Decarbonizing Trade through Climate Regulations: Policy Implications for the CAREC Region

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List of Abbreviation

ADP Asian Development Bank
CAREC Central Asia Regional Economic Cooperation
CNTG Contiguity
DIST Bilateral Distance
EMS Environmental Management System
ENVPRV Environmental Provisions in Regional Trade Agreements
ENVTAX Environmental Taxes
EU European Union
ESO Economic and Social Council
FSC Forest Stewardship Council
FTAs Free Trade Agreements
GBOND Green Bonds
GDP Gross Domestic Product
IMF International Monetary Fund
IPCC Intergovernmental Panel on Climate Change
ISO International Organization for Standardization
LANG Language Commonality Between Country Pairs
MSC Marine Stewardship Council
NDC Nationally Determined Contributions
ND-GAIN Notre Dame Global Adaptation Initiative
NTMs Non-Tariff Measures
OECD Organization for Economic Co-operation and Development
POLABT Pollution Abatement Expenditure by Governments
PPML Poisson Pseudo Maximum Likelihood
RTAs Regional Trade Agreements
SCR Sustainable Corporate Responsibility
UNCTAD United Nations Conference on Trade and Development
UNEP United Nations Environment Programme
UNFCCC United Nations Framework Convention on Climate Change
WTO World Trade Organization

Abstract

This study explores the intricate relationship between climate and trade dynamics in the Central Asia Regional Economic Cooperation (CAREC) region. Balancing economic development with climate imperatives is essential for effective regional climate policy. As of 2022, trade, which constitutes 35% of the region's combined GDP, has served as a vital driver for the development and integration of CAREC countries. However, a recent scoping review conducted by the Asian Development Bank (2023) on climate initiatives revealed a predominant emphasis on energy-related projects among previous climate change initiatives in the region. This highlights a notable gap between the intersectionality of climate policies and trade dynamics. The current study addresses this gap by empirically assessing the role of climate-related regulations in promoting low-carbon trade. We analyzed annual bilateral exports of low-carbon products from 2010 to 2019 using a gravity trade model with a Poisson pseudo maximum likelihood estimator. The findings reveal that government expenditures on pollution abatement and climate finance mechanisms, such as green bonds, positively influence low-carbon exports, whereas environmental taxes have a minimal impact. Trade agreements with environmental provisions and voluntary compliance with ISO14001 certification in exporting countries further boost low-carbon exports. The results also indicate that the effects of climate-friendly policies on low-carbon exports differ across economic contexts, highlighting the need for region-specific frameworks. Developing economies in the CAREC region face implementation challenges owing to limited institutional, financial, and technological capacity, which hinders the adoption of green practices. This study offers actionable policy insights for CAREC and its member countries to promote climate-smart trade, foster sustainable growth, and deliver economic benefits to governments and businesses.

JEL Classification: F10, F14

Keywords: climate, trade, low-carbon products, regional integration, CAREC region

1. Introduction

Climate change poses a significant threat to human civilization and challenge to economic development in the 21st century. Given the intricate interrelationships among economic development, trade, and the environment, environmental issues must be included in the agenda for economic development. International trade can be a powerful tool for mitigating and adapting to climate change, when accompanied by sound environmental policies. Following the adoption of the Paris Agreement by numerous countries in 2015, the involved parties have made concerted efforts to meet their climate mitigation objectives, with trade policy playing a crucial role in these strategies. Effective environmental policies have the potential to position international trade as a significant mechanism for both mitigating and adapting to climate change (WTO, 2020).

Over the past few decades, trade-led growth has helped millions of people in developing countries escape poverty. Trade has been instrumental in providing access to new markets, technology transfer, and increased investment opportunities, thereby contributing to economic development and poverty reduction. However, rapid growth in production and trade has also led to negative consequences such as the overuse of natural resources, increased emissions, and exacerbated inequalities within and between countries. Thus, proactive trade policy action is crucial to address these challenges effectively (UNCTAD, 2020). Trade policy measures can play a pivotal role in enhancing local access to environmentally sustainable goods and services, thereby promoting the availability of eco-friendly alternatives. Under the Paris Agreement, the Party's commitments entail the preparation, communication, and ongoing maintenance of progressively ambitious nationally determined contributions. Considering their common but differentiated responsibilities, capabilities, and national circumstances, each country's nationally determined contribution (NDC) reflects its most ambitions goal in combatting climate change (UNFCCC, 2023a). National efforts to achieve the general objectives of NDCs may result in increased trade in low-carbon products and services and trade competitiveness for developing countries, as well as the creation of new industries, such as green hydrogen. Fulfilling these obligations helps CAREC countries ensure transparency, accountability, and ambition in their collective efforts to combat climate change, as outlined in the Paris Agreement. These measures include increasing access to and incentives for the trade of environmental goods, mainstreaming multilateral climate agreements into regional arrangements, digitizing trade processes, promoting paperless cross-border trade, investing in smart and resilient border infrastructure facilities, and accelerating diversification to reduce heavy reliance on commodity exports.

By strategically addressing these dimensions through policy frameworks, CAREC member countries can contribute to fostering a more sustainable and resilient global economy, thereby reducing the regional consequences of climate change. The CAREC region is particularly susceptible to the adverse effects of climate change, such as water shortages, desertification, and an increased frequency of natural disasters. The CAREC region is vulnerable to the effects of climate change, including water scarcity, desertification, and natural disasters. As this region strives to meet its climate goals under international agreements, such as the Paris Climate Agreement, integrating climate considerations into trade policies becomes essential. Furthermore, as part of this agreement, CAREC member countries are required to reduce their greenhouse gas emissions by 10–20% by 2030 (CAREC, 2019)[1]. CAREC countries have all signed the 2030 global development agenda, which includes the Sustainable Development Goals (SDGs). A crucial component of SDG 13 is guiding CAREC nations towards enhanced resilience to climate change. By participating in collaborative initiatives that prioritize sustainability and building adaptive capacity, CAREC countries are making significant strides towards mitigating the adverse effects of climate change and promoting sustainable development. However, according to the Asian Development Bank (ADB, 2017), achieving this will require innovative approaches to reduce industrial pollution and shift towards greener production and trade to comply with environmental regulations. Furthermore, the CAREC region has implemented various climate-smart goods to address these challenges and promote sustainable development. These include renewable energy, energy efficiency, sustainable agriculture, sustainable transport, ecosystem-based adaptation, and climate information services. Through these initiatives, the CAREC region has demonstrated its commitment to reducing greenhouse gas emissions, providing economic growth through sustainable development, and improving its resilience to climate change. By assessing the climate risks and opportunities associated with trade activities, developing policies and regulations that promote climate-smart trade, leveraging existing trade agreements and initiatives, and building more resilient trade infrastructure, CAREC member countries can diversify and build more resilient economies and strengthen regional cooperation on climate change issues. Implementing green policies within trade frameworks is not merely an ethical choice, but a strategic imperative that aligns with contemporary market demands while contributing to environmental sustainability in the CAREC region. Integrating climate considerations into green trade policies can create a multifaceted array of benefits that not only advance environmental sustainability but also foster economic growth, increase trade opportunities, enhance international cooperation, and promote social equity and job opportunities. The intersection of trade and climate policy is being increasingly recognized as critical for addressing global challenges such as climate change, biodiversity loss, and resource depletion. By aligning trade rules with environmental objectives, CAREC countries can incentivize companies to adopt more sustainable practices and technologies, leading to a greener and more resilient economy. Climate-smart trade practices can also provide support for social issues such as poverty alleviation, gender equality, and indigenous rights by promoting fair and inclusive trade practices.

Non-tariff measures (NTMs), which encompass trade policy instruments beyond tariffs, can have a substantial impact on international trade. These measures shape market access, elevate compliance expenses for businesses, generate uncertainty for both exporters and importers and disrupt competitive dynamics in global markets. (Cadot & Gourdon, 2016; UNCTAD, 2010). NTMs can play a significant role in the achievement of SDG 13 by affecting trade patterns and economic activities related to environmental sustainability.

It is noteworthy that the trade activities of the world's largest CO2-emitting economies are subject to significant regulatory oversight. Among the top ten CO2 emitters, six impose climate change-related measures on over 30% of their imports, while eight face NTMs tied to climate change for 25 to 67% of

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[1] During a mission to Beijing and Urumqi in January 2006, the CAREC Secretariat received a request from the People's Republic of China to consider incorporating environmental initiatives into the CAREC Program (CAREC, 2006).

their exports. Middle- and low-income nations are also actively engaging in regulatory efforts, though their impact on trade remains comparatively limited. These outcomes are primarily influenced by the higher carbon intensity of import portfolios in high-income countries and large, industrialized middle-income economies. However, a more cautious perspective arises when examining regulatory intensity, as measured by the proportion of climate-related NTMs relative to total NTMs, which does not correlate with rising per capita income levels.

In the context of the CAREC region, harmonizing NTMs could help reduce trade barriers and promote economic cooperation among member countries. By addressing issues related to the transparency, consistency, and harmonization of NTMs, the CAREC region can enhance its competitiveness in global markets and attract more foreign investment. This could lead to greater economic integration within the region and foster sustainable development across various sectors. By promoting consistency in the application of NTMs, member countries can streamline their trade processes and reduce compliance costs for businesses operating in the region. Thus, policymakers should engage stakeholders from diverse backgrounds in addressing NTMs that affect trade in climate-smart goods. This inclusive approach ensures that the interests of various actors, including government agencies, industry representatives, civil society organizations, and consumers, are considered when formulating policy responses. Policymakers can develop effective strategies to balance trade facilitation with environmental sustainability goals by fostering dialogue and collaboration among stakeholders.

A global strategy is required to combat climate change, including engaging industrialized countries with a worldwide commitment (United Nations, 2019). A global approach is needed to address a problem for which the causes and consequences transcend national borders. However, export-oriented economies in general may hesitate to comply with requirement of climate agreements, because of the implications for domestic industries, mandatory imposition of environmental taxes, fear of losing market share, shifting global trade patterns, potential for economic disruption, and lack of public awareness and support.

Environmental regulations can lead to higher production costs for businesses, primarily because of the increased compliance costs associated with meeting environmental regulations (Dechezlepretre & Sato, 2017). This could involve investing in cleaner technologies, reducing emissions, or complying with stricter waste disposal standards. These added costs are reflected in the final price of the goods, making them less competitive in the global market. Environmental standards in competing countries may be weaker, resulting in lower cost burdens on their industries. Consequently, they can produce goods at a lower cost, providing them with a competitive advantage. This situation can lead to a “race to the bottom,” in which countries lower their environmental standards to attract businesses and maintain competitiveness. Taxes based on environmental damage require polluters to consider such costs when making decisions. The purpose of some taxes is to change behavior, whereas the purpose of others is to generate revenue. Both are governed by the principle of "the polluter pays.” Although this principle has not been officially adopted by the GATT/WTO[2], it may contradict the WTO rules in some circumstances. In this context, international

[2] WTO rules can intervene in tax reforms related to natural resources in international trade, although members have sovereign rights to manage their natural resources. Therefore, environmental tax measures that have a cross-border

agreements, such as free trade agreements (FTAs) with climate-relevant provisions can play an important role (Fischer et al., 2002).

Agreements can aim to harmonize environmental standards across countries, thereby creating a more level playing field for businesses and reducing the competitive disadvantages faced by domestic industries. Furthermore, agreements can incorporate provisions that promote sustainable trade practices and encourage businesses to adopt environmentally friendly methods. As early as the 1980s, climate-relevant provisions began to appear in FTAs, and this activity has significantly increased since 2010. More than 200 FTAs worldwide have climate-related provisions (Dent, 2021). However, to date, CAREC[3] countries have received relatively less attention in terms of incorporating climate-related provisions into FTAs. Nevertheless, efforts have been made to increase the number of climate-related provisions in the CAREC region's FTAs as part of the CAREC 2030 Strategy Framework, endorsed by ministers at the 16th Ministerial Conference on CAREC in 2017. This framework emphasizes the importance of sustainable and inclusive growth and recognizes the need for greater cooperation on environmental issues. It also recognizes the interconnectedness of economic development, environmental sustainability, and social inclusion and emphasizes the need for greater cooperation among member countries to address shared challenges.

The transition to a climate-smart trade system is a complex endeavor that requires a multifaceted approach involving actors from both the public and private sectors. Although governmental policies and international agreements are crucial, the private sector's commitment to sustainability through measures such as ISO-14001[4] certification can significantly influence the trajectory of trade towards climate-friendliness. By demonstrating their commitment to environmental responsibility, businesses can enhance their market access, reduce trade barriers, and contribute to a more sustainable global economy. However, achieving a truly climate-smart trade system requires concerted efforts from all stakeholders, including governments, businesses, consumers, and international organizations.

In today's global economy, organizations must effectively manage environmental, social, and economic issues. Traditional command-and-control regulations and government incentives have limitations, prompting the adoption of environmental management systems (EMS) as a valuable supplement. ISO

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impact may conflict with these regulations (Martinez, 2023). Although no scientific consensus has been reached on these risks, the WTO allows its members to impose trade restrictions to combat them. However, there is the possibility that ill-founded measures can be used to defend local markets, serving as protectionist barriers. WTO regulations, such as environmental taxes, are designed to ensure that global trade is not adversely affected (Herwig & Joerges, 2013).

[3] In 2014, the EU–Georgia FTA with Climate-Relevant Provisions was signed, which contains 11 provisions such as carbon trading and market instruments, promotion of trade and foreign direct investment in climate-relevant goods and services, promotion of renewable energy development, promotion of energy efficiency technologies, reduction of greenhouse gas emissions, adaptation to climate change, and harmonization of climate change-related legislation (Dent, 2021).

[4] ISO (International Organization for Standardization) introduced an environmental management system (EMS) in 1996. As part of the EMS, organizational structures, activity plans, responsibilities, practices, procedures, processes, and resources can be utilized to develop, implement, achieve, review, and maintain environmental policy (Blyde, 2021).

14001 is a globally recognized standard for EMS designed to increase industry awareness of the environmental impact of production and products. While ISO 14001 certification is voluntary and does not guarantee a reduced environmental impact, it can drive positive organizational change. Government policies often encourage or mandate compliance with ISO 14001 standards. Implementing these standards demonstrates commitment to environmental responsibility, enhances competitiveness, and fosters trust. It provides a structured approach for managing environmental aspects, ensuring regulatory compliance, and addressing critical issues such as climate change, biodiversity loss, and resource depletion. The benefits of ISO 14001 certification include reduced waste, energy conservation, cost savings, improved operational excellence and increased stakeholder trust.

The remainder of this paper is organized as follows. Section 2 presents some stylized facts relating to the climate situation in the CAREC region, and Section 3 presents the background to the problem by introducing our conceptual framework through a literature review. Section 4 examines the data and describes the endogeneity methods. The results are reported and discussed in Section 5, followed by the presentation of the policy implications and limitations in Section 6.

2. Study Objectives and Relevance to the CAREC

With climate change posing significant threats to regional ecosystems and economies, effective regulatory frameworks are crucial for mitigating environmental degradation and fostering trade in environmentally friendly goods. Trade is a fundamental driver of development and regional integration among the CAREC countries, particularly benefiting landlocked nations within the region. By facilitating the exchange of goods and services, trade not only strengthens economic ties among member countries but also bolsters connectivity with the broader global economy. In 2022, aggregate trade, comprising both exports and imports, amounted to US$6.7 trillion, representing approximately 35% of the combined GDP totaling US$18.8 trillion[5]. Recognizing that an effective regional climate policy cannot overlook key economic aspects such as trade, striking a balance between economic development and climate imperatives is crucial.

However, a recent scoping review conducted by the ADB (2023) on climate initiatives revealed a predominant emphasis on energy-related projects among previous climate change initiatives in the region. This highlights a notable gap related to the intersectionality of climate policies and trade dynamics. This gap underscores the urgent need to redirect attention towards addressing the dual challenges of environmental sustainability and economic development. By examining the impact of climate-related regulations, this study aims to fill this critical knowledge void and contribute to the development of holistic strategies that integrate climate considerations into trade policies in the CAREC region. Specifically, this study aims to critically discuss the prevailing climate–trade nexus in the CAREC region. Furthermore, this study uses empirical estimations to assess the role of climate-related regulations in promoting low-carbon trade. Based on the findings, this study offers actionable insights into policy adjustments that benefit the CAREC region as a while and its individual member nations.

[5] Trade is calculated using the IMF's Direction of Trade statistics, and GDP figures are based on the IMF's World Economic Outlook data. Data for Afghanistan includes information from 2021.

This study applies a theoretically sound and empirically rigorous econometric approach using data from 2010 to 2019 to examine the role of climate regulations as a policy tool to decarbonize trade. Identifying the sectors within the environmental goods market in which CAREC countries have competitive advantages, such as minerals, energy, and agriculture, will facilitate strategic investment. This targeted approach can help move economies away from reliance on traditional sectors, boost resilience to economic shocks, and promote sustainable growth trajectories.

Tailored policy recommendations are formulated based on the heterogeneous nature of member countries in terms of export composition and climate-related metrics, such as adoption, readiness, and vulnerability. At the country level, this study aims to empower nations to navigate global markets strategically by enhancing compliance with international climate regulations, thereby amplifying trade competitiveness and market reach. These outcomes collectively contribute to fostering sustainable economic growth through climate-smart trade while advancing cooperation within the CAREC region, with tangible benefits for both governments and businesses.

3. Climate Situation: Some Stylized Facts

We first briefly outline the situation in the CAREC region concerning climate indicators, trade shares, and the potential for climate-smart trade. Figure 1 highlights the frequency of extreme climate events in the CAREC region across four five-year periods from 2000 to 2020. Although the occurrence of droughts decreased steadily from nine events in 2000–2005 to four in 2015–2020, floods remained consistently high and fluctuated only slightly over this period. Heatwaves (extreme temperatures) showed a mixed trend, with a peak of 12 events in 2000–2005. Landslides notably declined over time, whereas storms exhibited some variability. Finally, wildfires remained relatively low throughout the period. Overall, the data indicate the varying dynamics of extreme climate events in the region over the past two decades, with some becoming more sporadic and others remaining persistent.

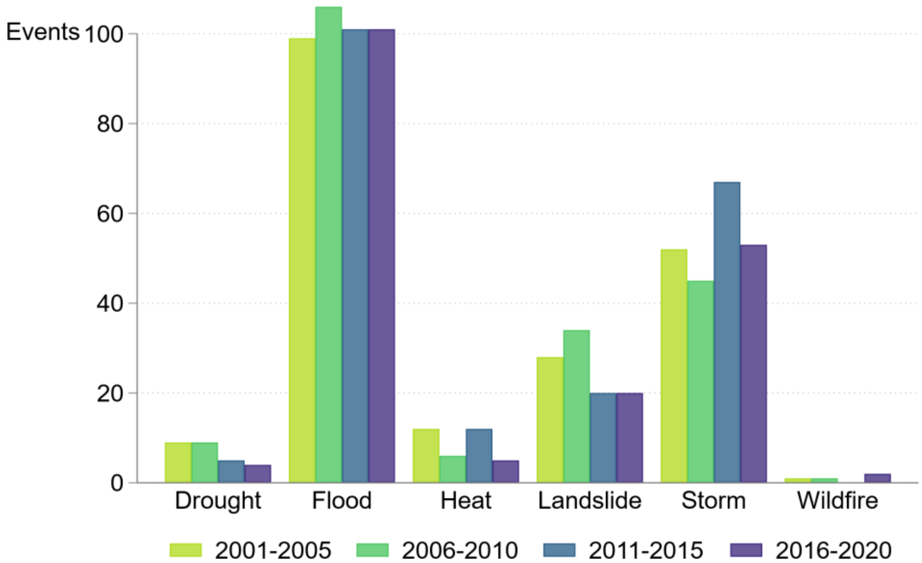


Figure 1: Occurrence of Extreme Climate Events in the CAREC Region

Source: Authors' graphic, based on the Emergency Events Database, Centre for Research on the Epidemiology of Disasters, Belgium. www.emdat.be

Figure 2 provides insights into the trade volume (in billion US$) of low-carbon technology products in the CAREC region compared to the global figures from 2000 to 2021. Both the CAREC region and the world witnessed steady growth in trade in low-carbon technology products over this period. In 2000, the CAREC region's trade volume stood at 5.75 billion US$. By 2021, the CAREC region had experienced a remarkable increase in trade, reaching 230.29 billion US$. Global trade moved from 465.39 billion US$ in 2000 to 2284.91 billion US$ in 2021.

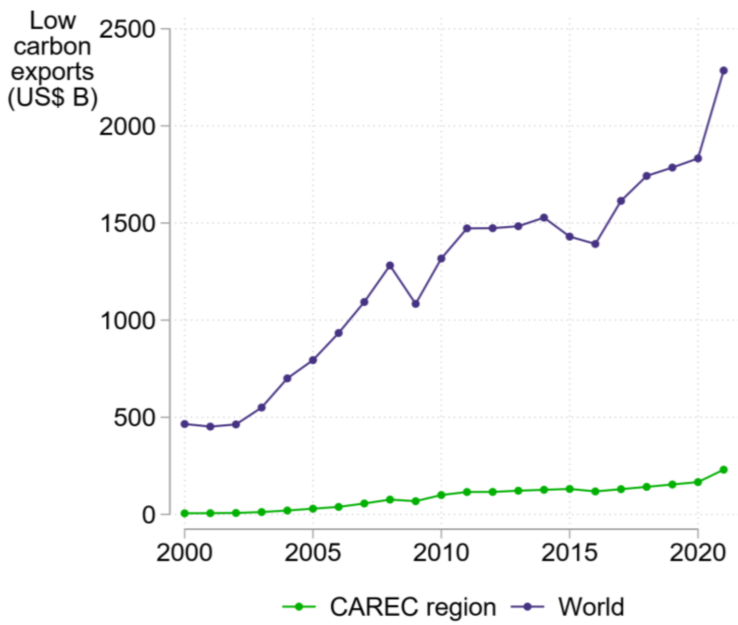
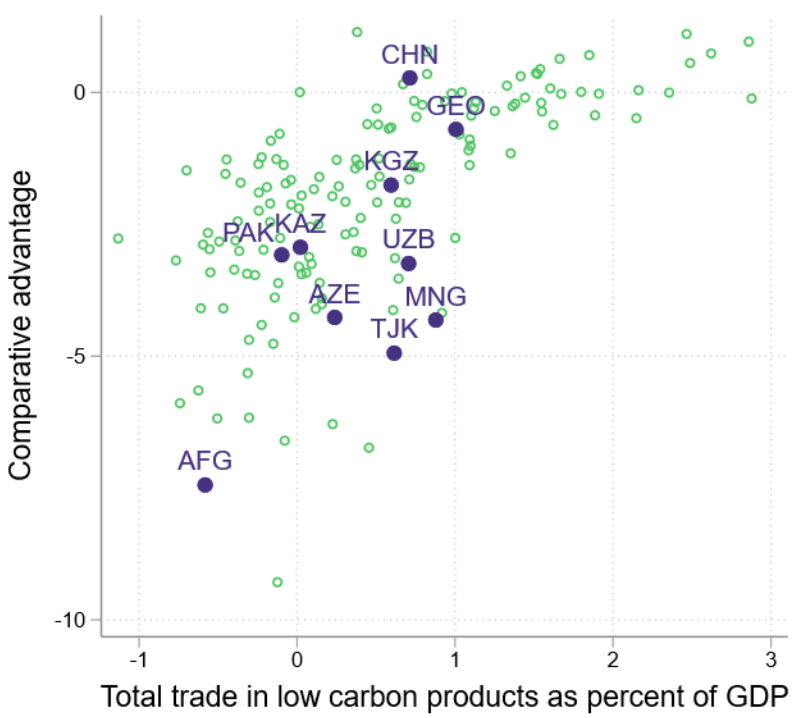


Figure 2: Trade in Low-Carbon Products, from 2000 to 2021



Note: Authors' graphics. For Low-Carbon Technology Harmonized System Codes, see https://climatedata.imf.org/documents/about

Figure 3: Comparative Advantages in the Export of Low-Carbon Products

Notes: The authors' graphic is based on data from the Department of Economic and Social Affairs, United Nations Comtrade Database https://comtrade.un.org. Comparative advantage is the ratio of a country's exports of low-carbon technology products to the world's exports of low-carbon technology products divided by the country's share of aggregate exports in aggregate world exports. The axis values are log-transformed.

However, significant heterogeneity exists among countries concerning their comparative advantages in exporting low-carbon technology products, as shown in Figure 3. Globally, nations such as Denmark, the Czech Republic, Romania, Germany, Hungary, Japan, and Slovakia have notable comparative advantages in the domain of low-carbon technology. Within the CAREC region, China stands out as the leader in this domain, with a comparative advantage of 1.318 for low-carbon technology products. Values were log transformed. After China, Georgia and Kyrgyzstan exhibit comparatively higher values than the other CAREC members. However, Afghanistan and Tajikistan are lagging in terms of comparative advantage.

The data presented in Table 1 provide insights into the trade dynamics of low-carbon goods for selected countries, showcasing their export and import figures alongside the share of low-carbon trade in their respective economies.

Table 1: Trade of Low-Carbon Technology Products

Country	Low-carbon exports (million US$)	Low-carbon exports share of total exports (%)	Low-carbon imports (million US$)	Low-carbon imports share of total imports (%)	Total low-carbon trade as percent of GDP (%)
Afghanistan	0.02	0.00	105.47	1.56	0.56
Azerbaijan	16.14	0.07	679.77	5.81	1.27
China	229879.03	6.82	132804.61	4.96	2.04
Georgia	109.02	2.57	400.32	3.96	2.73
Kazakhstan	164.33	0.27	1849.62	4.40	1.02
Kyrgyz	14.84	0.89	153.03	2.75	1.81
Mongolia	6.39	0.07	361.55	5.27	2.41
Pakistan	68.18	0.24	3093.91	4.27	0.91
Tajikistan	0.54	0.04	164.70	3.91	1.85
Uzbekistan	28.43	0.20	1382.24	5.82	2.03

Notes: Authors' elaboration is based on IMF data for 2021. The data on Afghanistan are available for the most recent year (2019). However, no data are available for Turkmenistan. Low-carbon products are defined based on the HS code, as presented in Appendix A4.

Notably, China has emerged as a significant player in the low-carbon trade domain with substantial exports and imports totaling 229,879.03 million US$ and 132,804.61 million US$, respectively. Despite these large volumes, its low-carbon exports represent only 6.82% of its total exports, which is considerably higher than that of Georgia (2.57 %). Although Georgia has a lower absolute value of low-carbon exports, its relatively higher share of total trade in both exports (2.57%) and imports (3.96%) indicates stronger engagement in low-carbon trade compared to other countries with smaller economies. Kyrgyzstan presents a different scenario. Although it has a modest share of low-carbon exports (0.89%) and imports (2.75%), its low-carbon trade as a percentage of GDP is 1.81%, which is lower than that of China (2.04%) and Georgia (2.73%). This suggests that, while Kyrgyzstan's absolute values are smaller, low-carbon trade plays a significant role in its economy relative to its overall size. Overall, the data underscore the varying degrees of involvement in low-carbon trade among these countries, highlighting both the opportunities and challenges in their transition towards low-carbon economies.

4. Climate–Trade Nexus: Brief Literature Review

The intricate relationships among government regulations, climate change, and international trade have garnered significant attention, highlighting their profound effects on economic growth and sustainability. Environmental policies, ranging from taxes and regulations to market-based solutions, are vital in combating climate change and fostering sustainable development. Environmental taxes, such as carbon taxes, are widely acknowledged for their effectiveness in reducing greenhouse gas emissions by internalizing the external costs of pollution (OECD, 2022). Climate provisions in NTMs, including environmental standards and technical regulations, also play a crucial role in shaping international trade patterns by ensuring that traded goods meet specific environmental criteria (IMF, 2021). The promotion of green patents and technological innovations is essential for advancing cleaner technologies and reducing the environmental footprint of economic activities (UNEP, 2020). Furthermore, digitization and the use of digital technologies are increasingly recognized for their potential to enhance environmental governance efficiency and transparency (World Bank, 2023).

Voluntary compliance mechanisms, such as adherence to standards from the Forest Stewardship Council (FSC) and Marine Stewardship Council (MSC), and compliance with Sustainable Corporate Responsibility (SCR) frameworks, complement mandatory regulations by encouraging businesses to adopt environmentally friendly practices beyond regulatory requirements (ISO, 2023). These standards provide a market-based approach to sustainability, promoting responsible resource management and corporate accountability (FSC, 2022; MSC, 2022).

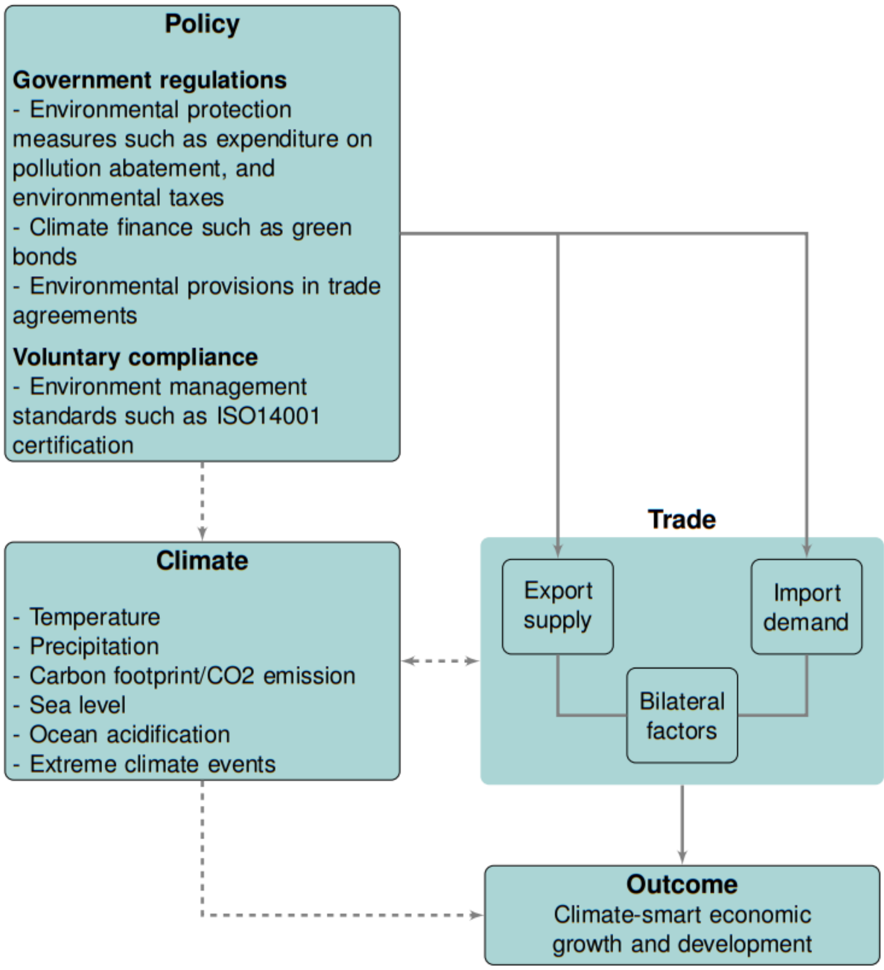


Figure 4: Climate–Trade Nexus

Notes: Bilateral factors such as climate-related non-tariff measures within regional trade agreements and the adoption of digital facilitation for cross-border trade, along with other policies such as environmental taxation and various standards governing production processes or product attributes, collectively influence export supply and import demand. Consequently, climate-related policies hold promise for promoting low-carbon trade, thereby facilitating sustainable economic development. The solid lines denote connections relevant to trade, whereas the dashed lines delineate the influence of policies on climate resulting from activities beyond trade. Source: Author's illustration.

Climate change has profound effects on various environmental and economic dimensions. Temperature fluctuations, precipitation patterns, and extreme climate events such as floods and droughts significantly affect agricultural productivity, water resources, and human health (IPCC, 2022). Carbon footprints and CO_2 emissions are critical indicators of a country's environmental performance, influencing global climate patterns and necessitating comprehensive mitigation strategies (UNFCCC, 2021). Ocean acidification and sea-level rise pose significant threats to marine ecosystems and coastal communities, highlighting the need for robust adaptation measures (NOAA, 2023).

The interplay between trade dynamics and environmental policies is crucial for understanding their broader impact on economic development. Bilateral trade factors, including export supply and import demand, are influenced by environmental regulations and climate conditions that affect economic competitiveness and sustainability (WTO, 2022). Regional trade agreements (RTAs) often incorporate environmental provisions to harmonize regulatory standards and promote sustainable trade practices (CEPII, 2023).

Research indicates that countries with stringent environmental regulations tend to be more innovative and develop cleaner technologies, leading to comparative advantages in green goods and services (Porter & van der Linde, 1995). However, some evidence indicates trade-offs, as stringent regulations can impose costs on businesses, potentially affecting their competitiveness in international markets (Jaffe et al., 1995).

However, ISO 14001 certification is a globally recognized EMS standard. It provides a framework for organizations to manage environmental responsibilities systematically and enhance their environmental performance. Studies have demonstrated that ISO 14001 certification can lead to significant improvements in environmental performance, including reductions in waste, energy consumption, and greenhouse gas emissions (Prajogo et al., 2012). Furthermore, it can enhance a company's reputation and competitiveness, as consumers and business partners increasingly prefer environmentally responsible companies (Melnyk et al., 2003). Certification also fosters compliance with legal and regulatory requirements, thus minimizing the risk of penalties for non-compliance (Zeng et al., 2005).

Environmental taxes are designed to internalize the external costs of environmental damage, provide economic incentives to reduce pollution, and promote sustainable practices. Studies indicate that environmental taxes can effectively reduce emissions and encourage the development of green technologies (Martin et al., 2014). However, their impact on international competitiveness must be carefully managed to avoid economic disadvantages for domestic industries (Barker et al., 2007).
In the context of environmental regulation, digitization involves the use of digital technologies to monitor and manage environmental effects more effectively. Digitization can enhance transparency, improve compliance tracking, and enable efficient data collection and analysis. Furthermore, it provides support for integrating environmental considerations into business processes and decision-making (Bonini & Görner, 2011).

Climate-related measures in trade agreements are becoming increasingly common, as countries recognize the need to address climate change through coordinated international efforts. These measures include provisions for reducing carbon emissions, promoting trade of climate-smart goods and technologies, and ensuring that trade policies do not undermine environmental objectives (Brandi, 2017). Such measures can help align trade and environmental policies, thereby promoting sustainable economic growth while addressing global climate challenges (Tamiotti et al., 2009).

According to the “Asia-Pacific Trade and Investment Report 2021” (United Nations, 2021), the link between trade facilitation and climate change remains underexplored in current agreements, with a lack

of recognition in multilateral and regional frameworks. However, potential exists for trade facilitation to mitigate climate effects by reducing the carbon intensity of transactions, especially in the context of increasing cross-border shipments due to e-commerce and the COVID-19 pandemic. Digital trade facilitation, exemplified by automated customs and paperless trade systems, shows promise for reducing carbon emissions. Additionally, trade facilitation not only lowers the costs of emission-intensive goods but also supports trade of environmental goods, which is crucial for addressing climate change.
In ‘‘Greening through Trade,’’ Jinnah and Morin (2020), analyzed how US preferential trade agreements (PTAs) impact trading partners’ environmental policies. The authors highlighted PTAs’ enforcement mechanisms for environmental protection, stressing their role in shaping global environmental dynamics.

FTA negotiations constitute a distinctive avenue for advancing global climate governance, given that bilateral and regional trade dialogues, characterized by a limited number of participants, frequently culminate in accords featuring heightened environmental commitments. Although the European Union (EU) has been at the vanguard of embedding climate considerations into trade negotiations, its influence in this domain has yet to permeate other stakeholders in the trade system (Morin et al., 2016).

Morin and Gauquelin (2016) explored trade agreements and provisions related to genetic resource access and benefit-sharing. Their work highlights clauses covering sovereignty, traditional knowledge protection, prior informed consent, the origin disclosure of patents, and bioprospecting conditions. Recent agreements encompass access and benefit sharing provisions mplementation measures, technical assistance, transparency, and dispute settlements. Latin America is ahead, whereas Canada and the United States lag. Their study emphasized the need for increased focus and broader integration of ABS commitments in international trade agreements, underscoring their significance in attaining environmental protection goals.

Trade agreements increasingly include provisions addressing specific environmental issues, such as biodiversity and hazardous waste management. Morin and Gauthier Nadeau (2017) argue that the rate of innovative environmental clauses per agreement has declined over the years. Their study highlights lesser-known measures to promote the diffusion of best practices, offering negotiators ideas to incorporate into future trade agreements.

A country’s comparative advantage influences the effects of an emissions tax on trade flows. Consider a country that is well-endowed with environmental resources, exporting environmentally intensive goods while importing capital- or labor-intensive goods. The implementation of an environmental tax reduces the relative production costs of capital- or labor-intensive goods, prompting the reallocation of production. However, this tax also creates a negative income effect because of the lower endowment, leading to a decrease in domestic demand for both types of goods if they are considered normal. Consequently, the country loses some of its comparative advantage and experiences a decline in real income, causing both imports and exports to decrease. If the environmental tax is increased to a point where the production of the "dirty" commodity falls below domestic demand, the country's comparative advantage and trade structure will shift, making the clean good an export and the "dirty" good an import (Klepper, 1994).

Environmental policies play a crucial role in stimulating the demand for sustainable products and technologies, complementing trade policies, and supporting global pollution reduction efforts (Sauvage, 2014). Despite the potential for positive global effects on environmental sustainability, challenges persist in achieving international cooperation, as observed in the limited participation of developing countries in Environmental Goods Agreement negotiations (De Melo & Solleder, 2020). Duarte et al. (2018) contributed valuable insights into the determinants of carbon emissions in world trade, emphasizing the need to understand the roles of producers and consumers in mitigating climate change. Yu et al. (2020) addressed the impact of climate change on cereal trade in Kazakhstan, highlighting the sensitivity of trade patterns to climatic variations and its potential implications for global food security. Cantore and Cheng (2018) explored the low diffusion of environmental goods in developing countries, emphasizing the influence of regulatory stringency on international trade. They identified a substitution effect between regulatory stringency and trade in environmental goods and various factors contributing to trade patterns. Zugravu-Soilita (2018) investigated the causal effects of trade intensity in environmental goods on air and water pollution. The findings highlighted the sensitivity of the results to the classification of environmental goods and identified a double benefit of ‘‘cleaner technologies and products’’ for addressing greenhouse gas emissions.

A recent study by Assogbavi and Dées (2023) examined the phenomenon of “carbon leakage,” revealing that stringent environmental policies generally reduce CO_2 emissions for traded goods but lead to leakage when analyzing imports from countries with the strictest policies. This underscores the challenges in achieving global climate policy cooperation. Osberghaus and Schenker (2022) contributed to the current understanding of the distribution of adverse weather shocks on exports, highlighting the significant short-term effects of high temperatures on exports, particularly for labor-intensive products.

Wang and Firestone (2010) addressed concerns regarding the fairness and effectiveness of the Clean Development Mechanism (CDM) in reducing greenhouse gas emissions. They emphasized the importance of total greenhouse gas emissions, project size, and host country infrastructure as primary determinants of CDM projects, while acknowledging the existing imbalances in its implementation.

Environmental policies are often developed in conjunction with other policy objectives. The potential loss of international competitiveness owing to environmental taxes or standards introduces additional industrial and trade policy considerations. Governments may therefore seek to integrate industrial targeting goals with environmental objectives by using a single policy instrument to address both aims. However, this approach typically results in suboptimal outcomes. Barrett (1992) examined the interaction between strategic trade policy and environmental policy goals and found that when governments consider the trade impact of environmental regulations, they may set environmental targets above or below the optimal level, resulting in marginal abatement costs that do not align with the marginal environmental damage. The outcomes vary based on the specific behaviors of governments and firms. Dinda (2011) explored the potential for expanding trade in climate-smart goods and technologies within Asia and with other regions, such as the EU and North America. That study used the gravity model to estimate the difference between actual and predicted export values and identify areas where trade can be increased. This analysis highlights the opportunities for enhancing trade in the CSGT sector, thereby fostering development and investment in these technologies across Asian countries and underscoring the continuing relevance of an export-led growth model centered on climate-smart goods for emerging Asian economies.

The CAREC 2030 strategy lacks explicit consideration of climate change as a crosscutting focal area, providing no guidance on CAREC's role in addressing this issue. This absence extends to the sector and thematic strategies, except for the Energy Sector Strategy, which notably includes climate change in its focal areas. In contrast, other regional platforms in Asia, such as ASEAN, GMS, and SAARC, have systematically addressed climate issues over an extended period. Although the ADB's country-level strategies prominently address climate concerns, they typically omit the regional dimension. This discrepancy highlights the need for a more comprehensive approach to climate change within CAREC's strategic framework (Asian Development Bank, 2023).

Integrating private and public regulations, climate factors, and trade dynamics creates a multifaceted approach to promoting climate-smart economic growth and development. For example, government regulations such as environmental taxes and digitization efforts can drive compliance with standards such as ISO 14001, whereas climate-related trade measures can facilitate the exchange of climate-smart goods and technologies. Export supply and import demand, influenced by bilateral trade factors and regulatory frameworks, are crucial for shaping trade flows. Ensuring that these flows align with environmental objectives can lead to a more sustainable and resilient economic system.

5. Methodology

5.1 Econometric Estimation Approach

The gravity trade model estimates bilateral trade flows by considering factors related to the exporting country, importing country, and trade costs between country pairs. Based on constant elasticity of substitution, the standard gravity trade model can be expressed as follows:

$$X_{ijt} = \frac{Y_{it}E_{jt}}{Y_t}\left(\frac{\tau_{ijt}}{\Pi_{it}P_{jt}}\right)^{-\theta} \quad (1)$$

where X_{ijt} is the bilateral exports between countries *i* and *j* in year *t*; *Y* is the global aggregate production; Y_i is domestic production of country i ; E_j is the expenditure of country j ; and the bilateral trade cost between the country pair is denoted by τ_{ij}. Intuitively, Equation (1) links bilateral exports to market size through the first term , and to the trade friction through the second term on the right-hand side. As originally coined by Anderson and Van Wincoop (2003), Π_i is the outward multilateral resistance of exporter i relative to other exporters, and P_j is the inward multilateral resistance of importer j relative to other importers. An empirical model, including the error term as specified in Equation (2) is obtained after log-transformation of Equation (1) as follows:

$$\ln X_{ijt} = \ln Y_{it} + \ln E_{jt} - \ln Y_t - (\theta)\ln\tau_{ijt} + (\theta)\ln\Pi_{it} + (\theta)\ln P_{jt} + \varepsilon_{ijt} \quad (2)$$

Traditionally, the gravity model specified in Equation (2) has been the most popular estimation approach. Despite its numerous applications, the model yields biased and inconsistent estimates (Yotov et al., 2016, p. 17). Thus, the empirical estimation of Equation (2) presents certain challenges.

The difficulty of estimating gravity Equation (2) lies the multilateral resistance terms $P_{j,t}$ and $\Pi_{i,t}$ being theoretical in nature and therefore unable to be observed directly. In their original study, Anderson and van Wincoop (2003) used iterative custom nonlinear least-squares programming to account for multilateral resistance in a static setting. An approach advocated by Hummels (2001) and Feenstra (2016) can overcome the computational difficulties of custom programming from Anderson and van Wincoop (2003) while simultaneously fully accounting for the multilateral resistance terms, consisting of using fixed effects. More recently, Olivero and Yotov (2012) extended the cross-section recommendations of Hummels (2001) and Feenstra (2016) and demonstrated that the multilateral resistance terms should be accounted for by exporter- and importer-time fixed effects in a dynamic gravity estimation framework with panel data.

The regression constant captures world aggregate trade. Country-specific factors are accounted for through fixed effects: exporter β_i and importer fixed effect γ_j.. These fixed effects absorb country-specific time-variant variables such as GDP, exchange rates, and other national policies, in addition to accounting for multilateral resistance. The remaining concern with the main variables is the bilateral trade cost τ_{ijt}, which can be specified as $(\theta)\ln\tau_{ijt} = \alpha_1\ln(\mathrm{DIST}_{ij}) + \alpha_2\mathrm{CNTG}_{ij} + \alpha_3\mathrm{LANG}_{ij} + \alpha_4\mathrm{CLNY}_{ij} + \alpha_5\mathrm{RTA}_{ijt} + \alpha_6\mathrm{POLICY}$. This bilateral cost is factored across several variables including distance (*DIST*), contiguity (*CNTG*), language commonality (*LANG*), colonial relationships (*CLNY*), RTA membership (*RTA*), and the policy (*POLICY*) variable of interest.

Zero trade flows and heteroscedasticity present further challenges in the gravity equation estimation. Traditional ordinary least squares estimation disregards zero trade flows, as they are omitted during the logarithmic transformation. To address this limitation, we employ the Poisson pseudo-maximum likelihood (PPML) estimation approach to compute Equation (3) as the PPML estimator, which effectively handles zero-trade cases and heteroscedasticity (Silva & Tenreyro, 2006, 2011) and demonstrates superiority over alternative estimators (Silva & Tenreyro, 2022).

We specify our empirical model in Equation (3), which includes the following common gravity trade model variables: bilateral distance (*DIST*), contiguity (*CNTG*), language commonality between country pairs (*LANG*), colonial ties (*CLNY*), and RTAs between trading country pairs (*RTA*). The climate-related variable, denoted by *POLICY,* is the main variable of interest. We include mandatory measures such as pollution abatement expenditure by governments (*POLABT*), environmental taxes (*ENVTAX*), climate finance through instruments such as green bonds (*GBOND*), and environmental provisions in RTAs (*ENVPRV*). Furthermore, we include voluntary compliance with international standards related to environmental management, such as ISO-14001 certification (*ISO14001*). The dependent variable (*EXPORTS*) is expressed in levels, whereas the continuous independent variables (e.g., distance) and policy variables (*POLABT*, *GBOND*, *ENVTAX*, *ENVPRV*, and *ISO14001*) are in logarithmic form.

$$\begin{aligned}\mathrm{EXPORTS_{ijt}} = \; & exp\left[\alpha_0 + \alpha_1 \ln(\mathrm{DIST_{ij}}) + \alpha_2 \mathrm{CNTG_{ij}} + \alpha_3 \mathrm{LANG_{ij}} + \alpha_4 \mathrm{CLNY_{ij}} + \alpha_5 \mathrm{RTA_{ijt}} \right. \\ & \left. + \alpha_6 \mathrm{POLICY} + \beta_i + \gamma_j + \delta_t\right] + \varepsilon_{ijt}\end{aligned} \tag{3}$$

$$\mathrm{EXPORTS_{ijt}} = exp\left[\sigma_0 + \sigma_1 \mathrm{RTA_{ijt}} + \sigma_2 \mathrm{POLICY} + \beta_i + \gamma_j + \delta_t + \varphi_{ij}\right] + \mu_{ijt} \tag{4}$$

Equation (3) includes fixed effects for exporters (β_i), importers (γ_j), and the year (δ_t). The coefficients α_1 through α_5 represent the control variables. The coefficient for the main variable of interest (i.e., climate regulations) is denoted by α_6 and σ_2 in Equation (3) and (4), respectively. We address endogeneity concerns by incorporating country-pair fixed effects (ϕ_{ij}) to capture unobservable cross-sectional trade costs. The country-pair fixed effects (φ_{ij}) absorb time-invariant variables such as bilateral distance, colonial relationships, and language commonality, along with any unobservable time-invariant trade cost components. This approach better accounts for the correlation between endogenous trade policy and the error term in gravity regressions, providing a more robust measure of bilateral trade costs than traditional gravity variables (Agnosteva et al., 2014; Egger & Nigai, 2015).

5.2 Data Description

Bilateral exports of low-carbon technology products (*EXP*) are measured in millions of US dollars and sourced from the International Monetary Fund (IMF). The bilateral geographical distance between trading pairs (*DIST*) is measured in kilometers. The variable indicating whether trading countries share a border (*CNTG*) is binary, with a value of one signifying a shared border. Similarly, the variable for common official language (*LANG*) is binary and set to one if the countries share a language. Historical colonial relationships (*CLNY*) are represented by a binary variable with a value of one indicating that such a relationship exists. RTA membership (*RTA*) is another binary variable that takes the value of one if the countries are members of an RTA. These variables (*DIST, CNTG, LANG, CLNY,* and *RTA*) have all been sourced from the Centre for Prospective Studies and International Information (CEPII).

For climate-related regulations, we include government expenditures on pollution abatement (*POLABT*) within the framework of the Classification of Functions of Government, sourced from the IMF. Green bonds (*GBOND*) represent self-labelled fixed-income instruments directed exclusively at financing or refinancing green projects and are sourced from the IMF. Environmental taxes (*ENVTAX*) levied on units that negatively impact the environment are sourced from the Organisation for Economic Co-operation and Development (OECD). Environmental provisions (*ENVPRV*) are environment-related measures included in trade agreements, sourced from the IMF. The number of ISO-14001 certificates (*ISO14001*), which are EMS standards, per country, was sourced from the International Organization for Standardization (ISO). The number of ISO-14001 certificates normalized by the GDP of the country

(*ISO14001gdp*) was also sourced from the ISO. The variables *POLABT*, *GBOND*, *ENVTAX*, and *ISO14001gdp* are percentages of GDP. See Appendix A1 for the tabulated details of these variables. Table 2 presents the descriptive statistics for the variables included in this study.

Table 2: Descriptive Statistics

	(1)	(2)	(3)	(4)	(5)
Variables	N	Mean	SD	Min	Max
EXP	81,599	38.01	365.6	0	30,041
DIST	81,599	7,160	4,413	18	19,706
CNTG	81,599	0.0179	0.133	0	1
LANG	81,599	0.109	0.312	0	1
CLNY	81,599	0.0140	0.117	0	1
RTA	81,599	0.326	0.469	0	1
POLABT	70,163	0.102	0.160	0	1.033
GBOND	24,811	0.00645	0.0190	2.15e-05	0.192
ENVTAX	73,442	2.285	0.946	0.0300	5.140
ENVPRV	81,599	10.79	38.51	0	383
ISO14001	81,599	3,371	5,659	1	34,852

This study encompasses annual data from 2010 to 2019. This period was chosen for two main reasons. First, although some variables have data updated to 2022, many do not. Second, trade values after 2019 are variably affected by COVID-19. Hence, data from 2010 to 2019 were used to ensure consistency across a large sample of countries. Appendix A2 lists the countries included in the regression analysis. Several variables had missing values, and we avoided filling these gaps to prevent data manipulation, which could affect the results. Therefore, the sample is based on all available original data for the included variables.

6. Results and Discussion

The regression estimations in Table 3 explore the effects of various factors on the bilateral exports of low-carbon technology products. The control variables are common to gravity trade models and include distance (*DIST*), shared border (*CNTG*), common official language (*LANG*), historical colonial relationship (*CLNY*), and RTA membership (*RTA*). These are included as controls for bilateral trade costs. In the odd-numbered columns (1, 3, 5, and 7), these variables are directly included, whereas in the even-numbered columns (2, 4, 6, and 8), pair-fixed effects absorb the impact of time-invariant variables (*DIST*, *LANG*, *CLNY*, and *CNTG*), leaving *RTA*, as it varies over time.

Table 3: Mandatory Regulations and Low-Carbon Exports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

Variables	Exports	Exports	Exports	Exports	Exports	Exports	Exports	Exports
DIST	-0.767***		-0.758***		-0.824***		-0.809***	
	(0.043)		(0.042)		(0.050)		(0.045)	
CNTG	0.197**		0.364***		0.135		0.239**	
	(0.099)		(0.091)		(0.102)		(0.099)	
LANG	0.390***		0.375***		0.436***		0.304***	
	(0.083)		(0.086)		(0.085)		(0.091)	
CLNY	0.399**		-0.016		-0.111		0.176	
	(0.167)		(0.198)		(0.239)		(0.209)	
RTA	0.403***	0.119*	0.178**	0.256***	0.171*	0.044	0.173*	0.143**
	(0.075)	(0.064)	(0.084)	(0.067)	(0.096)	(0.061)	(0.096)	(0.069)
POLABT	**0.020****	**0.020****						
	(0.009)	**(0.009)**						
GBOND			**0.015****	**0.014****				
			(0.006)	**(0.006)**				
ENVTAX					**0.065**	**0.068**		
					(0.124)	**(0.125)**		
ENVPRV							**-0.031**	**0.025****
							(0.021)	**(0.012)**
CONST	11.945***	6.365***	12.485***	6.613***	12.658***	6.531***	12.617***	6.439***
	(0.368)	(0.044)	(0.357)	(0.059)	(0.453)	(0.095)	(0.405)	(0.054)
FEEXP	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FEIMP	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FEYEAR	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FEPAIR	No	Yes	No	Yes	No	Yes	No	Yes
N	64,788	61,776	24,811	22,050	73,442	69,434	26,285	25,080

Notes: Bilateral trade as dependent variable is taken in levels. Robust standard errors in parentheses are clustered by country pairs. Fixed effects of exporter (*FEEXP*), importer (*FEIMP*), year (*FEYEAR*), and directional pair (*FEPAIR*) are included in the estimation but not reported for brevity. ***, **, and* denote significance levels of 0.01, 0.05, and 0.1, respectively.

The results show that greater geographical distance (*DIST*) consistently reduces low-carbon exports, as indicated by the negative and significant coefficients in columns 1, 3, 5, and 7. Sharing a border (*CNTG*) increases the exports of low-carbon technology products, with significant positive coefficients in columns 1 and 2. Sharing a common official language (*LANG*) also enhances exports, with significant positive coefficients in all relevant columns. Historical colonial relationships (*CLNY*) have a positive and significant impact only in column 1, becoming insignificant when paired fixed effects are included. RTA membership (*RTA*) consistently boosts exports, although its impact diminishes with the inclusion of paired fixed effects, as shown by the positive and significant coefficients across all columns.

The main variables of interest related to climate and environmental regulations include government expenditure on pollution abatement (*POLABT*), green bonds (*GBOND*), environmental taxes (*ENVTAX*), and environmental provisions in trade agreements (*ENVPRV*). The coefficients of *POLABT* are positive and significant in columns 1 and 2, indicating that higher government spending on pollution abatement is associated with increased exports of low-carbon technology products. The issuance of green bonds (*GBOND*) also positively affects exports, with significant coefficients in columns 3 and 4. Environmental taxes (*ENVTAX*) do not have a statistically significant impact, as indicated by the positive but insignificant coefficients in columns 5 and 6. This finding suggests that tax implementation is not sufficiently stringent to influence firms' production and trade decisions.

Several studies have suggested that various factors often render the relationship between environmental taxes and trade in CAREC countries insignificant. One major reason is the weak enforcement of environmental tax policies in these nations, as highlighted by Khan and Liu (2018), as limited institutional capacity reduces effectiveness. Additionally, the trade structure of CAREC countries, which focuses on low-value-added goods, makes trade less sensitive to such taxes (Chen & Zhang, 2020). Economic policies that support high-polluting industries further dilute the potential impact of environmental taxes on trade (Yadav & Sharma, 2019). Moreover, global trade dynamics and international competition may overshadow the influence of domestic environmental taxes, leading to insignificant results for the region (Liu & Hu, 2021). However, environmental provisions in trade agreements (*ENVPRV*) positively influence exports, with a significant coefficient in column 8. Collectively, these results highlight that the traditional gravity trade model variables significantly influence the bilateral exports of low-carbon technology products. Furthermore, specific climate-related regulations, particularly government expenditures on pollution abatement and green bonds, play a crucial role in promoting low-carbon exports.

The regression estimations in Table 4 assess the impact of voluntary regulations on bilateral exports of low-carbon technology products. The even-numbered columns (2 and 4) include paired fixed effects that absorb the impact of the time-invariant variables (*DIST*, *LANG*, *CLNY*, and *CNTG*). As in the analyses reported above, the coefficients of common gravity variables show the expected signs.

Table 4: Voluntary Regulations and Low-Carbon Exports

Variables	(1) Exports	(2) Exports	(3) Exports	(4) Exports
DIST	-0.829***		-0.829***	
	(0.050)		(0.050)	
CNTG	0.192*		0.192*	
	(0.101)		(0.101)	
LANG	0.391***		0.391***	
	(0.091)		(0.091)	
CLNY	-0.116		-0.117	
	(0.262)		(0.262)	

RTA	0.194*	0.065	0.191*	0.051
	(0.101)	(0.057)	(0.101)	(0.057)
ISO14001 (COUNT)	**0.155*** **	**0.147*** **		
	(0.036)	**(0.036)**		
ISO14001 (GDP NORM)			**0.064** **	**0.055* **
			(0.032)	**(0.033)**
CONST	11.353***	5.253***	12.585***	6.433***
	(0.576)	(0.317)	(0.436)	(0.065)
FEEXP	Yes	Yes	Yes	Yes
FEIMP	Yes	Yes	Yes	Yes
FEYEAR	Yes	Yes	Yes	Yes
FEPAIR	No	Yes	No	Yes
N	81,599	77,655	81,599	77,655

Notes: Bilateral trade as dependent variable is taken in levels. . Robust standard errors in parentheses are clustered by country pairs. Fixed effects of exporter (*FEEXP*), importer (*FEIMP*), year (*FEYEAR*), and directional pair (*FEPAIR*) are included in the estimation but not reported for brevity. ***, **, and * denote significance levels of 0.01, 0.05, and 0.1, respectively.

The main variables of interest related to voluntary environmental regulations include the number of ISO-14001 certificates (ISO14001) and number of ISO-14001 certificates normalized by GDP (ISO14001 GDP NORM). The coefficients of ISO14001 (*COUNT*) are positive and significant in columns 1 and 2, indicating that a higher number of ISO-14001 certificates is associated with increased low-carbon technology product exports. Similarly, the coefficients of ISO14001 (*GDP NORM*) are positive and significant in columns 3 and 4, suggesting that a higher number of ISO-14001 certificates relative to GDP also increases exports. These results indicate that voluntary environmental regulations, such as the adoption of ISO-14001 standards, play a crucial role in promoting the trade of low-carbon exports.

As a firm's export ability may vary by income level and region, the impact of climate policies on low-carbon exports should be evaluated across these dimensions. Differences in financial and regulatory capacities may influence policy effectiveness, making such an examination valuable for understanding sustainable trade potential at the global level.

Table 5: Heterogeneous Effects of Regulations Across Economic Development Levels and Geographic Regions

	Economic Development Levels		Geographic Regions	
Variables	Developed	Developing	Asia	ROW
	(1)	(2)	(3)	(4)
POLABT	0.020**	0.029*	0.062	0.016*
	(0.009)	(0.017)	(0.074)	(0.009)
GBOND	0.017**	-0.035**	0.032**	0.000
	(0.007)	(0.017)	(0.012)	(0.011)
ENVTAX	0.208	-0.064	0.011	0.150

	(0.135)	(0.128)	(0.204)	(0.104)
ENVPRV	0.026**	-0.027*	0.026	0.024*
	(0.012)	(0.014)	(0.020)	(0.013)
ISO-140001	0.148***	0.125***	0.224***	0.039
	(0.036)	(0.038)	(0.054)	(0.047)

Notes: Bilateral trade as dependent variable is taken in levels. Robust standard errors in parentheses are clustered by country pair. Fixed effects of exporter (*FEEXP*), importer (*FEIMP*), year (*FEYEAR*), and directional pair (*FEPAIR*) are included in the estimation but not reported for brevity. ***, **, and * indicate a significance level of 0.01. 0.05, and 0.1, respectively. The estimated coefficients for each variable are the results of regressions across income levels of exporting countries and their geographic regions. According to the World Bank's income classification, high-income countries are categorized as "Developed," while others are classified as "Developing." ROW stands for "rest of the world."

The results in Table 5 reveal that climate-friendly policies have differential effects on low-carbon exports based on economic development and region, indicating the importance of context-specific policy frameworks. Government expenditure on pollution abatement (*POLABT*) shows a positive effect on low-carbon exports, especially in the rest of the world (*ROW*), where even moderate investments foster export growth. However, green bonds () positively affect developed countries and Asia but are negatively associated with developing economies. Environmental taxes (*ENVTAX*) show minimal influence across all groups, suggesting that they alone are insufficient to boost low-carbon exports. Environment-related provisions in trade agreements (*ENVPRV*) benefit developed countries but negatively affect developing ones, where compliance costs can undermine competitiveness for low-income exporters. ISO 14001 certifications consistently support low-carbon exports, particularly in Asia, as they signal quality standards that enhance market access.

Government spending on pollution abatement boosts exports, especially in supportive investment environments (Hossain, 2024). As the global demand for sustainable products rises, countries investing in pollution reduction gain a competitive edge. For example, China's Low-carbon Pilot Policy has increased domestic value-added in exports, although its effects vary across sectors (Zhu & Sun, 2022). Green bonds drive sustainable finance in developed countries and Asia, where regulatory maturity supports positive economic outcomes. However, in developing economies, green bonds face barriers such as limited capital access and investor confidence, leading to a weaker economic impact (Banga, 2019; Hossain, 2024). Environmental taxes have a minimal influence on low-carbon exports, indicating the need for broader strategies beyond taxation. ISO 14001 certifications support low-carbon exports in Asia by enhancing market access and aligning with global standards (Margaret et al., 2023). In contrast, environmental trade provisions may create a disadvantage for developing countries, where compliance costs undermine competitiveness (World Bank, 2020).

Developing economies face unique challenges with green bonds and environmental requirements owing to their limited financial and technological capacities, making it difficult for these countries to adopt green production techniques or comply with stringent regulations (Yamahaki et al., 2020). This can restrict rather than boost low-carbon exports. In high-income countries, mature industries and policy frameworks enable the effective use of green finance. However, in developing regions, complementary support, such as financial incentives and capacity-building, is essential for fostering competitiveness in low-carbon exports. To achieve sustainable progress, governments in the CAREC region need to develop adaptable strategies that consider each the specific needs of each economy and balance sustainability goals with economic competitiveness.

The analysis of environmental provisions[6] within trade agreements among CAREC countries reveals a spectrum of commitments and priorities for integrating environmental considerations into international trade frameworks (Table 6). Leading the pack is the EU–Georgia agreement (2014), boasting 40 environmental provisions, underscoring the stringent environmental standards set by the EU. The EC–Kazakhstan (2015) and China–Korea (2015) agreements feature 28 and 26 provisions, respectively, indicating robust environmental governance frameworks within these partnerships. Conversely, the Ukraine–Uzbekistan (1994), Tajikistan–Ukraine (2001), and Kyrgyzstan–Uzbekistan (1996) agreements feature only one environmental provision each, suggesting minimal explicit environmental commitments in older or less comprehensive agreements. Notably, agreements involving China frequently include environmental provisions, such as the China–New Zealand (2008) and China–Peru (2009) agreements, each with 12 provisions, reflecting China's evolving approach towards embedding environmental concerns in its trade relationships. Overall, the diversity in the number of environmental provisions underscores varying levels of environmental integration across CAREC trade agreements, highlighting opportunities for harmonization and challenges in ensuring consistent environmental standards amid regional trade dynamics.

Table 6: Environmental Provisions in Trade Agreements of CAREC Countries

Trade Agreements	Member Countries	Number of Environmental Provisions
EU–Georgia (2014)	European Union, Georgia	40
EU–Kazakhstan (2015)	European Union, Kazakhstan	28
China–Korea (2015)	China, South Korea	26
EFTA–Georgia (2016)	Switzerland, Georgia, Iceland, Liechtenstein, Norway	17
China–New Zealand (2008)	China, New Zealand	12
Japan–Mongolia (2015)	Japan, Mongolia	12
China–Georgia (2017)	China, Georgia	11

[6] The environmental provisions can be categorized into trade restrictive and trade liberalizing provisions. For details, see Brandi et al. (2020).

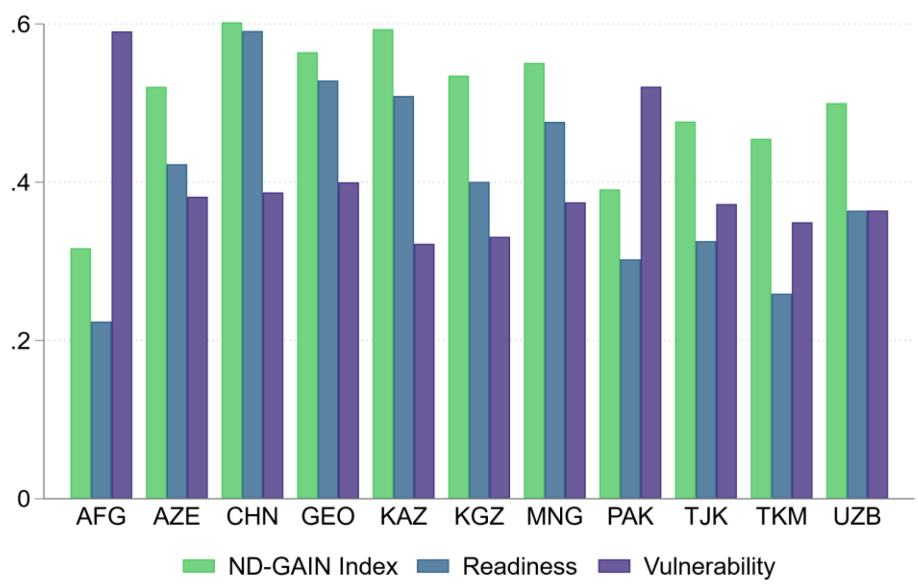
China–Peru (2009)	China, Peru	11
China–Costa Rica (2010)	China, Costa Rica	11
China–Iceland (2013)	China, Iceland	10
China–Switzerland (2013)	Switzerland, China	7
Chile–China (2005)	Chile, China	7
Honduras–Peru (2015)	Honduras, Kazakhstan, Peru, Russia	6
Malaysia–Pakistan (2007)	Malaysia, Pakistan	5
Australia–China (2015)	Australia, China	3
China–Singapore (2008)	China, Singapore	2
China–Pakistan (2006)	China, Pakistan	2
Economic Cooperation Organization Trade Agreement (ECOTA) (2003)	Afghanistan, Azerbaijan, Iran, Kyrgyzstan, Kazakhstan, Pakistan, Tajikistan, Turkmenistan, Turkey, Uzbekistan	1
Commonwealth of Independent States (CIS) (1994)	Armenia, Azerbaijan, Belarus, Georgia, Kyrgyzstan, Kazakhstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan	1
GUAM/GUUAM Organization for Democracy and Economic Development (2002)	Azerbaijan, Georgia, Moldova, Ukraine	1
Georgia–Turkey (2007)	Georgia, Turkey	1
Georgia–Ukraine (1995)	Georgia, Ukraine	1
Kazakhstan–Ukraine (1994)	Kazakhstan, Ukraine	1
Eurasian Economic Community (EAEC) (1999)	Belarus, Kyrgyzstan, Kazakhstan, Russia, Tajikistan	1
Armenia–Kazakhstan (1999)	Armenia, Kazakhstan	1
Kyrgyzstan–Uzbekistan (1996)	Kyrgyzstan, Uzbekistan	1
Tajikistan–Ukraine (2001)	Tajikistan, Ukraine	1
Ukraine–Uzbekistan (1994)	Ukraine, Uzbekistan	1

Notes: The agreements were sorted in descending order according to the number of environmental provisions included. Source: TREND database.

Consistent with the gravity model literature, we find that greater distance reduces low-carbon exports, as supported by Baier and Bergstrand (2007), Egger and Pfaffermayr (2003), and Anderson and van Wincoop (2003). Shared borders and common languages boost trade, thus highlighting the importance of geographical and cultural proximity. The positive impact of RTAs on low-carbon exports aligns with Frankel (1997) and Chen and Mattoo (2008), who emphasized reduced trade barriers and enhanced exchange of environmental goods. Our results for government expenditure on pollution abatement (*POLABT*) are aligned with those of Johnstone et al. (2010), indicating that such spending fosters environmental innovation. Flammer (2020) supported the positive effect of green bonds on exports, demonstrating their role in promoting green technologies. Zhou (2020) corroborates our findings on environmental provisions in trade agreements, which enhance environmentally friendly trade by setting standards and reducing barriers. The finding of Prakash and Potoski (2006) support our conclusion that ISO-14001 adoption improves environmental performance and competitiveness.

Figure 5 presents climate-related indicators for CAREC member countries delineated by the ND-GAIN Index[7], Readiness, and Vulnerability scores. Among the regional countries, China has the highest ND-GAIN Index of 0.602, indicating high readiness but moderate vulnerability. Other notable performers include Kazakhstan and Georgia with ND-GAIN Index values of 0.593 and 0.564, respectively, indicating relatively good readiness and lower vulnerability.

In contrast, Pakistan and Uzbekistan have lower ND-GAIN Index values of 0.391 and 0.499, respectively, indicating lower readiness and relatively higher vulnerability. Afghanistan has the lowest ND-GAIN Index at 0.317, coupled with moderate readiness and high vulnerability. Overall, these indicators provide insights into the varying levels of preparedness and vulnerability to climate-related challenges among CAREC member countries.



[7] The ND-GAIN Index, developed by the University of Notre Dame, measures a country's vulnerability to climate change and its readiness to enhance resilience, combining factors of exposure, sensitivity, adaptation capacity, and readiness across sectors such as food, water, and infrastructure.

Figure 5: Climate Adoption, Vulnerability, and Readiness of CAREC Countries

Notes: The Notre Dame Global Adaptation Initiative (ND-GAIN) index measures a country's current vulnerability to climate disruptions and assesses its readiness to leverage private and public sector investment for adaptive actions. Authors' graphic based on https://https://climatedata.imf.org/pages/access-data

Figure 6 illustrates the impact of green policies on the promotion of environmentally sustainable trade. The figure is divided into three stages, with each explaining a step in the process. In the first stage, public regulations, such as pollution abatement expenditures, environmental taxes, and green financing, play significant roles. These are complemented by private sector initiatives, such as voluntary compliance with eco-friendly certifications such as ISO 14000. Together, these efforts create a foundation for environmentally responsible practices in businesses and industries. In the second stage, these regulations and initiatives incentivize low-carbon exports by discouraging environmentally harmful products. Policies actively promote adherence to international environmental standards such as ISO 14001. By making the production and trade of low-carbon goods more attractive, these measures align business incentives with environmental sustainability goals. The final stage shows the outcome of these policies: an increase in green trade. This focus on low-carbon products fosters sustainable economic growth and development as businesses and economies shift towards more environmentally friendly trade practices. This continuous cycle of improvement contributes to long-term environmental sustainability and economic stability.

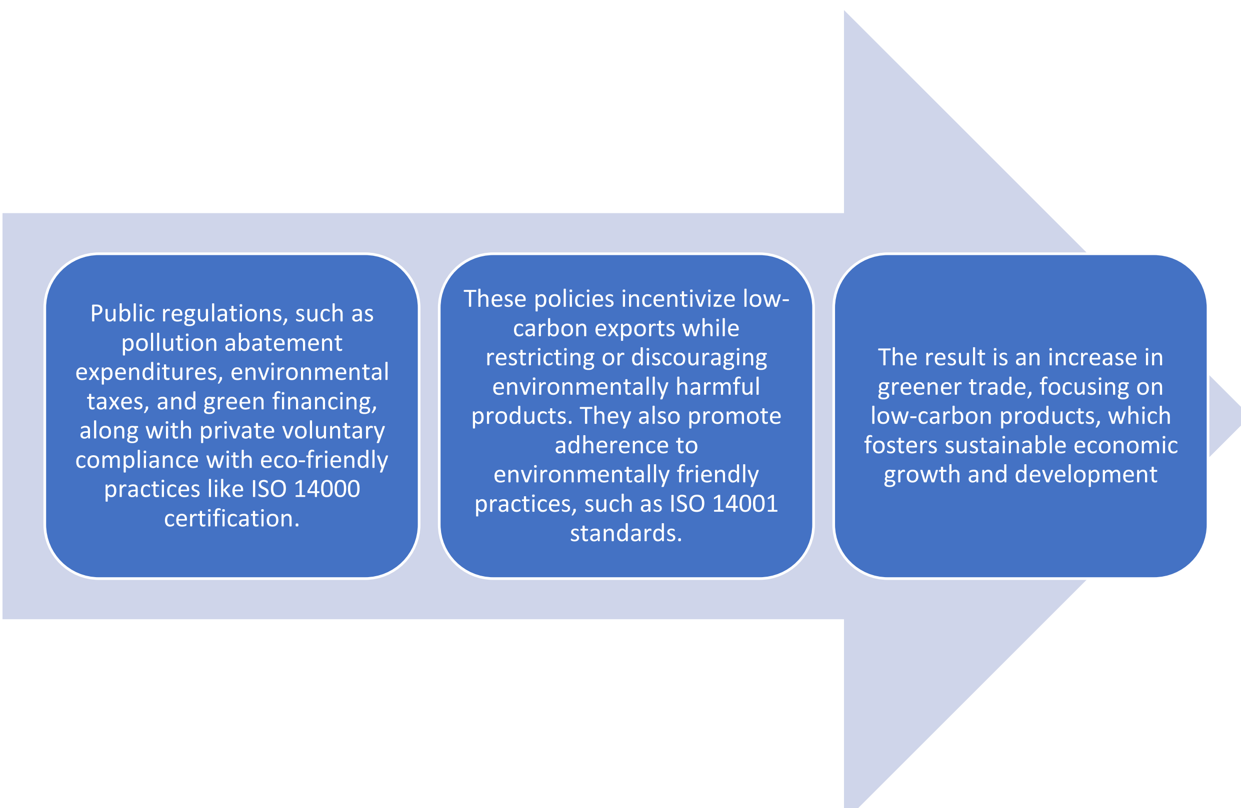


Figure 6: Pathway to Sustainable Trade through Green Practices

Source: Authors' graphic based on the study findings

Estimates suggest that climate regulations such as pollution abatement expenditures and ISO 14001 certification can boost low-carbon product exports. However, implementing these policies is challenging, particularly in developing countries. Limited budgets restrict the ability of governments to fund pollution control, and gaps in tax revenue caused by evasion, exemptions, and rent-sharing issues in the extractive sector worsen financial constraints (Mascagni et al., 2014). Furthermore, poor institutional quality and corruption undermine the effectiveness of environmental taxes in some regions. Countries with underdeveloped financial systems face difficulties financing and implementing green initiatives. China's green finance policies have successfully reduced industrial emissions, providing a model for other nations (Muganyi et al., 2021). Although green bonds hold promise, their high transaction costs and weak institutional frameworks limit their uptake by developing economies. This suggests a role for multilateral and national banks in managing green bonds and reducing costs (Banga, 2019). A broader evaluation of climate finance policies reveals mixed effectiveness based on policy type, with both successes and areas in need of improvement to increase the impact (Bhandary et al., 2021). In general, command-and-control and market-based regulations are common; however, limited regulatory capacity reduces their effectiveness in developing countries (Blackman et al., 2018). Appendix 5 presents some additional estimations.

7. Conclusions and Policy Recommendations

This study investigated the relationship between climate and trade dynamics within the CAREC region, and the findings highlight the importance of integrating climate policies with economic development. In 2022, the ratio of the region's aggregate trade to its combined GDP was 35%, underscoring the critical role of trade in driving growth and regional integration. However, a scoping review by the ADB (2023) revealed a predominant focus on energy-related projects, highlighting a significant gap in the intersection of climate policies and trade dynamics. This study helps fill this gap by empirically assessing the impact of climate-related regulations on the promotion of low-carbon trade. By analyzing the annual bilateral exports of low-carbon products from 2010 to 2019 using a gravity trade model with a PPML estimator, the study found that government expenditure on pollution abatement, climate finance mechanisms such as green bonds, and comprehensive environmental provisions in trade agreements positively influence low-carbon exports. However, environmental taxes were not found to have a significant impact. Additionally, ISO14001 certification in exporting countries supports the export of low-carbon products. These findings provide actionable insights for fostering sustainable economic growth through climate-smart trade practices, benefiting both governments and businesses. Based on the findings, the following policy recommendations are presented to encourage the decarbonization of trade in the CAREC region.

a) Although climate-related policies and voluntary compliance with environmental standards contribute to decarbonizing trade, regional organizations such as the ADB, CAREC Institute, climate think tanks, and other forums play critical roles in advancing these aspects in the policy arena. These organizations can help build a consensus among participating governments to increase the stringency of climate regulations across the region. Accordingly, these steps can promote cleaner trade practices and support sustainable economic growth. Furthermore, a comprehensive database of climate-related indicators needs to be established to regularly evaluate and monitor climate performance at both the national and regional levels.

b) Governments in the CAREC region should enhance pollution abatement spending under the Classification of Functions of Government framework to systematically reduce CO_2 emissions in the economy and trade with regional support from organizations such as the ADB and CAREC Institute for effective policy guidance. Furthermore, promoting climate finance mechanisms such as green bonds will attract investment in environmentally beneficial projects, accelerating the region's shift towards a sustainable economy. Existing and new trade agreements should incorporate strong environmental provisions to encourage sustainable practices and low-carbon trade, thus fostering an integrated approach to climate and economic policies across the CAREC region.

c) Targeted policy interventions are essential for CAREC countries to mitigate pollution from high-energy sectors, such as coal, oil, and gas extraction, as well as heavy industries, such as construction, cement, and steel, which produce significant hazardous pollutants. For key oil and mining economies, such as Azerbaijan, Kazakhstan, and Turkmenistan, strict environmental compliance is critical. Transitioning to renewable energy, adopting sustainable agriculture, and implementing cleaner technologies in industry will further reduce emissions. Expanding green finance such as green bonds and updating trade agreements to add environmental clauses can fund and incentivize low-carbon projects, thereby supporting sustainable growth and environmental responsibility across the CAREC region.

d) Countries in the CAREC region should promote compliance with international standards such as ISO 14001 certification. This certification helps organizations manage their environmental responsibilities effectively through a structured approach to identifying, monitoring, and improving their environmental impact. It ensures compliance with regulations, enhances resource efficiency, and boosts the international reputation for environmental stewardship. By adopting ISO 14001, countries can indirectly contribute to climate mitigation and adaptation efforts and support the SDGs through improved environmental management practices. Regional initiatives to increase awareness and facilitate certification processes could enhance these efforts further.

e) To enhance climate resilience and decarbonization across the CAREC region, countries with low green bond activity, such as Azerbaijan and Afghanistan, urgently need to develop frameworks for green bond issuance to enhance climate resilience and decarbonization across the CAREC region. These countries can take inspiration from China, which increased its green bond issuance from $0.145 billion in 2014 to $99.4 billion in 2022. Georgia doubled its green bond issuance from $0.5 billion in 2020 to $1 billion in 2021, demonstrating the potential for other countries to scale up their climate financing. Green bonds should target renewable energy, energy efficiency, and pollution abatement projects to help countries transition to low-carbon economies. Moreover, countries such as Azerbaijan and Kyrgyzstan, with minimal pollution abatement investments (0 USD until 2022 for Azerbaijan and 94 million USD for Kyrgyzstan), must substantially boost their expenditures to align with Kazakhstan, which allocated 195 billion domestic currency units for pollution control in 2019. Higher spending on pollution abatement will help mitigate environmental damage, especially in high-emission sectors such as energy and manufacturing.

f) China, with the highest ND-GAIN Index of 0.602, demonstrates high readiness but faces moderate vulnerability. To strengthen its climate resilience, China should focus on targeted investments in regions with higher vulnerability. Enhancing disaster preparedness, improving water management, and expanding renewable energy initiatives would reduce vulnerability while leveraging the country's strong readiness. Kazakhstan and Georgia, with ND-GAIN Index values of 0.593 and 0.564, respectively, should prioritize maintaining their readiness by investing in resilient infrastructure and scaling up climate finance mechanisms such as green bonds. Pakistan and Uzbekistan, with lower ND-GAIN Index values of 0.391 and 0.499, respectively, should focus on improving climate readiness by strengthening institutional frameworks and promoting climate-resilient infrastructure. Afghanistan, with the lowest ND-GAIN Index of 0.317, should prioritize basic adaptation strategies and seek international support to improve both readiness and vulnerability.

This study used a global sample to examine the impact of low-carbon exports under climate regulations. However, data on climate-related measures are limited for several countries, including those in the CAREC region. Developing a comprehensive database of climate measures would be invaluable, as it would allow for more targeted studies of the CAREC region and individual countries. Such efforts would enhance our understanding of the relationship between climate regulation and trade.

8. Appendices

A1: Explanation of Variables

Variables	Description	Units	Source
EXP	Bilateral exports of low-carbon technology products are essential. These products generate less pollution compared to traditional energy sources and are crucial for the shift towards a low-carbon economy. Low-carbon technologies encompass systems such as wind turbines, solar panels, biomass systems, and carbon capture equipment.	Million US$	IMF
DIST	Bilateral geographical distance between trading pairs.	Kilometers	CEPII
CNTG	The variable takes a value 1 if trading countries	Binary	CEPII

	share a border.		
LANG	The variable takes a value 1 if trading countries share a common official language.	Binary	CEPII
CLNY	The variable takes a value 1 if trading countries share a colonial relationship.	Binary	CEPII
RTA	The variable takes a value 1 if trading countries are members of a regional trade agreement.	Binary	CEPII
POLABT	Government expenditures on pollution abatement within the framework of the Classification of Functions of Government (COFOG).	Percentage of GDP	IMF
GBOND	Green bonds are self-labeled fixed-income instruments specifically designed to allocate funds, either partially or fully, towards financing or refinancing new and/or existing environmentally friendly projects. They are widely recognized as tools for supporting climate mitigation and adaptation efforts	Percentage of GDP	IMF
ENVTAX	A tax based on a physical unit (or its proxy) of an item known to have a specific, proven negative effect on the environment.	Percentage of GDP	OECD
ENVPRV	Environmental provisions in trade agreements between trading partners.	Count	IMF
ISO14001	Number of ISO-14001 certificates per country.	Count	ISO
ISO14001gdp	Number of ISO-14001 certificates per country normalized by the country's GDP.	Percentage of GDP	ISO

A2: List of Countries involved in Regression Analysis

Asian countries: Afghanistan, Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei, Cambodia, China, Cyprus, Georgia, Hong Kong, India, Indonesia, Iran, Iraq, Israel, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Laos, Lebanon, Macau, Malaysia, Maldives, Mongolia, Myanmar, Nepal, North Korea, Oman, Pakistan, Palestine, Philippines, Qatar, Russia, Saudi Arabia, Singapore, South Korea, Sri Lanka, Syria, Tajikistan, Thailand, Timor-Leste, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, Vietnam, and Yemen.

Others: Aruba, Angola, Albania, Andorra, Argentina, Australia, Austria, Bahamas, Barbados, Belarus, Belgium, Belize, Bermuda, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Canada, Cape Verde, Cameroon, Cayman Islands, Central African Republic, Chad, Chile, Colombia, Comoros, Republic of the

Congo, Democratic Republic of the Congo, Costa Rica, Ivory Coast, Croatia, Cuba, Czech Republic, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Eswatini, Estonia, Ethiopia, Fiji, Finland, France, French Polynesia, Gabon, Gambia, Germany, Ghana, Gibraltar, Greece, Greenland, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Hungary, Iceland, Ireland, Italy, Jamaica, Kenya, Kiribati, Lesotho, Liberia, Libya, Lithuania, Luxembourg, Madagascar, Malawi, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia, Moldova, Montenegro, Morocco, Mozambique, Namibia, Nauru, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, North Macedonia, Norway, Panama, Palau, Papua New Guinea, Paraguay, Peru, Poland, Portugal, Romania, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, San Marino, Senegal, Serbia, Seychelles, Sierra Leone, Slovakia, Slovenia, Solomon Islands, Somalia, South Africa, South Sudan, Spain, Sudan, Suriname, Sweden, Switzerland, Tanzania, Togo, Tonga, Trinidad and Tobago, Tunisia, Turks and Caicos Islands, Tuvalu, Uganda, Ukraine, United Kingdom, United States of America, Uruguay, Vanuatu, Venezuela, Zambia, and Zimbabwe.

A3: List of Harmonized System (HS 2017) Codes Included in the Definition of Low Carbon Products

Low-carbon technology products produce less pollution than their traditional energy counterparts and play a vital role in the transition to a low-carbon economy (Source: IMF Climate Change Indicators). The following is a list of product codes based on the Harmonized System (HS 2017) for low-carbon products: 252390, 280519, 282520, 282690, 282739, 283691, 392010, 441873, 560314, 680610, 680690, 700800, 701931, 701939, 730820, 730900, 732111, 732190, 732490, 761100, 761290, 840110, 840120, 840140, 840219, 840290, 840410, 840420, 840490, 840510, 840681, 840690, 841011, 841012, 841013, 841090, 841181, 841182, 841199, 841290, 841581, 841780, 841790, 841861, 841869, 841919, 841939, 841940, 841950, 841960, 841989, 841990, 842121, 842129, 842139, 842199, 847420, 847982, 847989, 847990, 848340, 848360, 850161, 850162, 850163, 850164, 850231, 850239, 850300, 850490, 850650, 850680, 850710, 850720, 850730, 850740, 850750, 850760, 850780, 850790, 851410, 851420, 851430, 851490, 853120, 853224, 853710, 853931, 853950, 854140, 854390, 860120, 870220, 870230, 870240, 870340, 870350, 870360, 870370, 870380, 871160, 900190, 900290, 901380, 901390, 901580, 902610, 902620, 902680, 902690, 902710, 902720, 902730, 902750, 902780, 902790, 903149, 903180, 903190, 903210, 903220, 903289, 903290, and 903300

A4: Summary of the Literature

Study	**Key Focus**
ADB (2023)	Overview of climate finance flows, investment gaps, and the landscape of climate finance in Asia and the Pacific Region and needs for climate adaptation and mitigation in the region.
NOAA (2023)	Threats to marine ecosystems and coastal communities due to ocean acidification and sea-level rise.
Assogbavi & Dées (2023)	Carbon leakage associated with stringent environmental policies and its global impact.
CEPII (2023)	Environmental provisions in RTAs and their impact on sustainable trade practices.

ADB (2022)	Explores the challenges faced by countries in building resilience against various stressors, including economic shocks, climate change, and pandemics.
WTO (2022)	Interaction between trade dynamics and environmental policies.
IPCC (2022)	Impact of climate change on the environment and economy, including agricultural productivity and health.
UNFCCC (2021)	Carbon footprints and CO_2 emissions as environmental performance indicators.
De Melo & Solleder (2020)	Participation challenges in the Environmental Goods Agreement and implications for developing countries.
Jinnah & Morin (2020)	Impact of US PTAs on trading partners' environmental policies.
Yu, Luo, Wang, & Feil (2020)	Impact of climate change on cereal trade patterns and food security in Kazakhstan.
Zugravu-Soilita (2018)	Effects of trade intensity in environmental goods on pollution levels.
Cantore & Cheng (2018)	Impact of regulatory stringency on the diffusion of environmental goods in developing countries.
Duarte, Pinilla, & Serrano (2018)	Determinants of carbon emissions in global trade and the roles of producers and consumers.
Morin & Gauthier Nadeau (2017)	Unique environmental provisions in trade agreements and their implications for policy.
Brandi (2017)	Climate-related measures in trade agreements and their impact on environmental policies.
Morin & Gauquelin (2016)	Analysis of genetic resource access and benefit-sharing in trade agreements.
Morin, Michaud, & Bialais (2016)	Examination of the EU's influence on global climate governance through trade agreements.
Sauvage (2014)	The role of environmental policies in stimulating demand for sustainable products.
Martin et al. (2014)	Effectiveness of environmental taxes in reducing emissions and promoting green technology.
Prajogo et al. (2012)	Improvements in environmental performance owing to ISO 14001 certification.
Bonini & Görner (2011)	Enhancements in environmental management through digital technologies.
Tamiotti et al. (2009)	Integration of trade and environmental policies to address climate challenges.
Barker et al. (2007)	Impact of environmental taxes on the international competitiveness of domestic industries.
Zeng et al. (2005)	Relationship between ISO 14001 certification and legal compliance.
Melnyk et al. (2003)	Enhancements in reputation and competitiveness through ISO 14001 certification.

Jaffe et al. (1995)	Trade-offs between stringent regulations and international competitiveness.
Porter & van der Linde (1995)	Innovation and comparative advantage in green goods owing to stringent environmental regulations.
Klepper (1994)	Effects of environmental taxes on comparative advantage and trade flows.

A5: Additional estimations

We analyzed various climate-related regulatory variables, including pollution abatement, environmental taxation, environmental provisions in trade agreements, green finance, and the certification of environmental standards. Using these variables, we developed a composite index, CLMREG (Climate Regulations). We employed two methodologies to construct this index. First, we applied principal component analysis (PCA) to derive CLMREG_PCA, with the corresponding estimates reported in columns (1) and (2). Second, we utilized a normalization approach, in which each variable was normalized to a 0–1 scale, and their mean was calculated to create CLMREG_NORM. The corresponding results are presented in columns (3) and (4). Our findings indicate that the cumulative impact of these climate-related regulations facilitate the export of low-carbon products. These estimates further suggest that these measures collectively enhance the international competitiveness of environmentally sustainable goods.

Table A1: Climate regulations and low-carbon exports: Additional estimations

	(1)	(2)	(3)	(4)
DIST	-0.683***		-0.684***	
	(0.047)		(0.047)	
CNTG	0.245***		0.245***	
	(0.064)		(0.064)	
LANG	0.460***		0.460***	
	(0.075)		(0.075)	
CLNY	0.235		0.233	
	(0.162)		(0.162)	
RTA	0.327***	0.175***	0.325***	0.155***
	(0.069)	(0.052)	(0.070)	(0.049)
CLMREG_PCA	**0.021****	**0.020****		
	(0.009)	**(0.009)**		
CLMREG_NORM			**0.224*****	**0.231*****
			(0.059)	**(0.061)**
Constant	11.995***	6.992***	12.376***	7.389***

	(0.381)	(0.031)	(0.382)	(0.103)
FEEXP	Yes	Yes	Yes	Yes
FEIMP	Yes	Yes	Yes	Yes
FEYEAR	Yes	Yes	Yes	Yes
FEPAIR	No	Yes	No	Yes
Observations	27,744	24,735	27,744	24,735

Notes: Bilateral trade as dependent variable is taken in levels. Robust standard errors in parentheses are clustered by country pair. Fixed effects of exporter (FEEXP), importer (FEIMP), year (FEYEAR), and directional pair (FEPAIR) are included in the estimation but not reported for brevity. ***, **, and * denote significance levels of 0.01, 0.05, and 0.1, respectively.

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