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Global Impacts of Climate Policy and Trade Agreements on Greenhouse Gas Emissions

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Abstract: To limit increasing air pollution and fossil- energy production, several environmental and climate agreements have been established globally. In addition, trade agreements could also serve to achieve climate-mitigation goals, through a trade policy with environmental regulation. By removing tariffs and harmonizing standards on environmentally friendly products and eliminating distortionary subsidies on fossil-energy production, climate change can be mitigated. The objective of the research is to explore the effects of economic growth, international trade agreements and climate conventions on greenhouse gas emissions between 1990 and 2019, at the global level. As an econometric method, an air-pollution function is estimated by panel-regression models. The results confirm that global climate agreements have a significant, but only small, mitigating impact on global greenhouse-gas emissions. The results supported the inverted-U-shaped environmental Kuznets curve. In contrast, the environmental impacts of free-trade agreements had ambiguous results on emissions, as the members of the World Trade Organization contributed to the decrease in air pollution, while countries that signed the regional trade agreements were unable to limit emissions.

Keywords: climate change; environmental Kuznets curve; Kyoto Protocol; Paris Agreement; regional trade agreement; World Trade Organization

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1. Introduction

After the Industrial Revolution, global production expanded remarkably. This increased greenhouse gas (GHG) emissions significantly, which caused environmental problems at the global level. The concentration of greenhouse gases in the atmosphere is projected to double by 2030, and is estimated to lead to an average temperature increase of 1.5–4.5 degrees Celsius by 2100 [1]. The Kyoto Protocol and the Paris Agreement were the two most important agreements signed and ratified by a wide range of countries, specifying concrete carbon-emission targets.

Since 1950, global trade has increased more than twenty-sevenfold in volume [2]. The share of international trade in the global gross domestic product (GDP) has increased from 25% in 1970 to 56.5% in 2021 [3]. The increase in international trade raised the debate on the interrelation between trade and the environment. Economic growth is the main driver of trade expansion, which has a direct impact on the environment (increasing pollution and degrading natural resources). In turn, increased trade can support economic development and welfare, and improve access to new technologies [4].

In addition to global climate agreements, trade agreements might also help achieve climate-change-mitigation goals. Trade policies can be adjusted by removing tariffs and harmonizing standards on environmental goods, eliminating distortionary subsidies directly or indirectly leading to carbon emissions (CO_2). However, trade agreements are expanding, and climate change is a global phenomenon; there is a lack of literature researching the partial effect of free-trade agreements and climate conventions as well as the impact of the environmental Kuznets curve on environmental pollution.

The objective of the paper is to investigate the effects of economic progress, climate conventions and free-trade agreements on GHG emissions between 1990 and 2019 at the global level. Besides testing the role of the environmental Kuznets curve as an environmental hypothesis, the paper aims to explore the effects of free-trade agreements represented by the membership of the World Trade Organization and the impact of the regional trade agreements, along with the role of international environmental agreements captured by the ratification of the Kyoto Protocol and Paris Agreement on global greenhouse-gas emissions.

This research contributes to the empirical literature in many ways. It analyses the role of trade liberalization and climate policy on global greenhouse-gas emissions, including a large number of countries representing the world economy. The novelty of this study is in discovering the partial impacts of the two main climate agreements (the Kyoto Protocol and the Paris Agreement) and the partial effects of regional (RTA) and global free-trade agreements (WTO). Empirical findings provide implications for global climate policy and provide a recommendation to improve the effectiveness of international trade policy in climate mitigation.

The structure of the paper is as follows. The following section gives an overview of the climate-trade related literature, i.e., addressing the impacts of climate convention, as well as trade agreements, on climate change. Section 3 provides the results of the regression models applied to the panel dataset. The final section concludes the paper and discusses the results.

2. Relevant Literature

In this section, the literature addressing the impacts of global climate policy (Section 2.1) and international trade policy (Section 2.2) on carbon emissions is discussed. Since climate change is a global phenomenon and international trade is increasingly globalized, the roles of the United Nations Framework Convention on Climate Change (UNFCCC) and the World Trade Organization (WTO) are presented.

2.1. The Impacts of Climate Agreements on Emissions

In 1992, the Earth Summit in Rio de Janeiro created the United Nations Framework Convention on Climate Change (UNFCCC) as a first step in tackling climate change. The 197 ratifying countries have become parties to the convention [5]. The next milestone of this process was the Kyoto Protocol, adopted in 1997. This is known as the world's first international climate agreement to reduce greenhouse-gas emissions. The Protocol legally obliges developed countries to meet their emission-reduction targets. It sets individual emission-reduction targets for developed countries. In the Protocol, Annex I, (industrialized) countries accepted achieving an average greenhouse-gas-emissions reduction of 5.2% CO_2, equivalent to the 1990 emission levels in the first period of 2008–2012 [6]. The Doha Amendment to the Kyoto Protocol was adopted for the second commitment period of the Kyoto Protocol (2013–2020). However, although several countries have made commitments to reduce GHG emissions, the Doha Amendment has not entered into force [6]. Finally, the Paris Agreement established in 2015, which came into force on 4 November 2016, was the first international regulation accepted by most countries, and targeted remarkable climate-mitigation goals. This was based on voluntary commitments to limit warming to 1.5 Celsius or to keep global warming below 2 Celsius, compared to the preindustrial level [7]. Concerning climate agreements, Tingley and Tomz [8] underlined the importance of proper calibration of these commitments, as too-high or too-low levels can harm the achievement of the desired levels.

Cifci and Oliver [9] suggested that the implementation of the Kyoto Protocol and the Paris Climate Agreement is weak because value systems may struggle to meet the targets of reducing greenhouse gas emissions. McGrath and Bernauer [10] added that, compared to the Kyoto Protocol, the Paris Agreement relies mainly on climate rules that are accepted independently and voluntarily. Furthermore, climate-policy preferences are driven by a range of disposition and cost considerations, which existing research has already explored quite extensively, rather than by considerations of what other countries do. Lawrence and Wong [11] stated that the development of the transparency, review and non-compliance elements of the Paris Agreement is essential but is not a substitute for strong political will to reduce emissions. Moreover, it is crucial to push political readiness to improve the climate-mitigation commitments of the Paris Agreement and transform them into rigid obligations. Stiglitz [12] highlighted that a voluntary agreement cannot include countries that export a significant amount of fossil fuel. According to Nordhaus [13], great progress in the scientific and economic understanding of climate change has met difficulties in forging international agreements, due to free-riding, as seen in the defunct Kyoto Protocol. Morin and Jinnah [14] underlined the fact that preferential trade agreements often include more detailed and enforceable provisions than international climate agreements. Another problem with GHG emissions is that national policies often fail to deal with non-carbon-related emissions [15].

Michaelowa et al. [16] noted that the market mechanisms of the Paris Agreement possibly increase international pressure, and require significantly higher ambitions to be able to deal with global warming [17]. In addition to this, current pledges of countries cannot limit climate change to inappropriate decarbonization [18]. Finally, outstanding methods would be needed to measure the additional effects of such policies.

In summary, these international climate agreements, i.e., the Kyoto Protocol and the Paris Agreement, may have a significant impact on CO_2 reduction and help control global warming. Based on the empirical literature, trade agreements also impact climate-mitigation policies and contribute to the reduction of greenhouse gas emissions in countries.

2.2. The Impacts of Free-trade Agreements on Emissions

The World Trade Organization (WTO) was established in 1995, replacing the General Agreement on Tariffs and Trade (GATT), linked to the end of the Uruguay Round Agreement. The WTO aims to facilitate international trade and help reduce trade restrictions and barriers. Currently, the WTO has 164 members that represent 98% of global trade [19].

Referring to the rapidly expanding international trade, the number of regional trade agreements (RTA) has increased significantly (Figure 1). Their main characteristics are reciprocity and preferentiality [20]. Some of them are bilateral, while others are multilateral. According to the available data on 1 February 2021, 339 RTAs were in force, corresponding to 548 notifications [20]. At the level of the type of notification, 63.32% of them are goods notifications, service notifications have a 31.39% share, and accessions with an RTA have only a 5.29% share [21].

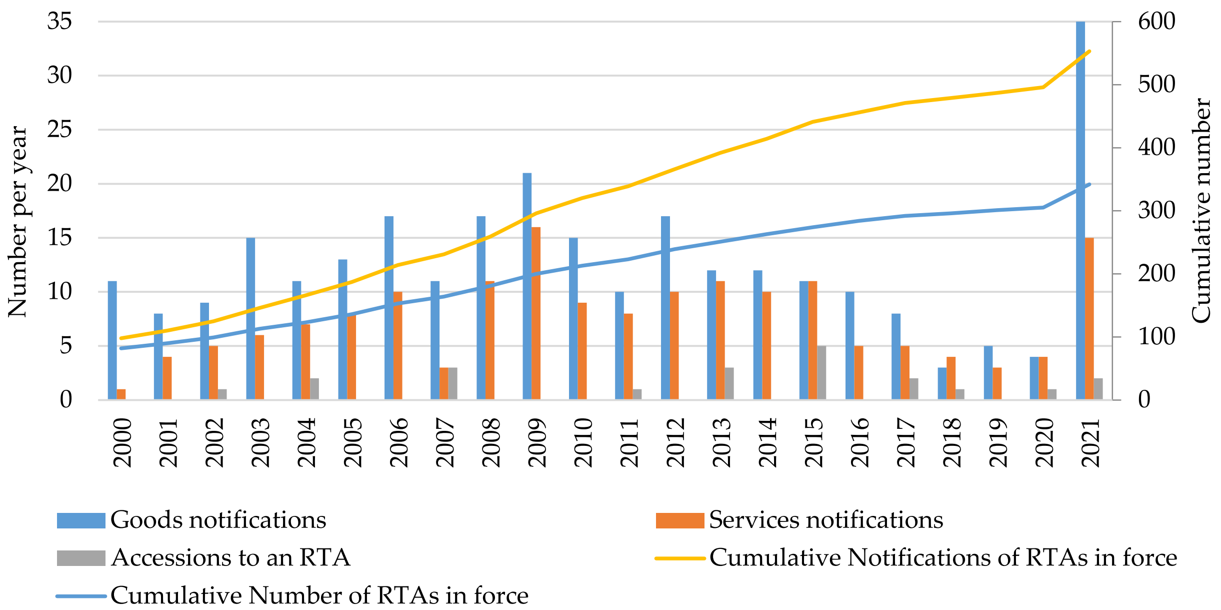

Figure 1. Evolution of RTAs, 2000–2021. Source: authors' composition, based on [21].

As seen above, 2021 was an exceptionally active year, especially in terms of new goods and service notifications. This was caused by Brexit; for example, 32 of the 35 goods notifications were signed between the UK and its 56 trading partners [22]. This also contributed significantly to the highest number of European RTA notifications in force (Figure 2). Furthermore, Europe, East Asia and South America have a high number of active RTAs (150, 100 and 70, respectively).

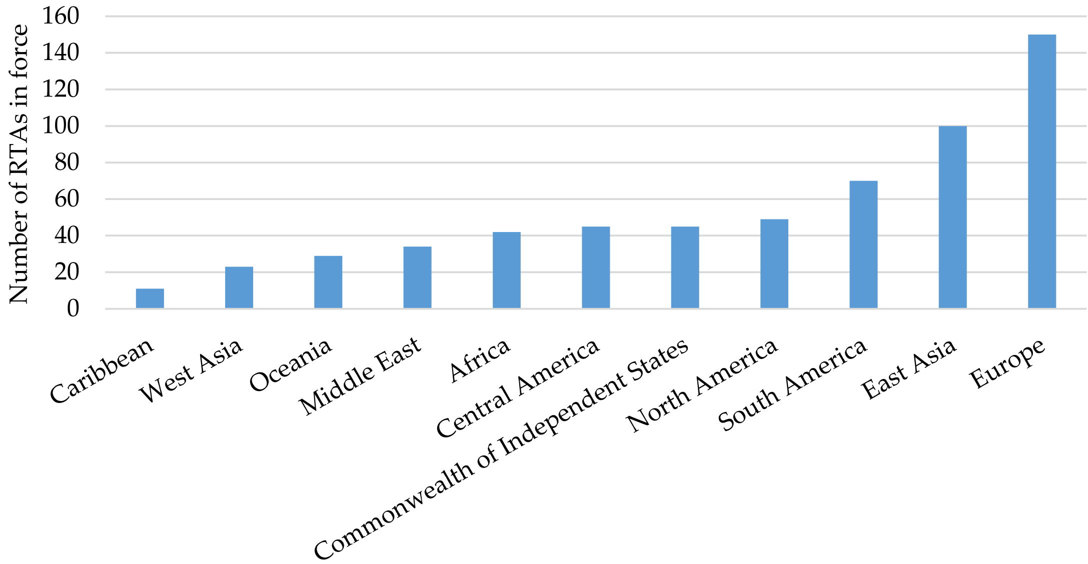

Figure 2. Notifications of RTAs in force by regions, 2021. Source: authors' composition, based on [23].

The connections between RTAs and climate change have been analyzed in the scientific literature. Many researchers [24–26] indicated that carbon-motivated regional agreements could mitigate the effects of climate change and improve sustainable-energy trade. Furthermore, the authors highlighted that greater cooperation between developed and developing countries, encouraging the production of more renewable energy [26]. Strategically designed climate treaties, combined with trade restrictions, are usually sufficient to enforce a trade agreement [27]. Furthermore, WTO members should pursue similar climate-friendly policies to achieve their climate goals [28]. According to Kirchner and Schmid [29], the arrangement of agri-environmental payments with WTO trading rules is crucial in the successful trade–environment debate. De Melo and Solleder [28] pointed out that delegating independent scientific experts to trade negotiations can change WTO rules in a climate-friendly direction. Small trade penalties on outsiders to trade agreements can induce a stable climate coalition with high levels of emission reduction [13].

Based on the empirical literature that evaluated the effect of trade agreements on climate mitigation, it can be stated that WTO membership and RTAs potentially influence emission reduction. Following these findings, we formulated and tested the following hypotheses.

H1: *International climate agreements (Kyoto Protocol, Paris Agreements) have a detectable impact on the reduction of greenhouse gas emissions of the signing countries, at the global level.*

The Paris Agreement provided an international regulation accepted by most countries, and aimed at achieving remarkable climate-mitigation goals. Since 2016, several countries have submitted their NDCs committed to significant reductions in greenhouse gas emissions, including the European Union, China, and India. Yao et al. [30] suggest that human capital and political regimes that affect energy efficiency and trade are critical factors in shaping environmental quality. Furthermore, international trade allows developing countries to import energy-saving technology that consume less energy and generate more output, from developed countries.

H2: *Increasing participation in Free-Trade Agreements (represented by membership of WTO, number of RTAs signed) contributes to global greenhouse-gas mitigation goals.*

Griffin et al. [31] indicated that trade agreements of the WTO could help achieve climate-mitigation goals by removing tariffs and harmonizing standards on environmentally friendly goods or services and eliminating subsidies on fossil fuels. Tian et al. [32] stressed that trade among Asia-Pacific countries increased and expanded with the reduction in regional tariffs. By contrast, it shaped the fact that complete tariff elimination increased global CO_2 emissions in this region.

H3: *An inverted U-shaped relationship exists between economic development and environmental quality at the global level.*

The hypothesis of the environmental Kuznets curve is valid for the world economy. The EKC hypothesis assumes that the inverted U-shaped relationship exists between economic development and environmental quality [33]. In other words, environmental pressure increases to a given level as economic progress rises; then, reaching a turning point, it tends to decrease, due to technical efficiency. Qin et al. [34] confirmed the validity of the EKC hypothesis for the G7 economies and concluded that environmental policy and green innovation help control carbon emissions. Furthermore, Khan et al. [35] argue that emerging countries could give more priority to economic growth by receiving foreign investments from more developed economies, and balancing the trade-off between economic growth and environmental protection. In addition, Khan et al. [36] found that uncertainty in economic policy, trade, and economic growth has a positive correlation with carbon emissions in East Asian economies.

3. Materials and Methods

To measure the potential impacts of climate-mitigation policy and international trade agreements, an econometric panel-regression model is designed. The research includes strongly balanced panel data, covering a series from 1990 to 2019, comprising 161 countries (n = 161, t = 30). The econometric estimation of the air-pollution function is written as follows [34,37,38] for panel data comprising the environmental Kuznets curve:

$$ln(CO_2pc_{it}) = \alpha + \beta_1\, ln(CO_2\, pc_{it})_{(t-1)} + \beta_2\, ln(CO_2\, pc_{it})_{(t-2)} + \beta_3\, ln(GDPpc_{it}) + \beta_4\, ln(GDPpc_{it})^2 + \beta_5\, Kyoto_{it} + \beta_6\, Paris_{it} + \beta_7\, WTO_{it} + \beta_8\, RTA_{it} + \varepsilon_{it} \quad (1)$$

where
β symbolizes the estimated coefficient of panel regression;
α is the constant;
t captures the dimension of time in years (the time frame is 1990–2019);
i illustrates a given country (161 countries are included in the analysis);
ε_{it} denotes the error term.

Climate change through greenhouse gas emission is represented by all greenhouse gases expressed in carbon-dioxide emission per capita (CO_2 equivalent). In our case, economic growth is captured by GDP and the squared term of per capita GDP for EKC, while pollution is captured by CO_2 emission. Table 1 presents the description of the applied variables in detail.

Table 1. Description of variables.

Variable	Description	Source
$ln(CO_2pc_{it})$	per capita carbon-dioxide emission as a dependent variable represents climate change expressed in kilotons	World Bank [39]
	Explanatory variables	
$ln(GDPpc_{it})$	per capita Gross Domestic Product in current Local Currency Unit	World Bank [39]

Table 1. *Cont.*

Variable	Description	Source
$ln(GDPpc_{it}) + ln(GDPpc_{it})^2$	environmental Kuznets curve (EKC) captures the existence of U-shaped curve	World Bank [39]
WTO_{it}	a dummy variable for WTO membership over time (equal to 1 if a country is a member of the WTO, 0 otherwise)	WTO [40]
RTA_{it}	captures the number of RTAs entered into force for a given country, over time	WTO [41]
$Kyoto_{it}$	represents a dummy for the ratification of the Kyoto protocol over time (Kyoto is equal to 1 if a country ratified the Kyoto Protocol, 0 otherwise)	UN [42]
$Paris_{it}$	represents a dummy for ratification of the Paris Agreement (it equals 1 if a country ratified the Agreement, 0 otherwise)	Open Climate Data [43]

Source: authors' composition.

We applied various preliminary tests to verify the structure of the data set and select the appropriate estimation method. We employed the Lagrangian multiplier test to choose between simple OLS and random-effects panel estimation [44]. We also carried out the Wooldridge [45] test for autocorrelation and a cross-section dependency test on our panel data. Finally, we used first- and second-generation [46] unit-root and cointegration tests for the variables selected. They are detailed in Appendix A. In line with the test results and empirical literature [40], we applied several estimation techniques to capture the impact of trade agreements and climate conventions. The estimation methods were as follows:

1. Generalized-least-squares (GLS) random-effects model estimation with robust standard-error option (RE);
2. Linear regression with panel-corrected standard errors (PCSE) [47]. In this estimation, the error structure is assumed to be panel-level heteroskedastic;
3. Fully modified ordinary-least-squares (FMOLS) estimations for cointegration regression [48];
4. Arellano and Bover [49], Blundell and Bond [50], estimation (DPD-SYS) that fits a linear-dynamic-panel-data model with the first- and second-lagged dependent variable.

4. Results

Before running our regression models, we applied three preliminary tests (the Lagrange multiplier, autocorrelation, cross-section-dependency, unit-root, and cointegration tests). Detailed results of descriptive statistics and tests are presented in Appendix A. Based on the Lagrange-multiplier test, the random-effect model (1) was more suitable, compared to the simple OLS regression. The Wooldridge test showed that first-order autocorrelation arises, and cross-section dependency is identified (Appendix A, Table A2). In addition, unit-root tests revealed unit roots assuming cross-section dependence (CIPS) and the null hypothesis of no cointegration was therefore rejected (Appendix A, Tables A4 and A5), behind the (2) panel-corrected standard-errors model (PCSE) and the (3) dynamic-panel estimates (DPD-SYS); we also applied cointegrated (FMOLS) regressions (4). First- and second-lagged dependent variables were used for dynamic-panel estimations and to handle autocorrelation. Table 2 gives an overview of our results.

Table 2. Panel-regression results.

	(1)	(2)	(3)	(4)
VARIABLES	RE $ln(CO_2pc)$	PCSE $ln(CO_2pc)$	DPD-SYS $ln(CO_2pc)$	FMOLS $ln(CO_2pc)$
$ln(CO_2pc)_{(t-1)}$	0.855 ***	0.855 ***	0.651 ***	0.855 ***
	(0.014)	(0.030)	(0.013)	(0.013)
$ln(CO_2pc)_{(t-2)}$	0.135 ***	0.135 ***	0.176 ***	0.135 ***
	(0.014)	(0.030)	(0.010)	(0.013)
ln(GDPpc)	0.010 ***	0.010 ***	0.001	0.012 ***
	(0.002)	(0.0025)	(0.005)	(0.002)
$ln(GDPpc)^2$	−0.0003 ***	−0.0003 ***	0.001 ***	−0.0004 ***
	(0.000)	(0.000)	(0.000)	(0.000)
Kyoto	−0.007 *	−0.007 *	−0.048 ***	−0.007 **
	(0.004)	(0.004)	(0.007)	(0.003)
Paris	0.001	0.001	−0.011	0.001
	(0.006)	(0.006)	(0.007)	(0.005)
WTO	−0.010 *	−0.010	−0.529 ***	−0.0002 *
	(0.005)	(0.007)	(0.059)	(0.000)
RTA	−0.0002	−0.0002 **	−0.011 ***	−0.010 *
	(0.000)	(0.000)	(0.001)	(0.005)
Constant	−0.0393 **	−0.039 ***	0.266 ***	−0.048 ***
	(0.015)	(0.014)	(0.068)	(0.015)
Observations	4508	4508	4508	4507
	0.993	0.994		0.989
Number of countries	161	161	161	161

Robust standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

As seen above, we received statistically significant results with most applied variables and estimation methods (RE, PCSE, DPDSYS and FMOLS). It was confirmed that higher income per capita (GDP) results in higher CO_2 emissions per capita in the world, during the analyzed period. We also tested the hypothesis of an inverted-U-shaped EKC curve by using the squared term of GDP per capita. We received a positive sign for the single per-capita-GDP variable, while mostly negative values for the squared term of GDP per capita (representing the EKC curve) were confirmed by most models, (1), (2) and (4). This means an inverted-U-shaped relation between economic development and environmental quality. It confirms the existence of the EKC curve [33]; therefore, our third hypothesis (H3) can be accepted. According to the literature, climate agreements (ratification of the Kyoto Protocol and Paris Agreements) contributed to a lower level of CO_2 emissions, although this impact was relatively small. In turn, the impact of the Paris Agreement was mostly positive, and insignificant in our models (1)–(2); (4). Behind the Paris Agreement, the Kyoto Protocol had a significant impact on emission reduction (negative sign); therefore, our first hypothesis (H1) can only be partly accepted. Furthermore, the estimated coefficient for trade agreements (WTO and RTA) provided consistent results. Being a member of the WTO led to better environmental performance (a negative sign of emission parameters), while per-capita-CO_2 emission decreased proportionally with a higher share of RTAs in force. Therefore, we can fully accept our second hypothesis (H2).

The Climate Action Tracker [51] has projected a 2.7 °C global warming, above preindustrial levels, by 2100. Regarding current climate policies, GHG-emission-reduction targets are noticeable, due to climate agreements in some countries; however, the level is not sufficient to remain on the path of the maximum 1.5 °C global-warming level. However, Blümer et al. [52] and Peterson [53] pointed out that democratic countries add more environmental provisions and are more ambitious regarding climate-change-mitigation actions than less-democratic nations.

5. Discussion

Keeping global warming through GHG emissions at an acceptable level is one of the main challenges humanity faces. Climate agreements, especially with a high number of participants, could be potential global solutions to reduce GHG emissions. The Kyoto Protocol was adopted in 1997, and aimed to reduce GHG emissions by 5.2% (second commitment period by 8%) by 2012, compared to the emission level of the year 1990. Its second commitment period (the EU and Iceland have agreed to meet a 20% reduction target) just finished, in 2020. The Paris Agreement was established in 2015, and came into force in 2016. According to the related literature [24–26], WTO members (countries joined) and RTAs, especially when they are carbon motivated, can initiate a reduction in GHG emissions (captured by CO_2).

We estimated an air-pollution function comprising economic growth per person and the environmental Kuznets curve, along with variables capturing the impacts of free-trade and climate agreements, aggregated in panel data. In the estimated-regression models, we compared four different estimation methods, including the dynamic-panel and cointegrated models. The findings show that only the Kyoto Protocol contributed significantly to the reduction in GHG emissions (negative effects on emissions are revealed) at the global level. The Kyoto Protocol had a generally robust emission impact, while the effect of the Paris Agreement was insignificant during the analyzed period.

Results only partly confirmed our first hypothesis, namely that international climate agreements encourage countries to reduce their GHG emissions. Although it was assumed, we did not find a clear climate-mitigating effect between the Paris Agreement and environmental performance (emission reduction) in line with [9,10,13].

The models suggest that WTO members made efforts to reduce their GHG emissions (negative sign), and the impacts of increasing RTAs were also efficient (H2), supporting the results of [24–26,31]. Overall, although the latest climate agreements were not sufficient to reduce CO_2 emissions, they may have some positive impacts, depending on their type. Therefore, we could only partly accept our first hypothesis (H1) as being true. The positive sign of the GDP variable and the negative sign of the squared GDP confirmed the existence of the inverted U shape of the environmental Kuznets curve, resulting in the acceptance of our third hypothesis (H3), in accordance with the literature in [33,34].

From a global point of view, free trade agreements were more efficient in reducing or limiting carbon emissions significantly than global climate agreements (especially the Paris Agreement), during the period analyzed.

In conclusion, so far, economic progress and the increasing number of free-trade agreements had a more crucial role in global climate mitigation than the Paris Agreement. However, most of the countries ratified the Paris Agreement and submitted their pledges, although their implementation of the pledged is lagging behind. The largest countries that emit the highest level of GHG and trade the most (the United States, China, the European Union countries, and India), should mitigate their emissions more rapidly and more efficiently by substituting their fossil-energy resources in their energy mix for green, low-carbon resources. Being one of the most important trade hubs, the EU plays a crucial role in promoting climate-action norms [54].

The trade policy of these countries should regulate and limit the trade of fossil energy and polluting products, stimulate the higher level of production of sustainable, environmentally friendly goods and services domestically, and enhance energy efficiency, renewable-energy investments, and sustainable trade (generating social, economic, and environmental benefits), more efficiently. This also implies that trade policies should be adjusted, comprising climate policy and climate mitigation; otherwise, environmental problems will probably be transported (outsourced) to other countries or regions with low environmental standards. This is particularly important for developing countries, as trade openness has a positive impact on GHG-emission reduction, especially in sub-Saharan African countries [55]. This could enhance the positive impacts of climate-related trade policies. Unlike developed countries, developing countries have fewer resources to invest in climate-change mitigation, which hinders their efforts to be carbon neutral [56]. Therefore, developed countries need to contribute to these actions to reduce the GHG emissions embodied in international trade [57]. However, it should be highlighted that FTAs with a cooperation framework contribute more to climate-change mitigation, compared to FTAs focusing on trade liberalization [54].

In general, effective climate policies should be diversified based on a wide range of low-carbon technologies, and flexibly adjusted to external shocks such as the recent COVID-19 pandemic, and the impacts of the Russian–Ukrainian war. Policies should stimulate green growth by restructuring the energy trade and international trade relations; otherwise, it will be impossible to move toward a more favorable emission path, achieve carbon neutrality by 2050, and decrease fossil-energy dependency.

The main limitation of the study is the selected period, which covers annual data between 1990 and 2019. The impact of the Paris Agreement is also limited, because it came into force only in 2016. The model focused on global-level analysis, while country-level research would further deepen our knowledge of the impacts of climate policies and trade agreements on GHG emissions.

Future research may focus on the impacts of the national climate policies of the largest emitters and their diversification in terms of emission cuts.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Descriptive statistics.

Variable	Observation	Mean	Standard Deviation	Min	Max
ln_CO2	4830	0.591	1.585	−3.897	3.864
ln_GDP	4830	10.726	2.801	−10.469	19.572
ln_GDP^2	4830	122.882	56.655	0.001	383.048
Kyoto	4830	0.482	0.500	0.000	1.000
Paris	4830	0.114	0.318	0.000	1.000
WTO	4830	11.553	14.438	0.000	45
RTA	4830	0.876	0.330	0.000	1.000

Source: authors' composition, based on sample data.

Table A2. Pesaran (2004) CD test for cross-section dependence in panel time-series data.

Variable	**CD-Test**	***p* Value**
ln(CO_2)	50.9	0.000
ln(GDP)	569.16	0.000
ln(GDP)^2	572.27	0.000

H_0: cross-sectional independence CD ~ N(0,1). H_a: cross-sectional dependence.

Table A3. Fisher-type unit-root test for ln(CO_2pc).

Based on augmented Dickey–Fuller tests for zero lag		***p*-value**
Inverse	chi-squared (414) P	0.000
Inverse	inverse normal Z	0.756
Inverse	logit t (1029) L*	0.512
Modified	inverse chi-squared Pm	0.000
Based on augmented Dickey–Fuller tests for one lag		***p*-value**
Inverse	chi-squared (412) P	0.000
Inverse	inverse normal Z	0.597
Inverse	logit t (1014) L*	0.048
Modified	inverse chi-squared Pm	0.000

Source: authors' composition, based on sample data.

Table A4. Second-generation panel-unit-root tests.

	(A) Maddala and Wu (1999) Panel-Unit-Root Test (MW)					**(B) Pesaran (2007) Panel-Unit-Root Test (CIPS)**				
	Specification without Trend			**Specification with Trend**		**Specification without Trend**			**Specification with Trend**	
Variable	lags	chi_sq	*p*-value	chi_sq	*p*-value	lags	chi_sq	*p*-value	chi_sq	*p*-value
ln(CO_2)	0	453.659	0.000	473.786	0.000	0	−4.255	0.000	−0.375	0.354
ln(CO_2)	1	531.328	0.000	524.984	0.000	1	−5.277	0.000	−1.239	0.108
ln(CO_2)	2	402.916	0.001	395.767	0.003	2	−2.384	0.009	1.880	0.970
ln(CO_2)	3	371.502	0.030	396.713	0.003	3	0.209	0.583	3.867	1.000
ln(CO_2)	4	294.344	0.864	293.69	0.869	4	3.094	0.999	9.018	1.000
ln(CO_2)	5	411.306	0.001	369.307	0.035	5	1.496	0.933	7.940	1.000
ln(GDP)	0	2005.192	0.000	702.73	0.000	0	−2.597	0.005	0.855	0.804
ln(GDP)	1	1103.032	0.000	1062.546	0.000	1	−15.322	0.000	−7.281	0.000
ln(GDP)	2	783.073	0.000	916.901	0.000	2	−11.012	0.000	−5.921	0.000
ln(GDP)	3	614.153	0.000	738.517	0.000	3	−10.861	0.000	−8.064	0.000
ln(GDP)	4	460.876	0.000	330.099	0.366	4	−3.216	0.001	1.610	0.946
ln(GDP)	5	458.205	0.000	313.156	0.628	5	0.211	0.584	2.728	0.997
ln(GDP)^2	0	1033.014	0.000	541.571	0.000	0	−3.477	0.000	1.665	0.952
ln(GDP)^2	1	525.018	0.000	639.412	0.000	1	−7.681	0.000	−3.489	0.000
ln(GDP)^2	2	508.286	0.000	647.028	0.000	2	−6.652	0.000	−2.786	0.003
ln(GDP)^2	3	509.842	0.000	608.379	0.000	3	−7.113	0.000	−4.643	0.000
ln(GDP)^2	4	356.168	0.092	268.03	0.987	4	−0.199	0.421	3.565	1.000
ln(GDP)^2	5	329.633	0.373	262.647	0.993	5	1.888	0.970	5.279	1.000

H_0: MW and CIPS tests: series is integrated of order one I (1). MW test assumes cross-section independence. CIPS test assumes cross-section dependence. Source: authors' composition based on sample data.

Table A5. Panel-cointegration tests.

Kao test for cointegration		**Statistic**	***p*-value**
Modified	Dickey–Fuller t	−86.605	0.000
Dickey–Fuller t		-57.784	0.000
Augmented	Dickey–Fuller t	−38.311	0.000
Unadjusted modified	Dickey–Fuller t	−94.314	0.000
Unadjusted	Dickey–Fuller t	−58.089	0.000
H_0: No cointegration			
H_a: All panels are cointegrated			
Pedroni test for cointegration			
Modified	Phillips–Perron t	−9.720	0.000
Phillips–Perron t		−38.096	0.000
Augmented	Dickey–Fuller t	−36.859	0.000
H_0: No cointegration			
H_a: All panels are cointegrated			
Westerlund test for cointegration			
Variance ratio		−9.499	0.000
H_0: No cointegration			
H_a: Some panels are cointegrated			

Source: authors' composition, based on sample data.

References

1. Masson-Delmotte, V.; Zhai, P.; Pörtner, H.-O.; Roberts, D.; Skea, J.; Shukla, P.R.; Pirani, A.; Moufouma-Okia, W.; Péan, C.; Pidcock, R.; et al. *Global Warming of 1.5 °C. An IPCC Special Report on the Impacts of Global Warming of 1.5 °C above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*; IPCC: Geneva, Switzerland, 2018.
2. WTO. The Impact of Trade Opening on Climate Change. Available online: https://www.wto.org/english/tratop_e/envir_e/climate_impact_e.htm (accessed on 5 June 2021).
3. World Bank. World Development Indicators. Trade % of GDP. Available online: https://data.worldbank.org/indicator/NE.TRD.GNFS.ZS?end=2019&start=1960&view=chart (accessed on 27 December 2022).
4. OECD. Trade and the Environment. How Are Trade and Environmental Sustainability Compatible? Available online: https://www.oecd.org/trade/topics/trade-and-the-environment/ (accessed on 3 June 2021).
5. UNFCCC. What is the United Nations Framework Convention on Climate Change? Available online: https://unfccc.int/process-and-meetings/the-convention/what-is-the-united-nations-framework-convention-on-climate-change (accessed on 10 March 2021).
6. UNFCCC. What is the Kyoto Protocol? Available online: https://unfccc.int/kyoto_protocol (accessed on 15 March 2021).
7. UNFCCC. Agreement—What is the Paris Agreement? Available online: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (accessed on 15 March 2021).
8. Tingley, D.; Tomz, M. International commitments and domestic opinion: The effect of the Paris Agreement on public support for policies to address climate change. *Environ. Polit.* **2019**, *29*, 1135–1156. [CrossRef]
9. Cifci, E.; Oliver, M. Reassessing the Links between GHG Emissions, Economic Growth, and the UNFCCC: A Difference-in-Differences Approach. *Sustainability* **2018**, *10*, 334. [CrossRef]
10. McGrath, L.F.; Bernauer, T. How strong is public support for unilateral climate policy and what drives it? *WIREs Clim. Chang.* **2017**, *8*, e484. [CrossRef]
11. Lawrence, P.; Wong, D. Soft law in the Paris Climate Agreement: Strength or weakness? *Rev. Eur. Comp. Int. Environ. Law* **2017**, *26*, 276–286. [CrossRef]
12. Stiglitz, J. Overcoming the Copenhagen Failure with Flexible Commitments. *Econ. Energy Environ. Pol.* **2015**, *4*, 29–36. [CrossRef]
13. Nordhaus, W. Climate Clubs: Overcoming Free-riding in International Climate Policy. *Am. Econ. Rev.* **2015**, *105*, 1339–1370. [CrossRef]
14. Morin, J.-F.; Jinnah, S. The untapped potential of preferential trade agreements for climate governance. *Environ. Polit.* **2018**, *27*, 541–565. [CrossRef]
15. Harmsen, J.H.M.; van Vuuren, D.P.; Nayak, D.R.; Hof, A.F.; Höglund-Isaksson, L.; Lucas, P.L.; Nielsen, J.B.; Smith, P.; Stehfest, E. Long-term marginal abatement cost curves of non-CO2 greenhouse gases. *Environ. Sci. Pol.* **2019**, *99*, 136–149. [CrossRef]
16. Michaelowa, A.; Hermwille, L.; Obergassel, W.; Butzengeiger, S. Additionality revisited: Guarding the integrity of market mechanisms under the Paris Agreement. *Clim. Pol.* **2019**, *19*, 1211–1224. [CrossRef]

17. Tørstad, V.H. Participation, ambition and compliance: Can the Paris Agreement solve the effectiveness trilemma? *Environ. Polit.* **2020**, *29*, 761–780. [CrossRef]
18. Rauner, S.; Bauer, N.; Dirnaichner, A.; Van Dingenen, R.; Mutel, C.; Luderer, G. Coal-exit health and environmental damage reductions outweigh economic impacts. *Nat. Clim. Chang.* **2020**, *10*, 308–312. [CrossRef]
19. WTO. WTO in Brief. Available online: https://www.wto.org/english/thewto_e/whatis_e/inbrief_e/inbr_e.htm (accessed on 1 March 2021).
20. WTO. Regional Trade Agreements. Available online: https://www.wto.org/english/tratop_e/region_e/region_e.htm#facts (accessed on 20 March 2021).
21. WTO Regional Trade Agreements Database. RTA is Currently in Force 1948–2021. Available online: http://rtais.wto.org/UI/charts.aspx (accessed on 20 March 2021).
22. WTO. Facts & Figures. Regional Trade Agreements 1 July 2020–1 January 2021 World Trade Organization, Geneva, Switzerland. Available online: https://www.wto.org/english/tratop_e/region_e/rtafactfig21s1_e.pdf (accessed on 20 March 2021).
23. WTO. Regional Trade Agreements Database. RTA's in Force, Participation by Region. Available online: http://rtais.wto.org/UI/charts.aspx# (accessed on 20 March 2021).
24. Dong, Y.; Whalley, J. Carbon, Trade Policy and Carbon Free Trade Areas. *World Econ.* **2010**, *33*, 1073–1094. [CrossRef]
25. Dong, Y.; Whalley, J. Carbon motivated regional trade arrangements: Analytics and simulations. *Econ. Mod.* **2011**, *28*, 2783–2792. [CrossRef]
26. Leal-Arcas, R. New Frontiers of International Economic Law: The Quest for Sustainable Development. University of Pennsylvania. *J. Int. Law* **2018**, *40*, 83–133.
27. Barrett, S. Rethinking Climate Change Governance and Its Relationship to the World Trading System. *World Econ.* **2011**, *34*, 1863–1882. [CrossRef]
28. De Melo, J.; Solleder, J.-M. The EGA Negotiations: Why They Are Important, Why They Are Stalled, and Challenges Ahead. *J. World Trade* **2020**, *54*, 333–347. [CrossRef]
29. Kirchner, M.; Schmid, E. Integrated regional impact assessment of agricultural trade and domestic environmental policies. *Land Use Policy* **2013**, *35*, 359–378. [CrossRef]
30. Yao, X.; Shah, W.U.H.; Yasmeen, R.; Zhang, Y.; Kamal, M.A.; Khan, A. The impact of trade on energy efficiency in the global value chain: A simultaneous equation approach. *Sci. The Total Environ.* **2021**, *765*, 142759. [CrossRef]
31. Griffin, C.; Fisher, D.H.; Haider, A.; Dawar, K.; Green, A. *Climate Change and Trade Agreements Friends or Foes?* Economist Intelligence Unit: London, UK, 2019.
32. Tian, K.; Zhang, Y.; Li, Y.; Ming, X.; Jiang, S.; Duan, H.; Yang, C.; Wang, S. Regional trade agreement burdens global carbon emissions mitigation. *Nat. Com.* **2022**, *13*, 408. [CrossRef]
33. Dinda, S. Environmental Kuznets curve hypothesis: A survey. *Ecol. Econ.* **2004**, *49*, 431–455. [CrossRef]
34. Qin, L.; Kirikkaleli, D.; Hou, Y.; Miao, X.; Tufail, M. Carbon neutrality target for G7 economies: Examining the role of environmental policy, green innovation and composite risk index. *J. Environ. Man.* **2021**, *295*, 113119. [CrossRef]
35. Khan, M.K.; Trinh, H.H.; Khan, I.U.; Ullah, S. Sustainable economic activities, climate change, and carbon risk: An international evidence. *Environ. Dev. Sus.* **2021**, *24*, 9642–9664. [CrossRef] [PubMed]
36. Khan, Y.; Hassan, T.; Kirikkaleli, D.; Xiuqin, Z.; Shukai, C. The impact of economic policy uncertainty on carbon emissions: Evaluating the role of foreign capital investment and renewable energy in East Asian economies. *Environ. Sci. Poll. Res.* **2021**, *29*, 18527–18545. [CrossRef]
37. Sharma, S. Determinants of carbon dioxide emissions: Empirical evidence from 69 counties. *Appl. Energy* **2011**, *88*, 376–382. [CrossRef]
38. Balogh, J.M.; Jámbor, A. Determinants of CO_2 Emission: A Global Evidence. *Int. J. Energy Econ. Policy* **2017**, *7*, 217–226.
39. World Bank. World Development Indicators. Available online: https://data.worldbank.org/indicator/EN.ATM.CO2E.PC (accessed on 23 December 2022).
40. WTO. Members and Observers. Available online: https://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm#observer (accessed on 12 March 2021).
41. WTO. Regional Trade Agreements Database. RTAs in Force, including Accessions to RTAs, by Country/Territory (Regional Trade Agreements Notified to the GATT/WTO and in Force) By Country/Territory. Available online: http://rtais.wto.org/UI/publicPreDefRepByCountry.aspx (accessed on 24 March 2021).
42. UN. United Nations Treaty Collection Chapter XXVII Environment. Available online: https://treaties.un.org/Pages/Treaties.aspx?id=27&subid=A&clang=_en (accessed on 24 March 2021).
43. Open Climate Data. Paris Agreement Entry into Force. Available online: http://paris-agreement-entry-into-force.openclimatedata.net/data/paris-agreement-entry-into-force.csv (accessed on 23 March 2021).
44. Breusch, T.S.; Pagan, A.R. The Lagrange multiplier test and its applications to model specification in econometrics. *Rev. Econ. Stud.* **1980**, *47*, 239–253. [CrossRef]
45. Wooldridge, J.M. *Econometric Analysis of Cross Section and Panel Data*; MIT Press: Cambridge, MA, USA, 2002.
46. Choi, I. Unit root tests for panel data. *J. Int. Money Financ.* **2001**, *20*, 249–272. [CrossRef]
47. Greene, W.H. *Econometric Analysis*, 8th ed; Pearson: New York, NY, USA, 2018.
48. Wang, Q.; Wu, N. Long-Run Covariance and its Applications in Cointegration Regression. *Stata J.* **2012**, *12*, 515–542. [CrossRef]

49. Arellano, M.; Bover, O. Another look at the instrumental variable estimation of error-components models. *J. Econom.* **1995**, *68*, 29–51. [CrossRef]
50. Blundell, R.W.; Bond, S. Initial conditions and moment restrictions in dynamic panel data models. *J. Econom.* **1998**, *87*, 115–143. [CrossRef]
51. Climate Action Tracker. 2100 Warming Projections: Emissions and Expected Warming Based on Pledges and Current Policies. Available online: https://climateactiontracker.org/global/temperatures/ (accessed on 27 December 2022).
52. Blümer, D.; Morin, J.F.; Brandi, C.; Berger, A. Environmental provisions in trade agreements: Defending regulatory space or pursuing offensive interests? *Environ. Politics* **2020**, *29*, 866–889. [CrossRef]
53. Peterson, L. Silver Lining to Extreme Weather Events? Democracy and Climate Change Mitigation. *Glob. Environ. Politics* **2021**, *21*, 23–53. [CrossRef]
54. Dent, C.M. Trade, Climate and Energy: A New Study on Climate Action through Free Trade Agreements. *Energies* **2021**, *14*, 4363. [CrossRef]
55. Sun, H.; Enna, L.; Monney, A.; Tran, D.K.; Rasoulinezhad, E.; Taghizadeh-Hesary, F. The Long-Run Effects of Trade Openness on Carbon Emissions in Sub-Saharan African Countries. *Energies* **2020**, *13*, 5295. [CrossRef]
56. Kang, S.J.; Lee, S.; Lee, S.J. Impacts of Environmental Agreements on Bilateral Trade of Climate Industry. *Energies* **2021**, *14*, 7277. [CrossRef]
57. Zhong, Z.; Zhang, X.; Gao, W. Spatiotemporal Evolution of Global Greenhouse Gas Emissions Transferring via Trade: Influencing Factors and Policy Implications. *Int. J. Environ. Res. Public Health* **2020**, *17*, 5065. [CrossRef] [PubMed]