

Review

Trade–Climate Nexus: A Systematic Review of the Literature

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Abstract: In the climate–trade debate, moderate attention is dedicated to the role of trade agreements on climate. In turn, trade agreements could help countries meet climate goals by removing tariffs, harmonizing standards on environmental goods, and eliminating distorting subsidies on fossil fuels. This paper aims to provide an overview of the role of trade agreements on climate-change mitigation. This systematic literature review is based on the international economic literature published between 2010 and 2020. This literature review underlines that the effectiveness of the trade agreements and WTO negotiations on emission reduction is weak. This is due to different national interests and protectionism. The elimination of trade barriers stimulates trade, but this may also raise greenhouse gas emissions and cause other environmental problems (e.g., deforestation). Furthermore, this article points out that emission leakage is also a crucial issue hindering the success of global climate agreements on greenhouse gas reduction. The greatest beneficiaries of the trade agreements are usually the largest GHG emitters, such as China, the US, and the EU. By contrast, developing countries are in a weaker position regarding climate–trade negotiation. The literature review offers policy solutions which can contribute to emission reduction and tools for stimulating a trade-related climate-change abatement policy.

Keywords: trade agreements; WTO; climate change; carbon dioxide emission; literature review

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1. Introduction

Global warming and climate change will undoubtedly determine the present century, and they are frequently on the agenda of different international negotiations. The Intergovernmental Panel on Climate Change (IPCC) stressed the consequences of climate change caused by anthropogenic factors. According to the possible scenarios, the growth of the greenhouse gas (GHG) concentration in the atmosphere is expected to double by 2030, indicating an average temperature increase of 1.5–4.5 degrees (IPCC 2019). This changes the Earth's climate radically.

In line with the expansion of the world economy and the increasing environmental pollution, several international environmental agreements have been signed (Stockholm Declaration, Montréal Protocol, Kyoto Protocol, Paris Agreement, etc.). After the ratification of the Paris Agreement in 2015, certain small countries managed to cut back their carbon dioxide (CO₂) emissions successfully; however, most of the countries' climate policies show a lack of ambition (e.g., Russia, China, the USA, South Africa, Indonesia, and Japan). Consequently, the world probably remains on the track of temperature increases of more than 3 °C (Climate Action Tracker 2020). This path does not seem to be changing significantly, despite a slight decline in CO₂ emission induced by the COVID-19 pandemic (United Nations Environment Programme 2020).

Rising global average incomes have increased consumer demand for traded goods. Most countries are net importers of carbon emissions; therefore, their consumption-based emissions are higher than their territory-based emissions. In the past decades, the gap between consumption and production-based emissions¹ has been growing in high-income

countries, such as the US, the EU-27, the UK, Japan, and China (United Nations Environment Programme 2020). Moreover, China is responsible for half of the global carbon outflows through trade (Liddle 2017).

In the climate–trade debate, relatively limited attention is paid to trade agreements and climate change nexus. However, trade agreements can help to achieve climate mitigation goals by removing tariffs, harmonizing standards on environmental goods, and eliminating distorting subsidies on fossil fuels, as well as on the agricultural sector (Griffin et al. 2019). Despite the trade–climate synergies, reductions of the average tariff levels have increased trade in carbon-intensive and environmentally damaging products, such as fossil fuels and timber, more than it has for environmentally friendly products (Griffin et al. 2019).

Moreover, trade acceleration and liberalization may facilitate pollution-intensive activities, carbon emissions from fossil fuel combustion embodied in trade, degradation of natural resources and production growth (Balogh and Jámbor 2020). Deforestation can also be a result of trade (Heyl et al. 2021). Association of Southeast Asian Nations (ASEAN) countries are growing at the expense of their environment and giving way to emission-intensive trade (Solomon and Khan 2020).

In the 1970s, the connection between trade and environmental protection was recognized. During the Uruguay Round's trade negotiation (1986–1994), significant attention was paid to trade-related environmental issues. From 1948 to 1994, the General Agreement on Tariffs and Trade (GATT) facilitated world trade. In 1994, due to the Uruguay Round and the Marrakesh Declaration, the World Trade Organization (WTO) was established. The WTO incorporates GATT principles and provides an enduring institutional system for implementing and extending them. GATT Article XX on General Exceptions covers specific instances in which WTO members may be exempt from GATT rules. Paragraphs (b) and (g) of GATT Article XX are connected with the protection of the environment. According to these paragraphs, WTO members cannot adopt policy measures inconsistent with GATT regulations, except to protect human, animal or plant life/health or linking them to the conservation of exhaustible natural resources. Under WTO rules, members can adopt trade-related measures aiming to protect the environment, ensure sustainable development, and avoid protectionism (WTO 2020).

Climate policies often indicate conflicts that trade agreements try to reconcile. Nevertheless, trade agreements signed over the last decades have included more clauses relating to climate goals, initiating a more supportive relationship between trade and climate change (Griffin et al. 2019). These facts emphasize the importance of trade–environment-related issues in environment protection and GHG reduction.

Most review papers have analyzed the effects of the free trade agreements on climate change (Low and Murina 2010; Ackrill and Kay 2011; Meyer 2017; Morin and Jinnah 2018; Heyl et al. 2021). On the contrary, a limited number of review articles have addressed the influences of international trade on climate change (Friel et al. 2020; Balogh and Jámbor 2020), focusing on trade agreements, compared to empirical papers. This study aims to complement the existing literature by exploring these effects.

This paper addresses the research question of how international trade agreements affect climate change and whether they conflict with climate policy and contribute to decreasing or increasing GHG emissions. More specifically, this article applies a systematic literature review to explore the recent empirical findings on the role of international trade agreements, negotiations, and relations in climate policy and mitigation.

The contribution of the research to the existing literature is manifold. First, this overviews the recent empirical research investigating the impacts of the different trade agreements and WTO rules in climate change mitigation policies. This reflects the main climate-related concern linked to various trade agreements at the regional, multilateral, and bilateral level. It provides policy recommendations on how to tackle trade agreements' weaknesses in international climate and trade policy. The interrelation of climate and trade policy (under WTO), various trade agreements (RTA, NAFTA, and PTA), and their mitigation effects are also discussed.

The paper is structured as follows. The following section presents the Materials and Methods applied. Section 3 discusses the results by addressing problems and solutions offered by the literature review, while the final section provides conclusions.

2. Materials and Methods

The online databases of Web of Science (WoS), Scopus, and Google Scholar searched to answer the research question on the impact of trade agreements on climate change. The process of the systematic literature review was realized on 21 September 2020. The selection of relevant studies is based on the method of Moher et al. (2009).

The combination of keywords “trade agreement” and “climate change” (Scopus 2020; WoS 2020; Google Scholar 2020) were used, and they had to appear in the title, abstract or keywords of the studies. The search was limited to Web of Science categories such as environmental studies or agriculture multidisciplinary or economics or agricultural economics policy. In the Scopus search engine, the command TITLE-ABS-KEY (“trade agreement” AND “climate change”) AND LIMIT-TO (SUBJAREA, “ECON”) were used, limited the search to economics discipline.

Only English materials were selected (LIMIT-TO (LANGUAGE, “English”) and the search was limited to scientific journal articles (article or review), while book chapters or books were excluded from the dataset. The analyses restricted to the international economic literature published between 2000 and 2020.

The initial search (Scopus, WoS, and Google Scholar) resulted in 290 entries, out of which 12 were duplicates (appeared in WoS and Scopus as well), of 9 were books, book chapters and reports (retrieved from Google Scholar). These 21 articles (9 + 12) were excluded. Figure 1 provides an overview of the selection process.

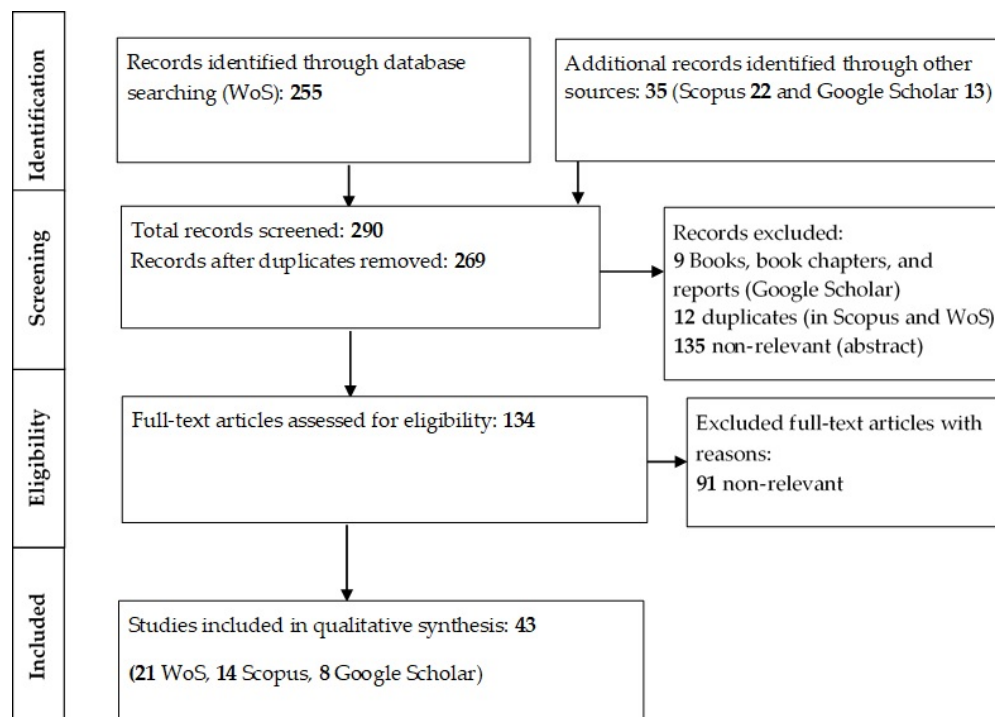


Figure 1. The steps of the literature selection process. Note: the time period of the search was restricted to the period of 2010–2020, and only journal articles and reviews were selected. Source: Authors’ composition based on Moher et al. (2009).

After the first screening, WoS and Scopus search resulted in 255 and 22 records, respectively. To ensure that only relevant articles are included in the final analysis, the abstracts were read and evaluated based on the selected keywords. The abstract screening

produced 135 (of 269) non-relevant studies. In the case of non-relevant studies, keywords were not included in their abstracts). The full texts of the remaining 134 articles were assessed for eligibility and provided 43 relevant publications for the systematic literature review (21 WoS, 14 Scopus, and 8 Google Scholar). Regarding the full-text screening, the excluded articles covered climate change-related issues without linking them to trade agreement, or the major focus of the studies was irrelevant (dealing only with decarbonization, energy policy, emission trading system, climate agreements, etc.). The applied PRISMA selection method (Moher et al. 2009) guaranteed that all the included articles are directly linked to the research question; therefore, they provide the opportunity for a detailed analysis of the trade–climate nexus.

Table 1 presents the impact of the articles analyzed measured by the citations in the corresponding databases. Based on these data, Nordhaus (2015), Yunfeng and Laike (2010), and Liddle (2017) were the most-cited authors in WoS.

Table 1. The impact of the articles measured by total citations in relevant databases.

WoS		Scopus		Google Scholar	
Authors	Total Citation	Authors	Total Citation	Authors	Total Citation
Nordhaus 2015	233	Barrett 2011 *	18	Yasmeen et al. 2018	33
Yunfeng and Laike 2010	182	Ackrill and Kay 2011 *	17	Shapiro 2020	16
Liddle 2017	75	Dong and Whalley 2010 *	15	Nemati et al. 2019	15
Beccherle and Tirole 2011	34	Dong and Whalley 2011 *	14	Balogh and Jámor 2020	13
Böhringer et al. 2014	24	Himics et al. 2018 *	10	Friel et al. 2020	10
Morin et al. 2018	24	Guevara et al. 2018 *	6	Chen 2017	1
Larch and Wanner 2017	11	Khourdajie and Finus 2020 *	5	Leal-Arcas 2018	0
Morin and Jinnah 2018	10	Young 2017	4	Liao 2017	0
Cai et al. 2013	9	Kuhn et al. 2019 *	2		
Hufbauer and Kym 2010	9	Dissou and Siddiqui 2013 *	2		
Fouré et al. 2016	7	Fang 2019	1		
Kirchner and Schmid 2013	7	Laurens et al. 2019 *	1		
Meyer 2017	7	De Melo and Solleder 2020 *	0		
Sauquet 2012	6	Monkelbaan 2017 *	0		
Avetisyan 2018	4				
Henschke 2012	4				
Blandford et al. 2014	2				
Low and Murina 2010	2				
Mathews 2016	1				
Montaga et al. 2020	0				
Yu et al. 2011	0				

Note: * articles are appeared in WoS as well. Source: Authors' composition.

The following chapter analyses the selected publications.

3. Results

Based on the 43 relevant articles, the existing literature was classified into three main categories: (i) trade negotiations and agreements, (ii) role of trade relations in CO₂ emissions reduction, and (iii) impacts of climate-related policy measures on trade. Furthermore, the authors were classified and grouped according to three main categories and associated concepts (Table 2).

Table 2. The three category-related notions and authors.

Trade Negotiation and Agreements			Role of Trade Relations in Emission Reduction	Effects of Climate-Related Policy Tools on Trade
trade liberalization elimination of trade barriers tariff reductions trade cooperation	WTO rules RTA, PTA NAFTA EGA	agricultural trade liberalization	trade related CO ₂ reduction ratification decision of trading partners emissions embodied in trade	border carbon adjustment carbon tariffs carbon pricing
	Ackrill and Kay (2011) Chen (2017) De Melo and Solleder (2020) Dissou and Siddiqui (2013) Fang (2019) Guevara et al. (2018) Henschke (2012) Hufbauer and Kym (2010) Laurens et al. (2019) Liao (2017) Meyer (2017) Monkelbaan (2017) Morin and Jinnah (2018) Morin et al. (2018) Young (2017)			Khourdajie and Finus (2020) Fouré et al. (2016) Avetisyan (2018) Böhringer et al. (2014) Khourdajie and Finus (2020) Larch and Wanner (2017) Mathews (2016) Montaga et al. (2020) Shapiro (2020)
Kuhn et al. (2019) Low and Murina (2010) Barrett (2011) Dong and Whalley (2010) Dong and Whalley (2011) Leal-Arcas (2018) Nemati et al. (2019) Nordhaus (2015)		Blandford et al. (2014) Himics et al. (2018) Kirchner and Schmid (2013) Balogh and Jámbor (2020)	Laurens et al. (2019) Cai et al. (2013) Guevara et al. (2018) Larch and Sauquet (2012) Larch and Wanner (2017) Yunfeng and Laike (2010)	

Source: Authors' composition.

Trade negotiation-related concepts (i) were linked with trade liberalization, elimination of trade barriers and tariff reduction, as well as changing the rules of WTO. Furthermore, this analyses the role what the North American Free Trade Agreement (NAFTA), the Regional Trade Agreements (RTAs) and the Preferential Trade Agreements (PTAs) played in emission reduction. Moreover, agricultural trade-related issues are also discussed under this category.

The category of trade relations (ii) was associated with influences of trade cooperation in emissions reductions, the impacts of the trading partners' ratification decision, trade-related CO₂ reduction and carbon emission embodied in trade.

Climate-related policy tools (iii) cover the subtopics of border carbon adjustments and analyze the effects of carbon tax or tariffs on trade.

Most of the scholars (10) researched the environmental effects of trade liberalization and the results of WTO negotiation (15) by assessing the possible impact of tariff reductions and the elimination of trade barriers. They also discussed agricultural trade (4) and the environmental issues of the North American Free Trade Agreement (2), MERCOSUR, Regional Trade Agreements and Preferential Trade Agreements, and Trans-Pacific Partnership as a subtopic. Articles dealing with trade relations (7) and climate-trade-related policy tools (12) were also discussed in the selected literature.

Exploring the applied methodologies, general equilibrium models (e.g., GTAP and MIRAGE), simulations (Monte Carlo, Stackelberg game, and climate policy game), panel regression (comprising Environmental Kuznets Curve), and partial equilibrium (CAPRI) models were the most widely used technics. This indicates that economic, econometric and mathematical modelling are the most popular ways of analyzing the relationship between trade agreements and climate change in economics (Figure 2).

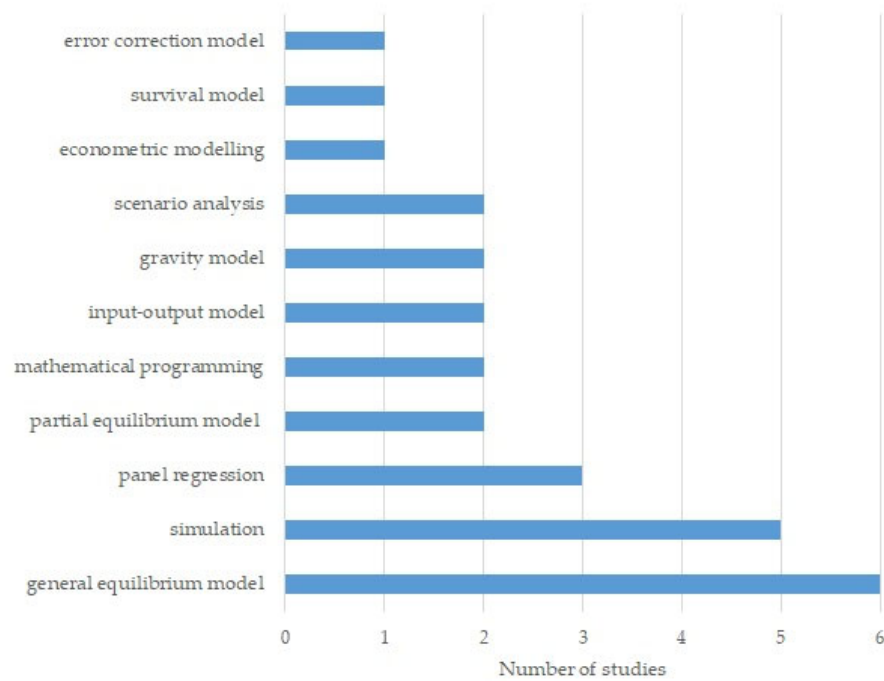


Figure 2. The applied methodologies by the reviewed literature. Source: Authors’ composition.

Most articles addressed various industries at the same time (17). Among the articles covering specific industries, the energy industry (10) was the most frequently studied, followed by the agricultural and fishery sector (9). Services (6) were the least investigated among the analyzed industries (Table 3).

Table 3. Analyzed industries.

Energy Industry	Agriculture and Fishery	Services	Various Industries
			Barrett (2011)
			Böhringer et al. (2014)
			Cai et al. (2013)
			De Melo and Solleder (2020)
			Dissou and Siddiqui (2013)
			Dong and Whalley (2010)
			Dong and Whalley (2011)
			Henschke (2012)
			Kuhn et al. (2019)
			Larch and Wanner (2017)
			Low and Murina (2010)
			Monkelbaan (2017)
			Morin et al. (2018)
			Nemati et al. (2019)
			Nordhaus (2015)
			Shapiro (2020)
			Yu et al. (2011)
Ackrill and Kay (2011)	Balogh and Jámbor (2020)	Avetisyan (2018)	
Böhringer et al. (2014)	Blandford et al. (2014)	Barrett (2011)	
Fang (2019)	Dong and Whalley (2010)	Böhringer et al. (2014)	
Guevara et al. (2018)	Dong and Whalley (2011)	Chen (2017)	
Larch and Wanner (2017)	Fouré et al. (2016)	Dong and Whalley (2011)	
Leal-Arcas (2018)	Himics et al. (2018)	Khourdajie and Finus (2020)	
Mathews (2016)	Kirchner and Schmid (2013)		
Meyer (2017)	Larch and Wanner (2017)		
Morin and Jinnah (2018)	Young (2017)		
Sauquet (2012)			

Source: Authors’ composition.

Discovering global-level issues or providing wide geographical coverage of trade–climate nexus were a general aim of the analyzed literature. The American, Asian, and European regions were overrepresented, while the trade-related climate issues of the African and the Pacific regions were underrepresented in the selected literature (Table 4). This indicates that the African and the Pacific regions can be identified as a potential research gap in this topic.

Table 4. Analyzed regions by the studies.

Analyzed Countries and Regions	Authors
Europe	
Austria, Marchfeld region	Kirchner and Schmid (2013)
Norwegian agriculture	Blandford et al. (2014)
European Union	Fouré et al. (2016)
European Union agriculture	Himics et al. (2018)
America	
Canada and the United States	Dissou and Siddiqui (2013)
NAFTA, United States–Mexico	Yu et al. (2011), Guevara et al. (2018)
NAFTA, MERCOSUR, AUSFTA	Nemati et al. (2019)
United States–Mexico–Canada Agreement (US-MCA)	Laurens et al. (2019)
Asia	
China foreign trade	Yunfeng and Laike (2010)
China, US–China trade	Fang (2019)
Pacific	
Trans-Pacific Partnership	Young (2017)
Africa	
East Africa (Kenya, Tanzania, and Uganda)	Liao (2017)

Source: Authors' composition.

3.1. The Role of Trade Relations in Emissions Reductions

Most of the authors highlighted the need for climate coalitions and incorporating trade restrictions in multilateral climate agreements addressing emission reduction.

Reducing tariffs on low-carbon products and setting penalties on non-member countries of regional trade agreements can force harmonizing trade and climate change regimes. However, the effects of carbon motivated regional trade agreements are often small even with penalty mechanisms (Dong and Whalley 2010; Dong and Whalley 2011).

Investigating free trade, Nordhaus (2015) argues that climate coalitions in agreements are not stable without sanctions against non-participant countries. In turn, country groups acting together as a climate club can apply trade penalties on non-participants and create a large, stable coalition with a high level of CO₂ abatement.

In other scholar's opinion, greenhouse gas emissions can be reduced by incorporating trade restrictions without losing gains from multilateral trade cooperation (Barrett 2011). Regarding climate coalitions, Kuhn et al. (2019) confirmed that emission reduction is higher, consumption patterns are more environmentally friendly, and coalition welfare is much more improved compared to the single-issued environmental agreements.

When free trade agreements are between only developed or developing countries, there is no environmental damage, and these types of agreements can be beneficial for the environmental quality in the long run. However, when developing and developed countries are in a trade agreement, overall environmental quality decreases due to the increased GHG emissions. The effect of free trade on the environment depends on the relative income levels of the countries involved in the agreement. Least developed countries need to be aware of the trade-off between increased economic growth and higher GHG emissions caused by the free trade (Nemati et al. 2019). Leal-Arcas (2018) added that greater cooperation is required between developed and developing countries to create stable agreements, boosting renewable energy trade. Higher engagement of the major GHG emitters (the US, the EU, and China) is needed to support the transition to renewable energy and the harmonization of carbon pricing.

Cai et al. (2013) found that larger countries are more likely to participate in climate agreements because a given output reduction leads to a higher reduction in global average temperature.

Investigating the impacts of trade relations on emission reduction, Sauquet (2012) showed that countries often follow the decision of their trading partners. This is induced by the reputation and competitiveness of their trading partners. Therefore, trade relations in environmental treaties are crucial factors that should be accounted for.

Yunfeng and Laike (2010) estimated the CO₂ emission embodied in the Chinese foreign trade. They showed that more emissions were exported than products consumed domestically due to carbon embodied in products. Consequently, a significant carbon emission occurs at the Chinese trading partners that should be considered in any new agreements.

To conclude, incorporating trade restrictions in agreements, setting penalties on non-member countries, and creating a climate coalition can strengthen climate–trade cooperation and enhance emissions reduction without losing the gains from trade cooperation. In this context, the main purpose of the trade restrictions is to enforce the agreement and encourage participation in emission reduction. In contrast, the emission reduction is often limited even with a penalty mechanism. Thus, further research should address the optimal characteristic of the trade–climate cooperation, adequate trade restrictions to stimulate efficient GHG emissions reductions. From this aspect, developed countries should take higher responsibility because these countries are the major emitters and they have more opportunities to invest into green energies. Trade relations have a crucial role in environmental treaties influencing the decision making of all trading partners. Furthermore, in trade negotiations, trade embodied carbon emission should also be analyzed to avoid the potentially harmful environmental impacts of a free trade agreement.

Agricultural Trade and Climate Nexus

Kirchner and Schmid (2013) indicated that the elimination of trade barriers and agri-environmental payments led to a substantial environmental deterioration in small countries and regions. Agri-environmental payments can contribute to the battle against climate change and emission reduction.

Second, the literature review revealed that trade liberalization has only modest effects on agricultural emissions. The combination of agricultural trade liberalization and carbon pricing in the European Union increased emission leakage in other parts of the world and undermined global climate mitigation goals (Himics et al. 2018).

Third, agricultural trade liberalization often influences the environment unfavorably. Tropical deforestation, biodiversity loss, soil erosion, and excessive water use were mentioned as the major problems associated with accelerating agri-food trade. The most significant impact of deforestation and biodiversity loss were caused in Brazil, India, Indonesia, and Sub-Saharan Africa (Balogh and Jámbor 2020).

Due to their weak environmental standards, free trade agreements also drive intensive farming methods with high external inputs, such as energy-intensive synthetic nitrogen fertilizers, which lead to agricultural land use change-related deforestation, soil degradation, and high biodiversity loss in tropical regions (Heyl et al. 2021).

In conclusion, the effect of trade liberalization on agricultural GHG reductions is ambiguous: it has only modest effects on air pollution, but it increases emission leakage and environmental degradation. Trade liberalization linked to the reduction of tariffs and trade barriers is also criticized, especially by developing countries.

After having discussed the relationship between trade and climate change mitigation, the next section addresses the environmental policy of the WTO and its negotiations.

3.2. WTO Rules and Negotiations

The general approach under the WTO rules is to acknowledge that some degree of trade restriction may be necessary to achieve certain policy. Several WTO rules are relevant to measures that aim at climate change mitigation. These measures include border measures, the prohibition of border quotas, the general principle of non-discrimination, rules on subsidies or technical regulations, disciplines relevant to trade in services, imposing general obligations such as the most-favored-nation treatment, or rules on trade-related intellectual property rights (WTO 2021a).

Regarding the WTO rules, several weaknesses reflected in the analyzed literature relating to environmental issues. The WTO Doha Round proposals on agriculture did not generate significant emissions cuts because emissions reduced by cutting back agricultural production via free trade did not lead to more climate-friendly production methods (Blandford et al. 2014). The arrangement of agri-environmental payments with WTO trading rules remains an important issue in the trade-environment debate (Kirchner and Schmid 2013).

De Melo and Solleder (2020) concluded that the Doha Round negotiation did not lead to a sufficient reduction of tariffs. Negotiations broke in 2016, consequently, adjusting tariffs under the Environmental Goods Agreement (EGA) were insufficient to mitigate climate change. They emphasized the urgent need for transformational changes in the WTO contracts to take transnational externalities and public goods into account. Reaching successful trade agreements also requires delegating independent scientific experts to the negotiating authority to adjust the WTO rules.

Moreover, the world largest fossil fuel exporters, many of them are located in the Middle East, had not historically been members of the World Trade Organization (Meyer 2017). In addition, the rise of state-owned enterprises in many oil-producing countries can cause a problem. Hence, the WTO rules on subsidies are inadequate to deal with the restriction of fossil fuel trade.

Assessing the impact of the WTO rules on carbon emission, we can see that the effects of tariff reductions on environmental goods are low, transnational externalities and public goods are not included in the agreements.

Regarding trade liberalization, more proposals are required to address climate change. Furthermore, the analyzed literature focused mainly on trade barriers, with limited interests in what rules have performed well and why in climate mitigation policy (Friel et al. 2020).

Trade barriers are identified as the largest obstacles to the dissemination of low-carbon energy technologies and associated services worldwide. Lower trade barriers on environmental goods might have advantages for both developed and developing countries. Finally, to date, Middle East fossil fuel exporters have not joined the World Trade Organization. All these issues make the WTO negotiation and trade rules insufficient to achieve a significant emission reduction and establish stable rules for environmental protection.

3.3. Regional and Bilateral Trade Agreements

Regional trade agreements are reciprocal preferential trade agreements between two or more trading partners (WTO 2021b). Liao (2017) argues that regional trade agreements can contribute to pursuing harmonization and cooperation under the WTO. The RTAs can provide opportunities for a group of countries with concrete commitments and rules to tackle climate change.

Analyzing the NAFTA and the United States–Mexico–Canada Agreement, many environmental concerns were highlighted. According to Yu et al. (2011), the free trade between the United States and Mexico contributes to increasing GHG emissions in both countries. As the United States is the top destination for Mexican exports, and there is an extensive intra-company trade between those two countries, the “pollution haven” hypothesis holds in this trade relation. Exploring the energy-related CO₂ emission between

NAFTA countries shows that NAFTA has not built an integrated energy system to reduce energy-related CO₂ emissions (Guevara et al. 2018). The United States–Mexico–Canada Agreement (USMCA)—known as the renegotiated NAFTA—has only made limited contributions to environmental protection. This agreement primarily replicated most of the environmental provisions included in the previous agreement. Moreover, the USMCA scaled back environmental provisions related to multilateral environmental agreements (Laurens et al. 2019). In terms of trade, the literature confirmed that NAFTA allows only limited space for environmental protection and did not comply with international climate mitigation goals.

3.4. Unilateral Trade Preferences

Limited number of studies addressed how unilateral trade preferences influence climate change. Preferential Trade Agreements (PTAs) are unilateral trade preferences in the WTO. They are generally created between a developed and a developing nation where developed countries favor developing ones by reducing import tariffs (WTO 2021c). Morin and Jinnah (2018) revealed that climate provisions in PTAs are sometimes specific and enforceable, in contrast, these provisions remain weakly legalized, fail to implement broadly in the global trade system. Moreover, the largest GHG emitters (the US, India, China, and Canada), except for the European Union, included only a few weak climate-related provisions. Hence, provisions in PTAs are not effective in climate mitigation as they address climate change indirectly.

3.5. Different Policy Measures in the Trade–Climate Nexus

Global-level policies provide an opportunity for global emissions reduction. However, Barrett (2011) concluded that the Kyoto Protocol had no trade-restrictive elements; therefore, it did not reduce GHG emissions. He emphasized that any future climate agreements should restrict trade in order to protect the trading system. Regional cap-and-trade systems may lead to a global climate agreement (Beccherle and Tirole 2011).

Blandford et al. (2014) argued for either a more effective trade liberalization or carbon taxes. Although both decrease agricultural activity but increase economic welfare in return. Encouraging the trade of low carbon-intensive goods by tariffs results in lower emissions, but this impact would be relatively small and ambiguous (Dong and Whalley 2010). Dong and Whalley (2011) identified its explanation, i.e., economic growth is a more significant reason for higher emissions than trade. Based on a model analysis, they also pointed out that both custom unions and free-trade agreements reduce emissions more than carbon motivated trade arrangements.

Avetisyan (2018) suggested the global GHG tax; however, a sector-specific tax performs worse than an all-sector tax, especially in developing regions subsidized from tax revenues. Due to the highly interconnected international trade, applying a consumption-based CO₂ accounting system would help to deal with the exported CO₂ emissions problem (Yunfeng and Laike 2010).

Finally, Mathews (2016) proposed the integration of trade (WTO) and climate (United Nations Framework Convention on Climate Change) issues to promote green products and processes.

WTO Rules Addressing Subsidies

Several countries apply trade subsidies to encourage exports and domestic market sales through direct payments. The WTO Agreement on Subsidies and Countervailing Measures (ASCMs) is a multilateral discipline that regulates the provision of subsidies, and the use of countervailing measures to offset losses caused by subsidized imports (WTO 2021d). The provision of emissions permits issued by countries in carbon trading schemes usually interacts with subsidies in the WTO ASCMs (Henschke 2012). Hence, countries need to avoid disproportionately favoring industries exposed to trade in the

distribution of carbon emissions permits. Otherwise, they risk that permit distributions may become prohibited under the ASCMs.

Analyzing RTA proposals including the fishery subsidies in the Trans-Pacific Partnership, Young (2017) found that certain subsidies may contribute to overfishing or illegal fishing. This should be revised during the arrangement of RTAs. However, fishery subsidies are special, as a majority of them are granted by net fish importers, such as Japan, to increase domestic production, and these subsidies mostly impact the access to the resources (Young 2017).

Arrangements of trade subsidies and sanctions were the main obstacles to reach an agreement at the South African UNFCCC conference in 2011 (Hufbauer and Kym 2010).

Similar to the fossil fuel subsidy reform, fishery subsidy is a complex issue with at least four dimensions: social, political, cultural, and environmental/ecological (Young 2017). According to Young (2017), every reform process should be based on the interaction between the different regimes and its key issues are openness, transparency, and contestability. In some cases, the subsidies allowed by the WTO led to overexploitation of natural resources. Therefore, the direct environmental impacts of trade subsidies should be investigated, especially in regions with high biodiversity resources.

The subsequent section discusses the climate-related policy tools of trade.

3.6. Effect of Climate Policy Measures on Trade and Economic Welfare

The Border Carbon Adjustment (BCA) is interpreted as an important climate-related policy measure. This taxes imported goods based on their carbon emission to limit emissions leakage and support domestic industries that produce goods with lower GHGs than the potentially cheaper but more pollutant imports (OECD 2020).

As a trade measure, BCA has many disadvantages and may be opposed by any WTO members under the dispute settlement mechanism. BCA implies export losses to the trading partners; therefore, it decreases agri-food exports, meanwhile leading only to a small decrease in global emissions (Fouré et al. 2016). In contrast, Khourdajie and Finus (2020) show that BCAs without restrictive membership can lead to stable climate agreements, associated with large global welfare gains. BCA creates stable climate agreements if climate treaties do not restrict membership, but this usually implies export losses for agricultural trading partners.

Import adjustments can be made compatible with the WTO obligations, while export refunds may constitute an illegal subsidy under the ASCMs, which has no exceptions for environmental purposes (Böhringer et al. 2014).

Evaluating the effects of carbon tariffs on trade, Larch and Wanner (2017) experienced with reduced welfare, mostly in developing countries, if trade decreases due to a carbon tariff. In turn, if a high tariff falls or is eliminated, carbon emissions are not shifted from countries with higher carbon taxes to countries with lower carbon taxes indicating the reduction of carbon leakage.

Shapiro (2020) revealed that if countries imposed similar tariffs and non-tariff barriers to trade (NTBs) on clean and dirty industries, global CO₂ emissions would fall, while real income would not change. As the final consumers are generally not well-organized, countries end up with greater protection on clean products and less protection on polluting goods.

According to Dong and Whalley (2011), most of the carbon motivated RTAs improve economic welfare. However, if countries with high emission are involved, carbon-based custom unions are even more effective. In the case of the broader climate agreements, Khourdajie and Finus (2020) highlighted that non-signatories enjoy various economic benefits without paying any costs. This includes environmental benefits, as well as economic benefits, if some parts of a ratifier's production are relocated to a non-ratifier country. Based on their modeling results, Montaga et al. (2020) highlighted a potential side-effect, namely international environmental agreements may lead to a welfare reduction in the non-participating countries.

4. Discussion

The reviewed literature discussed several problems hindering the advantageous effects of trade agreements on mitigating climate change. The main arguments against the effectiveness of trade liberalization on emission reduction are diverse. First, environmental degradation occurs (deforestation, biodiversity loss) caused by agricultural trade liberalization, especially in tropical regions (Balogh and Jámbor 2020). From this aspect, the combination of agricultural trade liberalization with carbon pricing increases emission leakage, especially in the agricultural sector of the non-EU countries (Himics et al. 2018). Furthermore, the elimination of trade barriers and agri-environmental payments causes substantial environmental damage at the regional level, as in the example of the Marchfeld region in Austria (Kirchner and Schmid 2013).

Second, the potential weaknesses of the WTO regulations are also highlighted. As a result of the Doha Round, the average tariff reduction on Environmental Goods under the Environmental Goods Agreement (EGA) was low and insufficient to mitigate climate change (De Melo and Solleder 2020). Moreover, the WTO Doha Round proposals on agriculture did not have a significant impact on GHG emission reduction. The impacts of the emissions reduction on agricultural activity depend on whether a climate agreement allows a credit for carbon sequestration activities on land extracted from agricultural production (Blandford et al. 2014). As reciprocal litigation exists in the renewable energy sector at the national and international level, the subsidies allowed under WTO are rarely used to stimulate the renewable energy sector (Meyer 2017) and may lead to overexploitation of natural resources.

Although PTAs include several environmental provisions, they remain weakly legalized and are not often approved by the world's largest GHG emitters. Neither the US, India, China, nor Canada include a significant number of climate change provisions in their PTAs (Morin and Jinnah 2018). Even including a penalty mechanism, the carbon motivated regional trade agreements only slightly reduced global emissions, and trade policy is likely to be a minor consideration in climate change containment (Dong and Whalley 2010; Dong and Whalley 2011). Yunfeng and Laike (2010) call attention to the damaging effects of export-oriented production on the environment in China.

Finally, the climate and trade negotiations are taking place under great uncertainty, and voluntarism at the national level results in an insufficient effort to address climate change (Low and Murina 2010).

The literature point out that the effectiveness of the trade negotiations on climate change is weak because trade liberalization may help to stimulate renewable energy trade, but might also cause environmental concerns such as deforestation, biodiversity loss, intensive agricultural production, and carbon leakage. The carbon emission leakage is often associated with developed countries' trade (emission embodied in trade) and climate mitigation policies (environmental provisions, carbon tax, border carbon adjustments). This results in the relocation of polluting industries to the developing and the least developed countries (e.g., Africa, South America, or Asia). The largest beneficiaries of the trade agreements are mostly the largest GHG emitters, such as the US, the EU, and China. They often outsource their industrial and agricultural production to developing countries with low environmental standards and export back the processed products.

In line with the findings of the literature review, trade liberalization under WTO at the present stage is unable to change production methods to be environmentally friendly; therefore, reconsideration of trade regulation and new renegotiations, especially among developing and developed countries (e.g., US–Latin America, US–Asia, and EU–Africa), are needed. In this context, trade regulation should account for production methods, all resources used during production, and the distance and method of product transportation from the producing country to the final consumers.

However, a few mandatory standards concerning deforestation were established in trade agreements (e.g., Mercosur, CETA, and the EU–Vietnam Free Trade Agreement).

These agreements lack a comprehensive legal framework to enhance environmental protection. Additionally, they have weak dispute settlement mechanisms to ensure compliance with sustainability measures, which limit their effectiveness (Heyl et al. 2021).

On the other hand, trade agreements can encourage emission reduction by applying restrictions on non-member countries, lowering tariffs on environmental goods, stimulating renewable energy (excluding biofuels and biomass from wood), and eliminating fossil fuel subsidies. All these efforts can be successful only if they are also approved by the largest GHG emitters and included in their foreign trade policies, enforced by their companies operating abroad. Finally, the harmonization of the trade agreements with national climate policies is needed to avoid counteractive measures and to make them compatible with global environmental policies and goals (e.g., the Paris Agreement).

Table 5 summarizes the problems hindering the success of trade agreements in reducing GHG emission and solutions offered to tackle them.

Table 5. Problems of the trade agreements and solutions offered.

Issue	Problems Detected	Solutions Offered
Impact of trade-related carbon adjustments		
Carbon tax	Causes intensification of production.	Imposing a carbon tax might lead to output reduction.
Carbon tariff	Trade decreased, welfare reduced in developing countries.	If countries imposed similar tariffs and NTBs to trade on clean and dirty industries, global CO ₂ emissions would fall, while real income would not change.
Carbon leakage	The combination of agricultural trade liberalization and carbon pricing increases emission leakage, especially in non-EU countries.	Carbon tariffs enable the reduction of global emissions by altering the production within and across countries, reducing carbon leakage.
Border carbon adjustments	BCA on imports of energy-intensive products in the EU indicates a small decrease in global emissions. May be opposed by a WTO member under the dispute settlement mechanism. Would imply export losses to the trading partners, could decrease agri-food exports.	BCA without restrictive membership can lead to stable climate agreements, associated with large global welfare gains.
Emission embodied in trade	Higher Chinese emissions were exported by carbon embodied in products than products consumed in China domestically.	Controlling export-oriented products.
WTO rules and negotiations		
WTO tariff reduction	Low average tariff reduction under WTO is insufficient to mitigate climate change.	Higher tariff reduction of environmental goods.
Subsidies	The subsidies allowed under WTO are rarely used to stimulate renewable energy and leads to overexploitation of natural resources (e.g., in the Trans-Pacific Partnership, certain fishery subsidies may contribute to overfishing or illegal fishing).	Reconsideration of trade regulation and renegotiations, especially between developing and developed countries, are needed.
Sustainable energy trade	Biofuels and biomass production may lead to increased deforestation, biodiversity losses in tropical areas and developing southern countries (Mexico, Brazil, India, Indonesia and Sub-Saharan Africa).	Biofuels and biomass production should be treated differently or restricted in trade policy.
WTO trade negotiation	Trade negotiations take place under great uncertainty and are often halted before coming to a conclusion	Delegating independent scientific experts to trade negotiation may help change rules and reduce emissions.

Trade agreements		
Emission reduction	Trade-related emission.	Creating universal agreements with differentiated and clear obligations can stimulate emission reduction.
Trade barriers	Technical barriers to trade.	Elimination of trade barriers on low-carbon and environmentally friendly products contributes to trade-related emission reduction. Motivates sustainability to be more WTO-compatible.
Trade restrictions	Trade penalties.	Applying trade penalties on nonparticipants of an agreement can stimulate their climate abatement policy. Small trade penalties on non-participants of trade agreements create a stable climate coalition with potentially high levels of CO ₂ reduction. Country groups acting as a climate club, applying trade penalties on non-participants, creates a stable coalition with a high level of abatement.
Externalities	Environmental externalities.	Incorporating transnational externalities and public goods in trade agreements are needed.
Interrelation of environmental and trade agreements	Lack of harmonization between environmental and trade agreements.	Environmental and trade agreements must be sufficiently integrated at the national and international policies to improve environmental quality and attain the benefits of free trade.
Climate provisions in PTAs	Climate provisions in PTAs offer limited progress, remain weakly legalized, and are not adopted by the largest GHG emitters.	Carbon-based custom unions are more effective than carbon motivated RTAs if high emission countries are involved.
Trade liberalization	Modest effects of trade liberalization on agricultural GHG emissions. Doha Round proposals on agriculture did not generate significant emissions reductions. Elimination of trade barriers and agri-environmental payments leads to substantial environmental damage in small countries.	Trade agreements are able to encourage emission reduction by applying restrictions on non-member countries, lowering tariffs on environmental goods, and stimulating renewable energy.

Source: Authors' composition.

Regarding solutions, different trade and WTO-related issues were posted. When free trade agreements are implemented between only developed or only developing countries, there is no environmental damage. However, when there are both developing and developed countries in a trade agreement, the environmental quality decreases (Nemati et al. 2019). Accordingly, greater cooperation would be necessary between developed and developing countries' trade policies to increase renewable energy trade (Leal-Arcas 2018).

In the WTO contracts, environmental externalities and public goods have to be taken into account to measure the additional environmental costs of polluting activities. Moreover, WTO members should pursue similar climate-friendly policies (De Melo and Solleder 2020) to harmonize their environmental standards. Biofuels and biomass trade should be treated differently from renewable energy in trade policy since their production might cause environmental damages. Technical Barriers to Trade help to establish WTO-compatible, sustainable principles (Ackrill and Kay 2011), protect consumers and preserve natural resources. The arrangement of agri-environmental payments with WTO trading

rules is crucial in the effective trade–environment debate, especially for small countries (Kirchner and Schmid 2013). Delegating scientific experts to negotiations can change the poorly specified WTO trading rules, reaching an agreement on tackling NTBs and environmental services (De Melo and Solleder 2020).

Considering trade relations, small trade penalties on non-participants of trade agreements can force a stable climate coalition with a potentially high CO₂ reduction (Nordhaus 2015). In addition, universal trade agreements with clear obligations offer the best solution for stimulating efficient emission reduction (Low and Murina 2010). If climate treaties are designed strategically, the threat to restrict trade will suffice to enforce an agreement (Barrett 2011). When a country's participation in joint emission reduction is higher, the consumption patterns are more environmentally friendly, and welfare is much more improved (Kuhn et al. 2019). Considering the welfare effects of climate policy measures, when countries impose similar tariffs and barriers on environmentally friendly and polluting industries, global CO₂ emissions tend to fall, while incomes do not change (Shapiro 2020). A nonrestrictive border carbon adjustment can lead to stable climate agreements and significant global welfare gains (Khourdajie and Finus 2020), while carbon tariffs enable global emissions reduction by altering the production within and across countries, resulting in the reduction of carbon leakage (Larch and Wanner 2017). In contrast, imposing a carbon tax might lead to output reduction and the intensification of production (Blandford et al. 2014). Mobilizing environmental goods, services, and technology to achieve the United Nations' Sustainable Development Goals is also needed (Monkelbaan 2017). Finally, the democratic countries facing import competition are more willing to include environmental provisions in their trade agreements (Morin et al. 2018).

5. Conclusions

In the climate–trade dialogues, a limited number of systematic reviews are dedicated to evaluating the effectiveness of trade agreements and negotiations on climate mitigation policy. This research aims to contribute to the existing literature by examining the role that various trade agreements and trade-related policy measures play in carbon emissions. This systematic literature review provides an overview of the recent literature in economics on the climate–trade nexus for the period of 2010–2020. After the initial research, removing duplicates, and evaluation of abstracts, the review of the full texts results in 43 relevant studies closely associated with the topic. Regarding the research methods, general equilibrium models, simulations, and panel econometrics were the most commonly applied in the empirical literature.

Based on the reviews, many scholars agree that trade agreements can support the mitigating effects of climate change. However, several sceptics emphasized the weaknesses of trade agreements and the WTO negotiation in decreasing air and environmental pollution. Regarding the problems hindering trade agreements to reduce the effects of climate change, many authors underlined that the effectiveness of the negotiations is fragile because they take place under high uncertainty, and countries often favor their national interests. Developing countries have a weaker position regarding climate–trade negotiations compared to the lobbying power of developed countries. The largest beneficiaries of the agreements are primarily the largest GHG emitters. They include only a limited number of climate-related provisions in their trade agreements or have not joined the WTO (oil-producing countries in the Middle East).

Low average tariff reduction under WTO negotiation on environmental goods is unproductive on emission reduction. Subsidies are allowed under WTO in some cases (e.g., fishery industry), and they may lead to overexploitation of natural resources. Energy sources such as biofuels and biomass from wood and timber cause deforestation; therefore, they should be separated from renewable energy in environmental provisions.

Carbon leakage, deforestation, and biodiversity loss are significant climate–trade related issues, and they are usually caused by increasing global trade, intensification of pro-

duction, and national agricultural policies. In turn, these impacts occur mostly in developing countries (outside the European Union or the US) such as India, Brazil, Mexico, and Sub-Saharan Africa.

The analyzed literature also offers policy solutions that contribute to GHG emission reduction and make WTO trade policy more compatible with the UN global climate mitigation goals. The most significant measures identified were the application of small trade restrictions on non-member countries, lowering tariffs on environmental goods, subsidizing renewable energy trade, international carbon tariff harmonization, unrestrictive border carbon adjustment, country groups' climate cooperation and changing policies indicating carbon leakage. Evaluating climate–trade-related policy measures, border carbon adjustment without restriction can lead to more stable climate agreements. Moreover, carbon tariffs can reduce emissions by altering the countries' production composition and reduce trade flows. A carbon tax might lead to output reduction, but it could stimulate the intensification of production, though its effect is controversial for climate change mitigation. Furthermore, greater trade cooperation is vital between developed and developing countries in climate–trade negotiations to allocate renewable energy resources fairly and harmonize tariffs and barriers of fossil energy sources. The issues of transnational externalities and policies indicating carbon leakage should also be addressed in the WTO negotiations. Harmonizing agri-environmental payments with WTO trading rules is crucial in trade–environment debate. Delegating scientific experts to the negotiation helps achieve more environmentally friendly WTO rules. Applying a consumption-based CO₂ accounting system would help document the exported CO₂ emissions (Yunfeng and Laike 2010).

In conclusion, the effectiveness of trade agreements needs to be improved by refining WTO trading rules, subsidizing renewable energy, and limiting fossil fuel trade through different tariffs. Incentives of renewable energy sources and environmental goods should also include trade policy, environmental provisions, and tariff reduction both in developed and developing countries. Moreover, promoting renewable energy trade may have negative effects on emissions if biofuels and biomass are also included. This may lead to increased deforestation and biodiversity loss in tropical regions of Asia, Africa, and Latin America.

Sub-Saharan Africa, North Africa, Latin America, the Middle East, and the Caribbean regions need to reform their institutional framework, leading to trade-led growth activities that encourage innovation, use cleaner technologies, and increase environmental quality (Yasmeen et al. 2018). Moreover, the Association of Southeast Asian Nations should implement policies that encourage sustainable trade and reduce environmental deterioration (Solomon and Khan 2020).

Finally, the largest CO₂ emitters (the US, China, the EU, India, and Canada) should take the highest responsibility in following the WTO rules, establishing high environmental provision in their trade policies to avoid carbon leakage (relocation of polluting industries), emission embodied in trade (transportation), and trade-related environmental damage (overexploitation of natural resources). They also have a responsibility in reducing CO₂ emissions in other parts of the world, as long as they are the engines of the world economy and trade, and influence the scale, method, and technology of production.

As of the practical implications of the paper, findings support that more sustainable trade agreements in trade negotiations can be created by improving the environmental provision and effectiveness of trade policy in emission reduction and selecting a set of adequate trade-related policy measures. However, as the trade and climate-related problems differ from country to country, solutions should be case-specific. Therefore, at least the type of the problem (trade-related carbon adjustments, WTO rules, and types of trade agreements) and the relations of trading partners (developing vs. developed countries) should be taken into account.

One of the main limitations of this study is the article selection method and the analyzed period. We used Scopus, WoS, and Google Scholar; therefore, our results are limited

to these sources. Using other sources, e.g., ScienceDirect, may increase the number of potential articles and enrich our findings. Another possible future path could be the use of an extended research period and application of a META analysis. Analyzing the environmental impacts of trade agreements in the African and Pacific regions has been identified as a potential direction for future research.

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Note

- ¹ Consumption-based emissions are allocated to countries where goods and services are consumed, and differ from territorial-based emissions, as they exclude national emissions required to produce exported products, instead of including emissions from other countries to import products.

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