0.051)	(0.036)	(0.137)	(0.088)	(0.049)	(0.053)	(0.047)	(0.046)
$PTAwCP_{i,t}$	0.031***	0.052**	0.023***	0.080**	0.271***	0.017**	0.011**	0.037***	0.010**
	(0.004)	(0.026)	(0.008)	(0.036)	(0.052)	(0.008)	(0.005)	(0.008)	(0.004)
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	298	298	298	731	841	738	490	607	497
Countries	43	43	43	106	123	107	71	89	72
Hansen test (prob.)	0.194	0.165	0.159	0.201	0.125	0.150	0.144	0.155	0.140
$PTAwoDCP_{i,t}$	-0.006	-0.026	0.102***	0.066**	0.122**	-0.002	0.012	0.024***	0.002
	(0.028)	(0.032)	(0.020)	(0.027)	(0.048)	(0.025)	(0.032)	(0.007)	(0.031)
$PTAwDCP_{i,t}$	0.180***	0.063**	0.103***	0.079***	0.096***	0.042***	0.363***	0.247***	0.162**
	(0.063)	(0.028)	(0.025)	(0.019)	(0.027)	(0.012)	(0.141)	(0.041)	(0.087)
Country FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	298	298	298	731	841	738	490	607	497
Countries	43	43	43	106	123	107	71	89	72
Hansen test (prob.)	0.167	0.134	0.263	0.140	0.136	0.179	0.151	0.153	0.162

Notes: EPI means environmental performance index. $PTAwoCP_{i,t}$ is the number of PTAs that do not have environmental provisions that address climate change-related issues either directly, indirectly, or both and are in force in country i in year t. $PTAwCP_{i,t}$ is the number of PTAs that have environmental provisions that address climate change-related issues either directly, indirectly, or both. $PTAwoDCP_{i,t}$ is the number of PTAs that do not have environmental provisions that directly address climate change-related issues while $PTAwDCP_{i,t}$ is the number of PTAs that have environmental provisions that directly address climate change-related issues. Other controls included in all the models are (i) $CPP^{\rho}_{i,t-1}$, the first lag of the dependent variable; (ii). $lnOpenness_{i,t}$, (iii) $lnGDPcap_{i,t}$, and (iv) $lnPopdensity_{i,t}$, are, respectively, the natural logarithms of trade openness (instrumented), gross domestic product per capita (instrumented), and population density for country i in year t. FEs means fixed effects. Intercepts, country and year fixed effects included but not reported for brevity. Standard errors, clustered at the country level, are in parentheses. ***, **, and * denote significance at 1%, 5%, and 10% respectively. The Hansen test results fail to reject the validity of instruments. All models are estimated using two-step system generalized method of moments (GMM).

6 Policy implications

As global trade in the past three decades has lifted millions out of poverty, keeping food markets open to trade remains crucial for global food security (K. Anderson, 2022; Brown et al., 2017). As preferential trade agreements proliferate, they need to be deepened to ensure that food systems remain sustainable. Our findings show that deep trade agreements with environmental provisions have positive effects on climate change mitigation. This suggest that the inclusion of environmental provisions in trade agreements could be a potent trade policy instrument in the existential fight against climate change. By joining trade agreements that have environmental provisions, countries are more likely to put environmental issues at the center of trade and environmental policy debates, leading to improved domestic environmental (climate) policy formulation and regulation, and improved climate change mitigation efforts. Our work compliments existing works (e.g., Baghdadi et al., 2013; Martínez-Zarzoso & Oueslati, 2018; Sorgho & Tharakan, 2022; Zhou et al., 2017) that show that the inclusion of environmental provisions in trade agreements is associated with improvements in environmental quality outcomes such as reductions in GHGs emissions. Our work, however, extends the existing evidence in stressing the fact that effective designing of PTAs is crucial. If PTAs are to achieve climate change mitigation efforts and address other environmental problems, they must directly address climate change issues (i.e., have climate change provisions).

7 Conclusion

International trade and climate change are intricately intertwined. While climate change can have enormous negative effects on international trade (e.g., by increasing trading costs, disrupting production and supply chains (World Trade Organization, 2022)), international trade can also worsen climate change effects by contributing to deforestation (Abman & Lundberg, 2020; DeFries et al., 2010; Leblois et al., 2017), loss of biodiversity (Bjelle et al., 2021; Chaudhary & Brooks, 2019; Kitzes et al., 2017; Lenzen et al., 2012; Marques et al., 2019; Wilting et al., 2021) and increased emissions of carbon and GHGs (Ermgassen et al., 2020; Johansson et al., 2020; Karstensen et al., 2013; Saikku et al., 2012). However, trade and well-designed trade policies remain crucial avenues for mitigating and adapting to climate change (World Trade Organization, 2022). But, do targeted trade policy instruments such as environmental provisions in trade agreements contribute to improved climate protection performance?

In this study, we analyse the effects of environmental provisions and climate change provisions in PTAs on environmental quality. We use the climate change performance index and the environmental performance index to objectively measure cross-country differences in addressing climate change and other environmental issues. We assess how heterogeneity environmental provisions in PTAs affect environmental quality outcomes. Our primary contribution is to provide comprehensive direct evidence on the effects of heterogeneity of environmental and climate change provisions in PTAs on climate change mitigation.

We use an autoregressive panel data model to estimate the effects of including environmental provisions and climate change provisions in PTAs on climate protection performance controlling for scale, composition and technique effects. We address potential endogeneity concerns using dynamic panel data estimation techniques and instrumental variables approaches. We find that, *ceteris paribus*, the inclusion of environmental provisions and climate change provisions in PTAs enhances a country's performance in improving its environmental health, ecosystem vitality, and adapting and mitigating climate change. The environmental quality-enhancing effects are primarily driven by gains in the areas such as emissions, renewable energy and climate policy. Moreover, PTAs that have direct climate change provisions (i.e., directly address climate change issues) have larger effects on climate protection performance, environmental health, and ecosystem vitality than PTAs that either address environmental issues in general and/or indirectly address climate change issues. It is important that trade agreements should include climate change provisions if they are to be an effective strategy for dampening potential negative environmental quality effects of trade and/or directly mitigating and adapting to climate change or addressing other environmental issues. Moreover, these should be complemented by effective political institutions.

Our analysis contributes to the contentious debate on trade, trade policy and climate change 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 concern such as climate governance. Although our findings have important implications for environmental- and climate protection, trade- and environmental policy, we recognise they could be limited in two ways. First, data on our main outcome variable (i.e., CCPI) is limited to selected countries that contribute to over 90% of global GHGs emissions. These countries are most likely different from most countries that are not tracked by the index which might limit the external validity of our results. However, we complement our CCPI analyses with analyses based on the environmental performance index to address the limited sample coverage problem and enhance external validity of our results. Second, we independently modelled and estimated the effects of environmental provisions and climate change provisions on the four components of the CCPI by assuming that they are statistically independent.

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References

Abman, R., & Lundberg, C. (2020). Does Free Trade Increase Deforestation? The Effects of Regional Trade Agreements. *Journal of the Association of Environmental and Resource Economists*, *7*(1), 35–72. https://doi.org/10.1086/705787

Abman, R., Lundberg, C., & Ruta, M. (2024). The Effectiveness of Environmental Provisions in Regional Trade Agreements. *Journal of the European Economic Association*, Article jvae023. Advance online publication. https://doi.org/10.1093/jeea/jvae023

Acheampong, A. O., Opoku, E. E. O., & Dzator, J. (2022). Does democracy really improve environmental quality? Empirical contribution to the environmental politics debate. *Energy Economics*, *109*, 105942. https://doi.org/10.1016/j.eneco.2022.105942

Afesorgbor, S. K., Fiankor, D.-D. D., & Demena, B. A. (2024). Do regional trade agreements affect agri-food trade? Evidence from a meta-analysis. *Applied Economic Perspectives and Policy*, *46*(2), 737–759. https://doi.org/10.1002/aepp.13410

Anderson, J. E., & van Wincoop, E. (2003). Gravity with Gravitas: A Solution to the Border Puzzle. *American Economic Review*, *93*(1), 170–192. https://doi.org/10.1257/000282803321455214

Anderson, K. (2022). Trade-related food policies in a more volatile climate and trade environment. *Food Policy*, *109*, 102253. https://doi.org/10.1016/j.foodpol.2022.102253

Antweiler, W., Copeland, B. R., & Taylor, M. S. (2001). Is Free Trade Good for the Environment? *American Economic Review*, *91*(4), 877–908. https://doi.org/10.1257/aer.91.4.877

Arellano, M., & Bond, S. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *The Review of Economic Studies*, *58*(2), 277. https://doi.org/10.2307/2297968

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, *68*(1), 29–51. https://doi.org/10.1016/0304-4076(94)01642-D

Baghdadi, L., Martinez-Zarzoso, I., & Zitouna, H. (2013). Are RTA agreements with environmental provisions reducing emissions? *Journal of International Economics*, *90*(2), 378–390. https://doi.org/10.1016/j.jinteco.2013.04.001

Bastiaens, I., & Postnikov, E. (2017). Greening up: the effects of environmental standards in EU and US trade agreements. *Environmental Politics*, *26*(5), 847–869. https://doi.org/10.1080/09644016.2017.1338213

Berthou, A., Chung, J. J.-H., Manova, K. B., & Sandoz Dit Bragard, C. (2019). Trade, Productivity and (Mis)Allocation. *SSRN Electronic Journal.* Advance online publication. https://doi.org/10.2139/ssrn.3502471

Bjelle, E. L., Kuipers, K., Verones, F., & Wood, R. (2021). Trends in national biodiversity footprints of land use. *Ecological Economics, 185*, 107059. https://doi.org/10.1016/j.ecolecon.2021.107059

Block, S., Emerson, J. W., Esty, D. C., Sherbinin, A. de, & Wendling, Z. (2024). *Environmental Performance Index 2024.* New Haven, CT: Yale Center for Environmental Law & Policy. epi.yale.edu

Blümer, D., Morin, J.-F., Brandi, C., & Berger, A. (2020). Environmental provisions in trade agreements: defending regulatory space or pursuing offensive interests? *Environmental Politics, 29*(5), 866–889. https://doi.org/10.1080/09644016.2019.1703383

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics, 87*(1), 115–143. https://doi.org/10.1016/S0304-4076(98)00009-8

Brandi, C., Schwab, J., Berger, A., & Morin, J.-F. (2020). Do environmental provisions in trade agreements make exports from developing countries greener? *World Development, 129*, 104899. https://doi.org/10.1016/j.worlddev.2020.104899

Brown, M. E., Carr, E. R., Grace, K. L., Wiebe, K., Funk, C. C., Attavanich, W., Backlund, P., & Buja, L. (2017). Do markets and trade help or hurt the global food system adapt to climate change? *Food Policy, 68*, 154–159. https://doi.org/10.1016/j.foodpol.2017.02.004

Burck, J., Uhlich, T., Höhne, N., Bals, C., & Nascimento, L. (2023). *The Climate Change Performance Index.* chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://ccpi.org/wp-content/uploads/CCPI-2023-Background-and-Methodology-1.pdf

Busse, M., & Koeniger, J. (2012). Trade and Economic Growth: A Re-Examination of the Empirical Evidence. *SSRN Electronic Journal.* Advance online publication. https://doi.org/10.2139/ssrn.2009939

Chaudhary, A., & Brooks, T. M. (2019). National Consumption and Global Trade Impacts on Biodiversity. *World Development, 121*, 178–187. https://doi.org/10.1016/j.worlddev.2017.10.012

Cherniwchan, J., Copeland, B. R., & Taylor, M. S. (2017). Trade and the Environment: New Methods, Measurements, and Results. *Annual Review of Economics*, *9*(1), 59–85. https://doi.org/10.1146/annurev-economics-063016-103756

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

Curzi, D., & Huysmans, M. (2022). The Impact of Protecting EU Geographical Indications in Trade Agreements. *American Journal of Agricultural Economics*, *104*(1), 364–384. https://doi.org/10.1111/ajae.12226

D'Andrea, B., Degain, C., Eberth, F., Rubínová, S., Snoussi-Mimouni, M., & Xu, A. (2024). Thirty years of trade growth and poverty reduction. *WTO Blog*. https://www.wto.org/english/blogs_e/data_blog_e/blog_dta_24apr24_e.htm

De Loecker, J., & Warzynski, F. (2012). Markups and Firm-Level Export Status. *American Economic Review*, *102*(6), 2437–2471. https://doi.org/10.1257/aer.102.6.2437

DeFries, R. S., Rudel, T., Uriarte, M., & Hansen, M. (2010). Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Geoscience*, *3*(3), 178–181. https://doi.org/10.1038/ngeo756

Dür, A., Baccini, L., & Elsig, M. (2014). The design of international trade agreements: Introducing a new dataset. *The Review of International Organizations*, *9*(3), 353–375. https://doi.org/10.1007/s11558-013-9179-8

Ermgassen, E. K. H. J. zu, Godar, J., Lathuillière, M. J., Löfgren, P., Gardner, T., Vasconcelos, A., & Meyfroidt, P. (2020). The origin, supply chain, and deforestation risk of Brazil's beef exports. *Proceedings of the National Academy of Sciences of the United States of America*, *117*(50), 31770–31779. https://doi.org/10.1073/pnas.2003270117

Fan, Z., Zhou, Y., & Anwar, S. (2024). Centralization of trade agreements network and global value chain participation. *The Quarterly Review of Economics and Finance*, *94*, 11–24. https://doi.org/10.1016/j.qref.2023.12.008

Feenstra, R. C., Inklaar, R., & Timmer, M. P. (2015). The Next Generation of the Penn World Table. *American Economic Review*, *105*(10), 3150–3182. https://doi.org/10.1257/aer.20130954

Fiankor, D.-D. D., Lartey, A., & Ritzel, C. (2023). Agri-food importing firms amid a global health crisis. *Food Policy*, *119*, 102507. https://doi.org/10.1016/j.foodpol.2023.102507

Frankel, J. A., & Romer, D. (1999). Does Trade Cause Growth? *American Economic Review*, *89*(3), 379–399. https://doi.org/10.1257/aer.89.3.379

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

Gaulier, G., & Zignago, S. (2010). BACI: International Trade Database at the Product-Level (the 1994-2007 Version). *SSRN Electronic Journal*. Advance online publication. https://doi.org/10.2139/ssrn.1994500

George, C., & Yamaguchi, S. (2018). Assessing Implementation of Environmental Provisions in Regional Trade Agreements. *OECD Trade and Environment Working Papers*, *2018/01*. https://doi.org/10.1787/91aacfea-en

Ghosh, S., & Yamarik, S. (2006). Do regional trading arrangements harm the environment? An analysis of 162 countries in 1990. *Applied Econometrics and International Development*, *6*(2), 15–36.

Grossman, G. M., & Krueger, A. B. (1991). Environmental impacts of a North American Free Trade Agreement. *NBER Working Paper*, *3914*.

Himics, M., Fellmann, T., Barreiro-Hurlé, J., Witzke, H.-P., Pérez Domínguez, I., Jansson, T., & Weiss, F. (2018). Does the current trade liberalization agenda contribute to greenhouse gas emission mitigation in agriculture? *Food Policy*, *76*, 120–129. https://doi.org/10.1016/j.foodpol.2018.01.011

Hoffmeister, O. (2020). *Development Status as a Measure of Development* (UNCTAD Research Paper No. 46). https://doi.org/10.18356/a29d2be8-en

Jafari, Y., Engemann, H., & Zimmermann, A. (2023). Food trade and regional trade agreements – A network perspective. *Food Policy*, *119*, 102516. https://doi.org/10.1016/j.foodpol.2023.102516

Jinnah, S., & Lindsay, A. (2016). Diffusion Through Issue Linkage: Environmental Norms in US Trade Agreements. *Global Environmental Politics*, *16*(3), 41–61. https://doi.org/10.1162/GLEP_a_00365

Johansson, E., Olin, S., & Seaquist, J. (2020). Foreign demand for agricultural commodities drives virtual carbon exports from Cambodia. *Environmental Research Letters*, *15*(6), 64034. https://doi.org/10.1088/1748-9326/ab8157

Johnson, T. (2015). Information revelation and structural supremacy: The World Trade Organization's incorporation of environmental policy. *The Review of International Organizations*, *10*(2), 207–229. https://doi.org/10.1007/s11558-015-9215-y

Karstensen, J., Peters, G. P., & Andrew, R. M. (2013). Attribution of CO 2 emissions from Brazilian deforestation to consumers between 1990 and 2010. *Environmental Research Letters*, *8*(2), 24005. https://doi.org/10.1088/1748-9326/8/2/024005

Laget, E., Osnago, A., Rocha, N., & Ruta, M. (2020). Deep trade agreements and global value chains. *Review of Industrial Organization*, *57*, 379–410.

Leblois, A., Damette, O., & Wolfersberger, J. (2017). What has Driven Deforestation in Developing Countries Since the 2000s? Evidence from New Remote-Sensing Data. *World Development*, *92*, 82–102. https://doi.org/10.1016/j.worlddev.2016.11.012

Lenzen, M., Moran, D., Kanemoto, K., Foran, B., Lobefaro, L., & Geschke, A. (2012). International trade drives biodiversity threats in developing nations. *Nature, 486*(7401), 109–112. https://doi.org/10.1038/nature11145

Lyn, G., & Rodríguez-Clare, A. (2013). External Economies and International Trade Redux: Comment. *Quarterly Journal of Economics*, *128*(4), 1895–1905. https://doi.org/10.1093/qje/qjt017

Managi, S., Hibiki, A., & Tsurumi, T. (2009). Does trade openness improve environmental quality? *Journal of Environmental Economics and Management*, *58*(3), 346–363. https://doi.org/10.1016/j.jeem.2009.04.008

Marques, A., Martins, I. S., Kastner, T., Plutzar, C., Theurl, M. C., Eisenmenger, N., Huijbregts, M. A. J., Wood, R., Stadler, K., Bruckner, M., Canelas, J., Hilbers, J. P., Tukker, A., Erb, K., & Pereira, H. M. (2019). Increasing impacts of land use on biodiversity and carbon sequestration driven by population and economic growth. *Nature Ecology & Evolution*, *3*(4), 628–637. https://doi.org/10.1038/s41559-019-0824-3

Martínez-Zarzoso, I. (2018). Assessing the Effectiveness of Environmental Provisions in Regional Trade Agreements: An Empirical Analysis. *OECD Trade and Environment Working Papers, 2018/02.* https://doi.org/10.1787/5ffc615c-en

Martínez-Zarzoso, I., & Oueslati, W. (2018). Do deep and comprehensive regional trade agreements help in reducing air pollution? *International Environmental Agreements: Politics, Law and Economics*, *18*(6), 743–777. https://doi.org/10.1007/s10784-018-9414-0

Millimet, D. L., & Roy, J. (2016). Empirical Tests of the Pollution Haven Hypothesis When Environmental Regulation is Endogenous. *Journal of Applied Econometrics*, *31*(4), 652–677. https://doi.org/10.1002/jae.2451

Morin, J.-F., & Jinnah, S. (2018). The untapped potential of preferential trade agreements for climate governance. *Environmental Politics*, *27*(3), 541–565. https://doi.org/10.1080/09644016.2017.1421399

Neyman, J., & Scott, E. L. (1948). Consistent Estimates Based on Partially Consistent Observations. *Econometrica*, *16*(1), 1. https://doi.org/10.2307/1914288

Povitkina, M., & Jagers, S. C. (2022). Environmental commitments in different types of democracies: The role of liberal, social-liberal, and deliberative politics. *Global Environmental Change*, *74*, 102523. https://doi.org/10.1016/j.gloenvcha.2022.102523

Ramalho, E. A., Ramalho, J. J. S., & Coelho, L. M. (2018). Exponential Regression of Fractional-Response Fixed-Effects Models with an Application to Firm Capital Structure. *Journal of Econometric Methods, 7*(1). https://doi.org/10.1515/jem-2015-0019

Ritzel, C., & Fiankor, D.-D. D. (2024). How do non-reciprocal trade preferences affect the food exports and food availability per capita of Global South countries? *Global Food Security*, *42*, 100800. https://doi.org/10.1016/j.gfs.2024.100800

Saikku, L., Soimakallio, S., & Pingoud, K. (2012). Attributing land-use change carbon emissions to exported biomass. *Environmental Impact Assessment Review*, *37*, 47–54. https://doi.org/10.1016/j.eiar.2012.03.006

Scoppola, M., Raimondi, V., & Olper, A. (2018). The impact of EU trade preferences on the extensive and intensive margins of agricultural and food products. *Agricultural Economics*, *49*(2), 251–263. https://doi.org/10.1111/agec.12413

Silva, J. M. C. S., & Tenreyro, S. (2006). The Log of Gravity. *Review of Economics and Statistics*, *88*(4), 641–658. https://doi.org/10.1162/rest.88.4.641

Sorgho, Z., & Tharakan, J. (2022). Do PTAs with Environmental Provisions Reduce GHG Emissions? Distinguishing the Role of Climate-Related Provisions. *Environmental and Resource Economics*, *83*(3), 709–732. https://doi.org/10.1007/s10640-022-00707-9

WHO. (2018). *COP24 special report: health and climate change*. Geneva: WHO. https://apps.who.int/iris/bitstream/handle/10665/276405/9786057496713-tur.pdf

Wilting, H. C., Schipper, A. M., Ivanova, O., Ivanova, D., & Huijbregts, M. A. J. (2021). Subnational greenhouse gas and land-based biodiversity footprints in the European Union. *Journal of Industrial Ecology*, *25*(1), 79–94. https://doi.org/10.1111/jiec.13042

Windmeijer, F. (2000). Moment conditions for fixed effects count data models with endogenous regressors. *Economics Letters*, *68*(1), 21–24. https://doi.org/10.1016/S0165-1765(00)00228-7

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of Econometrics*, *126*(1), 25–51. https://doi.org/10.1016/j.jeconom.2004.02.005

Wooldridge, J. M. (1997). Multiplicative Panel Data Models Without the Strict Exogeneity Assumption. *Econometric Theory*, *13*(5), 667–678. https://doi.org/10.1017/S0266466600006125

World Trade Organization. (2022). *World Trade Report 2022: Climate change and international trade*. Geneva: WTO. https://doi.org/10.30875/9789287053961

Young, A. (1991). Learning by Doing and the Dynamic Effects of International Trade. *Quarterly Journal of Economics*, *106*(2), 369. https://doi.org/10.2307/2937942

Zhang, R., Zhao, J [Jinlong], & Zhao, J [Jingyuan] (2021). Effects of free trade agreements on global value chain trade----a research perspective of GVC backward linkage. *Applied Economics*, *53*(44), 5122–5134. https://doi.org/10.1080/00036846.2021.1917763

Zhou, L., Tian, X., & Zhou, Z. (2017). The effects of environmental provisions in RTAs on PM2.5 air pollution. *Applied Economics*, *49*(27), 2630–2641. https://doi.org/10.1080/00036846.2016.1243218