World Trade Organization

WORLD TRADE REPORT 2022

Climate change and international trade

What is the World Trade Report?

The World Trade Report is an annual publication that aims to deepen understanding about trends in trade, trade policy issues and the multilateral trading system.

What is the 2022 Report about?

The 2022 World Trade Report explores the complex interlinkages between climate change and international trade, revealing how international trade and trade rules can contribute to addressing climate change.

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Website: www.wto.org
General enquiries:
enquiries@wto.org
Tel: +41 (0)22 739 51 11

Cover image:

Kamarjani, Bangladesh
Technicians travel with their equipment by rickshaw to install a solar power system at a rural house built on Kharzanir Chor, an island on the Jamuna River. These islands come and go over a period of around 10 to 20 years and thus connecting them to the national grid is impractical. However, a programme of rural electrification is being rolled out using solar panels and batteries installed at individual homes.

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The lead authors of the report are Marc Bacchetta, Eddy Bekkers, Cosimo Beverelli, Mateo Ferrero, Emmanuelle Ganne, Rainer Lanz, José-Antonio Monteiro, Roberta Piermartini, Daniel Ramos and Ankai Xu. Other authors are Absar Ali, Antonia Carzaniga, Svetlana Chobanova, Lory Iunius, Jonathan Hepburn, Thomas Kräuchi, Juneyoung Lee, Kathryn Lundquist, Sajal Mathur, Hanh Nguyen, Yves Renouf, Victor Stolzenburg, Enxhi Tresa, Ayse Nihal Yilmaz, Khadija Zaidi and Ruosi Zhang.

Other written contributions were provided by Marc Auboin, Christophe Degain, Peter Donelan, Kartikeya Garg, Simon Hess, Gergana Kiskinova, Katharina Laengle, Reto Malacrida, Jeanne Metivier, Marie Isabelle Pellan, Philippe Pelletier, Rishab Raturi, Melvin Spreij, Ludivine Tamiotti, Antony Taubman, Jessyca Van Weelde and Xiaoping Wu.

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Abbreviations

AoA	Agreement on Agriculture
APEC	Asia-Pacific Economic Cooperation
BCA	border carbon adjustment
CBDR	[principle of] common but differentiated responsibilities
CPC	United Nations Central Product Classification
CO_2e	CO_2 equivalent
CTE	Committee on Trade and Environment
EDB	WTO Environmental Database
EG	environmental goods
EGS	environmental goods and services
EIF	Enhanced Integrated Framework
EITE	emission-intensive trade-exposed
EKC	Environmental Kuznets Curve
EPP	environmentally preferable products
EREG	energy-related environmental goods
ES	environmental services
ETS	EU Emissions Trading System
EU	European Union
ET	environmental technologies
EWE	extreme weather event
FFEDC	fossil fuel export-dependent country
FFSR	Fossil Fuel Subsidy Reform
G7	Group of Seven
G20	Group of Twenty
GATS	General Agreement on Trade in Services
GATT	General Agreement on Tariffs and Trade
GDP	gross domestic product
GGP	green government procurement
GHG	greenhouse gases
GPA	Agreement on Government Procurement
GTM	WTO Global Trade Model
GVC	global value chain
HS	Harmonized System
ICAO	International Civil Aviation Organization
IDP	Informal Dialogue on Plastics Pollution and Environmentally Sustainable Plastics Trade
IEA	International Energy Agency
IMF	International Monetary Fund
IMO	International Maritime Organization
IP	intellectual property
ITC	International Trade Centre
I-O	input-output
IPCC	Intergovernmental Panel on Climate Change
IRU	International Road Transport Union
LDC	least-developed country
MFN	most-favoured nation
MSME	micro, small and medium-sized enterprise
NDC	nationally determined contribution
NGO	non-governmental organization
NAFTA	North American Free Trade Agreement
NTB	non-tariff barrier
NTM	non-tariff measure
OECD	Organisation for Economic Co-operation and Development
R&D	research and development
RCA	revealed comparative advantage
RTA	regional trade agreement
SCM	subsidies and countervailing measures
SDGs	United Nations Sustainable Development Goals
SIDS	small-island developing states
SPS	sanitary and phytosanitary
STC	specific trade concern
STDF	Standards and Trade Development Facility
TBT	technical barriers to trade
$TeCO_2$	Trade in embodied CO_2
TESSD	Trade and Environmental Sustainability Structured Discussions
TFA	WTO Trade Facilitation Agreement
TPRM	Trade Policy Review Mechanism

TRIMs	trade-related investment measures
TRIPS	WTO Agreement on Trade-Related Aspects of Intellectual Property Rights
UNCTAD	United Nations Conference on Trade and Development
TRAINS	UNCTAD Trade Analysis Information System database
UNDRR	United Nations Office for Disaster Risk Reduction
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
UN	United Nations
US	United States
WCO	World Customs Organization
WMO	World Meteorological Organization
WTO	World Trade Organization

Foreword by the WTO Director-General

Climate change is an existential threat to people's lives and is dramatically reshaping economic activity and trade. This year alone, from the Horn of Africa to China, from Europe to the Americas, we have seen increasing heat and prolonged drought damage crops and reduce electricity production, while low water levels in major rivers have made it difficult to transport industrial and agricultural goods. Severe flooding left a third of Pakistan under water, devastating key export crops and putting the country's food and economic security at risk.

The climate crisis is a problem of the global commons, and one that demands a collective and effective multilateral response. The *World Trade Report 2022: Climate Change and International Trade* reviews the role of trade, trade policy and international trade cooperation in addressing climate change. It discusses how changing temperature and weather – and the low-carbon transition required to contain rising greenhouse gas emissions – are likely to impact the welfare of nations' populations and alter their comparative advantages.

The report argues that trade is a force for good for climate and part of the solution for achieving a low-carbon, resilient and just transition. While trade itself does generate emissions from production and transport, trade and trade policies can accelerate the dissemination of cutting-edge technologies and best practices, and enhance incentives for further innovation while creating the jobs of tomorrow. Trade is instrumental for investments in clean energy to have the greatest reach and impacts, at lowest cost and where they are needed the most. These are returns we would be unwise to forego, especially now that the big green investment push we need will coincide with rising real costs of capital and looming uncertainty about energy security due to geopolitical tensions and war.

Trade and trade policies are also part of any sound strategy for climate change adaptation, helping individual countries, especially vulnerable developing ones such as small-island developing states, least-developed countries and land-locked developing countries, better respond to and protect themselves from extreme weather events, and, in the longer term, to adjust to shifts in agricultural productivity and changes in wider international competitiveness. At the global level, what we call "re-globalization" – more diversified and deconcentrated goods and services production, drawing in formerly marginalized countries and communities with the right business environment – would promote supply resilience and inclusion in a world of ever more frequent climate induced shocks. This would provide better risk management than reshoring, nearshoring or friend-shoring.

In tandem with other public policies, trade has already been playing an important role in the global climate response. For example, the cost of solar panel systems has plummeted in the last three decades, and about 40 per cent of the cost decline has been attributed to scale economies made possible in part by international trade and value chains. The capacity of solar panels traded across borders in 2017 reached almost 80 GW, equivalent to over 9 per cent of global electricity generation.

Further opening up trade in environmental goods and services could do more. The WTO estimates that reducing tariffs and non-tariff measures on energy-related environmental goods could increase total exports of these products by 5 per cent by 2030 and, at the same time, lead to a net reduction in carbon emissions. There are employment benefits, too: the International Energy Agency estimates that the shift to clean energy could generate 14 million new jobs in clean energy sectors and 16 million jobs in related sectors globally by 2030.

Beyond amplifying the impact of climate policies and financing, greater international trade cooperation is key to manage and minimize potential trade frictions associated with climate action. For instance, close to 70 carbon pricing schemes are presently in operation worldwide. Without common approaches for prices and comparing equivalence, there is a significant risk that unilateral measures aiming to prevent carbon leakage and loss of competitiveness could stoke trade tensions and create high administrative costs for firms and governments. Uncoordinated climate actions could also hamper decarbonization efforts by raising uncertainty and discouraging much-needed investment.

The ongoing proliferation of decarbonization initiatives and standards – there are more than 20 different decarbonization standards in the steel sector alone – creates confusion for producers and could potentially lead to trade frictions. In line with its longstanding role of promoting transparency vis-à-vis policy measures affecting trade and encouraging cooperation in the direction of comparability, compatibility and harmonization, the WTO could play a similar role for carbon pricing and standards. The WTO is working with other multilateral agencies – the International Monetary Fund, the Organisation for Economic Co-operation and Development and the World Bank – on bringing in a trade perspective to discussions and research on carbon mitigation approaches.

Clear, predictable and shared understandings about trade-related climate measures would serve the needs and development opportunities of businesses and consumers in developing countries far more effectively than the high transaction costs that would come with a mess of varying rules for different markets. But a just transition to a low-carbon economy demands additional measures, including financial support, to help low-income regions address and overcome the potential adverse effects of carbon pricing. The case for delivering on the US$ 100 billion climate financing pledge remains strong, and a robust response on loss and damage is urgently needed.

The Aid for Trade initiative – which is increasingly about investment for trade – can and should help developing and least-developed countries build climate-friendly critical trade infrastructure. This would support a resilient and inclusive low-carbon transition.

This report is being launched at the same time as the 27th United Nations Climate Change Conference (COP27). What I hope to see emerge there and elsewhere is a trade and investment facilitation pathway in support of a just transition to a low-carbon economy. Finance is one part of the equation – but it is not the only part. A good trade policy framework is necessary to turn climate investment into climate transformation. We must start to talk about trade not as a threat but as a solution to the climate crisis.

Achieving better trade and climate outcomes is possible – but we will need strong political leadership. Our success at the WTO's 12th Ministerial Conference in June 2022 – where members unanimously agreed that trade must be part of the solution to climate change and struck an accord on curbing harmful fisheries subsidies that is the WTO's first agreement with environmental sustainability at its core – shows that this is possible.

Looking ahead, the WTO has an opportunity to use the present moment to strengthen its role as a forum for coordination on trade and climate change, to address trade policy barriers holding back the dissemination and use of low-carbon technologies, and to support structural changes needed to decarbonize the global economy. I hope we will make the most of this opportunity.

Dr Ngozi Okonjo-Iweala
Director-General

Key messages

- **Climate change is reshaping countries' economic and trade prospects, and is a major threat to future growth and prosperity.** Higher temperatures, rising sea levels and more frequent extreme weather events bring the prospect of productivity losses, production shortages, damaged transport infrastructure, and supply disruptions. Without significant reductions in global greenhouse gas (GHG) emissions, many countries are likely to find their comparative advantages changing, with agriculture, tourism and some manufacturing sectors particularly vulnerable to climate impacts.

- **Trade is a force multiplier for countries' adaptation efforts, reducing costs and increasing impact.** Climate shocks will remain costly and disruptive, but trade can help countries better prepare and respond, through access to technologies and critical goods and services, such as food and healthcare products. This is particularly relevant for the most vulnerable economies – least-developed countries, small-island developing states, and landlocked developing countries. In the longer-run, open international markets would help countries smooth necessary economic adjustment and resource reallocation, and more diversified sources of supply for key goods and services would translate into greater resilience against localized weather events.

- **Trade can reduce the cost of mitigation and speed up the low-carbon transition and the creation of green jobs.** Though trade, like most current economic activity, generates GHG emissions, it also contributes to reducing them, by enabling access to cutting-edge climate technologies; incentivizing innovation in low-carbon technologies by expanding market size; and fostering competition and scale economies that help drive down costs. Trade and value chains have been major factors in the dramatic fall in the cost of generating solar and wind energy. With renewable energy now cheaper than fossil alternatives in some places, the adoption of renewables has accelerated. But there is scope to do more: WTO simulations suggest that eliminating tariffs and reducing non-tariff measures on a subset of energy-related environmental goods could boost exports by 5 per cent by 2030, while the resulting increases in energy efficiency and renewable uptake would reduce global emissions by 0.6 per cent. To the extent trade helps speed up the low-carbon transition, it would contribute to job creation: one estimate suggests the global shift to clean energy will generate as many as 30 million new jobs in clean energy and related sectors by 2030.

- **International trade cooperation can make climate actions more effective, and the low-carbon transition more just, by minimizing trade frictions and investor uncertainty.** As governments ramp up climate action towards nationally determined contributions, there is a risk that unilateral measures aiming to prevent carbon leakage and the loss of competitiveness of domestic industry could stoke trade tensions, create investment-discouraging uncertainty, and impose disproportionate costs on firms and governments in developing countries. International cooperation on trade-related aspects of climate policy, such as carbon pricing and decarbonization standards, would reduce these risks. The WTO could play a more valuable role as a venue for transparency, comparability and potential harmonization of such measures. Aid for Trade, as well as trade-oriented private investment, can help developing and least-developed countries build climate-resilient trade infrastructure, contributing to making the low-carbon transition more just and fair.

Executive summary

Climate change represents a severe, pervasive and potentially irreversible threat to people, ecosystems, public health, infrastructure and the global economy. Left unabated, it could undo much of the progress made over recent decades in development, poverty reduction and prosperity creation. Developing countries – in particular small-island developing states and least-developed countries (LDCs) – are likely to suffer the most, due to their greater exposure and vulnerability to climate risks and natural disasters, and their more limited capacity to adapt to climate change. Leveraging trade to tackle climate change presents several development and growth opportunities and will require significant policy actions to advance a just transition towards a low-carbon, inclusive and resilient future.

In the face of this existential threat, the 2022 *World Trade Report* explores the multifaceted relationship between international trade and climate change. It looks at how international trade might exacerbate climate change, how the consequences of climate change might alter trading patterns and relationships, and how trade could be a force multiplier for the global response to the climate crisis. The report spells out various ways international trade cooperation, fostered by the WTO, could support and lower the cost of implementing the Paris Agreement and fulfilling the Glasgow Climate Pact's goal of net-zero greenhouse gas (GHG) emissions by mid-century (IPCC, 2022a). The report's core message is clear: trade is a critical point of leverage for transforming the global economy and putting the planet on a sustainable trajectory.

Climate change is a problem of the global commons. Markets do not suffice to address the threats from GHG accumulation in the atmosphere because firms and consumers often do not directly face the costs of the emissions they cause. To correct these market failures, carefully constructed climate change mitigation policies are needed to incentivize behavioural change and increased investment in energy efficiency and climate-friendly technologies.

Ambitious GHG mitigation policies face a wide range of challenges, including conflicting economic and development priorities, divergent energy strategies and geopolitical competition. Fragile economic recovery from the COVID-19 pandemic, rising inflationary pressures, increasing food security challenges and the war in Ukraine have added further uncertainties. While the transition to a low-carbon economy entails substantial short-term investment and adjustment costs, it will yield major economic dividends and create wide-ranging opportunities for more sustainable and fair development. A well-managed low-carbon transition can limit climate risks, promote biodiversity and improve food security. Investments in clean energy also promise better air quality, public health and quality of life for people across the world. Bold climate actions could yield a cumulated economic gain of US$ 26 trillion between 2018 and 2030 (Garrido et al., 2019). The low-carbon transition could also create millions of new jobs in clean energy and energy-related sectors and support a more inclusive economy, not least because more women work in the renewable energy sector than in the fossil fuels sector (IRENA, 2021).

Because the existing build-up of GHGs in the atmosphere makes some degree of climate change unavoidable, adaptation strategies are also required to make communities more resilient in the face of sea level rise, more intense storms and changed rainfall patterns leading to more floods, droughts and wildfires as well as significant effects on agricultural productivity. These consequences will profoundly impact international trade and coping with them requires adaptation efforts to identify, prevent and reduce climate risks, and minimize unavoidable losses and damages (IPCC, 2022b).

The report makes clear that trade and climate change are deeply intertwined, and that more effective responses to mitigate and adapt to climate change will require stronger and better international trade cooperation.

The report makes three key points. First, while climate change can have profound negative impacts on international trade, trade and trade policies are essential elements of sound climate change adaptation strategies. Second, although trade generates GHG emissions, trade and trade policies can foster the transition to a low-carbon economy by providing access to and spurring innovation in low-carbon technologies, disseminating best practices and helping clean energy investments achieve the greatest reach at the lowest cost. Third, improving the ambition and effectiveness of climate action requires greater international trade cooperation at the WTO.

Even though climate change can have profound negative impacts on international trade, trade and well-designed trade policies are essential elements of sound climate change adaptation strategies.

Climate change can cause productivity losses, supply shortages and transport disruptions, severely impacting trade. Because these impacts will differ across regions, some economies will be at a disadvantage. Export growth of agricultural products and light manufacturing from LDCs have been found to decrease, on average, by between 2 and 5.7 per cent in response to a rise in the country's temperature by 1°C (Jones and Olken, 2010).

Extreme weather events can also affect key transport corridors and infrastructure, potentially creating vulnerabilities in the global trade network. Maritime transport – which accounts for 80 per cent of world trade by volume – is particularly exposed to climate change, while other modes of transport can also be impacted. Small economies and landlocked countries, which trade through a limited number of ports and routes, can suffer major trade bottlenecks from climate-related disruptions. For instance, the Paraná River transports 90 per cent of Paraguay's international trade of agricultural goods, but recurrent droughts have in recent years frequently lowered water levels, diminishing the weight barges can carry, causing congestion and delays.

Climate-induced disruptions tend to be more severe in heavily concentrated global value chains (GVCs) where intermediate inputs are difficult to replace in the short run. For example, in 2011, flooding in Thailand disrupted the global electronic and automotive industries, causing an estimated 2.5 percentage point decline in the rate of growth of global industrial production (Kasman, Lupton and Hensley, 2011). Climate-induced supply chain risks are often exacerbated by firms' limited capabilities to assess climate risks and implement risk management strategies.

Without significant reduction in GHGs, climate change is likely to alter countries' comparative advantage and trade patterns by changing endowments in natural resources or altering the efficiency with which land, labour, capital and other production factors can be deployed to produce goods and services. Commodity dependence and lack of diversification can exacerbate vulnerabilities to climate change, underscoring the need to support efforts to accelerate economic diversification.

Agriculture, tourism and some manufacturing sectors are particularly vulnerable to climate change. Agriculture is the most exposed and vulnerable sector to changes in temperature and precipitation, raising serious concerns about future food security. Sub-Saharan Africa and South Asia are expected to experience larger adverse agricultural yield shocks than other regions; and given their high share of agricultural employment, they may face more severe labour market disruptions. Changes in climate might also reduce the touristic appeal of long-favoured destinations, while sea level rise and extreme weather events could permanently damage tourism infrastructure. Manufacturing sectors dependent on climate-sensitive inputs, such as food processing, could suffer from reduced access to raw materials. Labour-intensive production could also be adversely affected as rising temperatures diminish capacity to work and raise risks of accidents and heat exhaustion.

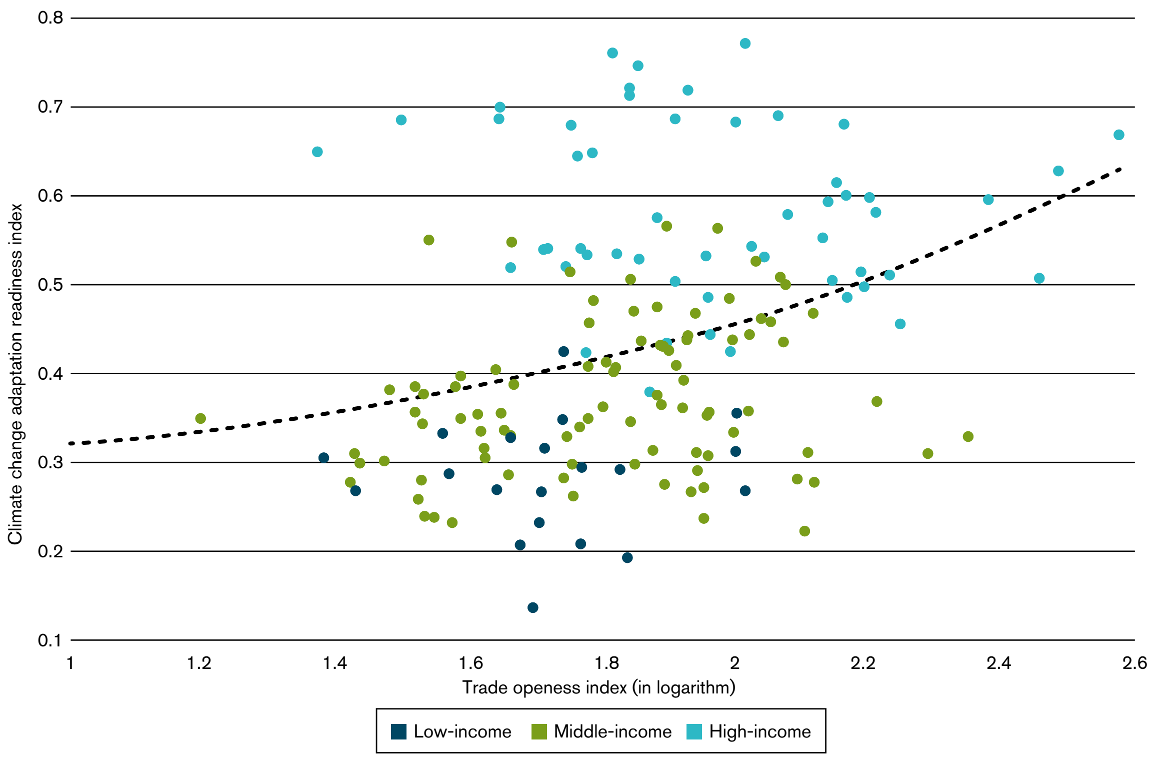
Adapting to climate change is a sustainable development imperative. Without understating how costly and disruptive adaptation will continue to be, trade can make an important contribution to climate risk prevention, reduction and preparedness.

Trade can facilitate the development and deployment of pro-adaptation technologies, such as climate-resistant crop varieties, early warning systems and water conservation and storage systems. By fostering higher economic growth, trade can generate additional financial resources to invest in adaptation strategies such as climate-resilient infrastructure. Trade openness also allows for wider access to services that help prepare for climate-related shocks, such as weather forecasting, insurance, telecommunications, transportation, logistics and health services.

Access to imported essential goods and services, such as food and medical supplies, can help economies cope and recover after an extreme weather event hits. Facilitating imports of construction materials can contribute to post-disaster reconstruction. Allowing trade to resume faster after climate-induced shocks can also support economic recovery. Even in the absence of extreme weather events, long-term shifts in weather patterns can still cause crop yields to fall, and trade can help alleviate food insecurity by allowing regions to import food to fill demand gaps. Overall, countries more open to trade tend to have a greater capacity to adapt to climate change (see Figure 1).

The role of trade in coping with climate change underlines that trade policies must be an integral

Figure 1: Greater capacity to adjust to climate change tends to be associated with greater openness to trade



Sources: Authors' calculations based on ND-GAIN Climate Readiness Index and the trade openness index for 2020 from the World Development Indicators.

Note: The climate change readiness index measures a country's ability to leverage investments and convert them to adaptation actions. The trade openness measures the sum of a country's exports and imports as a share of that country's GDP in percentage.

part of climate change adaptation strategies. A small but increasing number of trade measures notified by WTO members between 2009 and 2020 are related to climate change adaptation, though these measures – which mostly take the form of support in the agricultural sector – account for less than 4 per cent of all notified climate-related trade measures (161 out of 4,629).

Trade and trade policy are, however, not a panacea to adapt to the highly disruptive consequences of climate change. Addressing the factors and conditions underpinning the vulnerabilities and exposures to climate risks is essential. In addition, well-functioning markets, including in the areas of infrastructure, finance, food and labour, are important to facilitate adjustment.

Although trade generates GHG emissions, trade and trade policies can be part of the solutions to support a low-carbon transition.

Trade, like most economic activities, emits GHGs. The world share of carbon dioxide (CO_2) emissions embodied in world goods and services exports peaked in 2011 and was estimated to account for around 30 per cent of global carbon emissions in 2018. This share indicates the close relationship between production, trade, consumption and the consequent emissions under current technologies and production processes.

International trade has complex effects, both positive and negative, on GHG emissions, going well beyond the emissions released during the production and transportation of the exported goods and services. The overall impact of trade on carbon emissions depends, among others, on the sector and countries involved as well as the energy sources, production methods and modes of transport.

On the positive side of the ledger, international trade increases the worldwide diffusion and deployment of lower-emission goods, services, capital equipment and know-how. It also reduces the costs of these products through efficiency improvements, economies of scale and learning-by-doing. For instance, the cost of solar electricity has plunged by 97 per cent since 1990. A significant part of the cost decline of solar panel systems has been attributed to GVCs, which have enabled producers to lower production costs and reap economies of scale by locating different production stages in different countries (WTO and IRENA, 2021). Market opportunities for low-carbon exports can also spur more investment and innovation in new low-carbon technologies and encourage efforts to better adapt these technologies to local conditions.

In addition, trade opening can reduce the carbon intensity of economic output by shifting resources to more productive and cleaner firms, as firms engaged in international trade tend to be more competitive and energy efficient than purely domestic firms. The higher incomes typically associated with greater integration into global trade also give individuals the space to demand higher environmental quality and to pressure governments to adopt more stringent climate regulations and provide additional financial resources for environmental protection.

International trade in renewable energy and electricity has also the potential to help compensate for the uneven geographical distribution of usable sunlight and wind, though this will hinge on important technological breakthroughs – notably in energy storage. More developing countries are already moving to harness their abundant renewable energy potential. For instance, Morocco hosts the world's largest solar power station, while Egypt is building a solar photovoltaic park touted to become the world's largest.

On the negative side of the ledger, trade opening raises GHG emissions by increasing the production, transportation, consumption and disposal of products. The fragmentation of production represented by GVCs involves more transport and therefore more emissions. Trade may – in the absence of relevant policies – incentivize emissions-boosting deforestation.

Changes in the sectoral composition of production – a standard result of trade opening – can also increase or reduce GHG emissions, depending on whether the country in question has a comparative advantage in carbon-intensive industries, which in turn depends on factors including resource endowments, technological level and environmental and energy policies (WTO, 2021a).

Rising concern about trade-related GHG emissions has led to calls to limit imports in favour of producing and consuming local goods and services. But if countries close their borders to trade, meeting demand for previously imported goods and services would cause domestic production and associated GHG emissions to rise; while foregoing the broader gains from trade would cause living standards to fall.

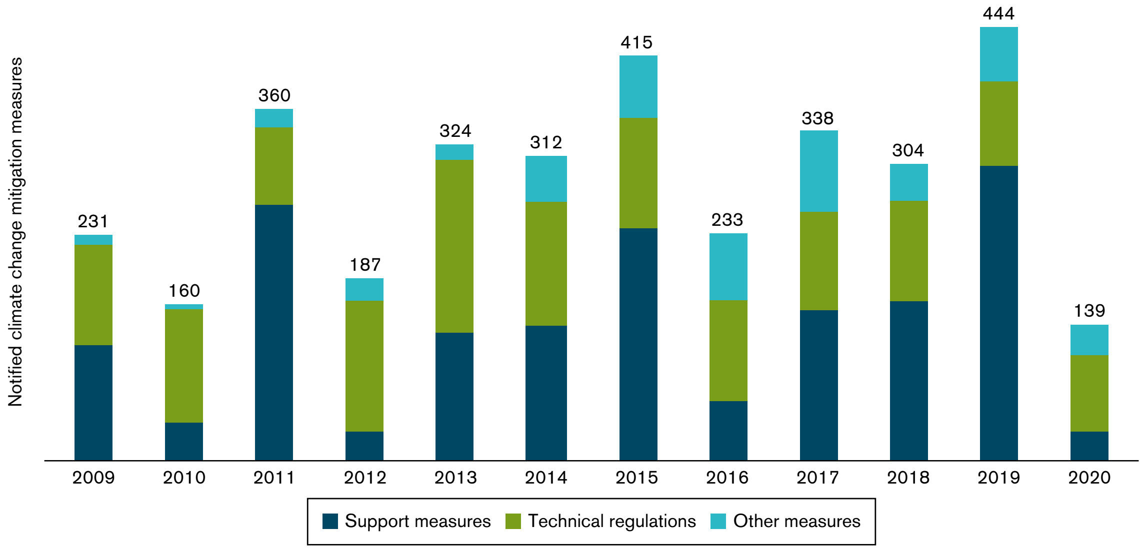
Instead of re-shoring, the low-carbon transition would be better supported – and accelerated – by cleaner trade, which would involve reducing the carbon intensity of production, transportation and GVCs, developing and deploying climate-friendly technologies and promoting trade in climate-friendly goods and services. Major decarbonization pathways for international transport include switching to lower-carbon fuels, improving vehicle efficiency and phasing-out carbon-intensive vehicles.

Well-designed trade policies must support the role of trade in deploying and disseminating climate mitigation technologies. Trade and trade policies are an integral part of a limited but increasing number of countries' plans to achieve carbon emission-reduction targets under the Paris Agreement's nationally determined contributions. Complemented by other policies, trade policies can help countries diversify away from reliance on carbon-intensive sectors, create new jobs and increase the ambition of mitigation efforts. Between 2009 and 2020, WTO members notified 3,460 trade-related climate change mitigation measures explicitly addressing climate change mitigation, energy conservation and efficiency, and alternative and renewable energy. Support measures and technical regulations are the main types of notified trade-related climate change mitigation measures (see Figure 2).

Despite the benefits of opening trade in the environmental industry, barriers to trade in environmental goods and services remain significant. In addition, tariff and non-tariff barriers tend to be lower in carbon-intensive industries than in clean industries (Shapiro, 2021).

Removing barriers to trade in environmental products can contribute to addressing climate change. WTO

Figure 2: Support measures and technical regulations are the most common trade-related climate change mitigation measures



Sources: Authors' calculation, based on the WTO Environmental Database.

Note: The category "technical regulations" includes conformity assessment procedures. One notified measure can cover more than one type of policy.

simulation analysis suggests that eliminating tariffs and reducing non-tariff measures on some energy-related environmental goods and environmentally preferable products could increase global exports in these products by US$ 109 billion (5 per cent) and US$ 10.3 billion (14 per cent), respectively, by 2030. The resulting improvements in energy efficiency and renewable energy adoption are estimated to reduce net carbon emissions by 0.6 per cent, while the knock-on effects of accelerating the spread of environmental innovation would do much more, including increasing the demand for ancillary services relating to the sale, delivery, installation and maintenance of environmental technologies.

That said, harnessing the full potential of international trade in renewable energy and other environmental goods and services also requires ambitious climate policies and actions to upgrade power-generation, transmission and distribution infrastructure as well as to build a well-functioning quality infrastructure.

Improving the ambition and effectiveness of climate change action requires greater international trade cooperation.

Addressing climate change requires global cooperation on all fronts, and international trade cooperation, at the WTO and elsewhere, is an integral part of the efforts.

The bottom-up international climate regime, with nationally determined contributions and mitigation actions, encourages broad-based participation and underlines the urgency of climate action. But it also results in widely varying levels of climate ambition across jurisdictions, with the attendant risks of carbon leakage and competitiveness loss, especially in carbon-intensive and trade-exposed sectors. These risks have prompted some countries to consider border carbon adjustment measures. Uncoordinated trade-related climate policies, however, could give rise to trade tensions and heighten marketplace uncertainty in ways that discourage much-needed low-carbon investment. Avoiding such outcomes calls for leveraging every opportunity at the WTO and elsewhere for improving cooperation on the trade-related aspects of climate change policies.

At the regional level, a limited but increasing number of trade agreements, namely 64 out of 349 notified regional trade agreements (RTAs), explicitly contain climate change-related provisions. Some of these RTAs commit parties to effectively implement the Paris Agreement and adopt climate change policies, including carbon pricing, while a few others remove some trade and investment barriers to climate-friendly goods, services and technologies.

At the global level, as noted above, the open and predictable international markets underpinned by the multilateral trading system already facilitate access to environmental technologies, food and other critical supplies. WTO members notify climate-related measures and discuss potential concerns, as well as the underlying environmental rationale, in various WTO bodies such as the Committee on Trade and Environment. These discussions are also a venue for exchanging national experiences and practices.

The WTO agreements expressly recognize the rights of members to adopt measures to protect the environment, so long as they are not applied arbitrarily and are not more restrictive than necessary to meet the objective in question. Climate objectives, rather than the protection of domestic producers, must be the central rationale for the development and implementation of trade-related climate policies. Trade-related climate policies should also consider their impact on other nations' climate efforts. The protection and enforcement of intellectual property rights, as provided by WTO rules, is also essential to support innovation in environmental technologies while promoting the transfer of technology.

But WTO members can do much more to enhance the contribution of trade and trade policy to their climate objectives.

First, with the increasing number of trade-related climate measures being taken nationally, there is a strong case for strengthening the role of the WTO as a forum for coordination and dialogue, and for identifying potential action on trade and climate change. The committee process could be used to identify transparency and knowledge gaps, opportunities for coordination, capacity needs and perspectives of developing countries, and areas for further work, including potential negotiations. At the 12th Ministerial Conference in June 2022, WTO members concluded an agreement that prohibits certain types of fisheries subsidies. Continuing work on additional provisions for a comprehensive agreement on fisheries subsidies would further contribute to sustainable management of marine resources and biodiversity.

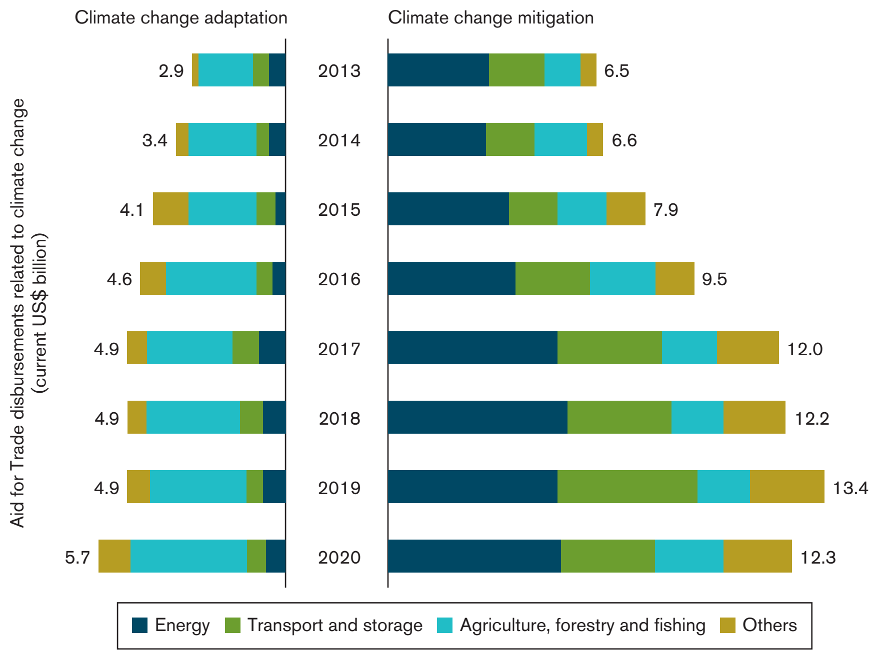
Second, members are already beginning to pursue a new generation of sustainability driven initiatives aimed more at using trade as a means to help achieve global public goods than at correcting a particular trade distortion. These initiatives include the Trade and Environmental Sustainability Structured Discussions, the Informal Dialogue on Plastics Pollution and Environmentally Sustainable Plastics Trade, and the Fossil Fuel Subsidy Reform initiative.

Some of these discussions focus on traditional fare for trade negotiators, namely tariff and non-tariff policies. For instance, removing trade barriers on environmental goods and services would lower costs, expand markets and boost the deployment of climate-friendly technologies. Pursuing greater alignment on low-carbon standards would lower compliance costs and encourage greater scale and investment.

Other initiatives focus instead on generating new knowledge that can inform and improve governments' efforts to integrate trade into their environmental and climate change strategies. This could involve a better understanding of the environmentally harmful impacts of subsidies or of trade-related linkages with the circular economy. Finding a balance between support incentives for low-carbon technologies while minimizing negative spillovers on trading partners would also provide more predictable and credible market signals for low-carbon investment and consumption. The dialogue on plastics seeks to generate knowledge on plastic trade flows in order to support negotiations on an international plastics treaty under the auspices of the United Nations Environment Programme.

Third, WTO members could work on supply side factors to enhance the climate resilience of their supply chains. Deepening and diversifying supply and transport networks would not just help reduce vulnerability to the kinds of supply chain disruptions seen since the start of the pandemic; it would also enhance resilience in the face of localized climate events. Stronger information sharing and monitoring would help food and energy security for all members, while helping them manage risks related to supply chain bottlenecks. An example of how this might work in practice is the Agricultural Market Information System, which is a platform of international agencies, including the WTO, which tracks the supply of key agricultural commodities and provides a forum for

Figure 3: Aid for Trade disbursements related to climate change have increased over the past decade



Sources: Authors' calculations, based on Organisation for Economic Co-operation and Development DAC-CRS (Development Assistance Committee Creditor Reporting System) Aid Activities Database.

Note: Only projects with an explicit objective of adapting to or mitigating climate change and projects identifying climate change as important but secondary objective are considered as climate change-related official development assistance. Projects can be cross-cutting and have both adaptation and mitigation objectives.

coordinated policy responses when needed to prevent markets from seizing up. At the 12th Ministerial Conference, WTO members vowed to address the global food security challenges by exempting from export restrictions food bought by the World Food Programme for humanitarian purposes and pledging to facilitate trade in food, fertilizers and other agricultural inputs. Implementing these decisions could contribute to managing the knock-on effects of surging food prices during a crisis, thus increasing food security.

Fourth, improving the ability to understand and manage climate-related risks and investment opportunities would improve the synergies between climate finance and Aid for Trade. Climate finance to developing countries continues to fall short of the US$ 100 billion goal for 2020 (OECD, 2022a) and has not achieved the balance between adaptation and mitigation finance set out in the Paris Agreement (UNEP, 2021a, 2021b). However, the Aid for Trade initiative, supported by the WTO and other organizations, can help developing countries, particularly LDCs, to build climate-resilient trade capacity and infrastructure, and support trade policies to foster a low-carbon transition. Between 2013 to 2020, Aid for Trade disbursements related to climate action totalled US$ 96 billion, with a larger share of the disbursements directed at climate mitigation (see Figure 3).

Finally, reinforcing the WTO's existing cooperation with international and regional organizations, including in the areas of climate risk prevention, climate-induced disaster relief, transport decarbonization and climate finance, is important to advance trade cooperation on climate change. Over the past few years, WTO members have started to address some of these issues. However, the scale and urgency of the climate crisis demand additional efforts in support of a more inclusive and just transition to a low-carbon economy and a more resilient future.

A Introduction

Tackling climate change requires a transformation of the global economy. While limiting consumption and changing lifestyles would help, reducing greenhouse gas emissions to net zero will be impossible without technological and structural change on a global scale. This transformation will involve costs, but also opportunities – not just to head off an environmental catastrophe, but to reinvent the way the world generates energy, manufactures products and grows food. Just as trade helped to drive economic progress in the past – by incentivizing innovation, leveraging comparative advantages and expanding access to resources and technologies – trade can play a central role in driving progress towards a low-carbon global economy. But harnessing the potential of trade will demand new policies and more cooperation.

Contents

1. The next great transformation

Paradoxically, economic progress is both the cause of and the solution to the climate crisis. To head off dangerous climate change, the Paris Agreement aims to limit the global warming to 1.5°C this century. This means that greenhouse gas (GHG) emissions need to be cut by roughly 50 per cent by 2030 and reach net zero by 2050.[1] The most realistic way modern economies can achieve this goal – without cutting back living standards in richer countries and cutting short development in poorer ones – is by modernizing even more, harnessing human innovation, ingenuity and entrepreneurship to advance low-carbon technologies and to use the planet's resources more sustainably.

Dramatic advances in automation, transportation and industrialization – all powered by fossil fuels – have driven the exponential growth of the global economy over the past two and half centuries, resulting in rising living standards, increased mobility, and improved material well-being for a fast-growing global population. In important ways, the industrial revolution was also an energy revolution (Wrigley, 2010). By discovering how to convert fossil fuels into mechanical energy, starting with the steam engine, humanity unlocked seemingly limitless supplies of energy to power seemingly limitless economic growth and development.

But ever-expanding growth has also released ever-greater amounts of heat-trapping GHG emissions into the atmosphere – from electricity generation, transportation, industry, agriculture and deforestation – which in turn has contributed to the warming of the planet and its negative climactic and environmental knock-on effects. Almost three-quarters of global GHG emissions come from energy consumption; another 18.4 per cent from agriculture, forestry and land use; 5.2 per cent from industrial processes; and 3.2 per cent from waste (Ritchie, Roser and Rosado, 2020). As long as the world remains dependent on high-carbon technologies, increasing economic production will almost inevitably lead to increasing GHG emissions.

Yet, while technological and economic progress has "fuelled" the climate crisis, it is also indispensable to mitigating and overcoming it. Replacing fossil fuels with renewable energies – solar, wind and geothermal power, and others – is essential to avoid and reduce GHG emissions, as are steps to decarbonize transportation, steel production, cement manufacturing and agriculture, and to make economic ecosystems less wasteful and more resource-efficient overall.

Adapting to the adverse effects of climate change will also require technological solutions – from developing drought-resistant crops and resilient water supplies, to building flood defences, improving weather forecasting and setting up early warning systems (UNFCCC, 2016a).

Given that many lower carbon technologies – from solar panels and electric cars to vertical farms and electric arc furnaces – already exist, the challenge is to scale up their production and deployment. One influential study argues that two-thirds of economies, including major emitters like the United States, the European Union and China, could reduce their GHG emissions by 80 per cent by 2030, and achieve carbon neutrality by 2050, through the mass adoption of electrification based on existing wind, hydro and solar technologies (Jacobson et al., 2017).

Even more cutting-edge technologies, such as green hydrogen or direct air carbon capture and storage, are also advancing rapidly. Then there are the myriad "soft" climate technologies – data-crunching, information-sharing, training and education – which are easier to adopt, and which will be just as critical to shift economies towards low-carbon alternatives.

It is also important to focus not just on what technologies are needed, but on how they are used. It has long been recognized that it is only by using new technologies that we learn how to optimize and exploit their full potential (Arrow, 1962). This "learning-by-doing" dynamic can take time (David, 2002). In the same way that it took decades for the invention of the dynamo to translate into mass electrification, it could take years to realize the full potential of solar power or carbon farming. Thus, it makes sense to scale up new, clean, low-carbon technologies now, even if the initial investment costs are high, as expanding capacity early on can encourage usage, improve performance, drive down prices, and ultimately make renewable technologies more attractive and competitive.

Realizing the potential of one innovation also often hinges on marrying it to another innovation (Harford, 2017). Just as the explosion of the internet after the mid-1980s depended on parallel innovations in satellite and fibre optic telecommunications, electric vehicles are now poised to revolutionize clean-energy transportation because they are benefitting from other technological breakthroughs, including the mass production of affordable lithium-ion batteries, the roll-out of electric vehicle charging networks and more readily available renewable energy.

Conversely, the absence of synergistic technologies can significantly slow or block economic progress.

For example, the lack of affordable and efficient technological solutions to the challenge of long-term, large-scale energy storage – a challenge arising from the intermittent nature of some lower carbon energy technologies such as solar and wind power – is a key missing piece of the renewable puzzle which urgently needs to be "discovered" if renewables are to become a reliable replacement for fossil fuels worldwide.

This positive process of technological interaction, cross-fertilization and mutually reinforcing innovation takes place at the global, not just the firm, level. The fact that photovoltaic (PV) cells, which convert solar energy into electricity, are increasingly affordable and available is the result of mutually supportive back-and-forth innovations across several continents, including US investments in PV cell research and development (R&D) in the 1960s and 70s; European policies to accelerate domestic solar panel installation in the 1990s and 2000s; and Chinese efforts to improve and scale production after 2011 (IEA, 2022a).

Technological cooperation, competition and cross-fertilization do not just spur innovation; they also encourages needed technological diffusion. Many developing countries have abundant renewable energy potential that access to low-carbon technologies and infrastructure could unleash (IRENA, 2022). This is starting to happen. Kenya is already a world leader in the number of solar panel systems installed per person, while 90 per cent of Nepal's electricity comes from hydro-electric power. Locally generated renewable energy allows developing and least-developed countries to bypass many of the logistical difficulties and high costs involved in the transmission and distribution of fossil-fuel energy, improving their energy access and self-sufficiency. Bringing clean energy to the 759 million people in the developing world who still lack access to electricity would not only stimulate economic growth and job creation and reduce poverty, but would significantly improve essential services, such as healthcare, education and the internet.

The shift to low-carbon farming – especially climate-smart agriculture techniques that focus on intercropping, crop rotation, agroforestry, and improved water management – can bring similar benefits to developing-country farmers in terms of improved productivity, greater resilience, less deforestation, and reduced reliance on fertilizers and fuels (Brakarz, 2020). In short, the diffusion of low-carbon technologies can provide poorer countries with the essential tools they need both to limit GHG emissions and to accelerate their development.

Achieving a shared and "just" transition to a low-carbon global economy is not just the right thing to do; it is also in everyone's interests. Climate change will not be stopped if only wealthy economies have access to low-carbon technologies while poor economies continue to have to rely on fossil fuel-fired power plants and internal combustion engines. Since everyone is impacted by climate change, everyone has an interest in ensuring that the technological tools and resources to reduce emissions are as widely available as possible.

Wealthy economies can also benefit in more direct ways from technological development in poorer countries. A striking example of North-South technological collaboration is the ambitious plan to deliver Moroccan solar and wind farm electricity to UK consumers via an underwater cable stretching 3,800 km – the world's longest cable of this kind. When completed in 2030, it is hoped that the Xlinks Morocco-UK Power Project will deliver low-cost, clean power to over 7 million UK homes, representing 8 per cent of current UK electricity needs (Hook, 2021).

Indeed, the transition to a low-carbon global economy will create enormous investment, employment and growth opportunities – not just adjustment costs – for developed and developing countries alike. For example, global investment in the low-carbon energy transition – across sectors ranging from power generation, energy storage and electric vehicles, to sustainable materials, electrical efficiency and carbon capture – already totalled US$ 1.3 trillion in 2021, doubling the investment of US$ 655 billion in 2017 (IEA, 2022b). In order to reduce GHG emissions to net zero by 2050, cumulative investment in renewable energy would need to reach US$ 131 trillion over the next 30 years (McKinsey & Company, 2022).

Similarly, massive investment opportunities are opening up in the steel, cement, farming, forestry and waste management industries as they shift to low-carbon technologies and processes. Building low-carbon industries and infrastructure will not only require new investment and equipment; it will also require new workers and skills. Shifting to clean energy, for instance, could generate 14 million new jobs in clean energy sectors and 16 million additional jobs in energy-related sectors globally by 2030 (IEA, 2021). In short, the transition to a low-carbon economy will entail the construction of a new economy.

The good news is that low-carbon technologies are expanding – and at a faster pace than many predicted (Naam, 2020).[2] For example, renewables accounted for roughly 11 per cent of global primary energy and 30 per cent of electricity generation in 2021 (IEA, 2022b). Despite supply chain bottlenecks, rising raw material prices and growing geopolitical tensions, the International Energy Agency (IEA) projects that renewables are on track to account for almost 95 per cent of the increase in global power capacity through 2026, with solar power alone providing more than half of that increase. The IEA expects the amount of renewable capacity added between 2021 and 2026 to be 50 per cent higher than between 2015 and 2020 – and even these optimistic forecasts may underestimate the speed and scale of the transition.

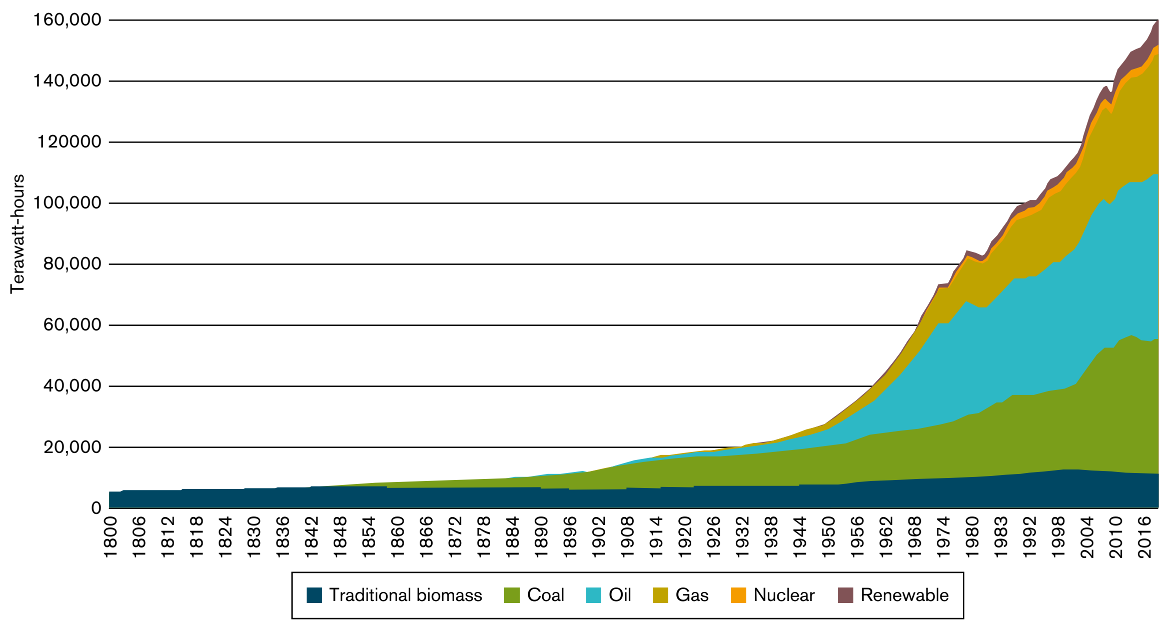
The bad news is that although global renewable energy capacity is growing rapidly, overall global energy demand is growing almost as fast, so fossil fuel consumption continues to rise (see Figure A.1). Nearly 80 per cent of the world's energy is still generated by burning fossil fuels, notably oil, coal and gas, partly because supplies of renewable energy need to be scaled up, and partly because fossil fuel consumption is still subject to strong path dependence due to technological, infastructural, institutional and behavioural lock-ins. Global energy-related carbon emissions rose by 6 per cent in 2021 to 36.3 billion tonnes – their highest level ever, and 65 per cent higher than they were in 1990 (IEA, 2022c). The IEA estimates that the current pace of renewable power capacity growth will need to double over the next decade if the global economy is to stay on a pathway to net zero emissions by mid-century.

Other sectors also face the challenge of accelerating the shift to low-carbon technologies and practices. The challenge is especially daunting in agriculture – compared to power generation or transportation, for example – because the emissions-reduction technologies are more amorphous and the sector is more diffuse, requiring changes to how over two billion people farm and how billions more eat (McKinsey & Company, 2020). At the same time, the challenge is intensified because of agriculture's unique vulnerability to climate change – including extreme weather events, frequent droughts, and invasive species and pests – and because of an expanding global population's growing need for food.

2. Harnessing the transformative power of trade

What role will trade play in the transition to a low-carbon global economy? In the past, trade has been part of the problem, contributing to climate change both directly, by generating increasing transport emissions (shipping, air freight, trucking and rail), and indirectly, by helping to drive carbon-intensive global growth. But in the future, with the right policies in place, trade can be a major part of the solution.

Figure A.1: Fossil fuels remain the dominant energy source despite increasing use of renewables



Source: Authors' calculations, based on Smil (2017) and BP Statistical Review of World Energy (2017).

Trade can increase counties' access to lower-emissions goods, services and capital equipment, and can help to diffuse critical technologies and know-how. It can drive down the costs of environmental products by encouraging efficiency, economies of scale and learning-by-doing. Perhaps most importantly, it can spur innovation by opening up new market opportunities for low-carbon exports and investments and by incentivizing entrepreneurs and industries to compete to fill them.

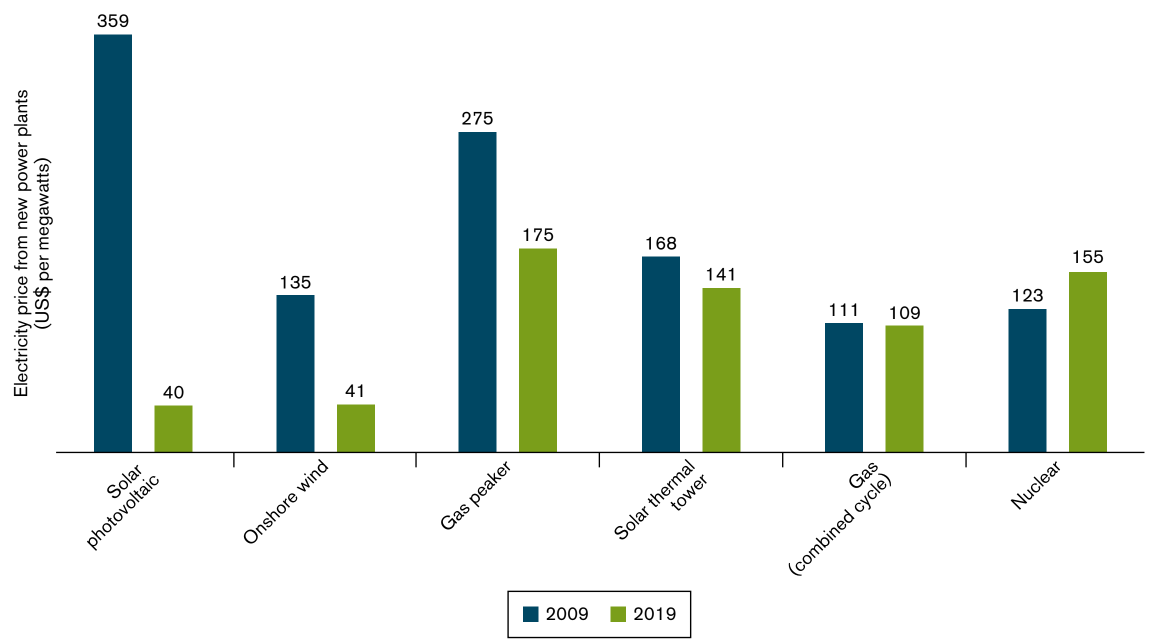
If low-carbon production reaches the point where it beats high-carbon production on price and performance – because environmental costs are internalized in high-carbon production through taxes and other policies or because technological advances alone make low-carbon alternatives cheaper and better – then market forces will increasingly drive the transition and progress will accelerate.

This is already happening. Scientific advances, more efficient production processes, and rising global demand – all supported by open world trade – have driven an astonishing reduction in price and improvement in performance of low-carbon technologies (see Figure A.2). The price of solar power, for example, has fallen by almost 90 per cent since 2010, while the efficiency of solar panels has doubled since 1980. Last year alone, the cost of electricity from onshore wind fell by 15 per cent, and from offshore wind by 13 per cent. The price of lithium-ion batteries has plunged by 97 per cent since 1990, while their energy density has nearly tripled in just 10 years.

Even more challenging sectors, such as steel production, managed to cut energy use in half between 1975 and 2015 – with reductions continuing – because of technological advances and a shift from traditional blast furnaces toward electric arc furnaces (IEA, 2020). As a result of these dramatic price and performance improvements, low-carbon technologies are becoming more economically competitive, not just more environmentally sustainable, alternatives. For example, almost two-thirds of the world's new wind and solar power plants are able to generate electricity more cheaply than the world's cheapest new coal plants (IEA, 2022a; WTO and IRENA, 2021).

The fundamental driver of this change is improvements in technology and production, which are in turn being driven by strong learning-by-doing effects. As the world gets better at building, installing and using solar panels, for example, the price falls and the technology improves. It has been estimated that every time the number of solar panels installed doubles, their price drops another 30 to 40 per cent (Naam, 2020). By helping to create a competitive, dynamic and integrated a global marketplace for solar and other clean technologies, trade plays a central

Figure A.2: The price of renewables has plunged in the last 10 years



Source: Authors' calculations, based on Lazard's Levelized Cost of Energy Analysis (2019).

role in underpinning and accelerating this process. It is significant that between 2010 and 2020, exports of solar panels increased and their prices fell sharply (see Figure A.3).

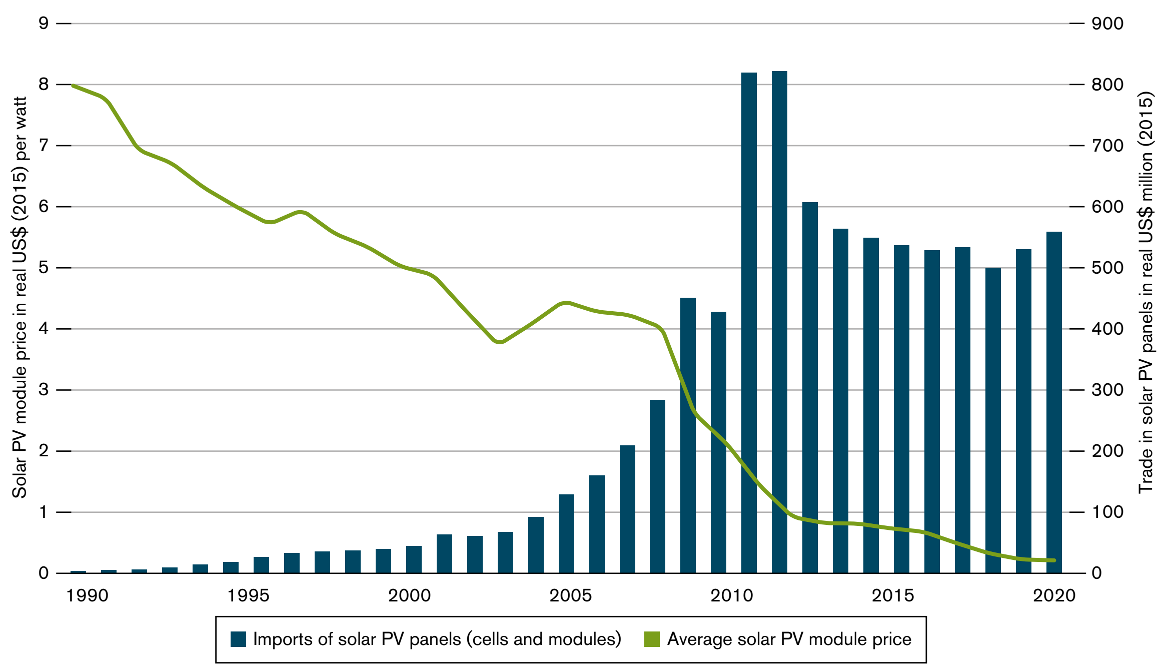
But the contribution of trade and trade policy to a just low-carbon transition could be strengthened and improved. One positive step would be to reduce trade-distorting measures on climate-friendly goods, services and technologies and to strengthen supply chains. Opening up trade across a range of low-carbon products and services would expand global access, increase competition and lower prices, making it easier and cheaper for economies to transition to low-carbon energy, mobility and production alternatives, and thus reducing overall emissions. Conversely, by making it more difficult to import key environmental technologies, e.g., by raising tariffs or imposing restrictions, the shift from a high- to a low-carbon economy will only be slowed and impeded.

Another key issue is the interface between trade and environmental subsidies and other support measures. A growing number of countries use subsidies either to encourage producers to invent, adopt and deploy low-carbon technologies, or to encourage consumers to purchase environmentally sustainable products and services. If they are well-targeted and non-discriminatory, environmental subsidies can play a positive role in scaling up new technologies and making climate-friendly products more affordable. Government incentives to insulate homes, install solar panels or buy electric vehicles are increasingly common examples.

But subsidies can also be used to support carbon-intensive production and consumption, making the climate crisis even worse. In the case of fossil fuel subsidies – which amounted to US$ 440 billion in 2021 (IEA, 2022d) – many governments find themselves in the contradictory position of encouraging oil, gas and coal industries even as they are discouraging them with carbon taxes and regulations. Moreover, subsidies can negatively impact other trade partners by distorting markets or unfairly boosting exports. The challenge is to find an optimal balance between maximizing positive spillovers from environmental support measures – both nationally and globally – and minimizing negative ones.

One of the most challenging issues is the relationship between trade and carbon pricing. Environmental

Figure A.3: As the use of solar panel exports increases, their price falls



Source: Authors' calculations, based on data on solar PV module costs from Kavlak, McNerney and Trancik (2018) and Bloomberg Terminal and trade figures from the UN Comtrade database.

Note: The trade data covers the Harmonized System (HS) code 85414.03, which does not distinguish between solar PV cells and modules and other products such as light-emitting diodes.

subsidies and carbon prices are essentially the opposite sides of the same coin. The former makes environmentally friendly purchases cheaper, while the latter makes environmentally damaging ones more expensive, all with the aim of persuading firms and consumers to switch to less carbon-intensive alternatives.

Ideally there would be a global agreement on carbon prices. Instead, close to 70 separate carbon pricing initiatives have been adopted in 46 national jurisdictions worldwide – which risks creating a patchwork of different systems, tax rates, covered products and certification procedures. As a result, countries with high carbon taxes worry that their industries will shift to low- or no-carbon tax countries – i.e., "carbon leakage" concerns. Conversely, countries with no carbon taxes worry that their exports will be unfairly shut out of carbon-taxing countries – i.e., "hidden protectionism" concerns. Although WTO rules – especially those concerning national treatment – allow tax adjustments at the border, adjusting taxes for carbon could prove far more complex than adjusting them for alcohol, for example. The challenge is to find a policy mix that balances the need to discourage carbon emissions with the need to encourage trade to support a low-carbon transition.

Arguably the most important way trade can contribute to a "just" transition to a low-carbon global economy is by helping to expand, diffuse and share technological progress. Today's world economy is an increasingly interdependent system, and climate change is the most challenging collective action problem it has ever faced. It is unrealistic, not to mention unfair, to expect poorer countries to take the same steps to curb carbon emissions as advanced ones if they lack the technological and financial resources to do so. Indeed, this is explicitly recognized in the core concept of "common but differentiated responsibilities" set out in the Paris Agreement. The developed world has a direct stake in helping the developing world to manufacture, deploy and maintain low-carbon technologies, if only because no one country can solve the climate crisis on its own. Trade cooperation is key to driving this global transformation; trade fragmentation would invariably set it back.

3. Overview of the report

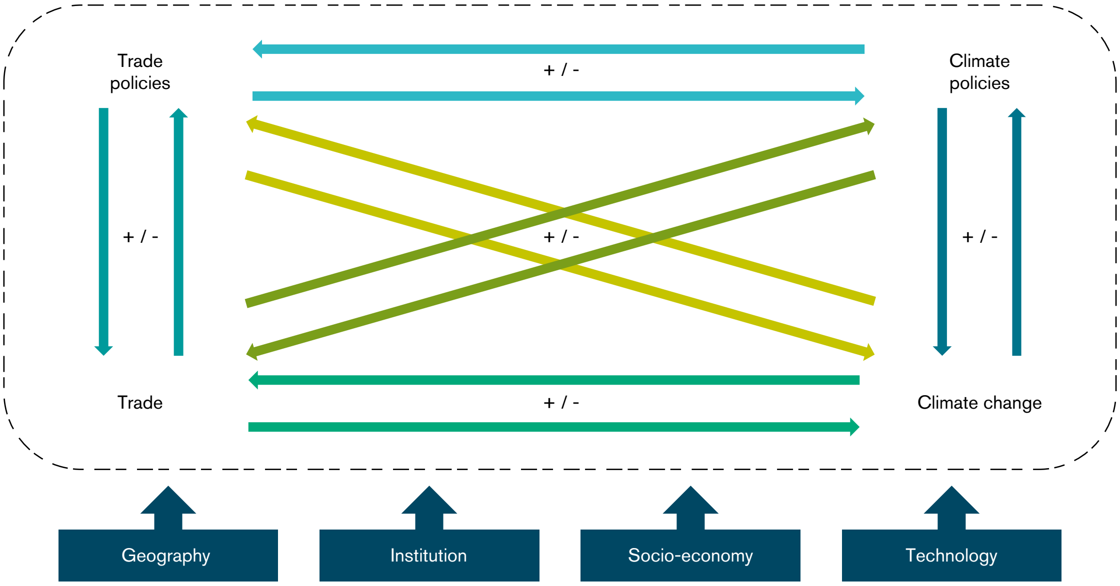
This year's *World Trade Report* looks at the relationship between climate change and trade, examines why trade is an indispensable part of the solution to tackling climate change, and discusses areas where policies need to improve. A core message of the report is that solving the climate crisis depends on a far-reaching transformation of the global economy, and that trade will be critical to driving the needed technological and economic shift to a low-carbon future.

The other core message is that this unprecedented global shift will require unprecedented international cooperation – and that there is no alternative to achieving a just transition where the costs and benefits are more evenly and equitably shared. Thirty years after the adoption of the United Nations Framework Convention on Climate Change (UNFCCC), this report underscores how the goals of environmental sustainability and economic development are not only compatible, but inextricably and mutually dependent.

Although the issue of trade and climate change is by no means new, the relationship is complex, multifaceted and fast-evolving. This is partly due to the fact that the relationship not only involves the interplay between international trade and climate change, but also covers linkages with trade policies and climate policies (see Figure A.4). Their interactions occur in several directions, with both direct and indirect mechanisms which are in part determined by geographical, institutional, socio-economic and technological conditions. The global nature of climate change further amplifies this complexity (WTO and UNEP, 2009).

The report opens with a chapter on adapting to the consequences of climate change. While reducing GHG emissions to limit the rise in global temperature to well below 2°C – and preferably to below 1.5°C – is essential to limit the consequences of climate change, past GHG emissions have already caused, and continue to cause, global temperatures and sea levels to rise, and have increased extreme weather events. Many consequences of climate change are already hard to reverse. Adapting to the changing climate and its cascading impacts is therefore a sustainable development imperative. Chapter B explores how the geophysical effects of climate change will affect international trade, and identifies the effects of such changes on trade costs, supply chains and the most vulnerable regions and sectors. It discusses ways in which international trade and trade policy can help with climate change adaptation strategies, and outlines how international cooperation, and the WTO in particular, can contribute to helping countries, and in particular developing and least-developed countries, adapt to some of the disruptive consequences of climate change.

Figure A.4: The relationship between climate change and trade is complex and multifaceted



Source: Authors' elaboration.

Mitigating climate change by reducing GHG emissions is essential but requires a large-scale transition to a low-carbon economy. Chapter C examines the role of ambitious climate change mitigation policies and well-functioning financial markets in supporting and accelerating the transition to a low-carbon economy. It discusses how the transition to a low-carbon economy could change trade patterns and provide new economic opportunities, as well as certain initial disadvantages for some economies. Such changes require enhanced international cooperation, and the WTO can play an important role in supporting climate-change mitigation efforts.

Among the many policies to mitigate climate change, carbon pricing has attracted increasing attention as it puts a price on carbon emissions as a means of reducing emissions and supporting investment into lower-carbon alternatives. Chapter D explores the role of carbon pricing in reducing GHG emissions and the relationship between carbon pricing, trade and trade policies. The necessity of developing a solution to the current patchwork of uncoordinated carbon pricing policies, which could lead to tensions in the global trading system, is discussed, as well as the importance of international cooperation to achieve convergence on global carbon pricing approaches.

While international trade separates production and consumption across space, the emissions generated in one country to produce goods and services are not necessarily the same as the ones required for its consumption. Chapter E analyses how the emissions originating from international trade can be measured, and examines how trade both contributes to GHG emissions and diffuses the technology and know-how needed to make production processes cleaner. The necessity for greater international cooperation to establish adequate carbon measurement and verification, improve carbon efficiency in transportation, and ensure the environmental sustainability of global value chains, is reviewed.

The development and diffusion of climate-friendly technologies, including renewable energy and energy efficient technologies, are key to tackle climate change. Chapter F discusses how trade in environmental goods and services can enable access, deployment and diffusion of environmental technologies, which are instrumental in mitigating carbon emissions and developing ways in which people and trade can adapt to climate change. While the WTO agreements ensure that trade in environmental technologies flows as smoothly and predictably as possible, the WTO could make an even greater contribution to promoting trade in environmental goods and services.

Endnotes

1 "Net Zero" involves reducing greenhouse gases (GHGs) to as close to zero as possible, so that any GHGs that are produced can be absorbed from the atmosphere. GHGs are gases in the atmosphere such as water vapour, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) that can absorb infrared radiation, trapping heat in the atmosphere. This greenhouse effect means that emissions of GHGs due to human activity cause global warming. The species of gases reported under the common reporting format of the United Nations Framework Convention on Climate Change (UNFCCC) are: CO_2 from fossil fuel combustion and industrial processes (CO_2-FFI); net CO_2 emissions from land use, land-use change and forestry (CO_2-LULUCF); methane (CH_4); nitrous oxide (N_2O); and fluorinated gases (F-gases), comprising hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3) (IPCC, 2022a). Although carbon dioxide is the primary GHG emitted through human activities, methane has become an emerging GHG given its more potent heat-trapping ability.

2 It has been pointed out that economic authorities have dramatically underestimated the rapid expansion and declining costs of renewables every year since 2000 (Beinhocker, Farmer and Hepburn, 2021).

B The role of trade in adapting to climate change

While reducing greenhouse gas emissions is essential to limit the consequences of climate change, climate change is already having a major impact on the environment, people and, as a result, the global economy. This chapter explores the impacts of climate change on international trade and discusses the role that trade, trade policy and international cooperation can play in supporting climate change adaptation strategies. Climate change increases trade costs and disrupts production and supply chains. However, trade and trade policies, in conjunction with relevant policies and international cooperation, can help to alleviate some of the impacts of climate change, including on food security, by contributing to enhancing economic resilience.

Contents

Key facts and findings

- Climate change can impact international trade by affecting trade costs, altering comparative advantages, and disrupting global value chains. A rise of 1°C has been found to reduce the annual growth of developing countries' exports by between 2.0 and 5.7 percentage points.
- Climate change adaptation encompasses actions that reduce the negative impacts of climate change, while taking advantage of potential new opportunities.
- International trade can help support climate change strategies, such as prevention and reduction of, and preparedness for, climate risk, as well as recovery and rehabilitation from climate disasters. Trade can also contribute to strengthening food security during climate-induced supply-side disruptions.
- Although climate change adaptation initiatives are mostly locally-led, international cooperation is essential to enhance the resilience of international trade with regard to climate-induced shocks and to improve economies' capacity to adapt to climate change.

1. Introduction

The consequences of climate change, including global warming, rising sea levels and extreme weather events (EWEs), are already tangible and are affecting lives, livelihoods and ecosystems around the world. The future holds higher global temperature, a faster sea level rise, more frequent and intense EWEs, and other short- and longer-term climate hazards (IPCC, 2021). Although reducing greenhouse gas (GHG) emissions is necessary to mitigate climate change and limit the most severe consequences of climate change, finding ways of adapting to climate change and its current and future consequences is a sustainable development imperative.

This chapter discusses how climate change can affect international trade through productivity alteration, supply chain disruptions, changes in trade costs and modified comparative advantages. It then reviews how international trade and trade policy can support climate change adaptation strategies. The chapter concludes by examining the role of international cooperation, and in particular that of the WTO, in helping with climate change adaptation.

2. Why does climate change adaptation matter?

Climate change is not only an environmental problem, but also a systemic risk affecting people and the economy. Its effects on international trade can already be seen. Global warming reduces capital and labour productivity, and EWEs can disrupt transport infrastructure. Without adaptation and mitigation, these effects will continue to increase in the future, impacting trade costs and factors of comparative advantage.

(a) Climate change has severe effects on people and the economy

Climate change affects almost all aspects of human life. Between 2030 and 2050, climate change could cause 250,000 additional deaths per annum as a result of malnutrition, malaria, diarrhoea and heat stress alone (WHO, 2018). It may also have severe social and political implications, including domestic or communal violence, resulting, for example, from forced migrations from one region to another due to rising sea levels or drought, especially in countries with weak property rights (see Box B.1) (Burke, Hsiang and Miguel, 2014).

Climate change poses a severe threat to the global economy. Projections by the OECD suggest that a warming of between 1.6°C and 3.6°C above pre-industrial levels by 2060 could cause global annual GDP losses of between 1 and 3.3 per cent relative to a hypothetical reference scenario in which climate change damages do not occur (Dellink, Lanzi and

Box B.1: Climate change impacts on security in the Sahel

The Sahel is a semi-arid transition zone dividing the Sahara Desert to the North and tropical Africa to the South. Agriculture and cattle-herding remain the main economic pillar of the region. Food, water and energy availability, and ultimately security in the region, are at risk as a consequence of climate change (Rose, 2015).

Successive years of poor rainfall and frequent droughts have pushed pastoralist populations to migrate to more humid regions for longer periods of time (Brottem, 2016; Nyong, 2007). Migrations of herders to land occupied by sedentary farmers can lead to conflicts over land use and other resources (Nyong, 2007). Confrontations tend to occur periodically, particularly around water resources and fodder, and in areas with a lower level of agricultural productivity (Nyong, Fiki and McLeman, 2006).

Climate change is expected to exacerbate these issues by extending the annual dry season and, thus, the period during which the same land is used both for maturing crops and for roaming cattle, further increasing the risk of conflict. A 1°C rise in temperature has been found to increase the probability of conflict between farmers and herders by 54 per cent in the Sahel, compared to a 17 per cent increase in the probability of conflict in places where farmers and herders do not have to compete over access to limited land and water resources (Eberle, Rohner and Thoening, 2020). Such conflicts limit the ability of local communities to adapt to climate change, potentially creating a “climate-conflict trap” (Granguillhome et al., 2021).

Climate change-induced instability can also affect trade, including small scale cross-border trade. Conflicts destroy food supply and the production capacity of farms, and ultimately deter investment across the agricultural value chain (Kimenyi et al., 2014). Such instability in agricultural markets often translates into increased food prices, which affect the poorest households disproportionately. In this context, risk management strategies, including climate-resistant agricultural investment, crop diversification, insurance and safety nets, can help farmers adapt to climate change, while mitigating conflict risks.

Chateau, 2019). Although the range of projected GDP losses at the global level is broadly consistent in the literature,[1] such projections are necessarily speculative, due to the uncertainty of how climate change will progress and how economies will adapt. Projections also vary based on modelling and calibration approaches. There is also considerable heterogeneity in projections across regions. For example, GDP losses are expected to be much higher in regions highly exposed and vulnerable to weather-related hazards and with lower resilience to losses, such as the Middle East and North Africa, South and Southeast Asia, and Sub-Saharan Africa (Dellink, Hwang, et al., 2017). The most vulnerable populations, in particular those in developing countries and in small-island developing states (SIDS), are likely to bear a disproportionate share of the burden due to their higher exposure and lesser capacity to adapt to climate change.

(b) The impacts of climate change on trade are heterogenous across regions and sectors

Climate change, both in terms of gradual changes – such as temperature and sea level rise or changes in precipitation regimes – and in terms of the increasing frequency and intensity of EWEs, can have severe effects on trade. In the short term, the damage caused by EWEs can reduce productivity, increase trade costs and disrupt supply chains. In the long term, climate change can affect trade through its impact on factor endowments and comparative advantage. As discussed by Danae Kyriakopoulou in her opinion piece, the risk of inaction in climate change has profound implications on international trade.

(i) Climate change will alter patterns of comparative advantage, leaving some economies at a disadvantage

The availability and productivity of arable land, water, capital and labour are being affected by climate change, and the effect differs across regions. Higher temperatures and the increased frequency and intensity of droughts, floods and rain are degrading land quality in some regions and reducing crop yields (Sleeter et al., 2018). Rising temperatures and sea levels and melting glaciers are altering the hydrological cycle (i.e., the circulation of water between the ground and the atmosphere), leading to flooding and loss of land. Meanwhile, groundwater reservoirs are declining in regions with low water runoff. Overall, the distribution of water is expected to become even more uneven (Lall et al., 2018; World Bank, 2016).

Human exposure to increased temperatures reduces labour productivity by diminishing capacity for physical work and mental tasks and by increasing the risks of accidents and of heat exhaustion or stroke (Kjellstrom, Holmer and Lemke, 2009; Somanathan et al., 2021; UNDP, 2016). Empirical evidence suggests that for every 1°C temperature rise above 25°C, labour productivity falls by 2 per cent (Seppanen, Fisk and Faulkner, 2003). One measure of adaptation to counteract the impact of increasing temperatures on human capital productivity is an increased use of energy-efficient air conditioning in workplaces. But this would entail higher costs both in terms of acquiring air conditioning systems and of energy costs to run them, with a consequent loss of competitiveness for firms.[2]

Rising temperatures may also reduce capital productivity. For example, higher temperatures can cause heavy machinery to overheat more often, requiring more frequent and longer cool-down periods. Outdoor infrastructure may depreciate faster, which would reduce its lifespan (IPCC, 2014a). Overall, the impact of climate change on trade through changes in productivity channels depends on the geographical localization of countries and on what they produce, and this is likely to alter comparative advantages.

Changes in the patterns of demand, beyond changes in production specialization, will also matter to shape the impact of climate change on trade. In this respect, a country's reliance on trade with climate-vulnerable countries and communities, and its levels of global integration more broadly, will also matter, as they determine the exposure of that country to climate impacts from abroad. In this regard, trade can be a channel through which climate change damages can spread across countries (Schenker, 2013; Schenker and Stephan, 2014; WTO, 2021c).

The impact of climate change is expected to be stronger on countries in lower-latitude regions, many of which are developing economies whose comparative advantage stems from climatic or geophysical factors. Based on projections, an increase in global temperatures of 2.5°C by 2060 could decrease export volumes by as much as 5 to 6 per cent for countries in South Asia and Sub-Saharan Africa, 3 to 4 per cent for the Middle East, North Africa, and South-East Asia, and 2 per cent in Latin America, compared with less than 1 per cent in Europe and North America (Dellink, Hwang, et al., 2017). However, the complex set of linkages that exist within and across economies makes it particularly difficult to predict to what extent an economy will gain or lose competitiveness in a given sector in response to a climate-related shock. At

OPINION PIECE

By Danae Kyriakopoulou

Senior Policy Fellow at the Grantham Research Institute on Climate Change and the Environment at the London School of Economics and Political Science, Advisory Council member at the Official Monetary and Financial Institutions Forum Sustainable Policy Institute, and Young Global Leader of the World Economic Forum

Climate inaction: implications for international trade

The pandemic-related disruption of supply chains and the political imperative to reorient partnerships following the outbreak of the Ukraine war have exposed the vulnerability of global trade to risks originating outside of the economy. Climate-related risks are increasing in frequency, intensity and geographic spread. Unlike the pandemic and the war, we can anticipate and manage them, albeit against a diminishing window of opportunity.

Policies aimed at mitigating climate change and adapting to its effects are occasionally dismissed as "too costly". In a post-pandemic environment of stressed finances for governments, businesses and households, an "expensive and unaffordable green transition" makes an easy target. Such narratives are dangerously short-sighted: delaying climate action bears the much greater opportunity cost of inaction.

Continuing with "business as usual" is becoming visibly more costly, not only in terms of the natural environment, but also in the global economic, financial and trade system. The trade implications of more frequent and intense extreme weather events (EWEs), of gradual climatic changes and of policy adjustments, such as climate-driven taxes and regulation, are already manifesting through multiple channels. EWEs, such as hurricanes and floods, are directly damaging critical infrastructure, including roads, bridges, ports, railway tracks and airports. More frequent disruptions hurt both goods and services trade, such as tourism. Food and agriculture trade is particularly exposed to heatwaves and droughts that can affect crop yields and tempt countries to restrict exports. In May 2022, India – a major wheat producer – banned exports on the grounds of national food security amid a heatwave.

But there doesn't have to be a natural disaster for there to be an economic one: gradual changes in temperature that expose capital equipment and labour to heat stress, or increase cooling costs in storage facilities, can also hurt productivity and disrupt global value chains (GVCs). Economies whose comparative advantage is tied to climatic processes are highly exposed: degraded land and water stress will impact agriculture, while ecosystem damage and shifts in weather conditions will affect tourism in sea or ski resorts. Such processes can shift patterns of comparative advantage and structurally change global trade.

While some risks can be partly managed by diversifying supply chains and building buffer stocks, these strategies have limits and would involve compromising on the fundamental building blocks of the modern trade system: specialization according to comparative advantage, economies of scale, and optimizing of global value chains (GVCs).

And it is not just the physical climatic disruptions that threaten global trade, but also the so-called "transition risks" inherent in the changing strategies, policies or investments needed in the green transition. The uneven pace of climate action across countries has led some governments to consider border carbon adjustment measures involving charges on imports and/or export rebates, to level the playing field among firms subject to different climate-related regulations and taxes. Such measures, while addressing carbon leakage, can unravel trade patterns by incentivizing re-shoring or short-circuiting supply chains.

The risks of inaction highlight the urgent need to redesign our economies in a way that works for the planet and its people, now and for the future. But this is not only a negative story about risks. It is a growth, investment and trade story of change towards a future that is enormously attractive, with more productive economies, healthier societies and more fruitful ecosystems.

the same time, understanding the mechanism through which this happens provides insights as to which economies are most at risk.

Whether an economy gains or loses comparative advantage in a given sector depends broadly on its initial productivity, and how its productivity and prices respond to a climatic change relative to other competing economies. It also depends on the linkages between different economic sectors, both within and across regions. For example, an analysis of the relative ability of a country to produce food products vis-à-vis its trading partners, commonly known as revealed comparative advantage (RCA),[3] shows that, in the case of an increase in global temperatures of 2.5°C by 2060, RCA could increase for some economies. However, it could also decrease for other economies faced with a similar agricultural yield shock if the latter depend more on domestic agricultural output for exports of manufactured food products. These impacts could be further amplified by the negative effect of climate change on income and, thus, on final demand (Dellink, Hwang, et al., 2017).

Geography-related temperature levels are a driving force behind the disproportionate impacts of climate change on developing economies and least developed countries (LDCs). Since the current temperatures in many developing economies and LDCs are already higher than in developed ones, the marginal negative impact of increasing temperatures on the former is also higher (while some developed countries in colder northern regions may even experience productivity gains in some sectors). A given temperature increase is likely to cause productivity to decline more in developing economies and LDCs, as their productivity in non-agriculture sectors is often lower than in developed economies, meaning these economies would lose not only their existing comparative advantages, but would also find it particularly challenging to develop comparative advantage in other sectors (Conte et al., 2021; Schenker, 2013). Since productivity losses and gains tend to be geographically concentrated, and neighbouring economies tend to trade more with each other than with more distant economies, losses and gains in trade are likely to be shaped by geographical patterns of productivity changes, which could increase international inequalities (Dingel, Meng and Hsiang, 2019).

These impacts can be amplified by economic factors such as commodity dependence or a lack of diversification (UNCTAD, 2019). Countries that have less diversified exports tend to be generally more vulnerable to climate change (see Figure B.1). For instance, Sub-Saharan Africa, in which most countries' exports are dominated by the agriculture, energy or mineral sectors, is one of the regions most exposed to climate change.

(ii) Climate change is likely to increase trade costs unevenly across regions

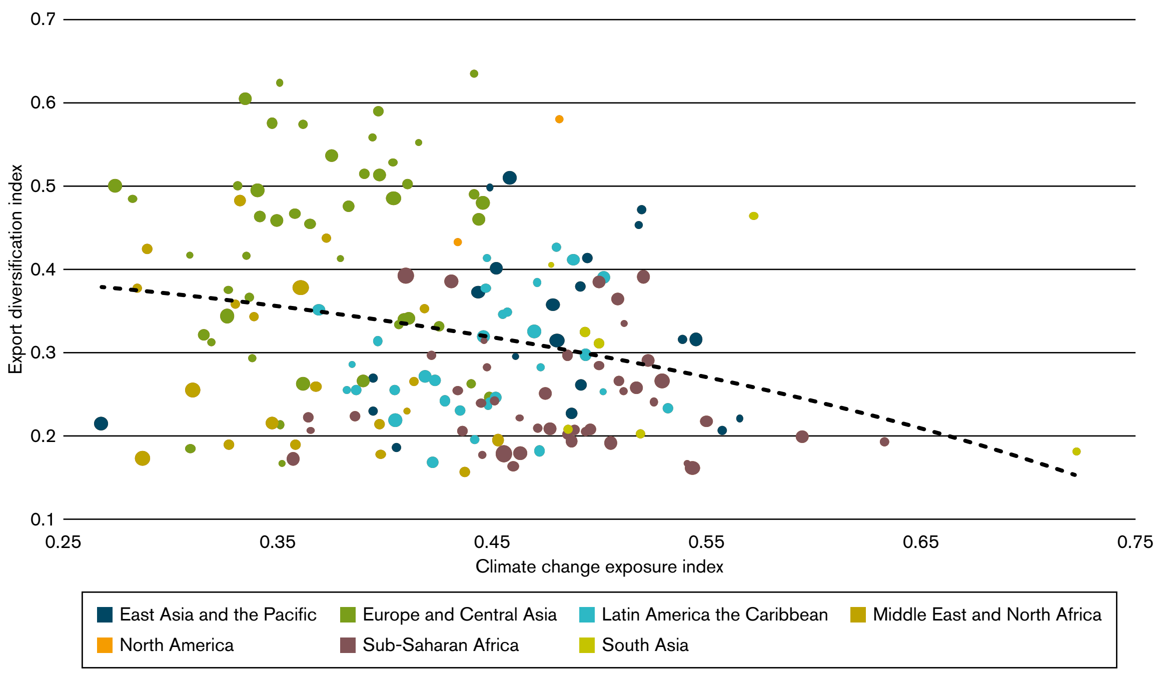
Transport infrastructure is dangerously at risk of damage both from gradual climatic changes and from EWEs (Koks et al., 2019; WTO, 2019). Increasing temperatures can cause roads, bridges, runways and railway tracks to depreciate faster. Transport infrastructure and inland waterways can become partially or completely inoperable due to EWEs and sea level rises in coastal regions (EEA, 2017; IPCC, 2014b). Climate change will increase infrastructure maintenance and repair costs, indirectly adding to trade costs. The unpredictability of damages related to EWEs is a source of uncertainties and high operational risks that can increase disruptions and delays, and in turn create additional costs, such as requirements for freight insurance (Barrot and Sauvagnat, 2016; Boehm, Flaaen and Pandalai-Nayar, 2019; WTO, 2021c). In particular, climate change can affect strategically important junctures on transport routes through which exceptional volumes of trade pass in the global trade network,[4] and this can create vulnerabilities for the trade system (Bailey and Wellesley, 2017).

While all modes of transport are likely to be negatively affected by EWEs, maritime transport – which accounts for 80 per cent of world trade by volume – is particularly vulnerable and exposed to climate change. In a worst-case "high emission" scenario where GHG emissions continue to rise unchecked and global temperatures rise by around 4°C by 2100, the number of ports at extremely high, very high or high risk from multiple climate hazards could almost double, from 385 to 691 key ports globally (out of 2,013 examined) (Izaguirre et al., 2021).

Greater heat stress and increased coastal flooding and overtopping due to sea level rise, can have a strong impact on waterways and port capacity, and negatively impact trade by exacerbating bottlenecks, capacity constraints, congestion and delays, thereby increasing trade costs. For example, in the three months following Hurricane Katrina in 2005, Gulfport and the Port of New Orleans saw a direct reduction of between 71 per cent and 86 per cent of both exports and imports due to the destruction of their port facilities, although there was no overall impact on aggregate US trade because other ports took up the slack (Friedt, 2021).

However, while developed and larger economies tend to have a more diversified and resilient transport infrastructure, small or landlocked countries, whose

Figure B.1: Economies with less diversified exports tend to be more exposed to climate change



Source: Authors' calculations, based on ND-GAIN Climate Vulnerability Index and IMF Export Diversification Index for 2014.

Note: The climate change exposure index measures how much societies and economies will be stressed by the physical impacts of climate change. The size of the dots represents each country's vulnerability to climate change. The climate change vulnerability index considers countries' exposure to climate change, their sensitivity to related impacts, and their adaptive capacity.[5] The export diversification index ranges from zero (no diversification) to one (complete diversification).

trade flows through a limited number of ports and trade routes, are especially vulnerable in this regard (Bahagia, Sandee and Meeuws, 2013; Izaguirre et al., 2021). For instance, the Paraná River, which transports 90 per cent of Paraguay's international trade of agricultural goods, 85 per cent of Argentina's and 50 per cent of Bolivia's, now frequently reaches very low levels due to recurrent severe droughts. Shallow water forces cargo ships to operate at half or lower capacity in order to navigate and transport agricultural commodities and other goods, causing significant congestion and delays around the waterways and ports (Batista and Gilbert, 2021). Other rivers, including the Danube and the Rhine, are experiencing similar situations with low water levels, making it impossible for many vessels to operate.

Although climate impact on transportation is expected to be largely negative, climate change could positively affect some regional transportation networks (WTO, 2019). For instance, a reduction in sea-ice may lead to the availability of new and shorter shipping routes. In the Arctic, the ice cap loss caused by warmer temperatures could open up the possibility of a northwest passage during portions of the year, which would reduce maritime shipping times and distances between parts of Asia and Europe by up to 40 per cent (Rojas-Romagosa, Bekkers and Francois, 2015). However, the benefits of these new routes remain uncertain because of factors such as underdeveloped communication and transportation infrastructure in the region and reduced speeds and potential damage to ships due to hazardous sailing conditions. Increased shipping activity in the region could also have adverse consequences for ecosystems.

(iii) Trade in agriculture and tourism are particularly vulnerable to climate change

If temperatures continue to rise in the absence of robust adaptation measures, climate change will have profound effects on trade in agriculture. Existing models emphasize two potential effects.

First, the effects of climate change on trade in agriculture are heterogenous across regions. For countries that would experience a loss in agricultural productivity, or negative yield shock, all else being equal, the impact on trade could depend on the magnitude of the shock relative to that experienced in other countries. Sub-Saharan Africa and South

Asia are the regions often projected as the most vulnerable to climate change effects. Economies in these regions are reliant on exports of agriculture, but are also major importers of agricultural commodities for domestic consumption. They are expected to suffer larger negative yield shocks compared to other regions (IPCC, 2022a; Jägermeyr et al., 2021). This means that as their production suffers, their exports could decline, forcing them to import more to meet domestic demand (Dellink, Chateau, et al., 2017; Gouel and Laborde, 2021; Hertel, 2018).

Second, under more severe climate damages, only a few economies in colder regions would experience productivity gains in agriculture. In such a scenario, international markets for agriculture could become concentrated, with few dominant exporters (FAO, 2018a).

Climate change is also likely to increase agricultural trade volatility. By increasing the risk of simultaneous failure of crop systems in multiple grain- or food-producing economies, climate change increases concerns about food security (Adams et al., 2021). For instance, the possibility of simultaneous production losses greater than 10 per cent happening in the four largest maize-exporting economies in any given year could increase from 0 per cent to 7 per cent as a result of global warming of 2°C, and to 86 per cent as a result of global warming of 4°C (Tigchelaar et al., 2018). Such an occurrence would cause widespread shortages and a surge in world prices of these commodities. This is especially worrisome in view of the evidence that governments often react to rising food prices by imposing export restrictions, which would exacerbate these effects (Giordani, Rocha and Ruta, 2012). Such higher global prices can make it even more difficult for net food-importing developing countries to purchase food (Welton, 2011).

Since climate is an important factor in the choice of tourist destinations, tourism is also expected to be affected by moving towards higher altitudes and latitudes as climactic zones shift northward (Biango, Hamilton and Tol, 2007; Hamilton, Maddison and Tol, 2005). Due to increasing temperatures, traditional summer destinations may lose their appeal in summer months but become more suitable in other seasons. More favourable climates in northern regions may also divert tourist flows, further increasing competition between tourist destinations. For instance, as the Atlantic and Northern European coasts become warmer, they could gain tourists at the expense of Mediterranean beach destinations which are becoming too hot (EEA, 2017). Similarly, warmer winters are a risk to winter and mountain destinations (WTO, 2019).

Low-lying island nations whose economies are highly dependent on tourism are particularly vulnerable to climate change. Sea level rise and EWEs could make these destinations permanently unattractive to visitors by causing damages to tourism infrastructure and sites. For example, in Pacific island countries, such as the Marshall Islands, Kiribati and Tuvalu, over 95 per cent of the built infrastructure is located in coastal regions vulnerable to risks caused by sea level rise and EWEs (Kumar and Taylor, 2015; Wolf et al., 2021).

(iv) Manufacturing sectors are exposed to climate-induced global value chain disruptions

Manufacturing sectors tend to be less vulnerable to climate change, partially because of a lower sensitivity and higher adaptive capacity to climatic variability. However, industrial sectors dependent on climate-sensitive inputs (such as food processing), labour-intensive sectors and sectors highly integrated into global value chains (GVCs) are likely to be affected. For example, export growth of agriculture products (e.g., cereals, dairy and eggs, leather, animal feed) and light manufacturing (e.g., clothes, shoes, furniture, consumer electronics and home appliances) from low-income economies to the United States have been found to decrease by between 2 and 5.7 per cent in response to a 1°C temperature increase (Jones and Olken, 2010). While the impact of temperature increase on agriculture-related exports is generally a result of climate-induced damage to agricultural productivity, the impact on light manufacturing trade is likely a result of reduced labour productivity at higher temperatures.[5]

Climate change will also affect the manufacturing sectors through disruptions in supply chains. For instance, the 2022 floods in Pakistan destroyed approximately 40 per cent of the country's cotton crop, severely impacting the textile industry – Pakistan's largest export – which relies heavily on domestic cotton production for raw materials. Adverse effects of local weather events can, under certain conditions, propagate along supply chains and across countries (WTO, 2021c). For example, in 2011, flooding in Thailand disrupted the global electronic and automotive industries, causing an 80 per cent decline in year-on-year global production in November 2011 (McKinsey Global Institute, 2020) and an estimated 2.5 per cent decline in global industrial production growth (Kasman, Lupton and Hensley, 2011). Japanese manufacturers, heavily dependent on intermediate inputs from Thailand, produced at least 423,000 fewer cars in 2011 because of the floods (Haraguchi and Lall, 2015).

Among GVC-intensive sectors, the potential impacts of climate-induced GVC disruptions are more severe, with effects lasting up to many months, for relation-specific supply chains than for other types of supply chains[6] because each supplier manufactures a unique and highly differentiated input that is difficult to replace in the short term. For instance, the supply chain of advanced semiconductors is relation-specific, with many components manufactured in the Asia-Pacific region. The probability of disruptive hurricanes in these manufacturing hubs is expected to increase two to three times by 2040. Any disruption could have cascading effects. For a five-month supply disruption, downstream industries could lose between 5 and 30 per cent of their revenue, depending on their level of preparation (McKinsey Global Institute, 2020).

Climate-induced supply chain risks can be further exacerbated by firms' limited capabilities to assess emerging risks from climate change and adopt risk management strategies. Firms, including in developed economies, do not always prioritize climate change as an operational risk (Tenggren et al., 2020). In addition, the complex structure of many supply chains makes comprehensive climate-related risk assessment and management particularly challenging.

3. International trade and trade policy can support climate change adaptation strategies

Even if the Paris Agreement's long-term goal of limiting the rise in global temperature to well below 2°C – and preferably to below 1.5°C – is met, past GHG emissions have already caused, and continue to cause, global temperatures and sea levels to rise, and more frequent and intense EWEs, making climate change adaptation an imperative. Climate change adaptation strategies encompass actions that reduce the negative impact of climate change, while taking advantage of potential new opportunities that climate change might create. Reducing the consequences of climate change can be achieved by identifying, preventing and reducing actual or expected climate risks, exposure and vulnerabilities, and by being prepared to cope with the effects of climate change and to minimize unavoidable losses and damages from climate change by adjusting existing systems (IPCC, 2007a, 2022b).

In practice, adjusting existing systems means adapting the behaviours of people, firms and governments, and modifying infrastructure to deal with the current and future changing climate.[7] Common examples of adaptation strategies include early warning and information-sharing systems, flood risk control, insurance, the introduction of new crop varieties, livelihood diversification, soil and water conservation, and sustainable forest management.

Although climate change adaptation and mitigation are often considered separately, they can be considered as two sides of the same coin. For instance, well-managed afforestation and reforestation can increase carbon storage capacity, while at the same time reducing exposure and vulnerability to weather-related risks, such as landslides.[8] Given the urgency to scale-up climate change actions, synergies between climate change adaptation and mitigation can help achieve climate resilience more effectively.

While international trade affects climate change (see Chapter E), it can also play an important role in climate risk prevention, reduction and preparedness, and in climate disaster recovery and rehabilitation, even though the consequences of climate change will remain disruptive and costly. Trade can help strengthen food security, and facilitate access to essential goods and services after EWEs hit. In that context, trade policies can also be integrated into climate change adaptation strategies. However, other coordinated policies and actions are important to mitigate the costly adjustment to changes caused by climate change.

(a) Trade can support climate change adaptation actions through economic growth

Adapting to climate change requires important investment in infrastructure to increase resilience and reduce vulnerability at the community, local, regional, sectoral and national level. Investing in improved climate resilience offers a significant cost-benefit ratio, ranging from 2:1 to 10:1, and in some cases even higher, since it can avoid far worse damage later on (GCA, 2019). Yet, efforts to adapt to the impacts of climate change are still lagging.

Although developing countries are considered to be those most vulnerable to a rapidly changing climate, progress in climate change adaptation strategies tends to be more frequently and rapidly achieved in advanced economies. For many developing countries, lack of finance remains an obstacle to invest in climate change adaptation.

In this context, international trade, as a driving force for sustained economic prosperity,[9] can indirectly help economies steer some of their financial resources towards climate change adaptation strategies. Developing economies that opened up to trade have, on average, enjoyed a 1 to 1.5 per cent higher rate of growth, culminating in 10 to 20 per cent higher growth after a decade (Irwin, 2019). Higher economic growth can, in turn, provide financial support and material preparation for essential climate change adaptation, such as investment in climate-resilient infrastructure.

(b) Trade can enhance economic resilience to climate change shocks

International trade can help countries prepare for, cope with and recover from climate-related shocks more effectively. Risk prevention and reduction can be achieved by explicitly integrating risk management into decision-making, including financial appraisal of risks and early warning systems. Climate risk screening, resilience performance rating or sustainability standard can be used to identify climate risks and evaluate and reward resilience attributes of public and private investments (World Bank, 2021). In parallel, preparedness encompasses strategies and actions effectively designed to anticipate, respond to and enable recovery from the impacts of likely, imminent or current climate-related shocks. Some of these strategies can include developing disaster responses and contingency plans, identifying priorities and reviewing insurance coverage. In that context, trade in services, including weather forecasting, insurance, telecommunications, transportation, logistics and health services, can play a key role in the preparation of firms, citizens and governments for climate-related shocks (WTO, 2021c).

When an extreme weather-related shock hits, international trade can, under certain conditions, spread its effects across countries, but at the same time it can contribute to making economies more resilient by ensuring the timely availability of essential goods and services. Imports provide a vital channel for increasing the availability of goods and services that may be in short supply in a disaster-struck country. Such goods and services include food, medical supplies, emergency equipment and expertise to aid relief and recovery efforts. Efficient customs clearance, transit procedures and public procurement processes are essential for trade to play this role effectively.

Allowing trade to resume faster in the aftermath of climate-induced shocks and disruptions can be an important economic stimulus that supports economic recovery (WTO, 2021c). For instance, facilitating imports of construction materials can contribute to sustaining infrastructure and post-disaster reconstruction.

(c) Trade can contribute to improving food security arising from changing comparative advantages

Open trade can help countries to adapt to changes in comparative advantages caused by climate change, and to benefit from potential new opportunities, although systemic cascading risks from climate change will remain. Extreme heat has been found to reduce productivity in manufacturing and services less than in agriculture, which could ultimately change countries' comparative advantages (Conte et al., 2021; Nath, 2022), as warmer countries could be forced to adapt to climate change by shifting domestic production toward manufacturing and services, while increasing food imports from relatively more temperate regions. Some developing countries have already started to shift away from agriculture and manufacturing towards services. High trade costs could, however, prevent such trade-related adjustments (Conte et al., 2021), as countries more exposed to the direct impacts of climate change tend to bear higher trade costs (see Figure B.2).

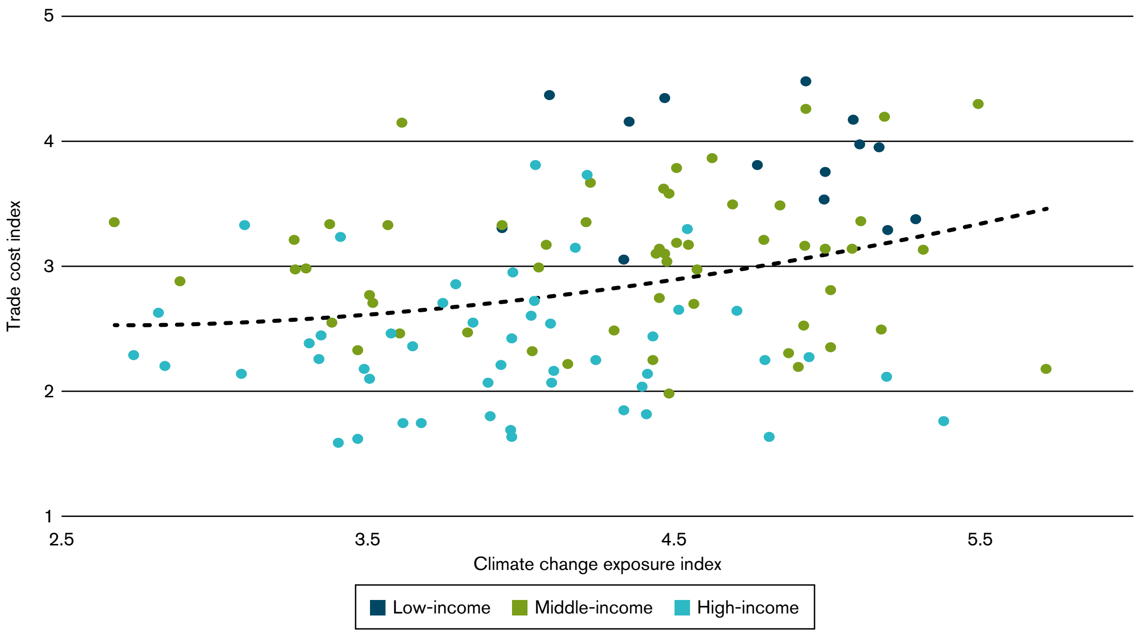
Policies aimed at reducing trade costs can support part of the adjustment caused by changes in comparative advantages due to climate change, while minimizing changes in patterns of consumption through imports, and thus potentially minimizing welfare losses. Simulations suggest that reducing trade costs in lower-income economies would, all things being equal, reduce their welfare losses caused by climate change by up to 68 per cent (Nath, 2022). Promoting trade could also reduce the incidence of climate-induced migrations, as trade and international labour mobility tend to be substitutes rather than complements (Conte et al., 2021).[10]

Trade and well-functioning markets can contribute to improving food security across multiple dimensions, including food availability, nutrition, access and utilization (FAO, 1996; 2018b, 2018c). Trade can directly contribute to improving the availability of food by easing its movement between surplus and deficit economies. However, low levels of purchasing power among vulnerable population groups are likely to be further exacerbated by climate change and continue to compromise people's access to food.

(d) Trade can facilitate the acquisition and deployment of technologies that can contribute to climate change adaptation

Adapting to climate change can require adopting specific technologies to adjust existing systems

Figure B.2: Countries more exposed to climate change tend to face higher trade costs



Source: Authors' calculations, based on ND-GAIN Climate Vulnerability Index and WTO Trade Cost Index for 2017.

Note: The climate change exposure index measures how much societies and economies will be stressed by the physical impacts of climate change. The trade cost index measures the cost of trading internationally relative to trading domestically.

to deal with current and future consequences of climate change. For instance, technologies that can offset negative agricultural yield shocks include crop varieties with higher heat or salinity tolerance, early warning system for biopesticide use, fertilizers and machinery, as well as irrigation, water conservation and storage systems (Kuhl, 2020). Trade and trade policies can increase access to these technologies, especially in countries most vulnerable to climate shocks. The removal of unnecessary barriers to trade could improve farmers' access to new technologies and reduce their exposure to climate-induced shocks. For example, barriers to trade in seeds, such as inconsistent or unnecessarily strict control procedures, can cause delays that reduce seed yield and productivity (Brenton and Chemutai, 2021).

Another potential mechanism for technology transfer is participation in GVCs (Sampson, 2022). GVC integration can facilitate access to foreign non-codified knowledge and technology transfers for firms to optimize production processes, help boost domestic innovation through international knowledge spillovers, and enhance absorptive capacity for new technologies (Branstetter and Maskus, 2022; Piermartini and Rubínová, 2022). For instance, some large retailers are collaborating with their food suppliers on resilient strategies to better manage growing conditions, improve yields and reduce the need for fertilizers.[11]

(e) Trade policies can be integrated into climate change adaptation strategies

By their very nature, climate change adaptation policies are varied. Although there is no comprehensive typology of climate change policies, they can be broadly classified into three types: structural, social and institutional (IPCC, 2014a). Structural and physical measures include, among other things, the application of technologies and the use of ecosystems and their services to serve adaptation needs (e.g., reforestation). Social measures target the specific vulnerabilities of disadvantaged groups and propose solutions (e.g., increasing investment in education and improving labour mobility). Institutional measures relate to specific economic and regulatory policies, which foster investments in adaptation to climate change. In that context, trade policy can also support climate change adaptation actions.

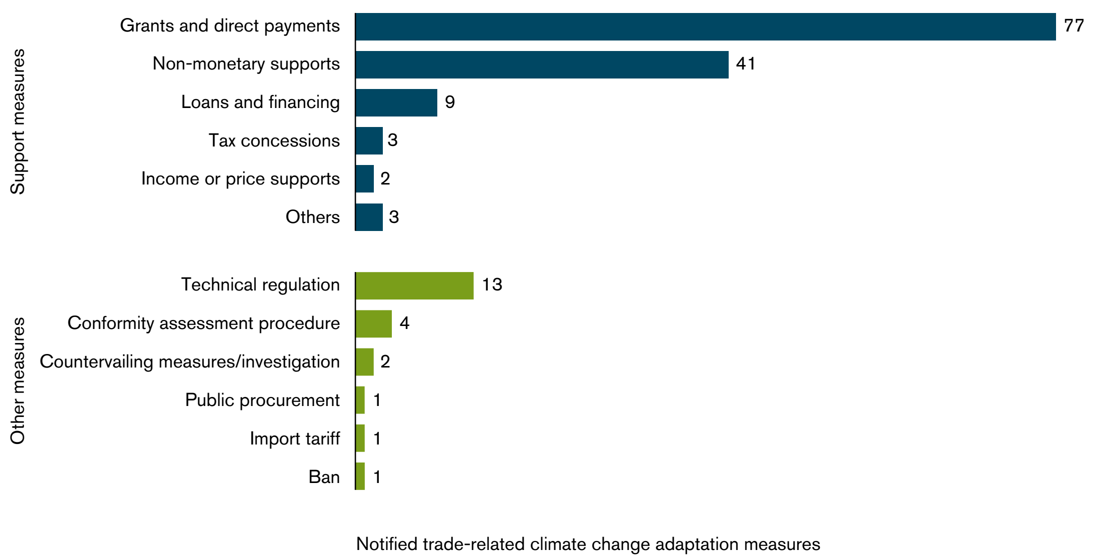
A review of all explicitly environment-related trade measures notified by members to the WTO between 2009 and 2020 shows that, while a large majority of notified climate change-related trade measures relate to mitigation, only 3 per cent of all notified climate-related trade measures (161 out of 4,629) can be explicitly linked to climate change adaption.[12] Trade-related climate change adaptation measures predominantly take the form of support measures, with more than three-quarters of notified measures covering grants and direct payments, non-monetary support and/or loans and financing. Technical regulations and conformity assessment measures are other common types of adaptation measures (see Figure B.3). More than half of the notified climate change adaptation measures cover the agricultural sector, illustrating its vulnerability to climate change and its need to adapt.

While international trade can be an important component of climate change adaptation strategies, trade policies alone cannot reduce the negative impact of climate change and help take advantage of potential new opportunities. Other policies and actions are essential to adjust to current or expected effects of climate change. Macro-fiscal policy planning is important to address climate adaptation, such as identifying contingent liabilities from natural disasters and environmental shocks, developing a financial strategy to manage contingent liabilities and evaluating climate and disaster risks of the financial system (Hallegatte, Rentschler and Rozenberg, 2020).

In that context, ensuring mutual supportiveness between economic policies, including trade policies, and climate change adaptation policies is essential to strengthen the role of trade while addressing broader challenges of adaptation (see Box B.2). For instance, the role of international trade in improving food security can be strengthened by improving the functioning of markets for food and agriculture, including by reducing distortions,[13] improving competition, and ensuring that the true costs of food and farmed goods are reflected when traded internationally. The resilience of vulnerable economic actors can be enhanced by redressing the under-provision of public goods, for example, by improving the availability of advisory services or investing in research into new crop varieties and livestock breeds that are more resistant to climate impacts (FAO, UNDP and UNEP, 2021; Gadhok et al., 2020).

Policies that support social inclusion, such as access to basic services, digital technologies, financial inclusion, and social protection are essential to attenuate some of the consequences of climate change. While the disruptions caused by climate change are unlikely to be fully avoided, well-functioning labour markets are important to help economies both maintain existing comparative advantages and build comparative advantages in new sectors. For example, while trade can provide access to new technologies such as high-yield climate-

Figure B.3: Financial support and technical regulations are the most common trade-related climate change adaptation measures



Source: Authors' calculations, based on the WTO Environmental Database.

Note: The figure reports climate change adaptation measures notified to the WTO between 2009 and 2020 by types of policies. One notified measure can cover more than one type of policy.

Box B.2: Making the "blue economy" last in Mauritius by leveraging trade and sustainability

Mauritius is one of the most vulnerable countries to climate change and EWEs. Over the coming 35 years, 7 per cent of its GDP could be lost to cyclones alone (Beejadhur et al., 2017). What the island will produce and trade in the future could depend on the decisions it takes today in terms of the adaptation, resilience, restoration and sustainable development of its natural "blue", or ocean, capital and its pathways for a just transition to a low-carbon economy.

To build back better from the COVID-19 recession, the Mauritian Government's "Vision 2030" aims to promote the blue economy as one of its main pillars of development (WTO, 2021e). The goal is to increase the contribution of the blue economy, which constituted nearly 12 per cent of the country's GDP before the pandemic, to 25 per cent by 2025, by strengthening traditional economic ocean activities such as tourism, fisheries and seaport activities, and by developing emerging industries such as aquaculture, maritime services, ship-building and repairs, marine biotechnology, and mineral exploration. A set of incentives under new premium investment certificates for aquaculture, industrial fishing and seafood processing have been launched to promote innovative and sustainable solutions, but challenges remain.

The fact that Mauritius is an island increases the pressure on the sustainability of its ecosystem. Recent shocks with concomitant impacts on health or food and energy security have exposed the country's vulnerabilities. Building a sustainable blue economy requires a robust plan that takes into account several conflicting objectives within and across sectors. This process has started in sectors such as port infrastructure, shipping, tourism, seafood, aquaculture and energy. For instance, for economic diversification and to better meet its energy needs, Mauritius recently evaluated its offshore hydrocarbon potential. Economic gains from hydrocarbon exploitation for Mauritius could outweigh the costs of less effective climate actions (Moolna, 2021). However, climate policies to deal with, for example, ocean acidification or sea-level rise are not an either/or option for Mauritius.

Mauritius can also, through international trade, better leverage the benefits of the ocean economy. Strategically located at the crossroads of Asian and African sea routes, Mauritius' seaport has the potential to become a hub of global trade flows, including container transhipment. However, it is urgent that trade and environmental policies, which have often evolved independently, be integrated to support the blue economy (de Melo, 2020).

Steps are already being taken to align the blue economy with the Sustainable Development Goals (SDGs). A new Ministry of Blue Economy, Marine Resources, Fisheries and Shipping was created in 2019 to improve coordination and management of ocean-related matters. Mauritius is a party to a number of fisheries management arrangements and multilateral environment agreements. The island has adopted legislation on coastal zone protection as part of its Integrated Coastal Zone Management framework. The Environment Protection Act and Climate Change Act also provide for the protection of the coastal environment. More capacity-building and technical assistance are needed, and economic, including trade, and climate policies need to support one another in order to address the short- and long-term costs and opportunities accompanying the expansion of the blue economy.

resistant crops, the lack of technical skills of some farmers can slow down their uptake and ultimately negatively impact agricultural productivity further exacerbating the impacts of climate change. Labour mobility obstacles or frictions can also slow down or prevent shifts to new comparative advantages. Individuals working in sectors that are contracting due to climate change may lose their jobs, and may only be able to find new job opportunities in expanding sectors if they possess the relevant skills and have the financial resources to relocate to a different region if necessary. Labour market adjustment policies, including skills development programmes, are important to reduce labour mobility frictions (WTO, 2017).

Certain vulnerable groups, such as micro, small and medium-sized enterprises (MSMEs) and women in certain socio-economic groups, face even greater difficulties in adjusting due to social, economic and cultural reasons (IPCC, 2014a; Nellemann, Verma and Hislop, 2011) (see Box B.3). For example, in low- and lower-middle-income countries, 52 per cent of the female workforce is employed in agriculture (World Bank and WTO, 2020), and as climate change puts a strain on agricultural sectors, social norms or household responsibilities may prevent these women from seeking employment in other sectors – especially if this means having to move to a different area – and this can negatively affect both households and economies at large. In addition, the consequences of climate change may cause some individuals to lose their means of livelihood permanently. However, social policies, such as education and compensation policies, like lump sum payments, can support the groups most exposed to the economic consequences of climate change.

4. International cooperation is essential to assist countries in adapting to climate change

Although climate change adaptation initiatives are often locally led, international cooperation in climate change adaptation is key to leverage synergies and help limit and manage the risk of losses and damages from climate change. This is because unilateral national policies aimed at tackling the effect of climate change can produce negative spillovers on other countries. It is important to coordinate responses to climate shocks and to assist countries, particularly the developing economies that are the most affected, in their adaptation efforts. Although climate change will remain highly disruptive, cooperation on international trade is essential to enhance the resilience of global trade to climate-related shocks and crises and to improve economies' capacity to adapt to climate change, while minimizing negative cross-country spillovers. International trade cooperation toward adaptation to climate change can, however, be challenging in situations where climate change issues intersect with national security priorities (see Box B.4).

(a) International cooperation on climate change adaptation is cross-cutting

The need for the widest possible international cooperation on climate change has been recognized in the UN 2030 Sustainable Development Agenda, in keeping with which the international community has committed to take urgent action to combat climate change and its impacts under Sustainable Development Goal 13 ("Climate Action"). Climate change adaptation is addressed through several extensive international cooperation initiatives. Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and the Paris Agreement

Box B.3: Climate change impacts on MSMEs

MSMEs are the most vulnerable of all types of firms to EWEs, and are set increasingly to experience trade- and climate-related disruptions (Skouloudis et al., 2020). For example, trade in tourism, a sector in which many MSMEs are active, will continue to be challenged as EWEs interrupt travel and impact destinations (Badoc-Gonzales, Mandigma and Tan, 2022). Yet, when it comes to adaptation, only 38 per cent of small businesses have made investments to reduce climate-related risks, compared to 60 per cent of large firms (ITC, 2021). MSMEs tend to be "reactive" rather than "proactive" when it comes to adaptation, and respond to regulation or market requirements (Burch et al., 2016). Some reasons for this lag are that their access to information, financial resources, expertise and time is more limited (Burch et al., 2016; ITC, 2021; WTO, 2022a). MSMEs led by women and young people tend to struggle even more with adaptation, and may have less capacity and fewer skills to take advantage of new opportunities (ITC, 2021).

On the flip side, efforts to adapt to climate change can create opportunities and benefits for those MSMEs that have re-focused on environmental themes, such as "ecopreneurs" who develop new products and services. In addition, MSMEs that succeed in increasing production efficiency and lowering business costs may thereby discover new opportunities. According to a recent survey, more than half of African firms reported that improving their companies' environmental performance had led to improvements in the output and quality of their products, access to new markets, reduced input costs and a better ability to access green finance (ITC, 2021).

Even though MSMEs are slow to initiate change, and international trade can spread climate-related business disruptions, trade can also drive MSME climate adaptation, especially through consumer demand and exposure to "external actors" (ITC, 2021; Klewitz and Hansen, 2014). Although MSMEs may not be able to take the most drastic changes, they are generally more nimble than larger firms and can better identify new market opportunities to fill the related gaps (Burch et al., 2016). However, further research is required to better understand the interlinkages between climate change adaptation and MSMEs' trade challenges and opportunities.

Box B.4: Climate change and the emerging "geoeconomic order"

A growing suspicion towards globalization has led to the emergence of "geoeconomics", a macro-level change in the relationship between economics and security in the regime governing international trade and investment (Roberts, Choer Moraes and Ferguson, 2019). The development of geoeconomics may lead to the expansion of economic isolationism, leading to a technological and trade decoupling of national economies, eventually lowering welfare and increasing geopolitical frictions.

Climate change could impede the pursuit of geoeconomic policies by countries heavily dependent on imports of environmental technologies or of agricultural products, the domestic production of which is negatively affected by climate change. Likewise, countries applying ambitious climate change policies could limit their vulnerability to geoeconomic measures from countries producing carbon-intensive products by reducing their dependence on fossil fuels and, in the case of other raw materials, by boosting recycling and the use of secondary materials. They would thus reduce risks of geopolitical frictions without undermining the multilateral trading system. However, countries may also adopt restrictive trade measures impacting environment-friendly goods and services in an attempt to preserve the strategic resources, foreign supplies or trade routes put at risk by climate change, and which they deem essential for their survival.

The extent to which geoeconomics can threaten climate change adaptation is already visible from the consequences of the conflict in Ukraine, such as blocking the planting, harvesting and transportation of grains. In a geopolitically volatile context, geoeconomic strategies pursued aggressively with "beggar-thy-neighbour" intents could lead to a carbon "race to the bottom" as countries in crisis lower their environmental standards and "self-sufficiency" policies lead to the opening or re-opening of domestic carbon-intensive industries.

Ideally, the response to such risks should be to increase international cooperation, both on climate change and on related trade policies. However, should geoeconomic policies become prevalent as the impact of climate change on trade worsens, countries may eventually equate the protection of their essential economic interests with national security. Given that such measures may not be amenable to justification under the WTO "General Exceptions", such as those found in Article XX of the General Agreement on Tariffs and Trade (GATT) and Article XIV of the General Agreement on Trade in Services (GATS) because of their strategic or geopolitical dimension, WTO members may invoke the "Security Exceptions" of Article XXI of the GATT, XIV bis of the GATS or Article 73 of the WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). These exceptions on national security would nonetheless continue to provide a multilateral legal framework with which unilateral geoeconomic measures would have to comply. Improved transparency and monitoring of these measures could also contribute to limiting their impact on the multilateral trading system.

recognize that adaptation is a global challenge and a key component of the long-term global response to climate change. The UNFCCC Nairobi work programme (NWP) assists countries, in particular developing countries, in improving their understanding and assessment of impacts, vulnerability and adaptation, and in making informed decisions on practical adaptation actions and measures. The Least Developed Countries Expert Group (LEG) further provides technical guidance and support to the LDCs to formulate and implement national adaptation plans and programmes of actions. Climate change adaptation is recognized by UNFCCC as having the same importance as mitigation, and is supported by financial mechanisms such as the Green Climate Fund (GCF) and dedicated funds such as the Special Climate Change Fund (SCCF), the UNFCCC Least Developed Countries Fund (LDCF), and the Adaptation Fund.

In addition, many international organizations and regional development banks are engaged in different aspects of climate change adaptation. For instance, the United Nations Office for Disaster Risk Reduction (UNDRR) supports the implementation of the intergovernmental Sendai Framework on Disaster Risk Reduction to strengthen resilience to climate change-related, and other natural and man-made, disasters (WTO, 2021f). Similarly, the World Meteorological Organization (WMO) tracks weather records and disseminates weather information that can facilitate better preparation and forewarning of EWEs.

(b) International cooperation on trade can help increase the ambition and viability of climate adaptation strategies

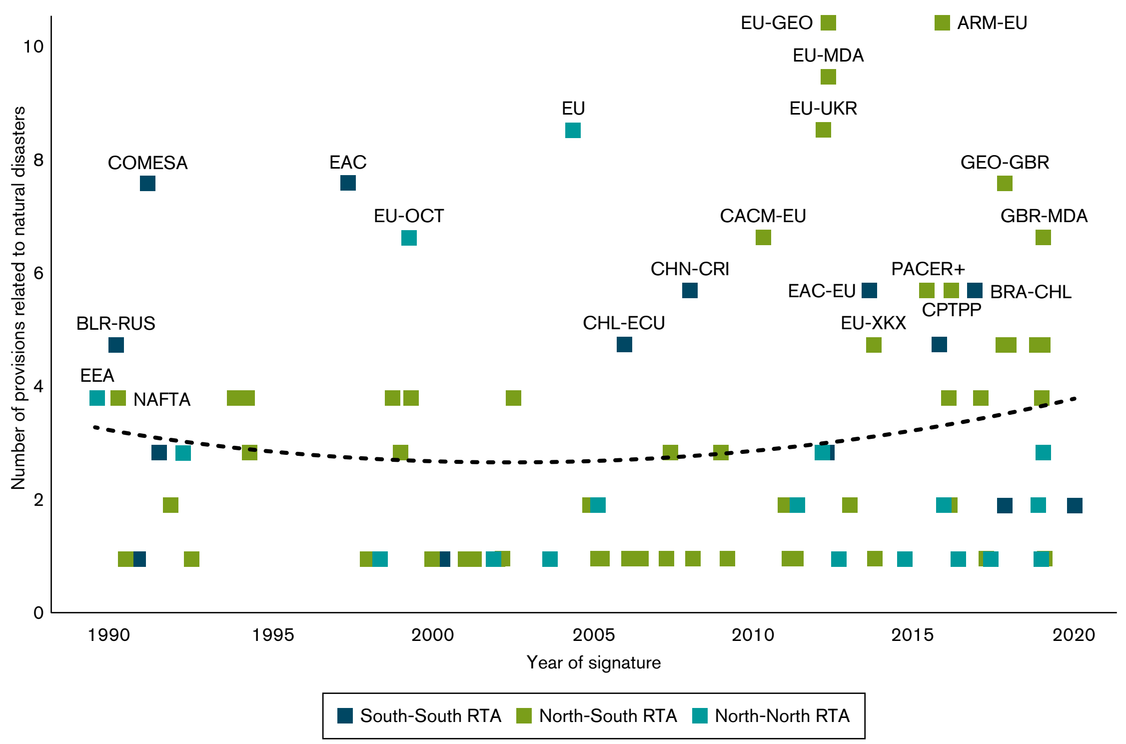
International cooperation on trade and trade-related policies can help support different dimensions of climate change adaptation, from climate risk prevention, reduction and preparedness to climate disaster response and recovery. International cooperation on trade policies can assist governments in reducing climate risks and vulnerabilities and in coping with and recovering from the consequences of climate-induced shocks.

Regional trade agreements (RTAs) are increasingly considered as laboratories for negotiating new types of provisions to address recent trade-related issues. A limited number of RTAs incorporate provisions explicitly addressing climate change adaptation. These provisions cover various commitments, from adopting measures for evaluating the vulnerability and adaptation to climate change[14] to facilitating the removal of trade and investment barriers to goods, services and technologies that can contribute to adaptation.[15] Other most common explicit provisions promote cooperation activities, including vulnerability and adaptation assessments.

These provisions on climate change adaptation are complemented by other explicit provisions addressing natural disasters (WTO, 2021f). Although the inclusion of provisions explicitly addressing natural disasters in RTAs is not a recent phenomenon, the number of these provisions in any given agreement has increased over the years (Figure B.4). These provisions cover a broad range of issues. Several RTAs require the adoption of natural disaster management measures.[16] Some RTAs lay down exemptions in case of natural disasters, such as full rebate of customs duties on imports for rescue and relief assistance.[17] Cooperation provisions remain the most common explicit provisions on natural disasters, covering various issues, including disaster prevention, mitigation and response; early warning systems, and recovery and rehabilitation.

While the new Agreement on Fisheries Subsidies is the first WTO agreement to put a primarily environmental objective at its core (see Box B.5),[18]

Figure B.4: The number of provisions related to natural disasters in RTAs has increased in recent years



Source: Monteiro (2022a).

Note: Analysis based on RTAs notified to the WTO. "North" is defined as high-income countries, whereas "South" is defined as middle- and low-income countries according to the World Bank's country classification.

the WTO also contributes to climate adaptation efforts by providing a framework that minimizes trade-related negative spillovers effects and maximizes positive spillovers effects. This framework comprises the following elements.

First, WTO members have the right to adopt trade-related measures aimed at protecting human, animal or plant life or health in the context of climate adaptation. At the same time, WTO rules ensure trade-related climate change adaptation measures are not disguised protection. These rules are monitored in WTO committees and councils, which allow members to exchange views and address specific trade concerns arising from certain measures. WTO rules are further enforced through the dispute settlement mechanism, which formally deals with trade conflicts among members.

Second, the WTO Agreements promote transparency by requiring formal, publicly available notifications of relevant laws and regulations affecting trade, including those related to climate change adaptation. The collective assessments of each member's trade policies and practices, under the WTO Trade Policy Review Mechanism, promote greater transparency in, and understanding of, members' trade policies and practices, including those that relate to climate change adaptation.

Third, the WTO, through its committees, councils and other bodies, serves as a platform for members to exchange views on important trade-related issues and address trade concerns, including those related to climate change adaptation. Some of these WTO bodies cover specific areas of trade measures, such as technical regulations and subsidies, or specific

Box B.5: Marine resources, climate change adaptation and the role of the WTO

Vulnerability to climate change is exacerbated by the loss of biodiversity, which occurs when natural resources, including marine resources, are not sustainably managed (World Bank, 2008). For example, overfishing and illegal fishing are serious global problems that threaten the ocean ecosystem, as well as livelihoods and food security. Although many factors are responsible for unsustainable fisheries management, certain fisheries subsidies are an important driver. Subsidies directed to the fisheries sector may be worth in excess of US$ 30 billion every year, out of which more than 60 per cent could have a capacity-enhancing effect leading to unsustainable overfishing (Sumaila et al., 2019). Climate change adds to the burden on fish stocks, because many marine fish stocks are diminished by ocean warming, and overfishing further exacerbates the vulnerability of these stocks (Free et al., 2019).

A major complication in tackling fisheries subsidies comes from the fact that marine resources do not stop at national borders. Unilateral action by a single country is not sufficient to preserve fisheries resources, and any subsidy or government intervention is likely to have international repercussions. For example, if a country institutes quotas on fish catches or increases monitoring of fishing activities, all countries benefit. Nevertheless, if other countries sharing the same fisheries resources do not commit to similar measures, the restrictions will likely be compensated by an increase in catches by other nations (Pintassilgo, 2003).

International cooperation is, therefore, the most effective means to address these externalities. In this context, the WTO is in a unique position to address fisheries subsidies, given its existing framework of binding multilateral subsidies disciplines and the multilateral nature of WTO negotiations, along with the economic and trade implications of such subsidies.

At the WTO's 12th Ministerial Conference in June 2022, WTO members concluded the WTO Agreement on Fisheries Subsidies that prohibits (i) subsidies contributing to illegal, unreported, and unregulated fishing or fishing-related activities in support of such fishing; (ii) subsidies regarding overfished stocks (except subsidies implemented to rebuild the stock to a biologically sustainable level); and (iii) subsidies provided to fishing or fishing-related activities in the unregulated high seas.

WTO members also resolved to continue work on additional provisions that would achieve a comprehensive agreement on fisheries subsidies, including through further disciplines on certain forms of fisheries subsidies that contribute to overcapacity and overfishing. Equally importantly, the WTO Agreement on Fisheries Subsidies sets out a mechanism to enhance notification and transparency on fisheries subsidies. This new agreement also contributes to achieve target 14.6 of the Sustainable Development Goals calling for the prohibition of certain forms of fisheries subsidies.

sectors, such as agriculture and services. Others deal specifically with trade-related environmental issues. For instance, the WTO Committee on Trade and Environment (CTE) provides a forum to support policy dialogue and share knowledge and best experiences in trade-related climate change adaptation strategies.

Finally, the WTO also provides trade-related technical assistance and capacity building to developing countries and LDCs, which can help to build climate-resilient trade capacity. Current initiatives include Aid for Trade, the Enhanced Integrated Framework (EIF), and the Standards and Trade Development Facility (STDF).

(c) Predictability, dialogue and coordination are key to increasing climate resilience of supply chains

Although GVCs have been very effective in lowering global production costs allowing countries to engage in international trade and maximize their comparative advantage, they can be, as discussed above, particularly exposed to the effects of climate change. International cooperation supporting preventive action against climate-related risks can help improve the adaptation and resilience of GVCs to climate change.

An open and predictable trading system can foster foreign direct investment, provide options for production diversification, and allow firms to organize their supply chains by prioritizing resilience over other concerns like fiscal considerations. WTO provisions allow and sometimes even encourage countries to take trade-related measures that may prove beneficial in responding to and building resilience against EWEs (see Table B.1).[19]

Trade facilitation plays a key role in supporting the resilience in the face of climate-related shocks. It smooths the functioning of supply chains during normal times, and, as the COVID-19 pandemic demonstrated, it is also vital for speeding imports of essential goods such as food, medical supplies and emergency equipment in response to a disaster. The WTO TFA seeks to minimize the incidence and complexity of import and export formalities in order to facilitate trade, including for goods in transit. The TFA simplifies customs processes for both regular trade and for post-disaster assistance. In this regard, the TFA requires members to take "additional trade facilitation measures" for the benefit of traders, commonly known as "authorized operators", who have been approved by or on behalf of the national customs administration as complying with specific supply chain security standards. Such measures include lighter documentary and data requirements, a reduced rate of physical inspections, elimination of fees and unnecessary delays or restrictions on goods in transit, pre-arrival filling and processing of transit documentation, rapid release time, deferred payment of duties and other charges.

Climate-related shocks and associated fears of shortages or inflation can provoke governments into taking trade-restrictive measures such as export restrictions, thus disrupting value chains. The WTO's trade policy monitoring and other transparency mechanisms play a role in enhancing information and fostering coordination among members to ensure restraint regarding restrictive trade policies. In this regard, more can be done by engaging a discussion on how to improve cooperation to avoid the imposition of restrictive uncoordinated export measures.

Further strengthening the WTO's trade policy monitoring and coordination functions could also help to identify challenges and opportunities for building supply chain resilience to climate change. The WTO's work with vaccine manufacturers during the COVID-19 pandemic could serve as a blueprint for dialogue among governments, businesses and other stakeholders to address potential climate change-induced bottlenecks in supply chains.[20] International cooperation can further strengthen the resilience of supply chains, including by disciplining reshoring policies, information-sharing, cooperating on standards, and managing risks of supply chain bottlenecks (WTO, 2021c).

(d) Well-functioning markets are important to address climate-related food security challenges

In order to maximize the opportunities that trade offers to enhance food security, it is important to have well-functioning food markets. Imports of essential commodities in countries that lack water or fertile soil, or that are subject to EWEs, need to move easily across borders. Disciplines in agriculture that foster an open, predictable and transparent environment are, thus, important, and complement rules that shape trade and markets in a number of other areas, such as trade facilitation, transport, telecommunications, financial services, competition and public procurement. Volumes of food imported or exported can be significantly reduced by port disruptions, as well as by high domestic transportation costs and lack of competition in the distribution sector, the latter particularly affecting poor people in rural areas,

Table B.1: Selected examples of resilience policies under WTO agreements and decisions
General Agreement on Tariffs and Trade (GATT) and Trade Facilitation Agreement (TFA) ▪ Define in advance domestic customs disciplines to be implemented during an emergency. ▪ Temporarily suspend regular customs charges on the entry of imported goods. ▪ Facilitate customs processes and procedures to speed up imports of relief goods and other necessities.
Technical Barriers to Trade (TBT) Agreement and WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) ▪ Ensure quality and safety of imported relief goods, including foodstuffs. ▪ Adapt technical standards for construction and building materials to local environmental constraints.
Agreement on Agriculture (AoA) ▪ Ensure access to goods of primary necessity, including food supplies. ▪ Provide financial support and government services for relief from natural disasters.
Agreement on Subsidies and Countervailing Measures (SCM) ▪ Provide financial support to enterprises to recover from climate-related natural disasters.
Enabling Clause, Decisions on waivers for preferential treatment for LDCs, Waivers under the Marrakesh Agreement ▪ Grant non-reciprocal preferences to support export diversification and, following EWEs, to promote the recovery of exports.
General Agreement on Trade in Services (GATS) ▪ Automatically recognize the professional qualification of foreign service providers for relief services and reconstruction. ▪ Improve access for the population and for businesses to cash aid resources. ▪ Improve the supply of weather-related services to build capacity to anticipate EWEs.
WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) ▪ Ensure balanced framework for innovation and diffusion of climate adaptation technologies. ▪ Support technology transfer to LDCs.
Agreement on Government Procurement 2012 (GPA 2012) (Plurilateral) ▪ Use emergency government procurement flexibilities to accelerate procurement processes for goods and services needed for recovery.

who thereby face more obstacles to benefitting from open markets.

The AoA recognises the need to take food security into account, both in existing commitments on market access and agricultural support and in ongoing negotiations.[21] In particular, WTO disciplines on agriculture promote open, fair and predictable trade in food, thus contributing to providing the necessary regulatory environment for food security.

For example, surging food prices often trigger export restrictions in key foodstuffs, which can ultimately exacerbate price increases (Giordani, Rocha and Ruta, 2012). Under the GATT, export prohibitions or restrictions temporarily applied to prevent or relieve critical shortages of foodstuffs or other essential products are allowed. However, the AoA requires WTO members to give due consideration to the effects of export restrictions on importing members' food security, as well as to consult importing members, and to notify the Committee on Agriculture before instituting such measures.

At the WTO's 12th Ministerial Conference (MC12) in June 2022, WTO members agreed to exempt from export restrictions food bought by the World Food Programme for humanitarian purposes. Ministers also adopted a Declaration pledging to facilitate trade in food, fertilizer and other agricultural inputs. They stressed the importance of not imposing export restrictions, and encouraged members with surplus stocks to release them on international markets. Importantly, they vowed to cooperate on enhancing agricultural productivity. Implementing this decision could contribute to enhancing food production and help to manage the knock-on effects of surging food prices during a crisis, thus increasing food security.

For over a decade, the Agricultural Market Information System (AMIS) (set up by the G20 in response to the global food price hikes of 2007-08 and 2010) has been helping to share information about food supply and stockpiles, promoting policy dialogue and contributing to strengthening resilience to shocks, including those associated with climate change. While AMIS currently focuses on four major crops (wheat, maize, rice and soybeans), enlarging its product coverage could help further improve transparency on agricultural markets.

The WTO's monitoring and transparency functions also contribute to helping markets to operate efficiently. The WTO Committee on Agriculture provides a forum for members to exchange views about compliance with existing rules and to address disagreements.

Although rules on agriculture and related negotiations aim to discipline and further reduce trade-distorting domestic support, the AoA exempts from reduction commitments programmes which cause only minimal trade distortions. These "Green Box" support measures include general services, such as research, pest and disease control, and extension and advisory services for farmers. The latter are particularly important in enabling producers in low-income countries to improve productivity sustainably, thereby strengthening climate resilience in agriculture.

WTO "Green Box" disciplines also cover public stockholding programmes that are used by some governments to purchase, stockpile and distribute food to people in need. While food security is a legitimate policy objective under the AoA, some stockholding programmes are considered trade-distorting when they involve purchases from farmers at prices fixed by governments.[22] Currently, pending the negotiation of a permanent solution, WTO members have agreed to refrain from challenging developing countries that exceed their agreed limits for trade-distorting domestic support through public stockholding programmes, subject to certain conditions.

The SPS Agreement, which sets out basic rules on food safety and on animal and plant health standards, helps ensure food security by facilitating safe trade. This is important because the increase in temperatures, rainfall, humidity and drought caused by climate change can facilitate the establishment and spread of invasive species and can contribute to increased and new SPS risks, which in turn could affect agricultural production, consumption and trade. International collaboration, for instance through the STDF (see section B.4(d)), is important to help developing countries with such issues. The SPS Agreement also allows for the speeding-up of control, inspection and approval procedures for foreign relief goods, such as in the case of food shortages.

WTO members could do more to ensure that trade contributes to more sustainable, resilient and equitable markets for food and agriculture products, and to put in place disciplines more supportive of policies promoting climate change mitigation and adaptation practices in agricultural production. For example, governments could consider updating existing rules and disciplines to transition away from price and production-linked subsidies, and to increase support for programmes improving the delivery of public goods. Such adjustments could ensure that subsidy programmes do not harm the competitiveness of producers elsewhere, while also sustainably increasing farm yields, raising incomes, and supporting job creation in ways that can strengthen adaptation to climate change.

Reducing trade barriers could also increase food availability in global markets and support efforts to overcome poverty. It could complement efforts to boost domestic farm productivity and help ensure that trade enables producers to respond to future demand growth. Estimates suggest that phasing out agricultural tariffs and implementing other trade facilitating measures could reduce the climate change impact on undernourishment by up to 64 per cent in 2050, meaning that as many as 35 million fewer people would suffer from hunger (Janssens et al., 2020).

(e) More trade-related technical assistance and capacity building for climate change adaptation is needed

To adapt to climate change, low-income and vulnerable countries need to enhance the resilience of their infrastructure and upgrade their productive capacities in agriculture and other sectors. Annual adaptation costs in developing countries are estimated at US$ 70 billion and are expected to reach US$ 140 to US$ 300 billion in 2030, and US$ 280 to US$ 500 billion in 2050 (UNEP, 2021b).

Climate finance has, however, fallen short of its US$ 100 billion goal for 2020 and has not achieved the balance between adaptation and mitigation finance called for in the Paris Agreement. Climate adaptation finance only represented a quarter of total climate finance in 2019, while climate mitigation finance and cross-cutting climate adaptation and mitigation finance constituted 64 per cent and 11 per cent, respectively. Adaptation finance is particularly important for the poorest and most vulnerable countries, which represents more than 40 per cent of climate finance provided and mobilized to LDCs and SIDS, almost double the share of adaptation finance in total climate finance for all developing countries (OECD, 2021) (see also Chapter C).

The Aid for Trade initiative helps developing countries, in particular LDCs, to build the trade capacity and infrastructure they need to increase their participation in and benefit from international trade. A limited but increasing number of Aid for Trade projects integrate environmental considerations (OECD and WTO, 2022). In 2020, Aid for Trade disbursements with a climate objective (adaptation, mitigation or cross-cutting) amounted to US$ 15 billion, representing 31 per cent of total Aid for Trade. Around US$ 5.75 billion, or 12 per cent of total Aid for Trade, were allocated to projects with adaptation as a single or cross-cutting climate objective.

More than half (54 per cent) of adaptation-related Aid for Trade went to agriculture in 2020, reflecting the degree to which climate change is disproportionally affecting this sector (Figure B.5). Besides agriculture, adaptation-related Aid for Trade targeted projects in the energy (11 per cent of adaptation-related Aid for Trade in 2020), transport and storage (10 per cent), banking and financial services (8 per cent) and forestry (7 per cent) sectors.

Although Aid for Trade disbursements related to climate change adaptation are limited, many projects show how investing in adaptation to transboundary climate risks represents an opportunity to build and increase the resilience to climate impacts (Benzie and Harris, 2021). For instance, when, in 2015, Cyclone Pam destroyed much of the seafront infrastructure of Port Vila, Vanuatu, the Enhanced Integrated Framework (EIF), together with Fairtrade Australia and New Zealand, helped Vanuatu rebuild and improve the waterfront with more climate-resilient materials, and in an economically inclusive way aimed to foster interaction between tourists and local small businesses. The EIF has been active in other Aid for Trade projects targeted at adaptation, such as providing greenhouses and hail nets to small farmers in Lesotho to promote resilience to changing weather patterns, and mapping landslide risk and promoting sustainable soil and water management as a way to enhance coffee-growing communities' adaptation and preparedness in Timor-Leste (EIF, 2022; Ramsay, 2021).

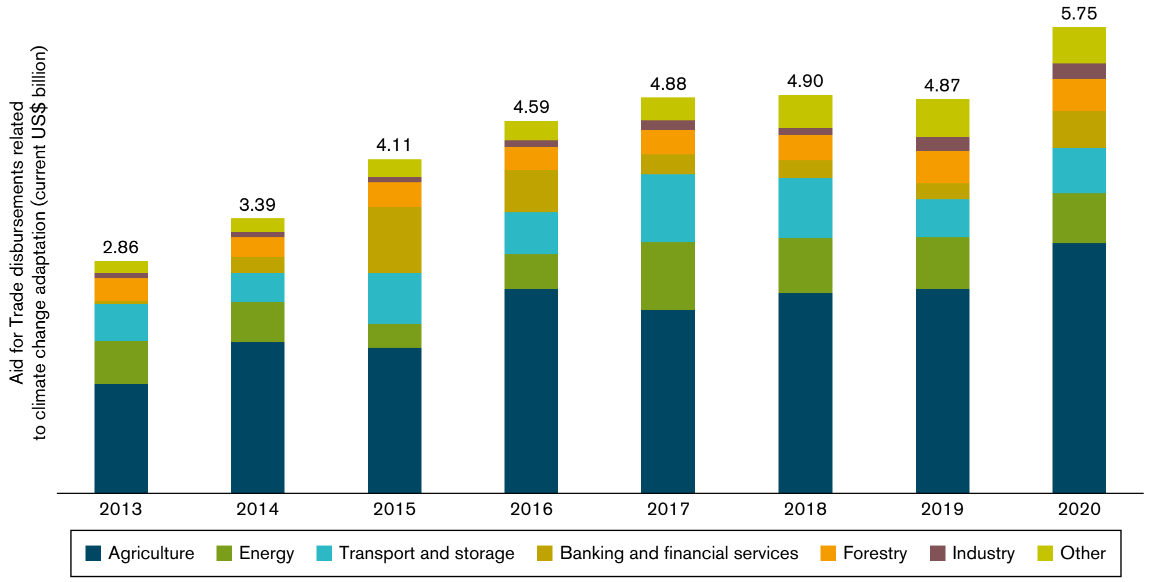
The WTO can also help countries mobilize support and build trade-related capacities for adaptation. For example, the WTO surveys LDCs' evolving technology needs and priorities and supports them by monitoring developed countries' programmes for transferring relevant technologies to LDCs in line with their obligations under the WTO TRIPS Agreement. Between 2018 and 2020, climate change adaptation, including disaster prevention and water management, was an important element in 25 per cent of the 152 environmental technology transfer programmes reported by developed members to the WTO (see also Figure C.7 in Chapter C).

The capacity-building needs of developing countries and LDCs relating to trade and climate change adaptation intersect with the work of several WTO committees, including the Committee on Trade and Environment (CTE), the Committee for Trade and Development, and the TRIPS Council.

Climate change adaptation is also increasingly incorporated into the work of the STDF, a global partnership providing a funding mechanism for innovative and collaborative SPS projects in developing countries to facilitate safe trade. The STDF also identifies and disseminates good practice on topics that cut across the areas of food safety, animal and plant health, and trade.

Although trade-related technical assistance and capacity-building for adaptation have increased in recent years, more can be done to better exploit synergies between climate finance and Aid for Trade. The Aid for Trade initiative could help to mobilize additional funding for climate change adaptation by

Figure B.5: Most Aid for Trade disbursements related to climate change adaptation cover agriculture



Source: Authors' calculations, based on Organisation for Economic Co-operation and Development (OECD) DAC-CRS (Development Assistance Committee Creditor Reporting System) Aid Activities Database.

Note: Only projects with an explicit objective of adapting to climate change and projects identifying climate change adaptation as important but secondary objective are considered as adaptation-related official development assistance.

better integrating the trade dimension into countries' national adaptation strategies and by including climate considerations in Aid for Trade projects. Strengthening the discussions on the trade-related adaptation needs of developing countries and LDCs in the WTO could also contribute to a higher degree of alignment and coherence between Aid for Trade and climate finance programmes.

5. Conclusion

Climate change is a current reality. In the short term, EWEs will continue to cause disruptions to supply chains and transport networks, shortages of key commodities, and international price fluctuations. Over the long term, further gradual climate changes and more frequent and intense EWEs will alter regional patterns of specialization. Left unchecked, climate change will lead to a humanitarian crisis characterized by increasing poverty, food insecurity, disease and unnecessary additional deaths. It may also contribute to geopolitical instability, as countries compete for access to dwindling resources and seek to protect their industries and markets through economic decoupling and the building of zones of economic and political influence.

Trade – with the multilateral trading system at its core – can help countries attenuate some of the effects of climate change by protecting themselves against, and responding to, short-term shocks like EWEs and by ensuring the timely availability of critical goods and services, such as food, healthcare, transportation and communication. Although adapting to climate change will continue to remain costly, trade may help countries adapt to climate-related changes in comparative advantages, for example by importing what they may no longer be able to produce and exporting what they may produce in excess. Trade can also facilitate access to technologies that minimize some of the costs and the economic effects of climate change.

WTO rules, supported by policy dialogue and cooperation, provide the open, non-discriminatory and predictable trading environment necessary for trade to be a means of adapting to some of the consequences of climate change. Some trade measures, such as suspending custom duties, opening markets to foreign service providers, and simplifying import procedures, can enhance the response to, recovery from and resilience to short-term climate-induced shocks, as well as support more long-term adaptation to climate change.

At the same time, a lot more can be done to help low-income and vulnerable countries to meet the challenges of climate change adaptation. Platforms for policy dialogues, like the WTO Committee on Trade and Environment, can be used by members to share knowledge and expertise necessary to develop successful climate adaptation policies. Aid for Trade and related initiatives such as EIF and STDF can also help to mobilize funding and build trade-related capacities for climate change adaptation in developing countries and LDCs.

Although international trade and trade policy can contribute to climate adaptation strategies, trade policy alone cannot automatically foster adaptation to climate change. While adapting to climate change will only get more expensive if GHG emissions are left unchecked, countries must adopt and implement comprehensive and coherent climate adaptation actions, such as strengthening transport networks, diversifying production, suppliers and customers, and making long-term investments in human capital, in order to avoid, to the extent possible, and minimize losses and damages caused by climate change.

Endnotes

1 See Bosello, Eboli and Pierfederici (2012), Bosello and Parrado (2022), Eboli, Parrado and Roson (2010), IPCC (2014a), Nordhaus (2014), and Roson and van der Mensbrugghe (2012). Larger losses have been estimated by the Swiss Re Institute (2021).

2 Some climate change adaptation actions, such as air-conditioning, can, in the absence of complementary actions, increase electricity demand and generate GHG emissions. Complementary actions include improving energy efficiency in air conditioning technology, supporting renewable energy sources and enhancing building thermal insulation.

3 Revealed comparative advantage is defined as the share of an economy's exports of given commodities in that economy's total exports, relative to the share of the world's exports of these commodities in total world exports.

4 For food trade, for example, these can be straits and canals, coastal infrastructure in major crop-exporting regions, and inland transport infrastructure in major crop-exporting regions.

5 For details on how the climate change exposure and vulnerability indexes are calculated, see Chen et al. (2015), and for the methodology of the export diversification index, see Henn et al. (2020), Loungani et al. (2017), and Papageorgiou, Spatafora and Wang (2015).

6 For example, a 1°C increase in temperature has been found to lower industrial output in low-income countries by 2.02 per cent (Dell, Jones and Olken, 2012).

7 For animals and plants, climate change adaptation implies either adjusting to the changing climate and its effects by spending more time and energy on life-sustaining measures (e.g., body temperature regulation) or moving, to the extent possible, to regions with less hostile environmental conditions.

8 Afforestation refers to the process of planting new trees in an area where there were no trees before, while reforestation refers to the process of planting trees in a forest where the number of trees has been decreasing.

9 See Alcalá and Ciccone (2004); Amiti et al. (2017); Amiti and Konings (2007); Frankel and Romer (1999); Wacziarg and Welch (2008); Gries and Redlin (2020); and Cerdeiro and Komaromi (2021).

10 For instance, an increase in international trade creates new employment opportunities and improves welfare outcomes, which tend to reduce the incentive to move abroad for job opportunities.

11 See for instance https://corporate.walmart.com/esgreport2019/environmental#climate-change.

12 Notified trade measures with the following objectives are considered to be related to climate change, namely: afforestation or reforestation; air pollution reduction; alternative and renewable energy; climate change mitigation and adaptation; energy conservation and efficiency; and ozone layer protection. For more information, see WTO (2021d).

13 In agricultural and food markets, governments tend to create price-altering trade policies when global agricultural and food prices rise substantially.

14 For example, Korea-Peru RTA.

15 For example, Colombia-Ecuador-European Union-Peru RTA.

16 For example, Canada-Chile RTA.

17 For example, Southern African Customs Union (SACU).

18 Paragraph 14 in the Outcome Document (WTO official document number WT/MIN(22)/W/16/Rev.1, which can be consulted at https://docs.wto.org/) of the 12th WTO Ministerial Conference (June 2022) recognizes the contribution of the multilateral trading system with regard to the 2030 Agenda.

19 Some RTAs replicate or build on existing WTO disciplines relevant to build climate resilience, while others establish new commitments (WTO, 2021c).

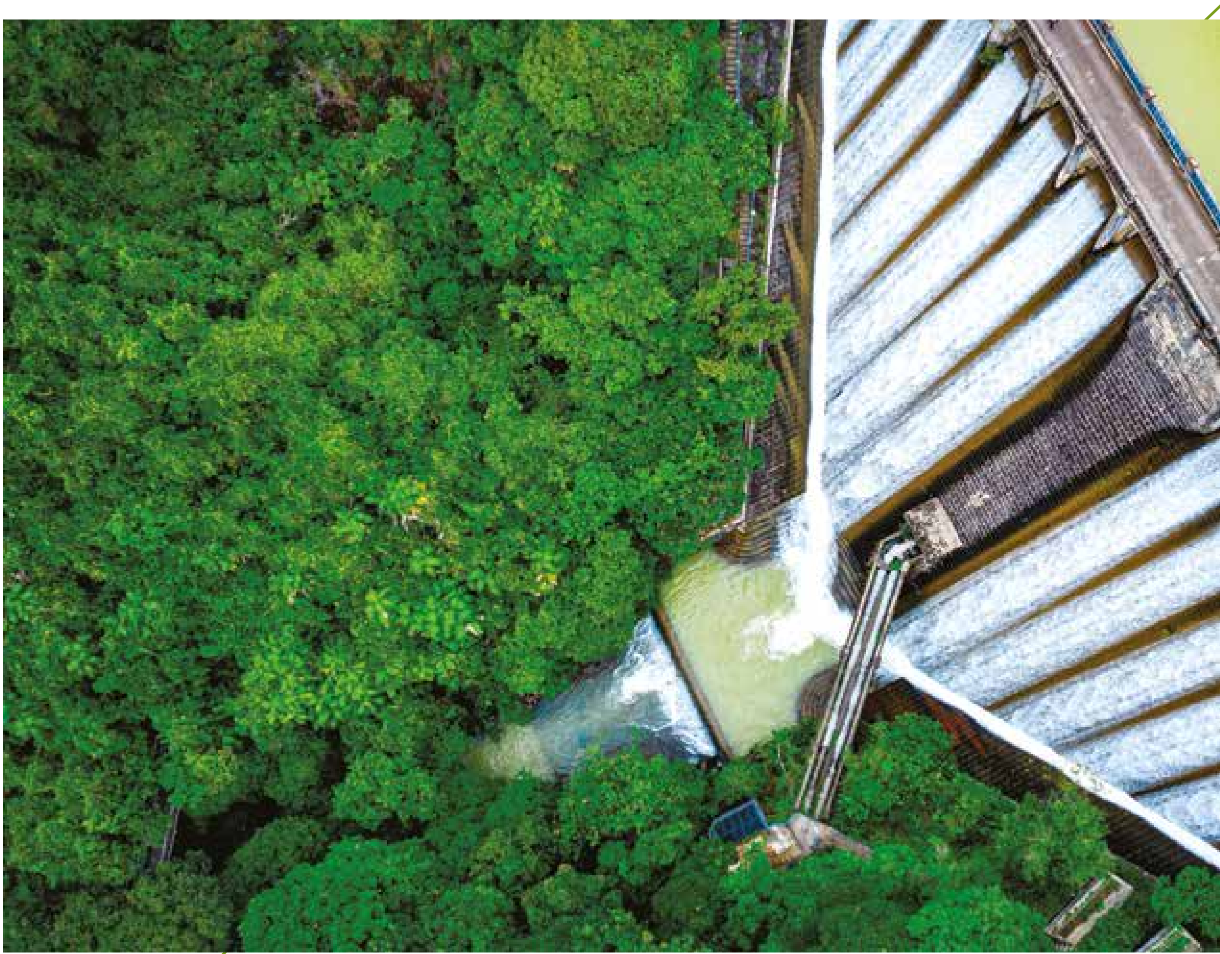
20 For example, a "Trade 4 Climate" dialogue among businesses, members and stakeholders organized by the WTO and the International Chamber of Commerce (ICC) in October 2021 (https://www.wto.org/english/tratop_e/envir_e/trade4climate_e.htm) highlighted the links between climate change and natural disasters, and their impact on trade.

21 The important role of trade and the WTO in contributing to food security is also reflected in the international community's commitment in Sustainable Development Goal 2b to correct and prevent trade restrictions and distortions in world agricultural markets (https://sdgs.un.org/goals/goal2).

22 For more information, see https://www.wto.org/english/tratop_e/agric_e/food_security_e.htm.

C The trade implications of a low-carbon economy

The global economy needs to effect wide-ranging and immediate changes to reduce its greenhouse gas emissions sufficiently to limit climate change. This chapter explores how the transition to a low-carbon economy could impact international trade patterns, and outlines the role that trade, trade policy and international cooperation can play in supporting a just low-carbon transition. Although a low-carbon transition entails short-term investment and adjustment costs, it can also provide important economic benefits and opportunities. The WTO has an important role to play in increasing the ambition and viability of climate change mitigation actions.



Contents

Key facts and findings

- Although the COVID-19 pandemic temporarily reduced greenhouse gas emissions, overall emissions have increased by more than 85 per cent since 1990. This highlights the urgency of transitioning to a low-carbon economy.
- Some of the available options to support a low-carbon transition include shifting the energy mix away from fossil fuels, promoting alternative and renewable energy, improving energy efficiency, and reducing production and consumption.
- A net-zero carbon economy could modify trade patterns by altering comparative advantages. While some economies could export more renewable electricity, others could benefit from opportunities to produce and export goods and services using clean energy.
- Unilateral and uncoordinated trade-related climate policies can, depending on their design and implementation, create trade tensions that can ultimately undermine climate change mitigation efforts.
- The fight against climate change calls for greater multilateral cooperation and coherent actions to support a just low-carbon transition. The WTO contributes to supporting climate change actions by helping to prevent unproductive trade frictions and promoting efficient trade-related climate policies.

1. Introduction

Although the COVID-19 pandemic caused a temporary reduction in greenhouse gas (GHG) emissions, levels of atmospheric carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) have increased by more than 85 per cent since 1990.[1] GHG emissions from human activities are already responsible for approximately 1.1°C of global warming since the pre-industrial period.

The 2015 Paris Agreement commits countries to limit the global average temperature from rising to well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature rise to 1.5°C. GHG emissions need to be cut by roughly 50 per cent by 2030 and reach net zero by 2050 in order to stay below 1.5 °C of global warming (IPCC, 2022b).

Reaching net zero emissions requires reducing GHG emissions to as close to zero as possible and offsetting any remaining emissions by removing an equivalent amount of GHG from the atmosphere and storing it permanently in soil, plants, or materials. For this to occur, important changes would have to be made in the structure of production and consumption, including specialization patterns and international trade. This raises the question of how trade, trade policy and international trade cooperation, as well as the WTO, can support the transition to a low-carbon economy.

This chapter discusses how ambitious climate change mitigation policies and well-functioning financial markets are essential to support and accelerate the transition to a low-carbon economy. It then discusses how a low-carbon economy could change trade patterns and provide new economic opportunities. The chapter concludes with a discussion of the role of international cooperation, and in particular that of the WTO, in supporting climate-change mitigation efforts.

2. Achieving a low-carbon economy is an imperative but faces challenges

Tackling climate change requires major climate policy actions to steer the economy towards a low-carbon emission path, yet there is no single strategy that can support the transition to a low-carbon economy. In addition, various challenges face the adoption and implementation of carbon mitigation policies, including conflicting economic, energy and political priorities (see Box C.1).

For instance, only 6 per cent of the US$ 13 trillion in COVID-19-related stimulus packages adopted by G20 economies in 2020 and 2021 has been allocated to areas that could also reduce global GHG emissions, including installing renewable energy systems, improving energy efficiency in buildings and electrifying transportation systems. Another 3 per cent of the stimulus packages has been directed at areas that are likely to increase emissions by supporting carbon-intensive activities (Nahm, Miller and Urpelainen, 2022). In comparison, 16 per cent of total global fiscal stimulus spending adopted during the 2008-09 global financial crisis was targeted at activities contributing to environmental protection, including climate change mitigation (Jaeger, Westphal and Park, 2020).

Addressing the distributional consequences of climate change policies is also important to ensure a fair and inclusive transition to a low-carbon economy. Well-functioning financial markets are also essential to support a low-carbon economy.

(a) Different strategies can support the transition to a low-carbon economy

Efforts to reduce and prevent GHG emissions into the atmosphere, commonly referred to as climate change mitigation, are essential to limit global warming and substantially reduce the future effects of climate change (IPCC, 2022b). The urgency to move towards a low-carbon economy requires a significant transformation of the way energy, goods and services are produced, delivered and consumed.

There is, however, no one-size-fits-all strategy to support a low-carbon transition. A low-carbon economy can be achieved in a number of ways, for example by shifting the energy mix away from fossil fuels; promoting alternative sustainable renewable energy sources, such as geothermal, hydro and solar power; improving energy efficiency in buildings, transport, industry and consumption; and reducing production and consumption.[2]

Inducing consumers to make behavioural changes could significantly support a transition to a low-carbon economy if these changes curb energy demand (IEA, 2021). This could involve encouraging consumers to purchase and adopt low-carbon products and technologies, such as solar water heaters and electric vehicles, and encouraging behaviour that is more conscious of the consequences of consumption, such as economical energy use, switching transport modes and consuming less carbon-intensive food (Lonergan and Sawers, 2022).

Box C.1: Implications of the war in Ukraine on climate change

The war in Ukraine is having a devastating impact on the Ukrainian people, infrastructure and economy. It is also having a disastrous impact on the environment, for example through the destruction of forest and marine ecosystems, air and water pollution, and waste. Given the important roles of both Russia and Ukraine in the global commodities and energy markets, cascading impacts of the conflict are being felt worldwide, including through higher food and energy prices and the reduced availability of certain Russian and Ukrainian exports (WTO, 2022b).

The war and its consequences highlight the importance of devising climate change strategies that balance energy and food security with environmental imperatives. It is, however, unclear at this stage, whether the war and its geopolitical consequences will slow down or accelerate the transition to a low-carbon economy.

In response to rising oil and gas prices consequent to the war in Ukraine and as a result of sanctions on many Russian exports, some countries have opted to diversify their energy suppliers, signing contracts for liquefied natural gas (LNG) from Africa, the Middle East and the United States (Dvorak and Hirtenstein, 2022). Some countries are also considering increasing natural gas and oil production, building new natural gas pipelines, and reopening or extending the operation of coal-fired power plants (Tollefson, 2022).

Although these new commercial energy contracts and projects may address the current urgent energy security problems, they could also slow down the transition to a low-carbon economy if, for example, new providers of coal, gas and oil demand long-term supply commitments. The race to secure LNG supplies by some countries could further exacerbate price spikes in LNG, which could drive some developing and least-developed economies to increase or switch their energy consumption to high carbon-intensive fossil fuels, such as coal and oil.

The war could also lead some governments to redirect public spending, initially allocated to tackling climate change, to other priorities, some of which may be carbon-intensive, such as military equipment. More generally, geopolitical tensions could imperil international cooperation on climate change, which is essential to make significant progress in tackling climate change.

At the same time, energy security concerns, in particular energy independence, stemming from the consequences of the war in Ukraine, could also accelerate the transition to a low-carbon economy. In response to the war, some countries have adopted plans to accelerate their clean energy transition by increasing energy efficiency and renewable energy production capacities. Energy price hikes could also lead some consumers to buy more energy-efficient products and smaller or electric vehicles.

An accelerated low-carbon transition would require a diversified and affordable supply of the metals and minerals required to produce renewable energy equipment and energy-efficient products, the availability of which is not currently guaranteed as a result of the war. However, international trade may help to ensure a more diversified and resilient supply of critical materials, and further contribute to the transition to a low-carbon economy.

(b) Ambitious climate change mitigation policies are essential

Every five years, signatories to the Paris Agreement submit roadmaps to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat, known as Nationally Determined Contributions (NDCs), which detail how they plan to achieve their carbon emission-reduction targets.[3] A review of the 164 latest available NDCs reveals that the most frequently listed measures in NDCs are related to the energy sector, including electric power generation from renewable energy and low- or zero-carbon fuels (UNFCCC, 2021). Many NDCs also report measures for enhancing carbon sequestration, the most frequently indicated being afforestation, reforestation and sustainable forest management.

While positive, the level of ambition of these policies is not currently enough to achieve a low-carbon economy consistent with the Paris Agreement's timeline, namely cutting by half GHG emissions by 2030 and reach net zero by 2050 (UNEP, 2021a).

The lack of progress stems in part from the fact that climate change is a market failure because it has been caused by actors who are not necessarily experiencing the consequences of their acts. For example, firms and consumers may not directly face the climate change-related consequences of the GHG they emit, and, as a result, they continue to emit excessive quantities of GHGs. Measures to tackle climate change can also be characterized by positive externalities, for example all economic actors benefit from increased climate change mitigation efforts, even if they did not contribute to these efforts. However, this can create incentives to free-ride on climate efforts made by others, limiting the global level of climate change mitigation efforts. Climate change mitigation policies are essential to tackle these market failures.

Other market failures may also call for policy interventions. For example, climate-friendly innovations in one country can benefit the innovation activity of all other countries since they increase the global stock of knowledge and support the decarbonization process of the economy. In the presence of such knowledge spillovers, companies that invest in research and development (R&D) into low-carbon technologies are often unable to capture the entire return of their investment. Economies of scale, sunk costs and costs of reorienting research and switching technology also give established, higher-carbon technologies an advantage (Acemoglu et al., 2012).

In addition, the capital required to transition to low-carbon alternatives is often subject to uncertainties, political risks and a lack of short-term return on investment which can often impede the funding of innovative or large-infrastructure projects. Low-carbon infrastructures often require substantive upfront investment in networks, such as electronic grids or charging stations for electric vehicles, which can also be difficult to establish without policy interventions. Finally, information about the energy efficiency or carbon content of a product or production process may not be available, making it difficult for economic agents to make informed decisions (Stern and Stiglitz, 2022).

(c) Climate change mitigation policies are multifaceted

Climate change mitigation policies can support the transition to a low-carbon economy by establishing incentives and requirements to deploy climate-friendly technologies and to facilitate the withdrawal or improve the energy efficiency of carbon-intensive assets.[4] The effectiveness of climate change mitigation policies depends on their design and on the responses of firms and consumers. Firms generally only change their behaviours if they are legally required to do so or it is economically profitable, while people generally only change their behaviours if they are legally obliged to do so, if the alternative is cheaper or better, or if they want to imitate or conform with social norms (Lonergan and Sawers, 2022).

Policy instruments for a low-carbon transition can be grouped according to their underlying mechanisms that aim to achieve climate change mitigation (IPCC, 2007b), namely (i) command-and-control instruments; (ii) market-based instruments; (iii) information instruments; and (iv) voluntary agreements.

(i) Command-and-control instruments

Command-and-control instruments are the most common form of climate mitigation policies (IPCC, 2007b). Command-and-control measures fall broadly into two categories: (1) regulatory measures on processes and production methods and (2) prohibition mandates of certain products and practices.

Reducing the environmental impact of production activities may sometimes involve setting standards and regulation for the way products are produced. These regulatory measures commonly take two forms: (1) performance standards, which dictate specific environmental outcomes to be achieved per unit of production (e.g. number of grammes of CO_2 per kilowatt-hour of electricity generated) and (2) technical standards, which specify various pollution abatement technologies or production methods to be used by producers (WTO and UNEP, 2009).

Prohibition, or phase-out mandates, as well as bans on sales and imports of high-emission equipment and energy-inefficient products, are increasingly common. Such mandates are introduced to eliminate existing fossil-fuel assets, such as coal-fired power plants, and to prevent new investment in high-emissions equipment (Finon, 2019).

(ii) Market-based instruments

In recent years, market-based instruments have become an alternative to traditional command-and-control policies (Peace and Ye, 2020). These instruments have the advantage of providing greater flexibility in how economic agents wish to reduce GHG emissions. Market-based instruments can be categorized into four broad groups: (1) carbon pricing, (2) support measures, (3) fossil fuel subsidy reform and (4) green government procurement.

Carbon pricing, including carbon taxes and emission trading schemes, is often highlighted by economists as an efficient way to reduce emissions (Aldy and Stavins, 2012; Metcalf and Weisbach, 2009; Stavins, 2022) (see Chapter D). Carbon pricing is associated with the idea that polluters should pay for the damage they cause. By putting a price on carbon emissions, the costs of economic agents' GHG-emitting activities are made explicit, thereby giving agents incentives to find ways to reduce emissions. Moreover, by giving agents the flexibility to choose the appropriate course of action to reduce emissions, carbon pricing can also stimulate innovation for new, low-carbon products and production processes.

Governments can also support a low-carbon transition by incentivizing the development, production and adoption of low-carbon products and technologies. R&D subsidies can lower costs and improve the performance of low-carbon technologies, as well as foster innovation in environmental technologies (Acemoglu et al., 2012; Bosetti et al., 2013; Verdolini et al., 2015). Subsidies can also be given to producers of renewable energy. Feed-in tariffs, for instance, allow renewable energy producers to receive a guaranteed price for each unit of electricity generated, guaranteed grid access and long-term contracts with electric grid utilities (Fell and Linn, 2013; Wilke, 2011). Subsidies can also be provided to consumers to encourage the adoption of low-carbon products and technologies, for example LED lighting or electric vehicles (Finon, 2019).

The phasing-out of fossil fuel subsidies also affects the carbon price. Because fossil fuel subsidies essentially function as a negative carbon price, removing these subsidies results in an increase in the price of carbon-based fuels (Jenkins, 2014; van Asselt and Skovgaard, 2021). Subsidy reform therefore enables the incorporation of costs of environmental externalities that were not reflected under the subsidized prices and thereby incentivizes a decreased use of fossil fuels. More generally, reforming support measures targeted at carbon-intensive products and activities, such as some agricultural subsidies, can lead to reduction in GHG emissions (OECD, 2022b; Springmann and Freund, 2022).[5]

Through green government procurement (GGP) policies, governments can influence private sector producers through their purchases of low-carbon goods and services, create markets for new entrants, and stimulate innovative solutions to climate change problems by awarding public R&D contracts. Given the sheer volume of demand for goods and services that government procurement can represent,[6] GPP can create a large and stable demand for new low-carbon solutions before a commercial market is viable.

(iii) Information instruments

Firms and consumers may act inefficiently when they lack the necessary information about the environmental consequences of their actions. Information instruments provide environment- and energy-related information on specific products and activities to allow investors and consumers to make climate-informed choices. The disclosure of environmentally related information includes labelling programmes, rating and certification systems, public awareness campaigns and environmental self-declaration claims.

Eco-labels, including carbon labels, are increasingly being adopted (OECD, 2016). The carbon-related information intended to consumers can be communicated in different ways.[7] A low-carbon label shows that the product's carbon footprint has been reduced without necessarily specifying by how much. A carbon neutral label indicates that the product's carbon footprint has been reduced but any remaining carbon emissions have been compensated via carbon offset projects. A carbon score lists the amount of carbon emitted across the product's lifecycle. A carbon rating shows how the product performs in terms of energy use and efficiency relative to others similar products in its category.

While information-enhancing initiatives can be owned or managed by governments,[8] environmental information instruments are increasingly adopted by the private sector and non-profit organizations. An increasing number of firms use eco-labelling to establish or foster niche markets for environmentally friendly products. Some firms also voluntarily disclose information about their environmental performance. Recently, collaborations between public and private sectors on environmental information schemes have become common, such as roundtable certification schemes.

(iv) Voluntary agreements

Voluntary agreements are customized contracts between a government authority and one or more private sector parties, that aim to improve environmental performance and resource utilization beyond compliance to regulated obligations (Cornelis, 2019; IPCC, 2007b).[9] There is no legal obligation to participate, and, in most cases, there are no penalties for terminating participation (Karamanos, 2001). Voluntary agreements can, in some cases, obviate the need to use legislative action. They can also encourage a proactive, cooperative approach between public and private sectors. In addition, they can lead other firms to imitate the environmentally friendlier practices of voluntary agreements-signatory firms.

(d) Addressing the distributional and political implications of ambitious climate change mitigation policies is essential

The adoption and implementation of ambitious carbon mitigation policies can face challenges in some segments of the population and some sectors. This is because the distributional consequences of carbon mitigation policies can include replacing existing sectors, activities and technologies with alternatives that are more efficient or that use low-carbon energy sources, and this can provoke opposition, which may impede implementation (Jenkins, 2014; Nemet et al., 2017; Stern, 2017a). In addition, as discussed in Section C.3., the trade implications of some climate mitigation policies, can affect governments' mitigation policy strategies and level of ambition, such as the risk of relocation of carbon intensive activities to countries with less stringent climate policies.

Carbon mitigation policies which aim to increase fossil fuel prices can, at least in the short term, increase energy prices generally, and negatively impact consumers and producers. Pressures from those who lose out, or who may lose out, because of decarbonization can slow down the transition to a low-carbon economy by hindering the use of more efficient, low-emission technologies. The climate change mitigation policies necessary to establish the transition to a low-carbon economy therefore require public support to ensure they are credible, effective and long-lasting.

For instance, carbon pricing policies often face significant political economy hurdles (Jenkins and Karplus, 2017) and raise concerns about the burden that carbon price increases may impose on low-income groups.[10] At the same time, however, the potential of these policies to raise revenue that can then be redistributed for various purposes (known as "revenue recycling") has been proposed as a possible remedy to distributional concerns (Jakob et al., 2016; Rausch and Yonezawa, 2021).

Similarly, fossil fuel subsidy reforms have been known to incur significant distributional and political implications with, in some cases, extensive strikes and violent public protests that have prompted governments to reverse their reforms.[11] Other structural factors, such as insufficient institutional or governance capacity, may also make it difficult to remove fossil fuel subsidies once they are in place (Lockwood, 2015; Skovgaard and van Asselt, 2019).

Some climate change mitigation policies can benefit certain groups more than others, and can thereby garner greater political support (Jenkins, 2014). For instance, subsidies encouraging households to purchase electric vehicles have been found particularly to favour high-income earners (Sherlock, 2019; Sovacool et al., 2019), while developing and expanding an affordable electrified public transportation network, through GPP, can particularly benefit lower-income and/or minority groups who may not own cars and who rely on public transport to commute to work and to school (Slastanova et al., 2021).

The distributional effects of some climate change mitigation policies may be more salient for producers than consumers, if the former face the direct impacts of the policies and cannot reflect the increased costs that result from these policies in the prices of goods and services (Johnstone and Serret, 2006). For instance, the compliance costs of regulations, including environmental ones, tend to impact micro, small and medium-sized enterprises (MSMEs) disproportionately (Crain and Crain, 2010). Nevertheless, climate change mitigation policies can be designed in such a way as to lessen the burden faced by vulnerable groups, which could help to support and lead a more fair and inclusive transition to a low-carbon economy.

(e) Well-functioning financial markets are essential to support the transition to a low-carbon economy

The transformation across all energy and land-use systems that a low-carbon transition could entail would require a significant expansion in investment (IEA, 2021). McKinsey (2022) estimates that a total investment of US$ 275 trillion would be required in capital spending on physical assets over the period 2021-50 in order to limit global warming to less than 1.5°C; this would represent an average of US$ 9.2 trillion per year. As discussed in Section C.4.1, achieving a low-carbon economy on a global scale also requires offering financial support to developing and least-developed countries (LDCs) to mitigate the adverse impacts of the transition and enable them to invest and take advantage of new opportunities.

Global funding for the energy transition alone is estimated to amount to US$ 131 trillion over the next 30 years (McKinsey, 2022), and annual clean energy investment worldwide would need to more than triple by 2030 to around US$ 5 trillion to reach net zero emissions by 2050. This investment could add an extra 0.4 percentage points to annual global GDP growth (IEA, 2021). The magnitude of the investment requirements implies that contributions from financial institutions and the private sector will be crucial.[12]

Firms finance their activities, such as investing in climate-friendly technology, by using the profits they generate, raising their debt or issuing bonds. The interest rate on debt and the equity cost of capital – two components of the cost of capital – can influence a firm's decision to invest in low-carbon-emission projects. For instance, high interest rates make investment more expensive, and less attractive, for firms and reduces their investment. Conversely, a high ratio of the firm's price to profits (also known as the price/earnings ratio) typically signals that the market considers that the firm in question is high quality and low risk or growing fast, and investors, typically, make money by acquiring equity shares in firms with high profits or high price/earnings ratios.

Financial markets, including central banks, can support the transition to a low-carbon economy by adopting strategies to reduce funding in carbon-intensive projects, enhancing risk management capabilities to identify new low-carbon opportunities, and developing new financial products to support investors in winding down carbon-intensive legacy assets. Total climate finance, comprising funds from corporations, commercial financial institutions and household consumption, has steadily increased over the last decade, reaching an annual average of US$ 632 billion in 2019 and 2020 (Climate Policy Initiative, 2021). Private-sector-led climate-related activities are most common in renewable energy investment, in particular on-shore wind and solar photovoltaic (PV) energy projects, and in energy efficiency investment and waste management. Other climate-related projects include land-fill gas capture and projects in agriculture and forestry and IT applications for process monitoring and control, to support resource efficiency such has smart irrigation and smart cold chain management.

Privately financed climate projects are typically the result of the combined effects of a range of public interventions and of broader enabling conditions (OECD, 2017). Innovative financial instruments such as carbon finance, green stock indices and green bonds raise money from investors to exclusively finance environmental projects. For instance, green bond markets have grown quickly in size and market coverage since the first green bond was issued in 2007 by the European Investment Bank. At the end of 2021, the global green bond market reached a total volume of US$ 517.4 billion, marking a market expansion trend of 10 consecutive years (Climate Policy Initiative, 2021).

Environmental, social and governance (ESG) criteria are increasingly incorporated into investors' analysis processes to identify material risks and growth opportunities in low-carbon investment, among others. While ESG is a promising approach, ESG ratings are not standardized, and unfortunately the ESG approach is also associated with free-riding, greenwashing and mis-selling risks (Lonergan and Sawers, 2022). Free-riding arises when firms are willing to undervalue high-carbon-emission assets and sell them to obtain a higher ESG score. Greenwashing arises when firms with a high ESG continue to hold high carbon emission assets. The risk of mis-selling comes from the investors' high expectation that ESG investment will necessarily deliver high returns, although many ESG investment remain risky.

Harmonizing ESG criteria and measurement tools and improving information disclosure and regulatory control can improve the effectiveness of ESG finance in contributing to a low-carbon economy by reducing the cost of capital of low-carbon projects.

3. A low-carbon economy would change trade patterns and provide new trading opportunities

History has shown that the dramatic opening of the world economy, combined with the rapid pace of technological change, have improved the welfare and living standards of billions of people around the world, including its poorest citizens. This process was necessarily accompanied by economic changes and some disruptions in the jobs market, as economies shifted from lower to higher productivity and from declining industries to rising ones (WTO, 2017).

The transition to a low-carbon economy should be no different, with economies shifting from fossil fuels to renewable energy sources and from high-carbon-intensive activities to low-carbon-intensive ones. This transformation is likely to affect international trade flows by altering comparative advantages. New trading opportunities for renewable energy and low-carbon-intensive products are likely to emerge, although addressing any climate-related trade tensions is essential.

(a) The transition to a low-carbon economy provides opportunities to support a more sustainable and equitable development

A low-carbon economy brings considerable environmental benefits that can contribute to a more sustainable development path. The transition to a low-carbon economy averts and minimizes the severe consequences of climate change, including a rise in global temperatures, sea levels and frequency, duration and intensity of extreme weather-related events, such as floods, cyclones, and droughts. The low-carbon transition also improves air quality, which in turn improves health and living conditions. Decarbonization through sustainable land management, climate-smart agricultural practices and forest protection can also promote biodiversity, improve food security and enhance climate resilience (see Chapter B).

While the transition to a low-carbon economy would entail short-term investment and adjustment costs, it could also provide important economic benefits and opportunities to support a more sustainable and fair development. It is estimated that bold actions in climate mitigation could yield a cumulated economic gain of US$ 26 trillion between 2018 and 2030 (Garrido et al., 2019). This transition would also limit the risks of a changing climate. As noted in Chapter B, without ambitious mitigation measures, climate change could cause 250,000 additional deaths per annum (WHO, 2018) and up to 18 per cent of global GDP loss by 2050 (Swiss Re Institute, 2021).

While the transition to a low-carbon economy is expected to change the way agricultural and manufacturing goods are produced, services are delivered and buildings are heated and cooled, the labour market is also likely to go through a transformation, with job opportunities moving between occupations and sectors. Workers in carbon-intensive industries, such as cement and steel, are likely to be disproportionately affected.

The low-carbon transition could also, however, bring about employment opportunities since the renewable energy sector is more labour-intensive than the fossil fuel sector (Garrett-Peltier, 2017). The renewable energy sector already provided 12.7 million jobs globally in 2021 (IRENA and ILO, 2022), and it is projected that 14 million jobs could be created in clean energy and 16 million additional jobs in energy-related sectors by 2030 (IEA, 2021).[13] Jobs in the renewable energy sector are also more gender-inclusive than jobs in fossil fuels, with women holding 32 per cent of total renewables jobs but only 21 per cent in fossil fuels jobs. The overall magnitude of the labour shift associated with a low-carbon transition could still be relatively limited, given that most jobs are likely to be neither high-carbon-intensive nor low-carbon-intensive (IMF, 2022).

The obstacles and labour mobility frictions experienced by workers who wish to move into sectors with rising employment (e.g., solar panel installation) and out of declining ones (e.g., coal mining) can be high. Mismatches between skills offered and wanted in the labour market impede workers' transition between jobs (ILO and WTO, 2017). In addition, geographical frictions, or barriers, account for a substantial share of the total mobility costs affecting the reallocation of workers between regions, and may be related to physical geography, social networks, family ties, cultural barriers, language and housing. Labour mobility costs tend to be higher in developing countries (WTO, 2017).

Supporting the labour market adjustment for workers displaced by the closure of carbon-intensive industries is essential to ensure a fair transition to a low-carbon-emission economy. Labour market adjustment policies can take different forms, including job-search assistance, skills development and training programmes (Bacchetta, Milet and Monteiro, 2019; WTO, 2017). Environmental and low-carbon-intensive jobs tend to be higher-skilled and better-paid jobs (ILO, 2018), which could attract some workers, including displaced workers, to these job opportunities. The wage premium in environmental jobs could thus also contribute to facilitating the labour market adjustment (IMF, 2022).

(b) International trade in low-carbon technologies and in renewable energy can support a low-carbon transition

Although international trade emits GHG, it can play an essential role in supporting and promoting the development, access and deployment of low-carbon technologies. Trade in renewable energy and electricity can also help to make production processes cleaner by providing access to affordable sustainable and renewable energy sources.

International trade can support a low-carbon transition by helping to share out the fixed and sunk investment costs of new environmental technologies, as high investment costs are often associated with the development of new technologies, including environmental ones. This can come about in supply chains when coordination between upstream and downstream firms can lead to cost allocation, shared decision-making and long-term commitment (Ghosh and Shah, 2015; Mattingly, 2017; Qin et al., 2021; Xu and Xie, 2016). Often, only a small number of countries have specific technological expertise in the manufacturing of specific environmental technology, such as renewable energy components and equipment, trade in environmental products thus provides access to technologies with a level of efficiency that cannot be replicated domestically in importing countries (Garsous and Worack, 2021).

International trade can also contribute to a low-carbon transition by promoting the diffusion of environmental technologies, as it increases the dissemination of knowledge across borders (see Chapter F). The diffusion of knowledge and ideas can also improve productivity. An increase in innovation in cleaner energy technologies, often measured by the number of relevant patents, has been found to reduce energy intensity and improve environmental performance (Chakraborty and Mazzanti, 2020; Ghisetti and Quatraro, 2017; Wurlod and Noailly, 2018). In addition, knowledge diffusion across countries and sectors can enable economies to exploit differences in comparative advantages more effectively, thanks to differences between countries in their access to and absorptive capacity of knowledge in environmental technologies (Bretschger et al., 2017).

International trade in renewable energy and electricity could also help to compensate for the uneven geographical distribution of clean energy sources, such as solar irradiation and wind power density. For example, the potential for solar energy production is particularly high in many countries in Africa, Asia, Latin America and the Middle East, while the potential for wind power tends to be very high along coastlines above the northern tropic and below the southern tropic. For instance, the world's largest solar power station was built in Morocco, while the largest offshore wind farm is located in the United Kingdom.

Trade and investment in goods and services related to sustainable renewable energy can contribute to increasing the global production of renewable energy at low cost. For instance, the capacity of solar panels globally traded in 2017 was estimated at almost 80 gigawatts, the equivalent of more than 9 per cent of the global electricity generation in 2017 (Wang et al., 2021).

However, the full potential of international trade in renewable energy and electricity requires addressing the structural challenges on existing power-generation, transmission, and distribution infrastructure created by new renewable electricity flows as well as the inherent variability of renewables, including potential imbalances in supply and demand and limited storage capacity (McKinsey & Company, 2021). Despite rapid and significant advances in high-voltage direct current power transmission (Patel, 2022), cross-border electricity transmission via high-voltage lines over long distances remains relatively costly. Renewable energy could alternatively be exported via pipeline or ship by using energy carriers, namely gases or liquids produced using renewable energy (van der Zwaan, Lamboo and Dalla Longa, 2021).[14] In recent years, the potential of green hydrogen as a versatile carbon-free energy carrier is being increasingly recognized, as discussed by Gauri Singh in her opinion piece.

The transfer of environmental technologies could also help to overcome the mismatch between the regional location of renewable energy resources and the availability of low-carbon technology. Recent analysis of patenting activity suggests that the trajectory of the climate change mitigation knowledge flow increased (especially from developed to developing countries) after the Kyoto Protocol and especially the Paris Agreement (Torrance, West and Friedman, 2022). Developing countries frequently lack significant legacy, carbon-heavy energy systems; which, with the relevant energy and environmental policies, could enable them to leapfrog directly to low-cost and reliable renewable energy technologies that are well-suited to serving dispersed rural populations with limited or no access to electricity or other sources of energy (Arndt et al., 2019).

The transition to a low-carbon economy is likely to take place in a world of increasing geopolitical tensions and supply chain disruptions (see Chapter B). In this context, it is essential that the supply of energy and key mineral resources needed to produce some low-carbon technologies, such as renewable energy equipment and energy efficient products, is diversified and resilient. In order to assemble a risk-based supply strategy, future energy needs need to be evaluated in light of energy security concerns, and transparency and coordination among trading partners must be supported (WTO, 2021c).

(c) A low-carbon economy would impact trade patterns

While climate change may alter countries' comparative advantages (see Chapter B), a low-carbon transition is also likely to lead to shifts in trade patterns. The impact of the low-carbon transition is likely to be stronger on those countries whose comparative advantage stems from fossil fuel energy and high-carbon intensive activities. While a growing literature on climate change and trade looks at the future consequences of climate change, in particular

OPINION PIECE

By Gauri Singh
Deputy Director-General,
International Renewable Energy Agency (IRENA)

Green hydrogen requires an appetite for action

The International Renewable Energy Agency (IRENA)'s *World Energy Transitions Outlook 2022*, which sets out in precise detail the route to achieving 1.5°C by 2030, argues in favour of using hydrogen to achieve full decarbonization (IRENA, 2022). This means raising global production to five times the current production, or 614 megatonnes of hydrogen per year, to reach 12 per cent of the final energy demand by 2050. Green hydrogen is expected to make up the vast bulk of this production.

Discussion of green hydrogen arrives at the right time. Renewable power generation costs have plunged over the past decade, driven by rapidly improving technologies, economies of scale, competitive supply chains and an ever-improving developer experience. To use just one example, electricity costs from utility-scale solar photovoltaics fell by 85 per cent between 2010 and 2020.

Unlike fossil fuels, renewable energy can potentially be produced by every nation. It is energy-fair. The same can be said of green hydrogen, which is a process of conversion, using water and electrolysis technology powered by renewable energy. The method could radically transform the way global energy is traded.

Green hydrogen can also be economical in locations with the optimal combination of abundant renewable resources, space for solar or wind farms, and access to water, matched with the capability to export to large demand centres. New power centres could be built in places that exploit these factors to become hydrogen hubs for its production and use.

Until recently, however, there has been no cost-effective way of transporting renewable electricity over long distances to link low-cost production sites with demand. Suitable transmission lines are rare and extremely expensive to construct. The use of hydrogen as an energy carrier could provide the answer, enabling renewable energy to be traded across borders in the form of molecules or commodities such as ammonia.

To make trade cost-effective, production of green hydrogen must be sufficiently less expensive in the exporting region than in the importing region to compensate for transport costs. This cost differential will loom large as the scale of projects increases and technology develops to reduce transport costs. Hydrogen trade can lower energy supply cost energy since cheaper energy is tapped into. It can also lead to a more robust energy system with more alternatives to cope with exploding crises.

We still have much to do. For the hydrogen trade to truly flourish globally, a market needs to be created to generate demand, promote transparency, and connect suppliers and end users. Underpinning the market, nations need to produce a market regulatory framework containing the flexibility to promote growth. And there must be an internationally accepted certification scheme accepted by all. Finally, innovation must dramatically improve the available technologies that reinforce the integrated value chain.

Green hydrogen is not going to leap on to the world's energy stage fully formed and ready to salvage efforts to achieve 1.5°C by 2030. It is going to require decisive action and dynamic innovation to create new production centres and stimulate demand. Above everything else, it will take ambition and clear-sightedness about our future prospects. The world must be prepared to extend its reach to grasp every opportunity for energy transition. Taking the first step is simple: we just have to reach out.

global warming, on some trade patterns, the trade implications of the transition to a low-carbon economy have been less discussed.

The WTO Global Trade Model (WTO GTM) was used to fill part of this gap and analyse how moving towards a low-carbon economy by 2050 could impact the economy and trade patterns.[15] It is important, however, to emphasize that the simulation scenarios are not forecasts or predictions for the future but representations of what could happen in the future under a set of assumptions. In this analysis, the low-carbon transition is assumed to be achieved thanks to international cooperation and the adoption of global carbon pricing, which is based on a combination of global emissions reductions with announced NDCs until 2030. Under this scenario, fossil fuels extraction and use are phased out by 2050, while electrification and renewable energy use increase to achieve low-carbon emissions by 2050.

(i) A low-carbon economy could spur regional trade in renewable electricity

Assuming a successful transition to a low-carbon economy, this transition is likely to change the structure of domestic energy production and the composition of energy trade. The simulation results suggest that the global share of fossil fuel exports in total energy exports would decrease, while the global share of trade in renewable energy in total energy trade is projected to increase with the level of decarbonization ambition (right panel of Figure C.1).[16]

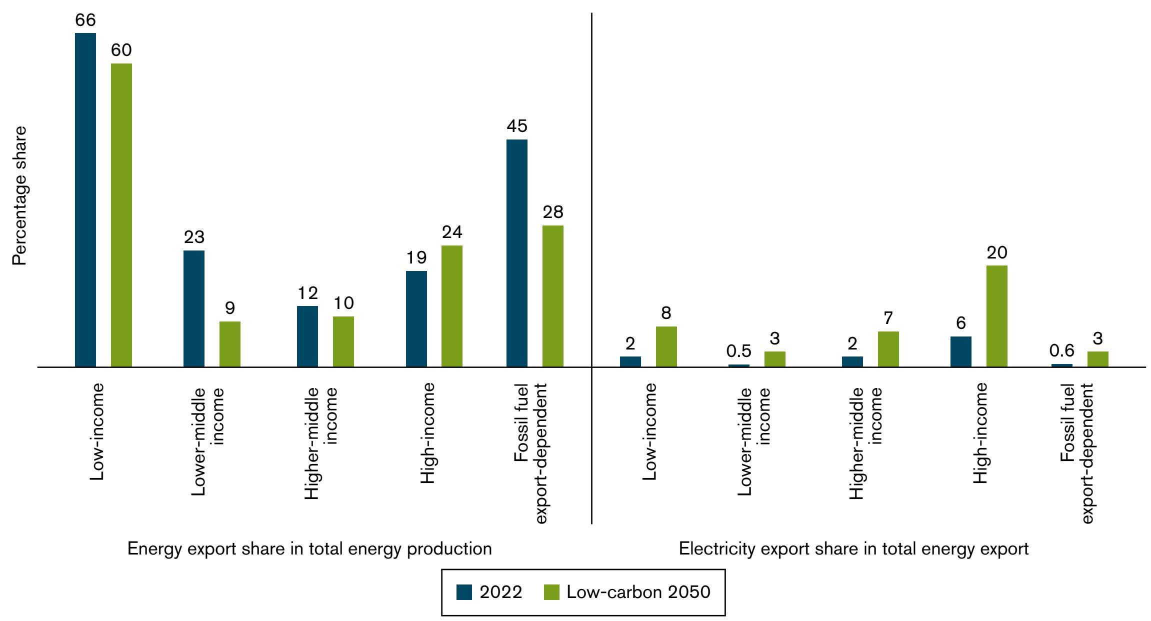
However, a low-carbon transition would lead to a 38 per cent reduction in energy trade from 2022 to 2050 (left panel of Figure C.1). Two forces may explain this result: a reduction in fossil fuel exports and an increase in trade in renewable energy. The latter is, however, not large enough to offset the former because fossil fuel energy (i.e., natural gas, coal, oil) is assumed to remain much more tradeable than trade in electricity, including from renewable energy sources, due to high costs to transport electricity.

(ii) The low-carbon transition would shift production and trade patterns, affecting regions differently

The economic impacts of a low-carbon transition are likely to be unevenly distributed, with those highly dependent on fossil fuel energy exports more severely impacted. In addition, a broad range of policies and a well-functioning financial and labour markets can contribute to mitigating the adjustment costs to a low-carbon economy and opening up new economic opportunities.

The simulation results suggest that a low-carbon economy would necessarily lead to a substantial

Figure C.1: Trade in electricity could increase in a low-carbon economy



Source: Bekkers et al. (2022).

Note: Simulation results based on the WTO GTM. The "low-carbon 2050" scenario assumes countries cooperate to achieve almost net zero emissions by 2050.

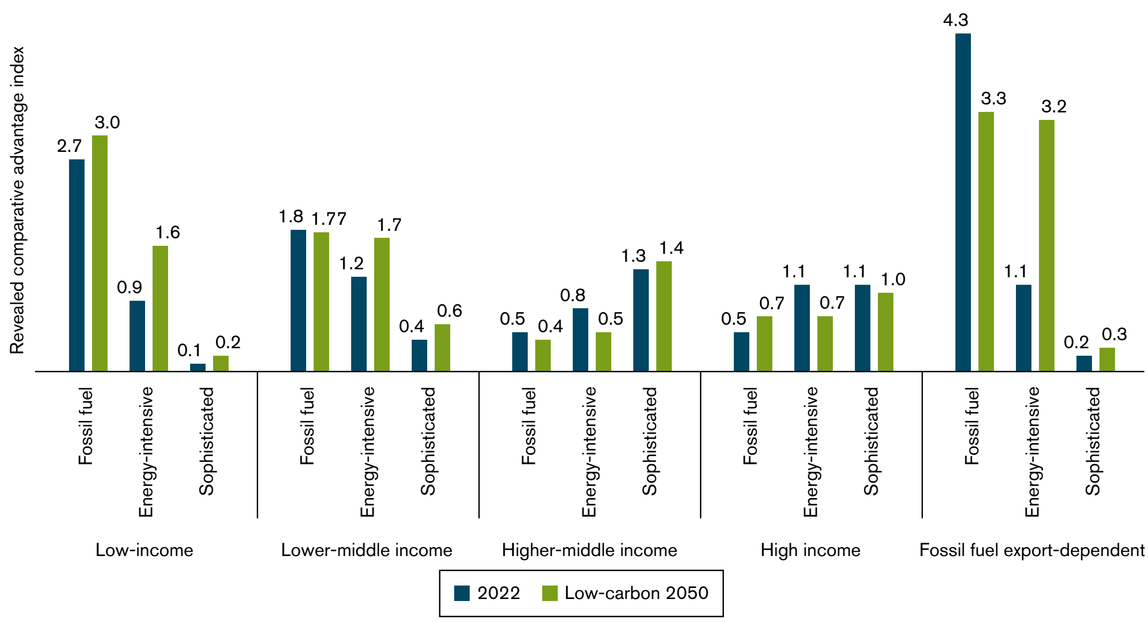
reduction in the real output of coal, oil, gas and refined petroleum products in all regions, ranging from between 50 per cent in fossil fuel export-dependent countries (FFEDCs)[17] to more than 60 per cent and 70 per cent in low- and higher middle-income countries. At the same time, capital and labour would likely be reallocated to different activities to ensure a low-carbon transition. Countries could thus shift their production and comparative advantages from fossil fuels sectors to energy-intensive industrial sectors, such as iron and steel, and to knowledge-based sophisticated sectors, such as computer electronic equipment and motor vehicles.

The change in trade patterns as a result of decarbonization is reflected in the relative ability of a country to produce a good vis-à-vis its trading partners, commonly known as revealed comparative advantage (RCA). The increase in the RCA of FFEDCs in energy-intensive sectors could be larger than in sophisticated sectors, because a reduction of fossil fuel prices as a result of decarbonization makes regions with large reserves of fossil fuels more competitive in energy-intensive sectors (see Figure C.2). This trend, though smaller in magnitude, could also be observed in low-income countries. Due to the shift of energy-intensive sectors and sophisticated sectors to other regions, high-income countries could experience a small reduction of their RCA in sophisticated sectors and energy-intensive sectors, although they would maintain their comparative advantage in sophisticated sectors.

At the same time, FFEDCs and low-income regions could benefit from a low-carbon transition. As mentioned in the previous section, decarbonization could help FFEDCs and low-income regions to diversify their economies away from volatile fossil fuel sectors towards more sophisticated sectors with more growth potential, offering new economic opportunities. Furthermore, FFEDCs and low-income countries with significant renewable energy source potentials could also shift towards production and exports of renewable energies. However, the current export revenues from fossil fuels would not be fully replaced with revenues from exporting renewable electricity, because unlike fossil energy, electricity, including from renewable sources, is less tradeable over long distances.[18] Production and export opportunities may also be explored in goods and services produced with renewable energy.

The materialization of these new economic opportunities hinges to a large extent on the adoption of complementary policies to facilitate access to and diffusion of environmental technologies, and shift

Figure C.2: A low-carbon economy could lead economies to shift their comparative advantages



Source: Bekkers et al. (2022).

Note: Results based on the WTO GTM. Revealed comparative advantage (RCA) is an index defined as the share of an economy's exports in that economy's total exports, relative to the share of the world's exports in that sector in total world exports. A RCA higher than one indicates a country has a revealed comparative advantage for a given sector. The higher the value of a country's RCA for a sector, the higher its export strength.

investment from fossil fuel-based physical capital to human capital (Peszko et al., 2020). Policies to tackle climate change, promote education and energy infrastructure are also essential to ensure that countries have the appropriate enabling conditions to support the environmental industry (see Chapter F). As discussed in Section C.4, financial and technical support are also important to mitigate the adverse impacts of the transition and enable countries, in particular low-income economies, to take advantage of new low-carbon economic opportunities.

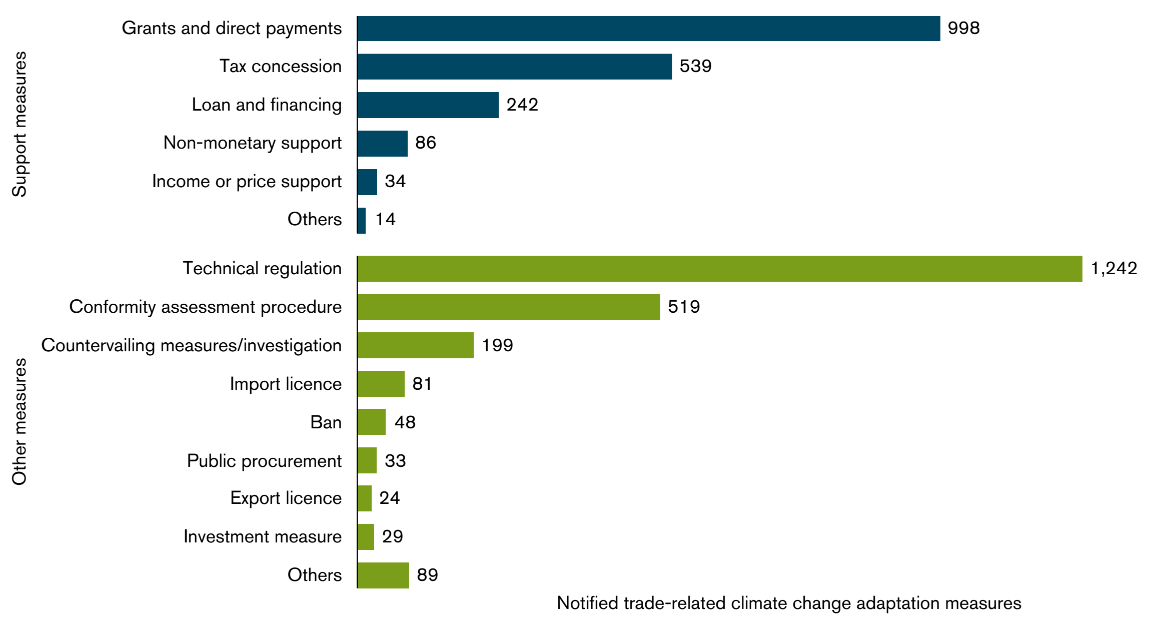
(d) Some climate change mitigation policies may have trade implications

The transition to a low-carbon economy requires ambitious climate change mitigation policies. Some of these policies can have trade impacts and generate cross-border spillovers, which may affect governments' mitigation policy strategies and levels of ambition. One key problem is that the effectiveness of certain mitigation policies, when adopted unilaterally, may be undermined by the lack of ambition in other countries and a loss of competitiveness (see also Chapter D).

While not all climate change mitigation policies have trade implications, trade-related climate change mitigation measures are often notified to the WTO. Between 2009 and 2020, WTO members notified 3,460 measures explicitly addressing climate change mitigation, but also energy conservation and efficiency, and alternative and renewable energy.[19] Most of these notified trade-related climate change mitigation measures are support measures and technical regulations and conformity assessment procedures (see Figure C.3). For example, notified measures include new regulatory requirements to reduce the use of fluorocarbons and promote alternative chemicals with low global warming potential,[20] preferential tax treatment for energy-saving and new energy vehicles and vessels,[21] and the use of import licences to regulate lighting with minimum energy performance standards.[22]

Depending on their design and implementation, trade-related climate change mitigation policies can raise concerns among trading partners on the grounds that these measures can discriminate among different trading partners or between imports and similar domestic goods, or can unnecessarily restrict trade. For instance, prohibition and phase-out mandates can have negative impacts on trade by forcing foreign suppliers that previously served a given market to redirect their exports or terminate them entirely.[23]

Figure C.3: Support measures and technical regulations are the most common trade-related climate change mitigation measures



Source: Authors' calculations, based on the WTO Environmental Database.

Note: The figure reports climate change mitigation measures notified to the WTO between 2009 and 2020 by types of policies. One notified measure can cover more than one type of policy.

Carbon pricing can also have trade implications, as discussed in detail in Chapter D.[24] Some types of support measures can also create trade tensions, such as support measures that attribute exclusive rights to the use of research output by domestic firms (WTO, 2020a) or that are provided to shield domestic producers from foreign competition, or strategically for industrial policy purposes (UNEP and DIE, 2017). For instance, subsidies with local content requirements can spur investment in homegrown climate-friendly infrastructure and technology, but at the same time be trade-restricting.

Fossil fuel subsidy reform can also affect trade competitiveness by increasing the prices of intermediates for energy-intensive industries (Burniaux, Château and Sauvage, 2011), thus increasing the production costs and reduce the competitiveness of carbon-intensive industries such as steelmaking, petrochemicals and aluminium (Cockburn, Robichaud and Tiberti, 2018; Ellis, 2010; Jensen and Tarr, 2003). The removal of support for fossil fuel consumption and production worldwide also impacts FFEDCs. However, ultimately, the trade impacts of fossil fuel subsidy reform depend on firms' response measures (Moerenhout and Irschlinger, 2020). Firms can, for example, substitute certain energy inputs for alternative sources, improve resource efficiency or pass directly the compliance costs on to consumers, although if firms decide to respond by increasing prices, this can harm their competitiveness in the international market (Rentschler, Kornejew and Bazilian, 2017).

The use and proliferation of informational instruments, such as environmental labels, has important trade implications. Few mandatory labelling requirements are currently in place, but prominent voluntary labels can ultimately become a market entry requirement (OECD, 2016). The multiplication of informational schemes may negatively impact the international competitiveness of producers by increasing compliance costs, including the costs of information-seeking, of switching to more expensive environmentally-friendly production methods, and of adopting complex certification and audit procedures. The latter are particularly burdensome for producers in developing countries and MSMEs, who often lack the infrastructure required for certification and traceability requirements (UNEP, 2005) (see Box C.2).

At the same time, some trade policies can incentivize higher levels of environmental protection. For instance, government support, such as R&D investments, can propagate knowledge diffusion across borders (Fadly and Fontes, 2019; Shahnazi and Shabani, 2019), and trade can play an important role in enhancing this effect. Similarly, GGP policies can be combined with more open government procurement markets to increase the number of suppliers participating in

Box C.2: The role of MSMEs in a low-carbon transition

MSMEs account for roughly 90 per cent of global businesses and an estimated 50 and 35 per cent of GDP in developed and developing economies, respectively (WTO, 2016). Many MSMEs are owned and led by women (World Bank and WTO, 2020).

Although MSMEs can play a large role in achieving global decarbonization targets, only a fraction of them have plans to decarbonize their activities (BCG-HSBC, 2021), despite the fact that the transition to a low-carbon economy offers them a number of opportunities and benefits, from new environmental products and services, to increased production efficiency and lower business costs (ITC, 2021). For instance, 25 per cent of total expected investment across 15 clean energy sectors in developing countries could be accessible to MSMEs (World Bank, 2014). Internationalization can further drive MSME sustainability practices, through exposure to new technologies, new compliance requirements in foreign markets, and demand for sustainability by foreign consumers (Hojnik, Ruzzier and Manolova, 2018).

Nevertheless, significant challenges inhibit further carbon mitigation initiatives by MSMEs. Capital-constrained businesses may be unable to invest without support in more sustainable production and energy-efficient techniques, despite their long-term payoffs (IEA, 2021). MSMEs may also struggle to comply with, or benefit from, climate change mitigation policies, particularly when national and international standards diverge (WTO, 2022c).

Often designed in developed economies, environmental standards and other non-tariff measures to support environmental products, including testing and conformity assessments, can be especially challenging for MSMEs from developing economies to comply with (Pesko et al., 2020). Clear climate change mitigation policies designed with MSME considerations in mind can both promote inclusivity and provide new environmentally sustainable business opportunities for all enterprises.

tenders, and potentially give government purchasers access to more climate-friendly goods, services and technological solutions.

Trade can also raise ambitions with regard to environmental standards and regulations, since firms that wish to export to highly regulated countries have an incentive to develop or adopt higher standards. Analyses of the car industry, for instance, have found that markets that have high emission standards for vehicles tend to put pressure on countries that do not, thereby inducing a ratcheting-up of regulations in these countries (Crippa et al., 2016; Perkins and Neumayer, 2012). As discussed in the next section, international cooperation plays an important role in mitigating potential negative trade impacts and in leveraging synergies through concerted, coordinated and transparent actions.

4. International cooperation is essential to achieve a low-carbon economy

Climate change is a problem of the global commons. In the absence of global coordination, the adoption of individual climate change mitigation strategies is likely to be less than optimal (Akimoto, Sano and Tehrani, 2017; Thube, Delzeit and Henning, 2022). In addition, economic agents may avoid reducing their GHG emission by free-riding on the mitigation efforts of others, while governments' concerns over losing competitiveness could lead to "race to the bottom" or "regulatory chill" situations in which they lower or fail to implement their climate policies, or refrain from adopting ambitious climate policies (Copeland and Taylor, 2004; Dechezleprêtre and Sato, 2017).

International cooperation can help to overcome these challenges and to scale up action on climate change mitigation. It helps to avoid unproductive frictions or obstacles and to address cross-border spillovers, both negative and positive, generated by unilateral climate policies (Kruse-Andersen and Sørensen, 2022). International cooperation ultimately can help allow for the reduction of GHG emissions at the lowest possible cost for growth and is essential for a just transition to a global low-carbon economy.

(a) Greater international cooperation is needed to support a just low-carbon transition

Despite the UNFCCC's 30-year history, progress on climate action has been too slow and uneven to fully contain global temperature increase. The current GHG emission reduction pledges that countries made under the Paris Agreement and other climate mitigation measures adopted would only reduce global carbon emissions by 7.5 per cent by 2030, more than six times less than what would be necessary to keep the global temperature increase below 1.5°C by 2100. In the absence of more ambitious climate change policies and initiatives, the world is projected to hit global warming of about 2.7°C by the end of the century (UNEP, 2021a).

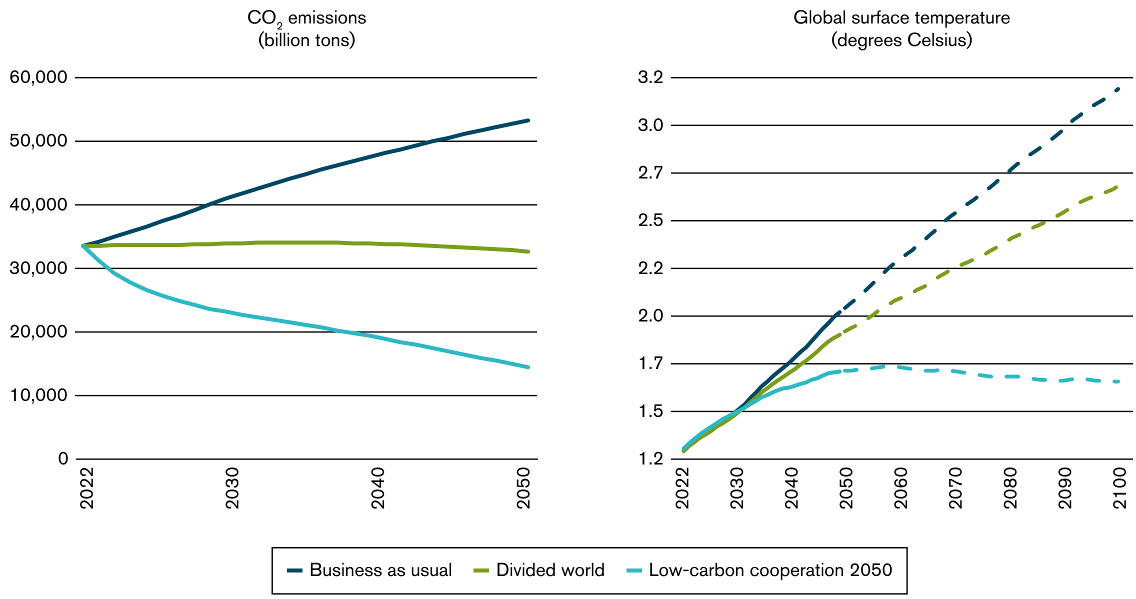
To keep the increase in global temperatures below 1.5°C, the aspirational goal of the Paris Agreement, the world needs to halve annual GHG emissions in the next eight years. This requires additional cooperation among countries. To illustrate the importance of international cooperation, the WTO GTM was used to assess the CO_2 emission and global temperature trajectories of three scenarios (Bekkers et al., 2022).[25]

The baseline "business-as-usual" scenario assumes countries continue to implement their climate change mitigation policies at their respective 2021 levels, without taking further action to implement their NDC pledges. The simulation results suggest that, in the absence of more ambitious global climate change mitigation actions, global annual carbon emissions could reach over 50 gigatonnes of CO_2 (Gt CO_2) in 2050, while the average global temperature could rise by 2°C warming and by over 3°C by the end of the century (see Figure C.4).

Under the "divided world" scenario, countries are assumed to take unilateral climate change mitigation policies, including national carbon pricing, in line with their NDC pledges until 2030.[26] After 2030, carbon prices are assumed to follow a linear growth pattern, resulting in a wide gap between unilaterally imposed carbon prices, which lead countries with high carbon prices to impose border carbon adjustments on imports from countries with less stringent mitigation policies (see Chapter D). Electrification and renewable shares would keep increasing in an uneven manner until 2050, while coal phase-out would be achieved only by countries which have pledged to do so by 2050. The lack of international cooperation could lead to relatively constant global carbon emissions and an average global temperature rise of 1.9°C by 2050 and 2.6°C by the end of the century, well above the Paris Agreement's objective to mitigate climate change.

The "low-carbon cooperation" scenario, described in Section C.3, assumes countries cooperate to tackle climate change by adopting ambitious climate changes policies, including a global carbon pricing system. In contrast to a situation marked by

Figure C.4: International cooperation is needed to reduce carbon emissions and limit global warming to less than 2°C



Source: Bekkers et al. (2022).

Note: Results based on the WTO GTM. The "business as usual" scenario assumes countries continue to apply their climate change policies at their 2021 levels. The "divided world" scenario assumes countries adopt unilaterally climate change policies. The "low-carbon cooperation 2050" scenario assumes countries cooperate by adopting a global carbon pricing system.

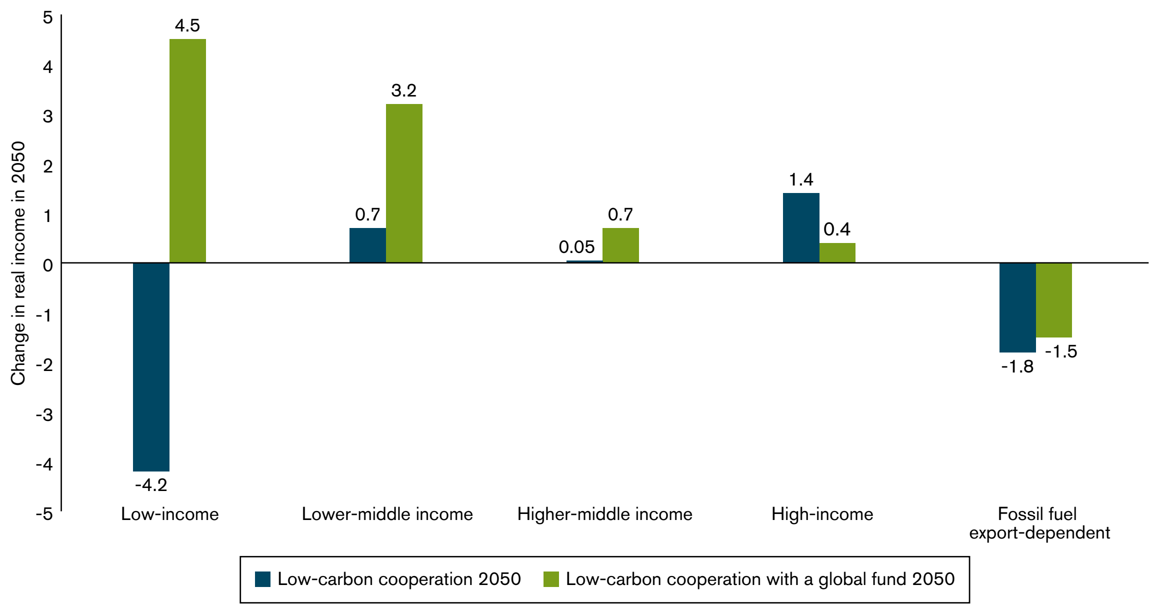
unilateral and uncoordinated climate change policies, international cooperation and coordinated actions could lead to annual global carbon emissions to fall to 14.4 Gt CO_2 and the global average temperature to rise by approximately 1.7°C by 2050, below the Paris Agreement's objective to limit global warming to well below 2°C above pre-industrial levels.

In addition to achieving carbon mitigation objectives, greater international cooperation is also needed to ensure a just low-carbon transition. As discussed in Section C.3, the impacts of decarbonization are unevenly distributed between high-income and low-income regions. Low-income economies could experience a slow-down in economic growth in the absence of complementary and adjustment policies because their economy is less diversified and relatively more reliant on fossil fuel than middle- and high-income economies (except FFEDCs). In addition, low-income economies tend to face a relatively high cost of capital and a limited access to international financial markets which hinder governments and firms in those countries to finance the transition towards a low-carbon economy.

Several options, including additional financial mechanisms, have been discussed in the literature to enable developing countries, and in particular LDCs, to offset the economic costs associated with the transition from an economy based on relatively cheap fossil fuels to an economy based on low-carbon technologies. For example, the so-called Global Carbon Incentive (GCI) would establish a global fund into which regions emitting more than the global average would contribute to the fund, while regions emitting less than the average would receive revenues from the fund (Cramton et al., 2017; Rajan, 2021).

The WTO GTM was used to explore how such a global fund could contribute to a just low-carbon transition. The simulations suggest that implementing an additional financing mechanism to distribute the low-carbon transition burden between high- and low-income countries could increase low and lower-middle income countries' real income by 4.5 per cent and 3.2 per cent, respectively, thus turning the initial negative impact of decarbonization for low-income countries into a positive impact on economic growth (see Figure C.5). Additional financing mechanisms can therefore play an important role in rebalancing the decarbonization impacts with a relatively minimal cost and contribute to a just low-carbon transition.

Figure C.5: Greater cooperation with additional financing mechanism would support a just low-carbon transition



Source: Bekkers et al. (2022).

Note: Results based on the WTO GTM. The figure displays the change in real income in 2050 relative to "business as usual" scenario. The "business as usual" scenario assumes countries continue to apply their climate change policies at their 2021 levels. The "low-carbon cooperation 2050" scenario assumes countries cooperate by adopting a global carbon pricing system. The "low-carbon cooperation 2050 with global fund" scenario assumes that countries cooperation by adopting a global fund to compensate adversely affected countries. Each country's net payment to the global fund is calculated on the basis of the difference between the country's per capita carbon emissions and the global average per capita emissions, multiplied by its population and a reference global price for carbon emissions.

(b) International cooperation on climate adaptation is broad and diverse

International cooperation on climate change mitigation is cross-cutting and involves a broad range of actors at the national, regional, plurilateral and multilateral level. The UNFCCC is the central multilateral framework for tackling climate change, providing an international forum for global negotiations on climate change, while also coordinating the implementation of climate policies. Such coordination can play an important role in the development of national GHG reduction policies, as it can provide assurance to domestic policymakers that commensurate efforts are being taken internationally by key trading partners. A number of countries also pursue bilateral and regional agreements on climate change mitigation in parallel to and in support of the commitments established under the UNFCCC (OECD, 2015).

Other international cooperation efforts, including through other multilateral environmental agreements, have also increasingly looked at how enhanced coordination under their own frameworks could support climate action. For example, the parties to the Montreal Protocol on Substances that Deplete the Ozone Layer adopted the Kigali Amendment to reduce the production and trade of hydrofluorocarbons (HFCs), a refrigerant with high global-warming potential. Its full implementation is expected to prevent up to 0.4°C of global warming by the end of the century. Some sectoral cooperation efforts are directly related to climate mitigation, such as sustainable forestry efforts under the International Tropical Timber Organization (ITTO), support for low-carbon energy transition at the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA), and efforts to decarbonize transportation under the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO) (see also Chapter E).

Cooperation and coordination among non-governmental organizations (NGOs), and between them and governments, are also on the rise.[27] The private sector has also intensified its engagement in international cooperation on climate change mitigation.

(c) International cooperation on trade can support and enhance climate change mitigation actions

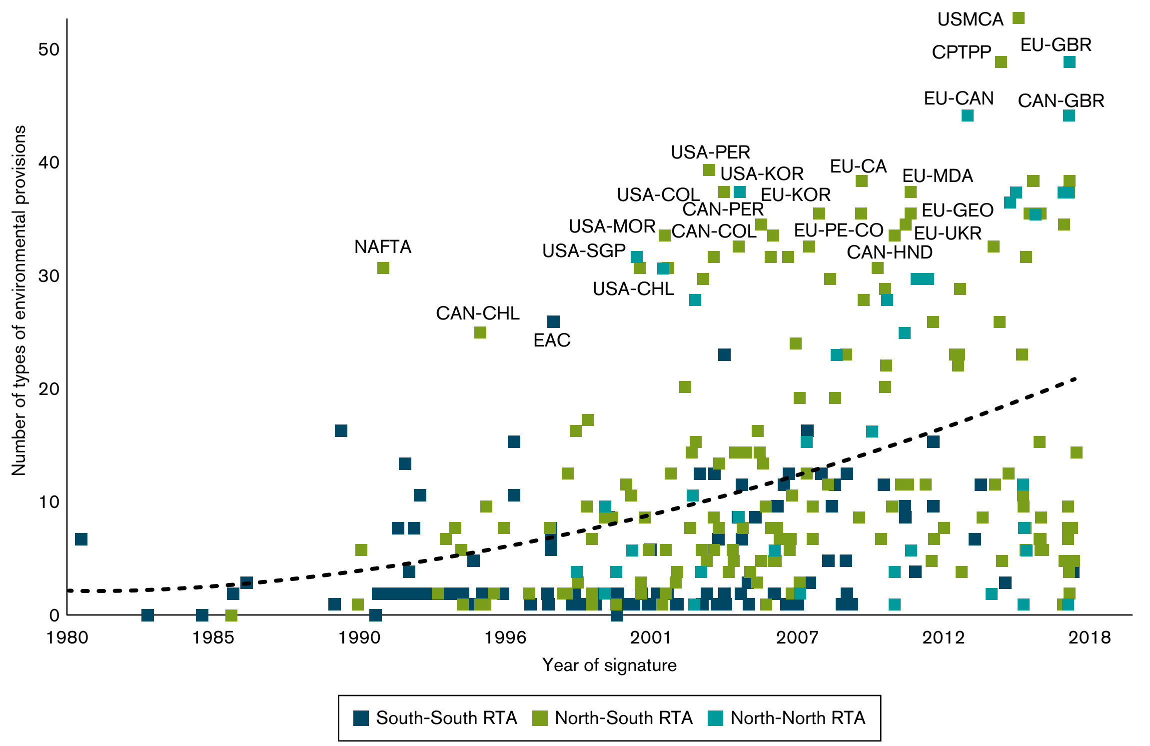
Although the term "international trade" does not feature in the Paris Agreement, its parties have discussed numerous trade-related elements to support climate efforts as part of their cooperation under several technical bodies, including the Forum on Response Measures, the Katowice Committee of Experts (KCI) and the Koronivia Joint Work on Agriculture. In such discussions, the potential role of trade to support parties in their climate efforts has often been highlighted, including the role of trade in helping countries to diversify economically away from their reliance on carbon-intensive sectors and with the just transition of workforces to new low-carbon sectors (UNFCCC, 2016b).[28]

International trade is also an integral part of a limited but increasing number of countries' NDCs to achieve their climate mitigation goals (WTO, 2021f). A review of the NDCs announced in the run-up to the 21st Conference of the Parties or Paris Climate Conference (COP21) of 2015 reveals that, while 45 per cent of NDCs included a direct reference to trade, only around 22 per cent of all NDCs referred to specific trade-related measures geared towards fostering emission mitigation (Brandi, 2017). The trade implication of some of these explicit measures listed in NDCs may, however, not necessarily materialize depending on the instruments and measures ultimately adopted at the domestic level to implement them.

The last 30 years have seen a rapid proliferation of regional trade agreements (RTAs). While RTAs traditionally aimed at lowering tariff and non-tariff trade barriers, an increasing number of RTAs explicitly address sustainable development and environmental issues. The number and level of detail of environmental provisions in RTAs has also increased significantly over the years (see Figure C.6), with the most detailed provisions often found within chapters dedicated to environment or sustainable development or within environmental cooperation agreements (Monteiro, 2016).

Provisions that explicitly address climate change in RTAs have similarly increased over the years, although these tend to be less frequent (namely, 64 RTAs notified to the WTO) and detailed than other types of environmental provisions (WTO, 2021b).

Figure C.6: Environmental provisions in RTAs continue to expand



Source: Authors' calculations, based on updated data from Monteiro (2016).

Note: Analysis based on RTAs notified to the WTO. "North" is defined as high-income countries, whereas "South" is defined as middle- and low-income countries according to the World Bank's country classification.

Provisions on climate change can take many forms. Some provisions underscore the importance of addressing climate change, including through trade in environmental goods and services and reducing subsidies for fossil fuels, while others require the parties to effectively implementing the Paris Agreement and adopt climate change policies.[29] The most common type of provisions identifies climate change mitigation as a cooperation area, covering different issues including alternative energy and energy conservation, sustainable forestry management, and activities related to aspects of the international climate change regime with relevance for trade.[30]

Explicit provisions on climate change are often complemented by other environmental provisions. For instance, provisions establishing level-playing-field commitments to ensure environmental policies are effectively applied. RTAs may also establish institutional arrangements as tools for ensuring implementation. These can entail, for example, setting up committees to ensure dialogue on implementation, implementing public accountability mechanisms, and carrying out *ex post* reviews of commitment implementation (Monteiro, 2016; Monteiro and Trachtman, 2020).

In addition to regional trade initiatives, the multilateral trading system provides an enabling framework that contributes to can support climate mitigation efforts. As discussed below in greater detail, WTO rules, the WTO monitoring and transparency functions, and the Aid for Trade initiative provide important mechanisms to foster a coherent linkage between trade and climate policies.

(d) WTO rules help to prevent protectionism and to promote efficient and effective trade-related climate policies

Measures adopted by WTO members in pursuit of climate goals may, by their very nature, restrict trade and thereby affect the rights, under WTO rules, of other members. The WTO Agreements expressly recognize the rights of WTO members to adopt measures to protect the environment so long as they are not applied arbitrarily and are not more restrictive than necessary. WTO members have also reaffirmed, at the political level, that WTO rules do not override environmental protection (WTO and UNEP, 2009, 2018).[31]

The preamble of the Marrakesh Agreement Establishing the World Trade Organization (WTO Agreement)[32] states that sustainable development and the protection of the environment are central objectives of the multilateral trading system. According to WTO jurisprudence, the preamble to the WTO Agreement "informs" the reading of all WTO covered agreements and "shows that the signatories to that Agreement were, in 1994, fully aware of the importance and legitimacy of environmental protection as a goal of national and international policy."[33]

The common understanding on the urgent need to act on climate, as enshrined, for example, in the Paris Agreement, is important since WTO law should not "be read in clinical isolation from public international law."[34] A deeper understanding by the trade community of the content and rationale of the multilateral climate framework can be key to enhancing the mutual supportiveness between the two systems. This requires enhanced domestic coordination between ministries and domestic agencies involved in trade and climate policies and diplomacy, but it is also carried out by the regular work of the Committee on Trade and Environment (CTE), as discussed below.

While WTO rules do not prevent members from adopting a wide range of ambitious climate measures, they do impose a series of requirements to ensure that measures are tailored to their objectives.[35] In particular, members seeking to adopt trade-related climate measures must respect a series of key WTO principles, such as non-discrimination between domestic and foreign products (national treatment) and among trading partners (most-favoured nation treatment), transparency in designing and implementing the measure, avoiding creating unnecessary barriers to trade, and the prohibition on quantitative restrictions to trade.

However, even if certain climate measures might, at first, appear to be contrary to one or more of such principles as defined in WTO Agreements (e.g., because they impose restrictions on trade in certain particularly carbon-intensive goods), WTO rules contain important flexibilities that allow for the accommodation of legitimate policies. Article XX of the General Agreement on Tariffs and Trade (GATT) introduces the "general exceptions" to obligations under this agreement, one of the main examples of such flexibility. However, several other WTO Agreements contain similar flexibilities, such as the General Agreement on Trade in Services (GATS), the Technical Barriers to Trade (TBT) Agreements, and the Agreement on Trade-Related Investment Measures (TRIMs Agreement). WTO adjudicators have reaffirmed time and again the rights of WTO members to determine their own environmental and climate policies, as well as the degree of protection they choose, even if that significantly restricts trade.[36]

Environment-related disputes at the WTO have helped to clarify that there are several useful checks to ensure that trade-related measures to fight climate change are not misused for protectionist purposes. These checks include:

- Coherence: The trade restriction or difference in treatment between domestic and imported products can be explained by the legitimate objective pursued rather than by the granting of protection to domestic sectors.
- Fit-for-purpose: The measure can efficiently contribute to the legitimate objective in a balanced way or is part of a domestic conservation policy also restricting domestic production or consumption.
- Mindful and holistic: The measure forms part of a holistic climate policy and considers the impact on other countries, as well as on other national, regional and international efforts on the same topic.
- Flexible: The measure is result-oriented and takes into account alternative measures to address the same challenge as effectively.

Environmental measures modified in light of these principles following WTO disputes have resulted in more coherent and effective measures to protect the environment, even if they have also led to more significant trade effects. That is because once the unjustifiable or arbitrary discriminatory elements of these measures were corrected or eliminated, the environmental policies were often applied to a wider and more coherent number of goods, more effectively, and more in line with the legitimate objective (WTO, 2020b).

Several other WTO disciplines also seek the same objective of ensuring better, more effective and less distorting trade policies aimed at legitimate objectives. A number of WTO agreements address specific types of trade-related measures, which can be applied to address climate change, as discussed in Section C.2.

The TBT Agreement covers mandatory technical regulations, voluntary standards and conformity assessment procedures in respect of all products (including industrial and agricultural products). It recommends that technical regulations should, to the extent possible, be based on performance, rather than on design and descriptive features. This principle helps to ensure that producers and innovators anywhere — including from developing countries and LDCs — can find the most effective and efficient way of fulfilling the requirements of the technical regulation. It can also avoid "locking-in" certain technological solutions that might no longer be the most environmentally efficient in the future. The TBT Agreement also recognizes the need to support developing-country producers to comply with such requirements.

The WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) establishes a balanced framework for the innovation and dissemination of climate technologies for the mutual benefit of innovators and technology users, in particular through a range of tailored domestic measures concerning the governance of the intellectual property (IP) system for social and economic welfare. The IP system works in conjunction with international trade to facilitate knowledge transfers and diffusion of critical mitigation technologies, including through the effect of GVCs and knowledge spillovers, and trade in knowledge-intensive goods (Delgado and Kyle, 2022).

Under Article 66.2 of the TRIPS Agreement developed-country members are required to provide incentives for enterprises and institutions in their territories to encourage technology transfer to LDCs. Since 2003, developed-country members have been required to submit annual reports on actions taken or planned in this area. A review of the annual reports submitted by nine developed-country members between 2018-20 reveals that some 754 technology transfer programmes, of which 152 covered environmental and climate change technologies transferred to 41 LDC recipients.[37] Around 82 per cent of these programmes focused on various climate-related issues, including renewable energy, energy efficiency, climate adaptation and sustainable water and forest management (see Figure C.7).

The Agreement on Subsidies and Countervailing Measures (SCM Agreement) disciplines the use of subsidies, and regulates the actions WTO members can take to counter the effects of subsidies. While not all climate support measures are covered by the SCM Agreement (as it only covers financial contributions, income or price supports that confer a benefit), subsidies that are specific to certain enterprises and cause adverse effects can be "actioned" by affected WTO members by applying domestic measures (countervailing duties) or through the WTO Dispute Settlement System (WTO, 2020b). In addition,

Figure C.7: Most environmental technology transfer programmes reported under TRIPS Article 66.2 relate to climate change

Source: Authors' calculations, based on the reports submitted by developed-country members under TRIPS Article 66.2

Note: The numbers in parenthesis report the number of environmental technology transfer programmes by type of environmental objective reported under TRIPS Article 66.2 between 2018 and 2020.

subsidies contingent upon the use of domestic goods or export performance are considered to be particularly harmful to trade and prohibited.[38]

The SCM Agreement used to include a list of certain "non-actionable" subsidies, including those for R&D, regional development and the adaptation of existing facilities to new environmental requirements. However, this provision applied only during the first five years that the SCM Agreement was in force. A revival of the category of non-actionable subsidies is often discussed within the context of government support for climate change mitigation (Howse, 2010).[39]

In recent years, a few disputes concerning support provided for renewable energy generation and conditioned upon the use of domestic content (i.e., local content requirement) were brought before the WTO Dispute Settlement System.[40] In none of these disputes was the goal of promoting renewable energy put into question. However, the aspects that were found to be contrary to WTO disciplines were the requirements for energy producers to use local components and products. In addition, the Appellate Body indicated that, when assessing the benefit from a support measure for renewable energy, due consideration of a country's sustainable energy production objectives should be given, and that an appropriate benchmark should be used that could take into consideration the differences in costs and environmental externalities involved in fossil fuel-based energy and renewable energy production.[41]

In effect, these trade disputes raise the question of whether local content requirements are effective and appropriate means of promoting renewable energy production. Some evidence suggests that local content requirements have hindered global international investment flows in solar PV and wind energy, reducing the potential benefits from international trade and investment (OECD, 2015; Stephenson, 2013) and ultimately can hamper or slow down climate change mitigation efforts (WTO and IRENA, 2021).

The increasing use of trade defence measures, namely antidumping, countervailing duties and safeguards, against imports of renewable energy goods and other products required for the low-carbon energy transition has also raised concerns about their impact on climate mitigation efforts (see Chapter F) (Horlick, 2014; Kampel, 2017; Kasteng, 2014; UNCTAD, 2014).

While WTO members have the right to decide whether to initiate investigations and apply trade defence measures (including based on public interest considerations, such as climate change), WTO rules seek to ensure that such measures and processes are not abused.

The Agreement on Agriculture (AoA) aims to reduce trade restrictions on agricultural products caused by barriers to market access, exports subsidies and subsidies that directly stimulate production and distort agricultural trade. The AoA contains, however, a category of permissible subsidies, known as "Green Box" support measures, which include certain flexibilities for domestic support afforded for environmental purposes. This, together with certain conditions and other flexibilities for limited distortive programmes, can provide members with opportunities to pursue climate-related measures in the area of agriculture (see Chapter B).

The plurilateral WTO Agreement on Government Procurement (GPA 2012) commits its signatories to opening their government procurement markets to each other's suppliers in a reciprocal manner.[42] The GPA 2012 can help governments to obtain better value for money for climate-friendly goods and services through GPP (See Section C.2). The agreement notably allows parties to apply technical specifications aimed at promoting natural resource conservation or protecting the environment, as well as to use the environmental characteristics of a good or service as an award criterion in evaluating tenders.

As the low-carbon transition entails a change in the composition of energy trade as well as trade in manufactured inputs and complementary products necessary to generate renewable energy, governments may increasingly resort to trade policies to adjust to and support this transition. Greater cooperation on trade policies, such as trade remedies, subsidies, IP protection and local content requirements, would be necessary to discuss further, and potentially clarify, strengthen and update WTO rules to ensure the low-carbon transition can be achieved as smoothly as possible.

(d) Transparency and dialogue support coherent and fit-for-purpose climate change policies

Transparency is an important feature of decision-making and regulatory action to address transboundary problems, such as climate change (Gupta and Mason, 2014). It contributes to build trust, enhance accountability, and potentially improve the effectiveness of climate change policies.

Several WTO agreements require WTO members to inform each other about new or forthcoming trade-related measures, including those related to climate change. The notification process is an essential tool to facilitate access to information about trade-related climate measures contemplated by members.

Under the Trade Policy Review Mechanism, WTO members also carry out periodic collective assessments of each member's trade policies and practices. These exercises promote greater transparency in, and understanding of, members' trade policies, including those that relate directly to climate change.

The WTO Environmental Database (EDB) compiles in one single interface the environment-related measures notified by members, as well as the environment-related information contained in members' trade policy review reports.

For transparency to be effective, it is essential to go beyond the simple exchange of trade-related information, and understand what is being notified and their implications on other members. Through its committees and other bodies, the WTO provides a forum that give members the opportunity to share experiences and best practices and address trade concerns and avoid trade disputes.[43]

Climate-related trade measures are discussed in most WTO bodies. For instance, the Council for Trade in Goods has recently discussed the European Union's plans for a carbon border adjustment mechanism.[44] Market access issues related to environmental services were addressed in the Council for Trade in Services.[45] The TRIPS Council discussed a wide array of policies and initiatives addressing the interplay of IP, climate change and development.[46] The TBT Committee considered several specific trade concerns related to technical regulations and conformity assessment procedures related to energy efficiency.[47]

A more focused discussion on trade and climate policies takes place in the CTE, where members specifically meet to discuss how trade and environmental measures could work better together to promote sustainable development. These discussions and information exchange also cover issues related to the low-carbon transition, such as environmental taxes and labelling schemes, sustainable natural resource management, environmental goods and services, and the environmental footprint of products and organizations. The CTE also serves as a forum where the secretariats of multilateral environmental agreements, such as the UNFCCC, and other institutions, such as the International Civil Aviation Organization, regularly brief WTO members on their trade-related environmental work.

At the same time, more could be done to ensure that the work in the WTO leads to solutions and concrete actions supporting the transition to a low-carbon economy. Three new environmental initiatives – the Trade and Environmental Sustainability Structured Discussions (TESSD) and the Informal Dialogue on Plastics Pollution and Environmentally Sustainable Plastics Trade (IDP) (both launched in November 2020), and the Fossil Fuel Subsidy Reform initiative (FFSR) (launched in December 2021), share the common goal of ensuring that trade and the WTO form part of the solution to climate change and environmental degradation.[48] These initiatives, which are open to all WTO members, also actively involve external stakeholders, such as NGOs, businesses, academia and other international organizations, each of which provide technical expertise and experience.

Climate change is one of the main themes of the TESSD, which aim to complement discussions in the CTE. Participants in the TESSD have been discussing how trade-related climate change measures can best contribute to climate and environmental goals and commitments, while remaining consistent with WTO rules. They are working towards identifying solutions and concrete actions to contribute to the transition to a low-carbon economy, including environmental goods and services, the circular economy, sustainable supply chains and the trade and environmental effects of subsidies.

The IDP is concerned with the rising environmental, health and economic costs of plastics pollution, since 99 per cent of plastics are fossil fuel-based, and can release emissions throughout their lifecycle (CIEL, 2019). Plastics currently generate 1.8 gigatonnes of CO_2-equivalent, and this could more than double by 2060 in the absence of significantly more stringent and coordinated action (OECD, 2022c). Participants in the IDP have been discussing how the WTO can contribute to strengthening policy coherence, exploring collective approaches among WTO members, and improving technical assistance to developing countries in support of global efforts to reduce plastic waste and move towards a circular plastics economy.

The FFSR initiative encourages the rationalization and phasing-out of inefficient fossil fuel subsidies that lead to wasteful consumption. Globally, countries subsidized fossil fuel production and consumption to the tune of over US$ 440 billion in 2021 (IEA, 2022d). The initiative foresees exploring the trade relevance of discussing FFSR in the multilateral trading system, including by taking stock of international efforts and members' priorities, discussing the development and social aspects of FFSR, and providing updates on members' actions with regard to transparency and reforms.

In addition to dedicated environmental initiatives, the WTO could further strengthen its role as a forum for coordination and dialogue on trade and climate change, as well as for cooperation with other international organizations to develop recommendations regarding the trade-related policies and instruments needed for the transition to a low-carbon economy (see, for example, Chapter D on carbon pricing). In addition, the WTO could also advance dialogue with the private sector to address trade-related challenges for decarbonizing supply chains (see also Chapter E).[49]

(e) Aid for Trade can play an important role in supporting a just transition to a low-carbon economy

As discussed in Section C.2, climate finance is vital for a just transition to a low-carbon economy. Yet, climate finance levels remain far below what is needed to prevent global temperature from rising above 1.5°C. Available estimates suggest that although total climate finance has increased, on average, by almost 15 per cent between 2011 and 2020, the increase in annual climate finance flows has slowed in recent years. Projections suggest that annual climate finance flows would need to increase by 590 per cent in order to reduce GHG emissions by 45 per cent by 2030 and avoid the most dangerous consequences of climate change (Climate Policy Initiative, 2021).

The Aid for Trade initiative can help to assist developing countries and LDCs in mobilizing some of the financial support required to meet their trade integration objectives while pursuing the transition to a low-carbon economy.

While Aid for Trade mainly tracks concessional financing (official development assistance flows), climate finance also includes non-concessional financing (other official flows), export credits and private finance mobilized through public climate finance. In 2020, climate-related Aid for Trade represented more than 50 per cent of climate-related official development assistance flows, illustrating the rising complementarities in trade, development and climate agendas (OECD and WTO, 2022).

Over the period 2013 to 2020, US$ 80 billion were disbursed to Aid for Trade projects with a climate-mitigation objective; disbursements almost doubled between 2013 (US$ 6.5 billion) and 2020 (US$ 12.3 billion) (see Figure C.8). In 2020, 43 per cent of mitigation-related Aid for Trade targeted renewable power generation, distribution and energy conservation, while 23 per cent went to climate-friendly infrastructure, and 17 per cent went to agriculture, forestry and fishing.

With more developing countries and their financing partners prioritizing climate mitigation in their development programming, the share of Aid for Trade dedicated to the transition to a low-carbon economy is set to grow. However, more could be done to exploit the synergies between climate finance and Aid for Trade by mainstreaming trade considerations into climate strategies – and climate considerations into trade cooperation strategies.

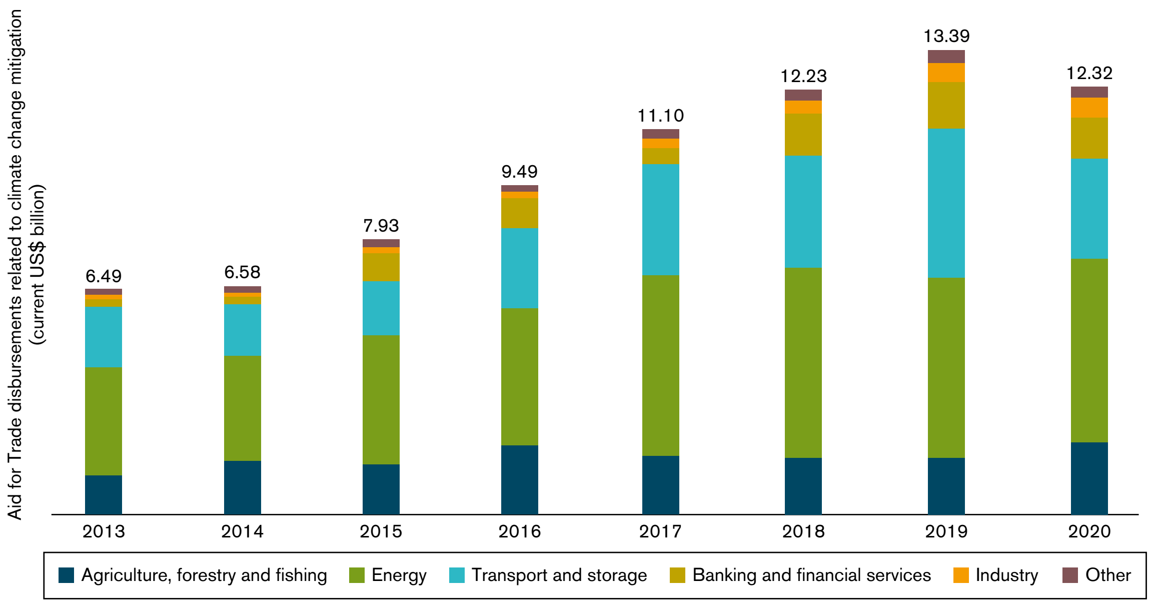
5. Conclusion

The transition to a low-carbon economy would require a substantial transformation of energy, production, transport and land-use systems. This transformation is unlikely to be achieved without ambitious climate change policies that may comprise a broad range of different measures, including market-based measures, command-and-control regulations, information-based instruments and voluntary agreements.

Trade can contribute to supporting the low-carbon transition by incentivizing environmental innovation, leveraging comparative advantages in the production of low-carbon technologies and renewable energy, and expanding access to and deployment of critical low-carbon goods and services. A transition towards a low-carbon economy is also likely to change what, with whom and how trade is conducted. Trade in renewable energy and electricity and trade in goods and services produced and delivered with clean energy could expand significantly.

While decarbonization offers new trading opportunities for many economies, including developing countries, a just low-carbon transition may require complementary policies to help affected regions and vulnerable groups, including MSMEs, to decarbonize and adjust production and consumption patterns more smoothly. Well-functioning labour and financial markets are

Figure C.8: Most Aid for Trade disbursement related to climate change mitigation covers energy and transport



Source: Authors' calculations, based on Organisation for Economic Co-operation and Development (OECD) DAC-CRS (Development Assistance Committee Creditor Reporting System) Aid Activities Database.

Note: Only projects with an explicit objective of mitigating climate change and projects identifying climate change mitigation as important but secondary objective are considered as adaptation-related official development assistance.

essential to support the economic changes needed to move to a low-carbon future.

International cooperation is essential to achieve a low-carbon economy. The WTO contributes to supporting climate change mitigation actions in several ways. WTO rules support members in pursuing their climate objectives by helping to prevent unproductive frictions and obstacles, and ensuring efficient and effective trade-related climate policies. By fostering transparency and providing a forum for policy dialogue, the WTO can contribute to coherent and fit-for-purpose climate policies. In addition, the Aid for Trade initiative can support a just transition to a low-carbon economy.

The progress on global climate actions, however, has been insufficient to fully contain global temperature increase. Greater international cooperation on climate change mitigation is essential to promote a just low-carbon transition. The WTO can further contribute to strengthening the interlinkages between trade and climate objectives by advancing solutions for trade-related climate action.

Endnotes

1 GHGs comprise carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases, including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphurhexafluoride (SF_6). Although discussions on climate change tend to focus on CO_2 because it is the main contributor to climate change, accounting for about three-quarters (74.1 per cent) of total emissions, it is estimated that methane contributes 17.3 per cent, nitrous oxide 6.2 per cent, and other emissions 2.4 per cent (WRI, 2022).

2 Reducing production and consumption to mitigate GHG emissions is commonly known as "degrowth". Although controversial, this strategy has been proposed by some scholars as an alternative means of achieving a low-carbon economy which would allow to minimize unfeasibility and unsustainability risks associated with strategies aimed at decoupling GDP and GHG emissions (Keysser and Lenzen, 2021; Lenzen, Keysser and Hickel, 2022).

3 Unlike the previous framework for climate action under the UNFCCC – the Kyoto Protocol – the Paris Agreement requires all parties, whether developed or developing countries, to take action and contribute to climate change mitigation and adaptation.

4 Nevertheless, several challenges to the transition to a low-carbon economy have been identified in the literature. For instance, the so-called "green paradox" could arise if fossil fuel owners chose to extract and monetize fossil fuel more quickly in reaction to an anticipated phase-out of fossil fuel assets, thereby causing more carbon emissions to be released more quickly (Sinn, 2012).

5 For instance, 87 per cent of global annual farm support (approximately US$ 470 billion) are estimated to be price-distorting, as well as being environmentally and socially harmful, with the vast majority of support provided for the most emission-intensive products. The removal of fiscal subsidies could decrease global GHG emissions from agricultural production in 2030 by 11.3 million tonnes of CO_2-equivalent (CO_2e), while the removal of all border measures could further reduce GHG emissions by 67.1 million tonnes CO_2e (FAO, UNDP and UNEP, 2021).

6 Government procurement amounts to approximatively US$ 11 trillion per year, accounting for about 12 per cent of world GDP (Bosio and Djankov, 2020).

7 So-called food miles labels indicate that the product is locally grown. As discussed in chapter E, although international transportation, especially by air and road, releases GHGs, it is not always the main contributor to a product's carbon footprint.

8 Eco-labels mandated by government agencies may also be considered as environmental regulations.

9 Like GGP, voluntary agreements are voluntary in nature. However, whereas GPP requires commitments on the part of the government to use environmentally friendly goods and services in the public procurement process, voluntary agreements require commitments and action from private-sector firms, with a view to reducing emissions.

10 In high-income countries, carbon pricing has a larger percentage impact on the cost of living for poorer households since they tend to spend a larger proportion of their income on fuels (Goulder et al., 2019). Conversely, in developing countries carbon pricing policies tend to have a larger negative impact on the cost of living of the rich households compared to the poor (Dorband et al., 2019).

11 The distributional impacts of removing fossil fuel subsidies tends to be more progressive in developing countries than in developed ones (Goulder et al., 2019). The removal of fossil fuel subsidies impacts equity through several channels. It impacts the cost of consumption directly, by raising the price of fuels, and indirectly, by raising the prices of fuel intensive products. Raising the price of fuels tends also to cause an increase in the labour intensity of production. This in turn raises employment opportunities and the greater scarcity of labour raises the wage rate in relation to the rental rate on capital (Malerba and Wiebe, 2021).

12 An accelerated delivery of international public finance will be critical to a low-carbon transition, and the private sector will need to finance most of the extra investment required. Indeed, of the amount required for the energy transition pathway aligned with the ambition to limit global warming to less than 1.5°C, around US$ 3.4 trillion (59 per cent) and US$ 2.2 trillion (60 per cent) are expected to come from private-sector equity and lending, in the periods from 2021 to 2030 and from 2031 to 2050, respectively (IRENA, 2021).

13 Learning effects, economies of scale and technological innovations, such as drones and artificial intelligence, could reduce the labour intensity of the renewable energy sectors in the long run (IRENA, 2021).

14 However, energy carriers are a less efficient mode of energy transport compared to fossil fuel energy because of the energy required for their production and potential reconversion processes (Brändle, Schönfisch and Schulte, 2021).

15 The WTO GTM is a computable general equilibrium model, focused on the real side of the global economy, modelling global trade relations See Aguiar et al. (2019) for a technical description of the WTO GTM.

16 For modelling purposes, renewable energy includes solar and wind power. It does not include hydrogen, which is included, for the purpose of the simulation, in the non-electricity nest of the production structure. Switching to renewable energy could lead to higher trade in that energy, but also to higher trade in other minerals.

17 In these simulations, fossil fuel export-dependent countries and regions are Russia, the Middle East and Northern Africa.

18 Although green hydrogen offers an opportunity for energy trade, the scale of trade in hydrogen is projected to be smaller than the current scale of fossil fuels. The share of trade in green hydrogen is projected to reach 17.6 per cent of total energy trade by 2050 compared to 72.9 per cent for fossil fuels exports in 2021.

19 Notified trade measures with the following objectives are considered to be related to climate change, namely: afforestation or reforestation; air pollution reduction; alternative and renewable energy; climate change mitigation and adaptation; energy conservation and efficiency; and ozone layer protection. For more information, see WTO (2021d).

20 See TBT Notification – Japan G/TBT/N/JPN/628.

21 See SCM Notification – China G/SCM/N/343/CHN.

22 See LIC Notification – Australia G/LIC/N/3/AUS/12.

23 See CMA Meeting, Japan-India, G/MA/M/74.

24 See also CMA Meeting Minutes G/MA/M/74; G/MA/M/73; G/MA/M/72.

25 The average global temperature levels implied by different paths of carbon emissions are obtained using the Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC) based on the projected CO_2 emissions by the WTO GTM Model. For the "business-as-usual" and "divided world" scenarios, it is assumed that CO_2 emissions post-2050 remain constant at 2050 levels. Non-CO_2 emissions follow the Shared Socioeconomic Pathway (SSP) 2-4.5 scenario of the IPCC, which assumes a "middle of the road" world where trends broadly follow their historical patterns resulting in a global warming of 2.5-2.7°C by 2100. For the "cooperation towards net zero" scenario, it is assumed that CO_2 emissions will reach net zero after 2050 and remain this way until 2100. Non-CO_2 emissions follow the SSP1-2.6 scenario of the IPCC, which assumes a world of sustainability-focused growth and equality resulting in a global warming of 1.7-1.8°C by 2100.

26 For modelling purposes, the different climate change policy instruments are not distinguished. These policies are implemented in the simulations as cost-neutral shifts in production methods.

27 Examples of initiatives include the "We Mean Business Coalition", the Science Based Targets initiative, the UN Alliance for Sustainable Fashion, the Global Cement and Concrete Association (GCCA) 2050 Net Zero Global Industry Roadmap, and the COP26 declaration on accelerating the transition to 100 per cent zero emission cars and vans.

28 Trade will also play a role in the implementation of Article 6 of the Paris Agreement, which establishes rules for internationally transferred mitigation outcomes (ITMOs), i.e., cooperative approaches to facilitate the exchange of emissions reductions above those pledged under NDCs. It has been estimated that, by 2030, carbon trading (i.e., the government-authorized buying and selling of credits corresponding to emissions of a certain amount of GHGs) under ITMOs could save US$ 250 billion a year in climate mitigation costs in the energy sector alone (Edmonds et al., 2019).

29 See for instance Colombia-Ecuador-European Union-Peru RTA and European Union-United Kingdom RTA.

30 Although there is limited empirical evidence on the effectiveness of provisions on climate change in RTAs, environmental provisions in RTAs have been found to reduce the emissions of certain pollutants, including CO_2 emissions (Martinez-Zarzoso and Oueslati, 2018) and deforestation (Abman, Lundberg and Ruta, 2021).

31 At the Doha Ministerial Conference, in 2001, WTO members recognized that, under WTO rules, no WTO member should be prevented from taking measures for the protection of the environment at the levels it considers appropriate, as long as these measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade. See ttps://www.wto.org/english/thewto_e/minist_e/min01_e/mindecl_e.htm.

32 See https://www.wto.org/english/docs_e/legal_e/04-wto_e.htm.

33 Appellate Body Report, US – Shrimp (1998), para. 129.

34 Appellate Body Report, US – Gasoline (1996), p. 17.

35 Appellate Body Report, US – Gasoline (1996), p. 25.

36 Appellate Body Reports, US – Gasoline, US – Shrimp; EC – Asbestos, Brazil – Retreated Tyres; and US – Tuna II (Mexico).

37 The nine developed-country members are the European Union (with 55 technology transfer programmes), the United States (35), Norway (24), Japan (10), Switzerland (10), the United Kingdom (8), Australia (6), Canada (3) and New Zealand (1). The main LDC beneficiaries of the technology transfer programmes are Bangladesh, Cambodia, Mozambique, Rwanda, Senegal, Tanzania, Uganda and Zambia.

38 Although not directly focused on climate mitigation, the Agreement on Fisheries Subsidies adopted at the 12th WTO Ministerial Conference in June 2022 could also help to contribute to climate mitigation strategies by improving the energy efficiency of vessels (Kristofersson, Gunnlaugsson and Valtysson, 2021) and supporting more sustainable diets (Gephart et al., 2021) (see Box B.5).

39 Some WTO members have, in the past, formally proposed the reintroduction of the non-actionable subsidies category, including that adopted for environmental purposes, specifically in favour of developing-country members. No decision on this matter has been adopted so far. See WTO official documents number WT/MIN(01)/17, TN/RL/W/41 and WT/GC/W/773, which can be accessed at https://docs.wto.org/.

40 See, for example, Canada – Feed in Tariff; India – Solar Cells; and US — Renewable Energy.

41 See Canada – Feed in Tariff, at paragraphs 5.174-190.

42 The GPA 2012 has 21 parties covering 48 WTO members. More information is available at: https://www.wto.org/english/tratop_e/gproc_e/gproc_e.htm.

43 It has been estimated, for instance, that through the work of the TBT Committee on specific trade concerns, € 80 billion worth of unnecessary trade costs affecting EU exports were avoided over a 10-year period (Cernat and Boucher, 2021).

44 See https://www.wto.org/english/news_e/news20_e/good_11jun20_e.htm

45 See https://www.wto.org/english/news_e/news20_e/serv_23oct20_e.htm

46 See https://www.wto.org/english/news_e/news21_e/trip_11mar21_e.htm

47 See, for instance, https://www.wto.org/english/news_e/news22_e/tbt_15jul22_e.htm

48 Three separate ministerial statements were launched at a joint event on 15 December 2021: TESSD Ministerial Statement (WT/MIN(21)/6/Rev.2); IDP Ministerial Statement (WT/MIN(21)/8/Rev.2); and FFSR Ministerial Statement (WT/MIN(21)/9/Rev.1).

49 For example, a virtual "Trade 4 Climate" Dialogue was hosted by the WTO and the International Chamber of Commerce (ICC) on 26 October 2021: https://www.wto.org/english/tratop_e/envir_e/trade4climate_e.htm

D

Carbon pricing and international trade

Although different instruments can be used to mitigate climate change, carbon pricing has attracted increasing attention. This chapter explores the role of carbon pricing in reducing greenhouse gas emissions and its implication on international trade and trade policies. Carbon pricing puts a price on carbon emissions, which can motivate firms and individuals to make more climate-friendly investing and purchasing decisions. While the proliferation of carbon pricing schemes highlights the urgency to tackle climate change, they may lead to an unnecessary complex patchwork of domestic and regional schemes. Greater international cooperation is essential to find common solutions to carbon pricing, and the WTO remains an appropriate forum to contribute to these efforts.

Contents

Key facts and findings

- Almost 70 carbon pricing initiatives, covering 23 per cent of global greenhouse gas emissions, have been adopted in 46 national jurisdictions worldwide. A proliferation of different carbon pricing initiatives increases the risk of creating a complex patchwork of different systems.
- A uniform global carbon price would be more efficient to reach emission reduction targets than regional carbon prices because it would allow emissions to be reduced in places where it costs less to do so.
- Carbon pricing policies in the absence of adjustment policies can adversely affect low-income regions and exporters of fossil fuels and of emission-intensive products. However, carbon pricing policies can also help countries to diversify their economies away from fossil fuel energy.
- Uncoordinated carbon pricing policies increase the risk of carbon leakage, competitiveness losses in regions implementing ambitious climate policies, and additional administrative costs.
- Although border carbon adjustment can, to some degree, help address carbon leakage and limit competitiveness loss, it can also generate trade conflicts and economic losses for countries affected.

1. Introduction

Achieving large greenhouse gas (GHG) emission cuts at the pace necessary to avoid the worst consequences of climate change has become a pressing challenge for policymakers and has reignited the debate about appropriate climate policy responses. Carbon pricing is often seen as an important instrument to accelerate a low-carbon transition by incentivizing firms and individuals to reduce their carbon emissions or pay for their carbon emissions.

This chapter explores the features, challenges and trade implications of carbon pricing. It reviews the trade relevance of a global carbon pricing scheme as a means of preventing a patchwork of uncoordinated carbon pricing policies. A proliferation of different carbon pricing policies could lead to high transaction costs and the introduction of border carbon adjustment (BCA) mechanisms, which could, in turn, lead to trade tensions. The chapter concludes by discussing the importance of international cooperation to address the fragmentation of carbon pricing schemes and support ambitious climate mitigation actions.

2. Carbon pricing can be an important instrument to reduce carbon emissions

GHG emissions create social and market costs, also known as externalities, which are not reflected in the value of products, services or financial assets (see Chapter C). To correct this market failure, carbon pricing is often presented, by many economists, as the most efficient approach to cut GHG emissions.

Carbon pricing is a market-based instrument that sets a price on carbon dioxide (CO_2) or equivalent GHG emissions. The carbon price reflects the additional cost on the environment and the society of emitting an extra unit of GHG (e.g., ton of CO_2 or equivalent GHG). Carbon prices encourage producers to decrease the carbon intensity of the production and transportation processes, and consumers to buy less carbon-intensive goods and services.

While a large part of the current debate about climate change policy relates to carbon pricing, the implementation of carbon pricing schemes faces important political challenges given its potentially major domestic and international distributional consequences. A well-designed carbon pricing policy needs to be complemented with additional policies to address distributional concerns and other market failures associated with a low-carbon transition (see Chapter C).

(a) Carbon pricing schemes proliferate but cover only a modest share of emissions

Carbon pricing can be imposed implicitly through the compliance costs of price-based regulations (e.g., fossil fuel prices or renewable energy subsidies) or explicitly by specifying a price directly on carbon emissions. Explicit carbon pricing can take two main forms: carbon tax and emissions trading scheme (Fischer and Fox, 2007; Goulder and Schein, 2013; WTO and UNEP, 2009).[1]

The carbon tax is determined by the regulator who sets a price on carbon through a tax or fee on GHG emissions or on the carbon content of fossil fuels. While the price of carbon is fixed, the quantity of emissions released into the atmosphere is initially unknown and will depend on the firms' and consumers' reaction to the carbon tax. Some might choose to pay the carbon tax and emit GHG emissions, while others might opt to reduce their carbon emissions so as to avoid paying the carbon tax. As a result, carbon tax makes the realization of carbon reduction targets more uncertain.

Under an emission trading system (sometimes referred to as "cap and trade" or "allowance trading"), the regulator sets a maximum quantity of GHG allowed to be emitted in a given year (i.e., cap) and issues allowances (or permits) to emit GHG to match the cap on total emissions. Operators must hold allowances for every ton of GHG they emit. An allowance market is created to allow operators to buy or sell allowances. Operators who emit more GHG than they have allowances for have to buy allowances. Conversely, operators that reduce their carbon emissions can sell their unused allowances. The interaction between the demand and supply in the market determines the price of an allowance, i.e., the carbon price. Unlike a carbon tax, the carbon price in an emission trading scheme is less certain but the quantity of GHG emitted is more predictable.

The number of jurisdictions with carbon pricing schemes has accelerated in recent years. As of 2022, close to 70 carbon pricing initiatives are implemented in 46 national jurisdictions (World Bank, 2022). Most carbon pricing schemes have been adopted in high- and upper middle-income economies, while a couple of lower middle-income economies, such as Côte d'Ivoire and Pakistan, are considering introducing a carbon pricing scheme.

Carbon taxes are more common than emission trading schemes, in part because they are relatively easier to manage and involve lower administrative costs than emission trading schemes. Some jurisdictions have implemented both a carbon tax and an emission trading scheme to address emissions from different sources.

Existing carbon prices vary widely across jurisdictions, ranging from less than US$ 1 to more than US$ 130 per ton of CO_2 (see Figure D.1). Carbon prices tend to be higher in high income-economies and have hit record levels in many jurisdictions in 2021.

Although the number of countries with carbon pricing is increasing, existing carbon pricing schemes cover only 23 per cent of total carbon emissions. In addition, less than 4 per cent of global emissions is currently covered by a carbon price in the range needed by 2030 to prevent the average global temperature from increasing by 2°C (World Bank, 2022). The High-Level Commission on Carbon Prices concludes, based on a review of literature and policy experiences, that a price between US$ 50 and US$ 100 per ton of CO_2 would be required to meet the Paris Agreement temperature objective (High-Level Commission on Carbon Prices, 2017).

(b) Pricing carbon globally could contribute significantly to the low-carbon transition

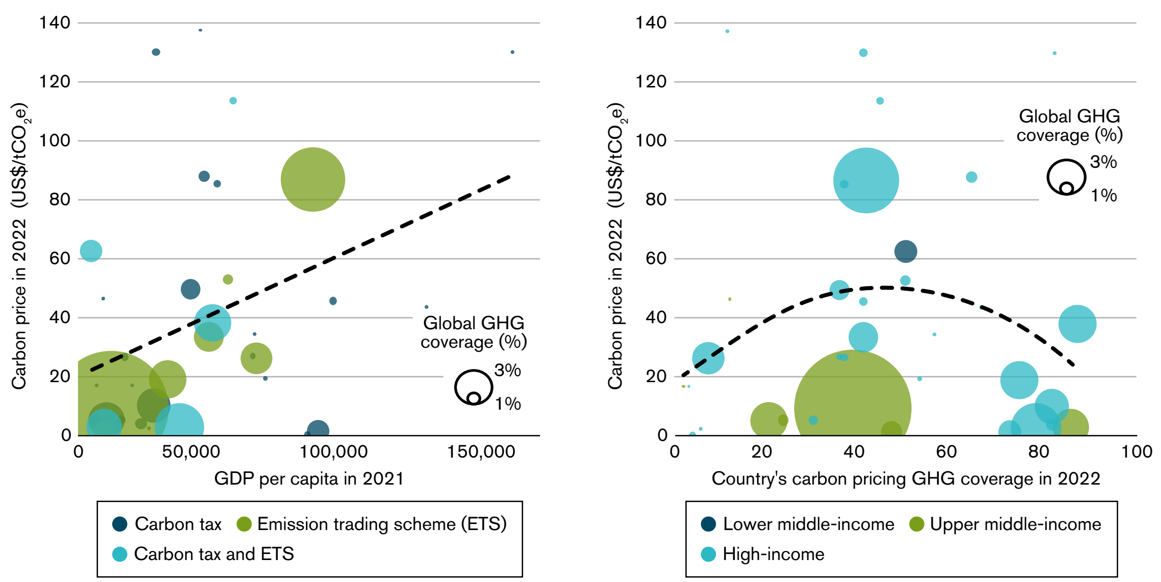
In adopting the Paris Agreement, countries committed collectively to limit the average global temperature rise to well below 2°C and to pursue efforts to limit warming to 1.5°C by the end of the century. To achieve that objective, each government chose its own national determined contribution (NDC) to limit and reduce GHG emissions (see Chapter C). However, while the international climate change regime encourages broad-based participation, it also causes heterogeneous climate change policies across countries, with some countries implementing more stringent climate policies than others.

Every five years, countries are required to revise and update their NDCs. Recent analysis shows that the current NDCs and other climate mitigation measures adopted would only reduce global carbon emissions by 7.5 per cent by 2030, well below the 50 per cent reduction by 2030 necessary to limit global temperature rise to less than 1.5°C (UNEP, 2021a).

Given the limited progress made towards a low-carbon transition, a number of economists, governments, international organizations and non-governmental organizations (NGOs) have called for a global carbon pricing mechanism, on the basis that a common approach would raise the price and thus decrease demand for carbon-intensive goods and services, leading to a reduction in GHG emissions.

A relatively recent strand of economic literature analyses the features, challenges and trade

Figure D.1: Carbon prices vary widely but their GHG emission coverage remains low



Source: Authors' calculation, based on data on carbon pricing schemes from the World Bank Carbon Pricing Dashboard.

Note: The figures display national and regional carbon prices in 2022. Each bubble represents the GHG coverage by a country's carbon pricing scheme(s) relative to global GHG emissions. The average carbon price is calculated for countries with more than one regional, national and subnational carbon price schemes.

implications of global carbon pricing schemes (Böhringer et al., 2021; Nordhaus, 2015; Stiglitz, 2015). Different types of global carbon pricing mechanisms have been proposed in the literature.

Under an international emission trading scheme, country-specific GHG emission reduction targets are set and countries would sell or buy the surplus or deficit of emission rights. In contrast, an international carbon taxation scheme requires countries to apply a tax on GHG emissions or policies realizing an equivalent reduction in GHG emissions (Cramton et al., 2017; Nordhaus, 2013).

The WTO Global Trade Model (GTM)[2] was used to simulate carbon emission paths under various scenarios and infer the carbon prices required to achieve by 2030 specific emission cut targets. The carbon prices are analysed under a uniform global carbon pricing scheme and under uncoordinated region-specific carbon pricing schemes. For the purpose of the simulations, two targets for cutting global emissions are considered: (i) the global emission reduction necessary to achieve the initial NDCs submitted in 2015;[3] and (ii) the global emission reduction that would limit the average global temperature rise to 2°C.

The simulation results suggest that the implementation of the initial NDCs would correspond to a 10 per cent reduction in global carbon emissions in 2030 compared to a baseline scenario in which countries do not take climate action. A reduction in carbon emissions of 27 per cent in 2030 would, however, be required to prevent the average global temperature from rising above 2°C (IPCC, 2022b).

The simulation results further confirm that a uniform global carbon pricing mechanism is more efficient than uncoordinated regional carbon pricing schemes. In particular, under uncoordinated carbon pricing schemes, an average international carbon price of US$ 73 per ton of carbon[4] would be needed to cut emissions to prevent the average global temperature from rising above 2°C. The same climate objective could, however, be achieved with a lower uniform global carbon price of US$ 56 (see Figure D.2). Unlike uncoordinated carbon pricing schemes, a uniform carbon price incentivizes economic operators to seek the lowest cost abatement options worldwide, allowing the GHG emission abatement to take place in the least costly place. In addition, a global carbon price establishes a transparent price signal that can spur even greater low-carbon innovation.

Carbon pricing would, however, also incur losses in output because it generates distortions to the economy. Following the introduction of a carbon price, the price of fossil fuel energy and other carbon-intensive goods and services increase, which makes production more expensive and reduces the demand and production. In order to prevent the global temperature from rising above 2°C, the projected reduction in output would correspond to 0.46 per cent of global GDP if a uniform carbon price is set globally. In contrast, uncoordinated regional carbon pricing would result in a 0.68 per cent reduction in global GDP (see Figure D.2).

However, it is important to note that these reported GDP effects do not reflect the global and regional benefits of climate change mitigation. Carbon pricing corrects market failures and thus contributes to a higher welfare, since it helps to limit and avoid the consequences of climate change at the global level and induces environmental and health co-benefits at the domestic level (see also Chapter C). In addition, carbon pricing can help countries to become less dependent on fossil fuels and support the transition to a more diversified low-carbon economy by mobilising public funding, and future-proofing long-term investments into assets aligned with low-carbon development objectives.

(c) Promoting carbon pricing globally faces major challenges

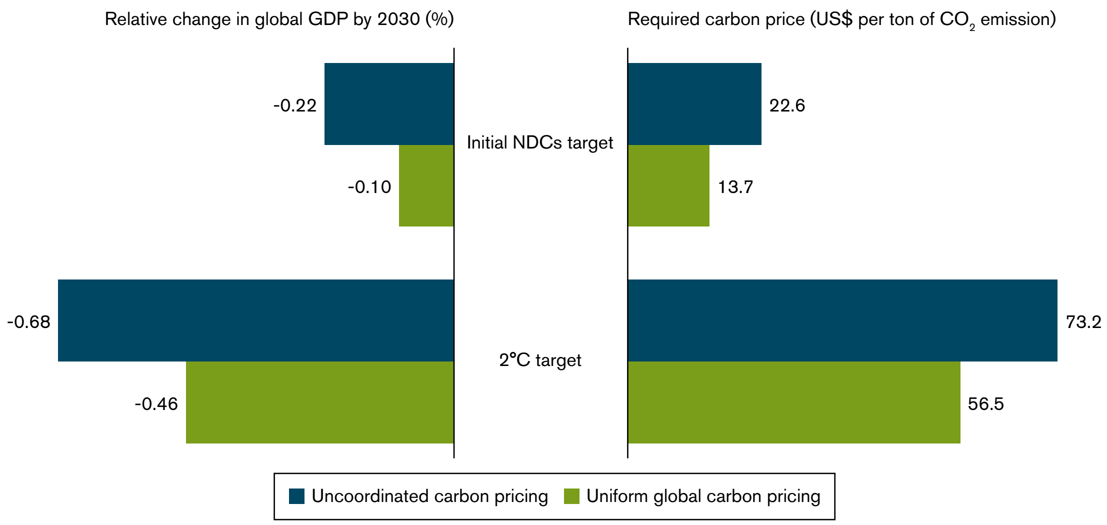
While a well-designed global carbon pricing scheme could support a low-carbon transition, its adoption and implementation at a global scale face a number of important challenges. In particular, two main challenges are associated with promoting a global agreement on carbon pricing: (i) free-riding and (ii) fair burden-sharing.

(i) Free-rider problem

In the absence of coordination, individual countries may have an economic incentive to hold off on adopting carbon pricing until they observe how other countries act, in order to benefit from the efforts of those other countries. If the benefits of climate mitigation accrue to all countries but the cost of carbon pricing is only borne by the countries that adopt carbon pricing, individual countries may not have sufficient incentives to introduce carbon pricing.

The simulation results based on the WTO GTM confirm that most countries and regions would not have enough incentive to introduce a carbon pricing scheme once a coalition of countries with more ambitious climate targets decided to adopt carbon pricing.[5] This is because, as discussed above, carbon pricing generates distortions and raises the

Figure D.2: Global carbon pricing is more efficient than uncoordinated carbon pricing



Source: Bekkers and Cariola (2022).

Note: Simulation results based on the WTO GTM. The right panel displays the (weighted) average carbon price (in dollars per ton of CO_2 emission) that is needed to achieve the respective carbon emission cut target. The left panel indicates the projected global GDP loss in per cent in 2030 following the implementation of carbon pricing relative to a hypothetical reference scenario in which countries do not take climate action. The "initial NDCs" scenario assumes CO_2 emission cut targets set out in countries' 2015 NDCs are achieved by 2030. The "2°C target" assumes CO_2 emission cuts by 2030 consistent with limiting the average global temperature rise to less than 2°C.

price of energy and the production costs, which can depress the production. The output loss as a result of introducing carbon pricing would deter most countries from adopting carbon pricing policies.

Various approaches to overcome free-riding have been proposed in the literature on carbon pricing. For instance, carbon tariffs could be imposed on non-participant countries to encourage them to join the coalition of countries that have adopted a common carbon pricing scheme (i.e., "tariff climate club") (Böhringer, Carbone and Rutherford, 2016; Nordhaus, 2015). Different types of carbon tariffs have been proposed, including a uniform import tariff duty on imports from countries outside of the climate club, regardless of the carbon content of the imported products (Nordhaus, 2015) and import tariff duties determined by the carbon content of imports (i.e., BCA). As discussed below, such options can have important trade implications. Alternatively, a global agreement on carbon pricing could be complemented with financial or cooperation mechanisms to incentivize non-participant countries to join the coalition by providing them with financial or technical support. For instance, as discussed in Chapter C, a global carbon fund could redistribute the revenues of carbon pricing between regions.

The WTO GTM was used to simulate potential, hypothetical scenarios to illustrate the challenges of promoting carbon pricing. The simulation results suggest that a coalition of ambitious regions[6] adopting a carbon pricing scheme and imposing on non-participant countries import tariff duties determined by the carbon content of imports would not be effective to encourage the adoption of carbon pricing schemes. This is because the incentive to avoid facing carbon tariffs would not be sufficient to offset the adverse impact of introducing domestic carbon policies in non-participant countries. Similarly, a global carbon fund redistributing the revenues of carbon pricing between regions according to their emission level per capita (Rajan, 2021) would not provide enough incentive for non-participant countries to adopt a domestic carbon pricing mechanism.

Conversely, the simulation results suggest that a uniform import tariff duty applied by a coalition of ambitious regions on non-participants' imports regardless of the carbon content of the imported products imposed, would provide sufficient incentives for non-participating regions to join the carbon pricing coalition (Nordhaus, 2015). Similarly, an emission trading scheme with relatively larger emission reduction targets for developed economies than for developing ones could incentivize developing economies to participate in a global emission trading scheme.

However, introducing a global emission trading scheme might involve a number of design challenges. Individual countries could be reluctant to make commitments on emission targets far into the future given the risk that the emission reduction targets set initially might ultimately be too high if economic growth were to turn out higher than expected. Furthermore, if global targets were negotiated first and country-level emissions targets subsequently, each individual country could have an incentive to set low targets and let other countries make ambitious commitments. In contrast, reaching an agreement on a global carbon tax scheme would require all countries to take responsibility at the same time (Cramton et al., 2017).

(ii) Fair burden-sharing

The economic costs resulting from the implementation of carbon pricing schemes need to be shared in a fair way, in line with the principle of common but differentiated responsibilities (CBDR) established under the Paris Agreement. According to the CBDR principle, all governments are responsible for addressing global environmental destruction, but are not equally responsible, in recognition of the fact that economies that industrialized earlier have historically contributed more to environmental degradation than those economies of recent or ongoing industrialization. The CBDR principle also reflects the differences in economic capacities to contribute to climate mitigation and adaptation efforts.

As discussed above, adopting a carbon pricing scheme in the absence of complementary policies and financial mechanisms could negatively impact non-participant countries, including LDCs and fossil fuel export dependent countries. To address fair burden-sharing considerations and incentivize more countries to introduce carbon pricing schemes, several proposals have been put forward in the literature. For example, an international carbon price floor (ICPF) system sets differentiated minimum international carbon prices according to countries' economic development, with a higher international carbon price floor for high-income economies and a lower one for low-income economies (Parry, Black and Roaf, 2021).

The simulation results based on the WTO GTM suggest that differential carbon price floors of US$ 25, US$ 50 and US$ 75 for low-income, middle-income, and high-income regions, respectively, would be insufficient to insulate low-income regions from the adverse effects of carbon pricing and a reduction in real income (see Figure D.3). For many developing regions, the real income decline would be nearly as large as under a uniform carbon price of US$ 48 that would produce equivalent reductions in global carbon emissions. The benefit of differential carbon prices for developing countries is limited because even a low carbon price would impact production decisions and thus reduce real income.[7] Furthermore, when high-income regions introduce higher carbon prices, there can be adverse spill-over effects on low-income regions. For example, fossil fuels exported from low-income countries will face higher taxes when they are exported to high-income regions.

According to the WTO GTM simulation analysis, other types of carbon pricing schemes, such as a carbon pricing scheme implemented by a coalition of countries, combined with a uniform import tariff duty or a BCA, would also impact negatively on low-income economies in the absence of support measures (Bekkers and Cariola, 2022). In fact, the simulation results suggest that a carbon pricing scheme with a global carbon fund (Rajan, 2021) or an emission trading scheme with relatively larger emission reduction targets for developed economies than for developing ones would enable to rebalance some of the carbon pricing's economic burden between low- and high-income countries.

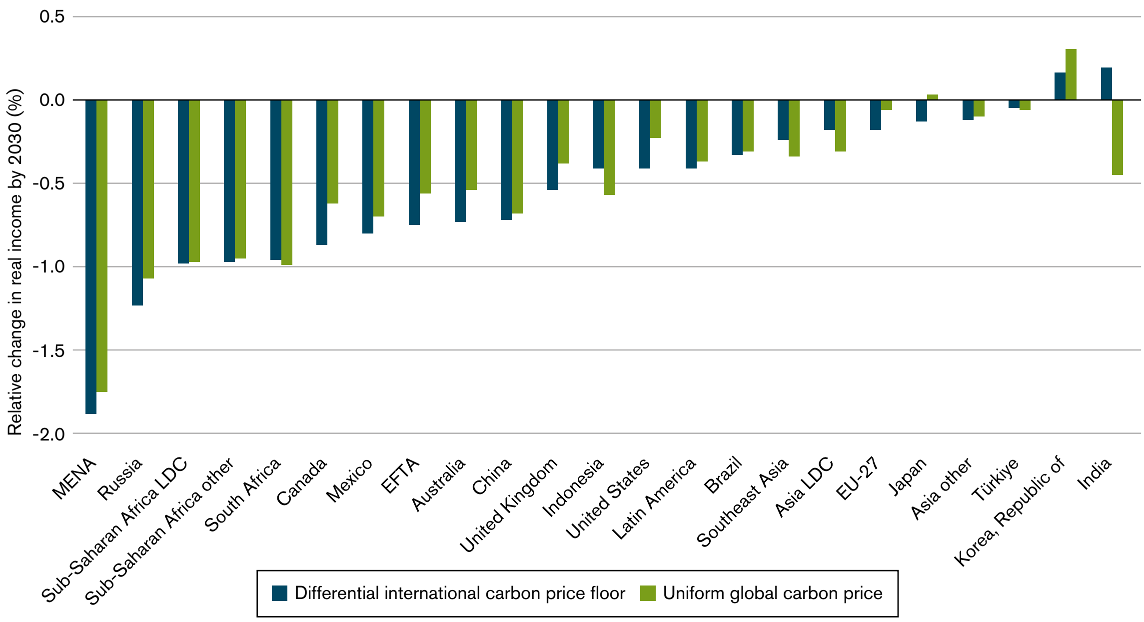
(iii) Technical challenges in global carbon pricing

In addition to the two main challenges, promoting carbon pricing globally also involves a number of design and implementation issues.

A key choice is between an international carbon tax scheme or an international emissions trading scheme. Carbon tax is often considered to be easier to implement than emission trading scheme. Other advantages of a carbon tax over an emission trading scheme include stable carbon prices that can facilitate investment decisions without fear of fluctuating costs and the possibility to generate large tax revenues (Avi-Yonah and Uhlmann, 2009).

On the other hand, negotiations over a global carbon tax also face challenges. Setting the international carbon price(s) and calculating the carbon content of products and services require relevant detailed and up to date information, including on carbon emissions, that might be missing for some countries or sectors. The credibility and effectiveness of a global carbon pricing system also depend on well-functioning

Figure D.3: Low-income regions would be adversely affected by a global carbon price without complementary mechanisms



Source: Bekkers and Cariola (2022).

Note: Simulation results based on the WTO GTM. The figure displays the change in real income relative to a hypothetical reference scenario in which countries do not take climate action. The scenario "differential international carbon pricing floor" considers carbon price floors of US$ 25, US$ 50 and US$ 75 for low-, middle- and high-income countries, respectively. The scenario "uniform global carbon pricing" considers a uniform carbon price of US$ 48 with equivalent aggregate carbon emission reduction. The abbreviations read as follows: European Free Trade Association (EFTA), European Union (EU-27) and Middle East and North Africa (MENA).

institutions and a high level of regulatory competence and monitoring system (Rosenbloom et al., 2020).

A global carbon pricing mechanism also requires a high level of coordination across jurisdictions. Cross-country financial and technology transfers might also be warranted, which could involve difficult negotiations.

In addition, in the absence of affordable alternative low-carbon technologies and solutions, carbon pricing might fail to modify the behaviour of firms and consumers, especially when the demand for carbon-intensive goods and services is not very sensitive to price changes. Other climate policies might have to be implemented first to remove certain economic and political barriers hindering the adoption of stringent climate policy (Lonergan and Sawers, 2022). More generally, effective carbon pricing policies need to be complemented by other policies, including on innovation, energy and infrastructure, to ensure the availability of alternative, low-carbon technologies and to address economic and political roadblocks that may arise during the low-carbon transition.

3. Uncoordinated carbon pricing policies could undermine climate action and lead to trade tensions

Beyond the risk of free-riding, unilateral and uncoordinated carbon pricing policies can raise concerns about their environmental effectiveness and impact on international competitiveness. Large disparities in carbon pricing between countries can lead to calls for the introduction of BCA mechanisms, which risk generating trade tensions. BCA raises a number of issues, both in terms of its design and of its relevance to WTO rules.

(a) Uncoordinated mitigation policies can lead to carbon leakage, loss of competitiveness and burdensome costs

Uneven and uncoordinated climate change mitigation efforts can displace carbon emissions from regions with stricter climate policies to those with laxer ones; this is known as carbon leakage (Mehling et al., 2019). It can also lead to competitiveness losses in industries and regions with more ambitious climate change mitigation goals, and can generate substantial compliance costs for companies complying with policies in different jurisdictions.

(i) Differences in carbon prices are likely to lead to limited carbon leakage

Carbon leakage occurs when the unilateral implementation of a climate policy, like carbon pricing, in one jurisdiction leads to higher emissions in other jurisdictions. Carbon leakage can materialize through different channels: (i) competitiveness, (ii) the energy market, and (iii) income (Dröge et al., 2009).

Leakage through the competitiveness channel happens when a unilateral carbon policy raises production costs in one jurisdiction, causing domestic firms to lose market share relative to foreign firms. Leakage through loss of competitiveness rises with the emissions differential between trading partners, and the emission intensity and trade exposure of products (Böhringer et al., 2022). Sectors particularly exposed to carbon leakage include, among others, cement, steel and aluminium.

Leakage through the energy market channel arises when demand for fossil fuels in jurisdictions with unilateral carbon policies is reduced, and this depresses the world price of fossil fuels, thereby increasing fuel consumption and carbon emissions in jurisdictions without carbon policies. Leakage through the income channel occurs when unilateral carbon policies lead to changes in terms-of-trade, which in turn affects the global distribution of income, consumption and emissions (Cosbey et al., 2020).

Different factors can mitigate the risk of carbon leakages. For instance, carbon leakage can decrease, if environmental innovations resulting from unilateral carbon pricing policies are adopted, through technology spillovers, in jurisdictions without carbon policies (Barker et al., 2007).

Carbon leakage can be measured in different ways, including with leakage rates, defined as the change in foreign emissions relative to domestic emissions reductions as a direct consequence of unilateral emissions pricing. For example, a leakage rate of x per cent in a given jurisdiction indicates that x per cent of the domestic emissions reduction resulting from emissions pricing is offset by an increase in emissions abroad.[8]

The empirical evidence on the extent of carbon leakage is mixed. For instance, numerous empirical studies find little evidence that the European Union's Emission Trading System has led to carbon leakage to jurisdictions outside Europe and attribute this situation to the high number of allowances freely allocated to emission-intensive trade-exposed (EITE) industries to avoid leakage (Dechezleprêtre et al., 2022; Naegele and Zaklan, 2019).

On the other hand, some empirical evidence also suggests that that carbon leakage differs across countries and can be substantial in some cases, mostly for small open economies (Misch and Wingender, 2021). The average leakage rate is found to be 25 per cent, implying that a reduction of 100 tons of carbon emissions domestically would be accompanied by an increase of 25 tons of carbon emissions abroad.

In addition to empirical studies, simulation studies have also assessed the risk of carbon leakage associated with carbon pricing. An analytical literature review of studies consisting mainly of computable general equilibrium analysis reports an average carbon leakage ratio estimated at around 14 per cent (Branger and Quirion, 2014). More recently, carbon leakage rates for industrialized countries have been estimated to range between 5 per cent and 30 per cent (Böhringer et al., 2022).

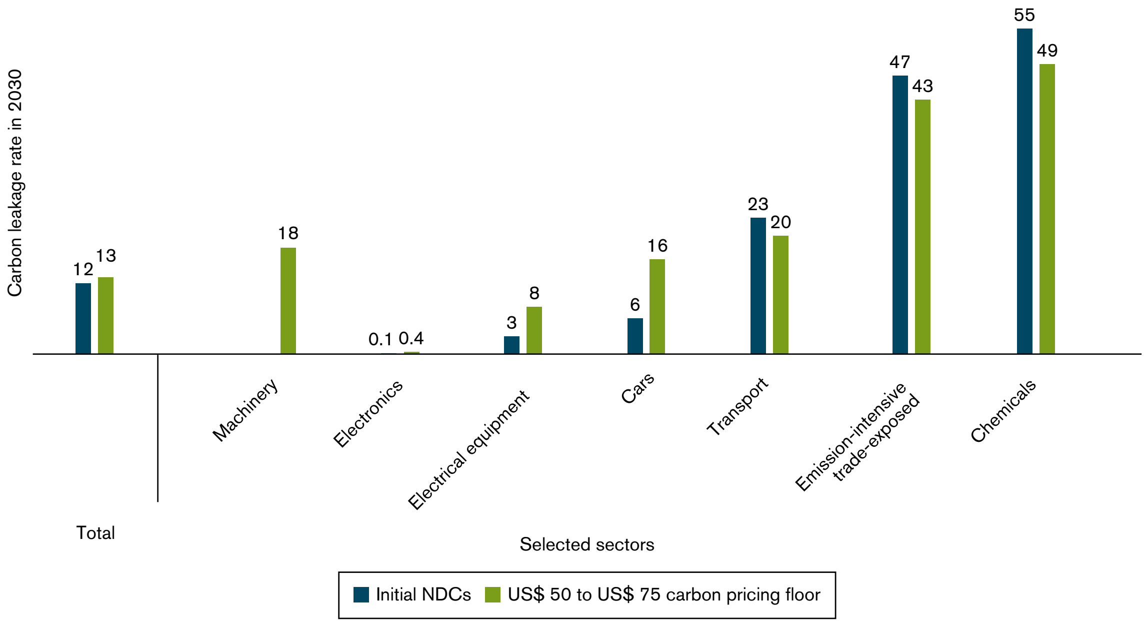
According to the WTO GTM simulation analysis, the estimated aggregate carbon leakage rates seem to be relatively limited and do not exceed 13 per cent (Bekkers and Cariola, 2022).[9] However, the magnitude of the estimated carbon leakage rates differs significantly by sector, with the chemical and EITE sectors particularly exposed to carbon leakage (see Figure D.4).

(ii) Competitiveness losses in emission-intensive trade-exposed sectors could be substantial

Firms in regions with more ambitious carbon policies can face a loss in competitiveness, because a higher carbon price increases the abatement costs and the production costs as firms have to divert financial and technical resources away from production and toward reducing GHG emissions.

The empirical evidence on the competitiveness consequences of environmental policy is mixed, partly reflecting differences in types of pollutants considered (i.e., local, regional and global pollutants) as well as the use of different conceptual frameworks, data sources and proxies, and econometric methodologies (WTO, 2013). Carbon pricing has been found to have only small effects on short-term competitiveness (Venmans, Ellis and Nachtigall, 2020).

Figure D.4: Estimated carbon leakage could be large in some sectors but would remain limited at the aggregate level



Source: Bekkers and Cariola (2022).

Note: Simulation results based on the WTO GTM. Leakage rate is defined as the increase in emissions in regions with less ambitious climate policies divided by the reduction in emissions in regions with more ambitious climate policies. Sectoral leakage rates also cover the indirect emissions from electricity use. The scenario "initial NDCs" assumes a set of high-income countries adopt a regional carbon pricing scheme to reduce emissions from zero reduction target to their initial NDC target levels, while the other countries do not have any targets. The scenario "carbon pricing floor" assumes that the group of high-income countries increases their carbon price from US$ 50 to US$ 75, while the other regions set carbon prices of US$ 25 (low-income regions) and US$ 50 (middle-income regions).

More generally, the empirical literature suggests that differences in the degree of stringency of environmental policies tend to influence the distribution of pollution-intensive production across countries, suggesting that more stringent environmental policy can have a deterrent effect on the production of pollution-intensive goods. For instance, in Canada, more stringent air quality standards have been found to have reduced export revenues by about 20 per cent (Cherniwchan and Najjar, 2022), and in the United States, changes in environmental compliance costs have been estimated to account for 10 per cent of the change in US trade flows to Canada and Mexico (Levinson and Taylor, 2008). Nonetheless, there is no robust empirical evidence that the potential deterrent effect of stringent environmental policy is strong enough to be the primary determinant of the direction of trade or investment flows (Copeland, Shapiro and Taylor, 2022) (see also Chapter E).[10]

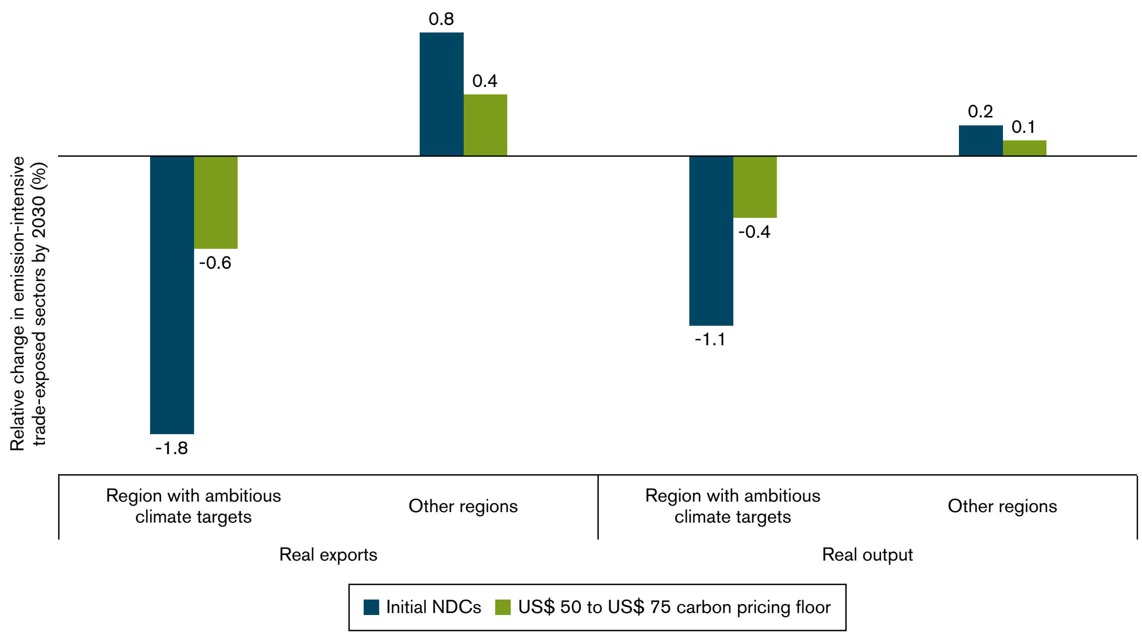
In addition to empirical analysis, simulation studies have been used to analyse the risk of competitiveness loss associated with carbon pricing. For instance, unilateral carbon pricing has been found to lead to competitiveness losses in EITE industries (Carbone and Rivers, 2020). The WTO GTM simulation results suggest that, although the overall loss of production in EITE sectors in regions with more ambitious climate targets would be modest, the loss of competitiveness could be more substantial for some carbon-intensive sectors, such as cement and aluminium (see Figure D.5) (Bekkers and Cariola, 2022).

(iii) Uncoordinated carbon pricing schemes increase administrative and compliance costs

In addition to concerns of carbon leakage and competitiveness loss, differences in carbon pricing policies can impose additional administrative and compliance costs.

Administrative costs correspond to the costs incurred by the government to implement, monitor, and enforce the carbon pricing scheme. Administrative costs of a carbon tax include taxpayer registration, returns filing and payments, inspection, audit, investigation of fraud and dispute resolution mechanisms. Administrative costs of an emission trading scheme

Figure D.5: Estimated overall losses of competitiveness of emission-intensive trade-exposed sectors would remain relatively limited



Source: Bekkers and Cariola (2022).

Note: Simulation results based on the WTO GTM. The figure displays the change in exports and output in EITE sectors relative to a hypothetical reference scenario in which countries do not take climate action. The scenario "initial NDCs" assumes a set of high-income countries adopt a regional carbon pricing scheme to reduce emissions from zero reduction target to their initial NDC target levels, while the other countries do not have any targets. The scenario "carbon pricing floor" assumes that the group of high-income countries increases their carbon price from US$ 50 to US$ 75, while the other regions set carbon prices of US$ 25 (low-income regions) and US$ 50 (middle-income regions).

include establishing a registry for carbon emission allowances, keeping track of the trade in allowances, determining the allocation of free allowances, and ensuring the integrity of auctions of allowances, among other things (Avi-Yonah and Uhlmann, 2009; Goulder and Schein, 2013). The administrative costs associated with coordinating emission trading schemes across jurisdictions can be lower than coordinating heterogenous carbon taxes, because the allowances establish a natural unit of exchange (e.g., *US$ X* for *Y* tons of carbon) that links different emission trading systems (Stavins, 2022).

Compliance costs are the costs borne by firms and consumers in order to comply (or sometimes not to comply) with the obligations set out in the carbon pricing mechanism. The proliferation of different carbon pricing schemes with different requirements can make it difficult for exporters, in particular MSMEs, to meet the many different criteria on which carbon pricing schemes are based, particularly when they target the same sectors or products (Tietenberg, 2010).

(b) The absence of coordinated climate actions could lead to the adoption of border carbon adjustment mechanisms

In the absence of coordinated climate actions, countries with more ambitious climate targets may have an incentive to adopt some BCA mechanisms to mitigate the risk of carbon leakage and competitiveness loss that large differences in carbon prices between countries might cause. Different types of BCA mechanisms have been discussed in the literature (WTO and UNEP, 2009).

BCA entails the introduction of a charge on the carbon embodied in imported products from a jurisdiction with a lower level of carbon pricing than in the importing country or on imported products whose embodied carbon was not otherwise priced.[11] BCA could also be applied by rebating the domestic carbon price paid by firms when exporting their goods to compensate for the higher carbon price faced domestically compared with firms in the country to which they are exporting. Because of the adjustment at the border, final consumers in a jurisdiction would in principle face the same carbon tax rate on domestic and imported goods (Elliott et al., 2013).

While the basic idea of BCA measures is relatively straightforward, it remains a controversial tool. A growing literature discusses the features, the advantages and drawbacks of BCA, while highlighting the various technical challenges associated with BCA.

(i) Economic arguments favouring border carbon adjustment

BCA could reduce carbon leakage through the competitiveness channel. By paying a BCA levy, foreign producers would face the same effective carbon price in an export market as domestic producers in that market. The BCA mechanism would remove any incentive for production to shift to regions with a lower carbon price.

Simulation studies suggest that BCA mechanisms could be effective in curbing carbon leakage through the competitiveness channel (Bellora and Fontagné, 2022; Böhringer, Balistreri and Rutherford, 2012; Branger and Quirion, 2014). The effectiveness of BCA in reducing leakage rates is found to be higher in studies that looked at sector-specific leakage for EITE industries, as these sectors are the ones with highest leakage rates (Böhringer et al., 2022). Simulations results based on the WTO GTM show that the leakage rate would be cut by about half when a BCA mechanism is introduced in the simulation scenarios discussed above. Although this reduction in carbon leakage seems significant, this would make only a small contribution to the reduction in global carbon emissions. Case studies of the real-world implementation of BCA suggest that reduction in carbon leakage will ultimately depend on the BCA design and the sector targeted (Fowlie, Petersen and Reguant, 2021).

Besides reducing carbon leakage, BCA could also limit the loss of competitiveness of domestic producers in EITE sectors. Simulation results based on the WTO GTM show that applying a BCA mechanism brings the levels of real exports and real output in the regions with more ambitious climate targets close to their levels before the introduction of a carbon tax.[12] In that context, it is sometimes argued that introducing a BCA mechanism would reduce the domestic opposition towards domestic carbon pricing, as BCA could level the playing field for domestic producers (Böhringer et al., 2022).

BCA mechanisms could also offer a means to encourage foreign jurisdictions directly affected by the BCA to adopt more ambitious carbon pricing to avoid border measures (Böhringer et al., 2022; Dröge, 2011). The incentive to adopt a carbon pricing scheme could also arise in anticipation of another country's intention to apply a BCA mechanism (World Bank, 2022). However, the WTO GTM simulations results discussed above seem to suggest that BCA would not provide sufficient incentives to regions without carbon pricing to join the group of ambitious regions in introducing carbon pricing.[13]

Finally, compliance with BCA would require firms to report the amount of carbon emissions embodied in the products they trade in order to calculate the tariff associated with BCA. Meeting this requirement could help enhance transparency of carbon footprints in supply chains.

(ii) Economic arguments against border carbon adjustments

Several concerns regarding BCA have been raised in the literature. First, imposing tariffs could reduce the global demand for imported goods, thereby driving down prices of such goods and deteriorating the terms-of-trade of exporters facing BCA (Bellora and Fontagné, 2022; Böhringer, Fischer and Rosendahl, 2010; UNCTAD, 2021). The projected negative terms-of-trade effects tend to be concentrated in countries exporting energy-intensive products to countries that impose BCA mechanisms (Weitzel, Hübler and Peterson, 2012). In addition, if a BCA mechanism is introduced by high-income economies with more ambitious climate mitigation targets, adverse terms-of-trade effects would be concentrated in low-income regions, thus creating a potential tension with the CBDR principle (Böhringer et al., 2022).

More generally, some important issues can be raised with regard to the relationship between the CBDR principle and efforts to address level playing field concerns through BCA mechanisms. While the CBDR principle recognizes the historical responsibility of industrialized economies to adopt more ambitious climate policies (e.g., Articles 2.2 and 4.3 of the Paris Agreement), BCA seeks to ensure that companies from different regions selling in the same market face equivalent carbon prices.

Independent of the legal standing of such principles and concepts under the applicable international legal frameworks, several economic design options have been discussed in the literature to try to reduce eventual gaps between the two objectives. One option could be to tailor the BCA to the level of development of a given economy. However, such an approach could raise administrative complexities and would not necessarily contribute to a level playing field. Another option identified in the literature could be to allocate the revenues from the BCA to a carbon fund used for mitigation or adaptation in low-income regions (Falcao, 2020).

BCA would also involve considerable administrative and compliance costs for governments and companies. Furthermore, BCA could potentially lead to trade conflicts between the regions imposing and facing such levies. Simulation analysis has shown that, for some economies, it would be optimal to impose countermeasures to BCA to limit adverse economic effects (Böhringer, Carbone and Rutherford, 2016). In such a case, BCA could lead to tit-for-tat trade conflicts and raises questions about its compatibility with WTO rules.

(iii) Adopting BCA involves a host of design questions

The design of BCA can influence an economy's competitiveness, its carbon leakage, its export opportunities and its promotion of carbon pricing policies. As discussed by Daniel C. Esty in his opinion piece, design details of BCA mechanisms are critical. Important questions on the design issues could include (i) sectoral coverage; (ii) country coverage; (iii) emission scope; (iv) embedded emission benchmarks; (v) the possibility to "rebut" a benchmark; (v) accounting for foreign carbon policies; (vi) export rebates; and (vii) revenue use.[14]

Sectoral coverage refers to the sectors targeted by the BCA mechanism. There are two broad options for this design feature: BCA can either cover only EITE sectors, or it can cover a larger number of manufacturing sectors. While including a larger number of sectors can be administratively complex, it can also lead to a larger reduction in carbon leakage (Branger and Quirion, 2014).

Determining the country coverage of BCA requires deciding whether the BCA-imposing country will exclude a group of countries from the policy. For example, the BCA-imposing country could apply a policy uniformly to all trading partners or, alternatively, it could exclude a group of countries based on various criteria, such as income level, trade volume in covered sectors, or national mitigation policies implemented.

The emission scope consists of the emissions in the life cycle of a product that are included in the calculation of BCA (Cosbey et al., 2020). As discussed in Chapter E, although definitions vary, scope 1 emissions are often referred to as the direct emissions from a production process, while scope 2 emissions are indirect emissions from the generation of purchased electricity, and scope 3 emissions are all other indirect emissions (not included in scope 2) that occur throughout the supply chain. This design feature is important because, in some sectors, the share of emissions stemming from the indirect use of electricity is substantial if the electricity purchased is generated with fossil fuels.

The reference for embedded emissions in the importing or exporting country involves two broad options. The first option is to use domestically-determined benchmark emission levels for the covered products. The second option is to use country-specific benchmarks that are determined by each exporting country facing BCA. Since emission intensities for the same product may differ significantly from country to country, this design feature may affect the effectiveness of the BCA scheme to meet its objectives.

A country imposing BCA may provide foreign firms with the possibility to "rebut" the imposition of border charges based on averages or benchmarks and, instead, ensure that the border charges ultimately imposed are based on their own actual emission levels. In principle, this gives these firms an incentive to reduce emissions if their individual emissions are lower than the benchmark emissions.

In order to take foreign mitigation measures into account, BCA can use different options for adjusting the price at the border, such as making an adjustment based on different forms of carbon prices or on non-price-based regulations in a foreign jurisdiction.

A country imposing BCA may also have to decide whether the scheme will include export rebates. If the BCA measure includes such rebates, exporters of the covered goods in the country imposing the BCA will be rebated for the additional carbon price paid domestically *vis-à-vis* the carbon price imposed in the destination market of the exports. If the measure does not include export rebates, the BCA will only apply to imports.

Lastly, the discussion related to revenue use revolves around whether revenues collected from BCA should be transferred to the general government budget of the implementing country or used specifically to support climate mitigation actions, for example, in developing economies. The way such revenues are used could change the distributional consequences of BCA.

4. Greater international cooperation is required to advance ambitious carbon pricing policies

Carbon pricing faces a number of challenges that arise from the lack of coordination between countries. Two-thirds of all submitted NDCs under the Paris

Agreement consider the use of carbon pricing to achieve their emission reduction targets. This means that more than 100 countries can potentially look into carbon pricing as a way to reduce their GHG emissions through emission trading schemes, carbon taxes and other approaches (UNFCCC, 2021).

The proliferation of different local, national and regional carbon pricing schemes highlights governments' ambitions to tackle climate change. However, it also risks creating a patchwork of different systems, tax rates, covered products and certification procedures, which ultimately can generate uncertainty for businesses, weaken the effectiveness of global efforts to mitigate climate change and impose additional transaction costs.

International cooperation can help to overcome the challenges associated with carbon pricing. Coordinated actions are essential to address the risks of carbon leakage and competitiveness concerns associated with carbon pricing, thereby avoiding unproductive trade frictions. By facilitating exchange of best practices and sharing administrative costs, international cooperation can contribute to improving the efficiency of carbon pricing schemes and reducing their administrative costs (Mehling, Metcalf and Stavins, 2018). Cooperation and coordination on carbon pricing can also help to avoid fragmentation of carbon pricing schemes and to ensure that all countries' views and concerns, including those of developing countries, are taken into account in discussions on carbon pricing approaches.

(a) International cooperation on carbon pricing is slowly taking shape

In view of the economic, policy and legal issues that carbon pricing raises, it is no surprise that diverging carbon pricing approaches and possible BCA have already elicited important discussions in a number of international fora, including at the meetings of the United Nations Framework Convention on Climate Change (UNFCCC), G7, G20, Organisation for Economic Co-operation and Development (OECD) and the WTO.

Various regional and international initiatives aim to promote policy coherence in carbon pricing. For instance, the UNFCCC Collaborative Instruments for Ambitious Climate Action (CiACA) initiative assists parties in the development of carbon pricing instruments for implementing their NDC and foster cooperative climate action with other jurisdictions. Other initiatives include the Carbon Pricing Leadership Coalition (CPLC), which is a voluntary partnership of national and sub-national governments, businesses, and civil society organizations that provides a platform to collectively share their best practices on carbon pricing policies and disseminate research, among other things.[15] The International Carbon Action Partnership (IACP) is also an international cooperative forum bringing together jurisdictions that have implemented or are planning to implement emissions trading schemes.[16]

More recently, the G7 issued a statement on June 2022 expressing its intention to establish an open, cooperative international climate club, consistent with international rules, by the end of 2022 to support the effective implementation of the Paris Agreement.[17] The climate club will seek to (i) advance ambitious and transparent climate mitigation policies; (ii) transform industries jointly to accelerate decarbonization; and (ii) boost international ambition, through partnerships and cooperation, to encourage and facilitate climate action, unlock the socio-economic benefits of climate cooperation, and promote a just energy transition. The G7 statement further requests that the OECD, the International Monetary Fund (IMF), the World Bank, the International Energy Agency (IEA) and the WTO support this process.

International organizations are actively working to enhance transparency and promote information sharing of carbon pricing policies. As discussed below, several WTO bodies have been exchanging views and experiences with respect to different aspects of carbon pricing and carbon footprint methodologies and schemes. Other initiatives include the World Bank Carbon Pricing dashboard, which provides up-to-date information on existing and emerging carbon pricing initiatives,[18] and the OECD data on the pricing of CO_2 emissions from energy use, including fuel excise taxes, carbon taxes and tradable emission permit prices.[19]

International efforts are also deployed to provide assistance to governments in designing and implementing carbon pricing schemes. For instance, the Partnership for Market Implementation, a 10-year programme administered by the World Bank, assists countries in designing, piloting and implementing pricing instruments aligned with their development priorities.

An essential step in carbon pricing is the measurement and verification of carbon footprint of a product. As discussed in Chapter E, several standards and guidelines have been published to provide overall guidance on calculating the carbon footprint of products and economic activities, such as the International Organization for Standardization (ISO) standard on carbon footprint of products (ISO

OPINION PIECE

By Daniel C. Esty

Hillhouse Professor at Yale University and Director of the Yale Center for Environmental Law and Policy and the Yale Initiative on Sustainable Finance

Trade implications of GHG pricing

Carbon pricing – more broadly and appropriately called greenhouse gas (GHG) pricing to encompass methane and other GHG emissions beyond CO_2 – is seen by many policymakers as a critical tool for driving down emissions and creating incentives for individuals and businesses across all sectors to move toward a clean energy future. Some 46 nations now impose a price on GHG emissions, either through carbon charges or emissions allowance trading systems – and dozens more are exploring pricing options. But divergent GHG prices across nations present a strategic challenge for the international trading system.

In light of the global commitment to halt GHG emissions, governments that fail to impose a price on emissions or otherwise regulate GHGs might well be seen to be offering their producers an inappropriate subsidy. To level the playing field, eliminate any incentive to shift production to places with laxer climate change policies, where operating costs might be lower, and to protect the efficacy of emissions reduction efforts, governments with strong climate change policies have begun to develop BCA strategies. Such mechanisms are intended to impose tariffs on imported goods based on the difference between the producer's level of GHG pricing and the carbon price in the importing jurisdiction.

Those seeking to better align the structure of the trading system with the international community's commitment to climate change action are urging the WTO to authorize appropriately structured BCA tariffs. But developing nations have expressed concerns about whether such tariffs will be implemented in a discriminatory fashion or in a manner that violates the commitment to common but differentiated responsibility, a principle of equity which undergirds the global climate change regime. Additional questions have been raised about GHG accounting and whether technical capacity limitations will disadvantage developing nations.

I have argued that the design details of any BCA mechanism will be critical, and that analytic rigour, validation, fairness and transparency must be prioritized (Dominioni and Esty, 2022). I believe that border tariffs designed to eliminate the unfair advantage arising from GHG externalities should be based on differences in effective rather than explicit GHG prices, which would allow nations greater flexibility in carrying out their climate change policies. An even more straightforward approach would require that the tariffs be based on the level of unabated GHGs attributable to an imported product multiplied by an agreed-upon global social cost of carbon. Domestic goods would, of course, have to adhere to the same GHG pricing framework.

Such a BCA methodology would reward producers with lower actual GHG emissions both domestically and internationally – and make it nearly impossible to deploy BCA tariffs as a disguised barrier to trade. It would require some effort to establish emissions accounting standards, but carbon calculators and GHG content databases are increasingly available. Equity considerations could argue that any funds collected from exports by the least-developed nations should be recycled to these countries to support their investments in the transition to a sustainable energy future.

The legitimacy of the trading system would be enhanced by a clear acknowledgement of the sustainability imperative and recognition of the urgency of global success in responding to the threat of climate change, paired with a reiterated commitment to sustainable development and access to global markets for developing nations (Lubin and Esty, 2010). Fundamental to such efforts would be a WTO initiative to validate carefully structured BCA mechanisms and thus reinforce – and not undermine – GHG pricing and other national climate strategies.

14067:2018) and the GHG Protocol Corporate Accounting and Reporting Standard. Greater global coherence is further needed to avoid an increasing proliferation of different standards and verification procedures (see Chapter E) (WTO, 2022c).

(b) International trade cooperation can contribute to supporting carbon pricing action

Given the important trade implications of carbon pricing, international cooperation on trade and trade policy can help support the adoption and implementation of carbon pricing.

A few recent regional trade agreements (RTAs) include provisions that explicitly address carbon pricing (WTO, 2021b). The most detailed provisions are currently found in a specific article on carbon pricing included in the RTA between the European Union and the United Kingdom. It requires the parties to have in place an effective carbon pricing system specifically covering GHG emissions from electricity generation, heat generation, industry and aviation. The article further calls on the parties to give serious consideration to linking their respective carbon pricing systems.[20] The recent RTA between New Zealand and the United Kingdom also commits the parties to promote carbon pricing, and support environmental integrity in the development of international carbon markets. A few RTAs explicitly promote the exchange of information and experience on designing, implementing, and operating mechanisms for pricing carbon and promoting domestic and international carbon markets.[21] Other environment-related provisions particularly relevant to carbon pricing include those that explicitly encourage the parties to use and rely on economic instruments, including market-based instruments, for the efficient achievement of environmental goals (Monteiro, 2016).[22]

The WTO also contributes to international trade cooperation on carbon pricing by providing a framework that can minimizes trade-related negative spillovers arising from carbon pricing policies while promoting their positive spillover effects. As discussed in Chapter C, the WTO acts as a forum to discuss trade-related issues and increase the transparency of decision-making processes.

A number of WTO members have raised in various WTO bodies their concern about BCA, arguing that BCA could be unfair and result in protectionism.[23] The discussions at the WTO cover methodologies to calculate the carbon content of imports and how carbon mitigation policies other than emission trading schemes (e.g., emission standards and regulations) are taken into account.[24] Another concern expressed by some developing countries is that certain carbon measures would be contrary to the Paris Agreement's CBDR principle.

The WTO's transparency mechanisms and its function as a forum for dialogue could help to mitigate potential trade frictions arising from the imposition of BCA. WTO transparency disciplines allow members to be aware of upcoming regulatory proposals, including some relevant to carbon pricing initiatives. Dialogue at the multilateral level also allows interested members to provide comments on these proposals, while the member seeking to adopt the new measure has an opportunity to make adjustments in response to concerns raised. Discussions in the Committee on Trade and Environment (CTE) and the Trade and Environmental Sustainability Structed Discussions (TESSD) have explored regulatory proposals pertaining to BCA and issues related to WTO compatibility with this type of measure. Specific carbon pricing schemes have also been discussed in other WTO bodies, such as the Committee on Market Access and the Council for Trade in Goods.[25]

Continuing these discussions and others, including on upcoming carbon pricing policies, in the WTO and other fora serve an important transparency objective and provides meaningful opportunities for comments and exchanges of views. Further discussions may focus key aspects that should be considered to avoid trade tensions, including issues such as methodologies to avoid double charging, principles for equivalent taxation, carbon accounting and revenue use, harmonization or convergence of carbon pricing coverage (e.g. carbon life cycle, sectors and emission scopes), emission benchmarks and sectoral averages, burden-sharing and methodologies for facilitated certification and verification, and guidance on CBDR and preferential treatment.

(c) WTO disciplines help to prevent protectionism and to promote well-designed carbon pricing

In essence, under WTO rules, WTO members are free to adopt environmental policies, including those related to climate change, at the level they choose, even if these significantly restrict trade, as long as they do not introduce unjustifiable or arbitrary discrimination or disguised protectionism (see Chapter C).

Several WTO disciplines could come into play if a carbon pricing scheme or its adjustment affects international trade. Key disciplines include the non-discrimination obligations (i.e., the national treatment principle and the most-favoured nation (MFN) clause) and the prohibition of quantitative restrictions. Other disciplines could also be relevant, such as those applicable to technical barriers to trade (TBT) and to subsidies and countervailing measures (SCM) (WTO and UNEP, 2009).

The WTO legal framework provides a great deal of guidance concerning the type of situations in which a BCA measure could potentially have a detrimental impact on imported goods, as well as concerning the types of conditions that must be met to justify this detrimental impact under WTO rules. Overall, carbon pricing policies and BCA mechanisms must be coherent and fit-for-purpose; they must contribute effectively and efficiently to reducing GHG emissions; and they must not be misused for protectionist purposes.

In particular, carbon pricing policies need to be carefully designed in order to account accurately for the carbon content of the goods affected by these policies, irrespective of where the goods are produced, while avoiding situations in which goods with higher carbon footprints are unjustifiably charged lower carbon rates or otherwise bear lower carbon tax burdens. This would inevitably involve important issues related to differences in policy approaches to carbon pricing, carbon accounting methodologies, access to certification facilities and sector- or product-specific challenges.

(d) The needs of all countries, and of developing countries in particular, must be part of the discussions on carbon pricing

To foster a just low-carbon transition, carbon pricing should be mindful of the challenges faced by producers with limited technical and financial resources, such as micro-, small- and medium-sized enterprises (MSMEs) and firms in developing countries. Facilitating access to low-carbon technologies and services and providing support for carbon accounting are essential to make carbon pricing more inclusive.

In particular, governments seeking to adopt carbon pricing measures should be cognizant of the fact that in the absence of complementary policies and well-designed financial mechanisms, certain countries and groups may be negatively impacted by carbon pricing. The literature has shown that developing countries, in particular LDCs, are more likely to be negatively affected by carbon pricing, as they tend to have fewer resources to achieve carbon reductions and thus need support to limit and adjust to the negative effects of increasing carbon costs. The importance of enabling countries at different levels of economic development to protect the environment is expressly recognized in the Marrakesh Agreement Establishing the World Trade Organization, alongside the objective of sustainable development.

There is not only a "just transition" argument for providing finance to developing countries to enable them to transition effectively to a low-carbon economy, but also an efficiency argument. Research shows that climate finance for developing economies can be more efficient than for developed economies. This is because investments supporting decarbonization result in higher emission reductions in developing economies, which typically rely on less efficient techniques and have more potential to substitute high-carbon energy with low-carbon energy.

Support must also be provided to facilitate access to low-carbon technologies, as this could permit developing countries, and especially MSMEs in these countries, to produce goods and services in a less carbon-intensive manner, thereby minimizing the need for carbon adjustment at borders and helping them to attain climate and sustainable development goals. Support for carbon accounting and certification of producers in the developing world is also indispensable (see Chapter E). This is in the interest of all economies, including those looking into adopting BCA.

There is scope for further support mechanisms, which could take the form of international cooperation on collection and distribution of carbon taxes, using the revenues to support low-income countries in the form of direct income support or support for environmental innovation.

If promoting carbon pricing at a global scale is not a feasible option in the short term, improving global convergence around pricing policies is a process that, over time, could reduce the trade tensions that may arise as a result of the adoption of divergent approaches. As discussed above, the WTO can play a key role in this context, as it already offers various fora for dedicated discussions on these matters, in which all countries, and developing countries in particular, can express their views and concerns on carbon-pricing approaches.

5. Conclusion

Although carbon pricing is considered an important element of climate mitigation policy, its implementation around the world is uneven. Current carbon pricing schemes cover only a modest share of global GHG emissions and their carbon prices vary significantly across countries and regions.

The increasing fragmentation in carbon pricing schemes can give rise to the risk of carbon leakage and competitiveness loss, especially in carbon-intensive and trade-exposed sectors. Uncoordinated carbon pricing policies can further impose additional administrative and compliance costs for governments and businesses.

Carbon leakage and competitiveness concerns might lead to calls for BCA measures to ensure that foreign competitors are subject to the same carbon costs as domestic producers. BCA mechanisms have both advantages and disadvantages. On the one hand, they are expected to contribute to reducing carbon leakage and to restoring the loss of competitiveness stemming from differential carbon pricing, thus contributing to a level playing field. On the other hand, BCA could generate adverse terms-of-trade effects for low-income regions and trigger trade conflicts. Different BCA mechanisms across jurisdictions could also create coordination problems and additional administrative costs.

Greater international cooperation is essential to common carbon pricing solutions. Simulations studies show that a global carbon pricing mechanism would be a more efficient approach to reducing GHG emissions than uncoordinated regional carbon pricing schemes. However, reaching a global agreement on carbon pricing requires overcoming the free-rider problem and ensuring a fair-burden sharing of the economic costs of carbon pricing between high- and low-income countries. Complementary measures, such as financial support, could help low-income regions to address and overcome the potential adverse effects of carbon pricing and ensure a just transition to a low-carbon economy.

International trade cooperation on carbon pricing can further help to achieve a more coordinated approach to global carbon pricing. The WTO, through its core functions, remains an appropriate forum to continue to serve as a platform for discussing and exchanging information and experience on carbon pricing and to collaborate with other international organizations to foster international cooperation and promote more integrated approaches.

Endnotes

1 While carbon pricing is a relatively recent strategy, taxes and emission trading schemes on local and regional pollutants have been adopted by some countries for many decades. For instance, a wastewater tax scheme was introduced in France in the early 1970s. The United States adopted in 1995 an emission trading scheme on sulphur dioxide and nitrogen oxides.

2 The WTO GTM is a computable general equilibrium model, focused on the real side of the global economy, modelling global trade relations. See Aguiar et al. (2019) for a technical description of the WTO GTM.

3 Several countries have submitted two different types of pledges in their NDCs: (i) "unconditional pledges" and (ii) more ambitious pledges that are conditional on reduction efforts of other regions, financial support, or other types of assistance (Böhringer et al., 2021). This simulation scenario is based on the unconditional pledges and excludes the pledges that some countries are willing to pursue on condition that other countries reduce their emissions.

4 The average global carbon price under the regional pricing regime is computed as the weighted average of the regional carbon prices, where the weights are regional CO_2 emissions.

5 The illustrative policy experiment compares two situations: (i) the adoption of a global emission trading scheme with the participation of all regions and (ii) the adoption of a regional emission trading scheme by seven "ambitious" regions (Australia, Canada, the European Union, the European Free Trade Association (EFTA), Japan, the United Kingdom and the United States), while the remaining regions, which are developing regions, do not adopt any carbon pricing mechanism (Bekkers and Cariola, 2022).

6 The illustrative policy experiment assumes that Australia, Canada, the European Union, the European Free Trade Association (EFTA), Japan, the United Kingdom and the United States adopt a regional emission trading scheme (Bekkers and Cariola, 2022).

7 The simulation results suggest that the real income of India and of the Republic of Korea is projected to rise under the "international carbon price floor" scenario. This is because India and the Republic of Korea are net importers of fossil fuels, and under the scenario the demand for fossil fuels is reduced, thus reducing the price of fossil fuels and improving their terms-of-trade. (Bekkers and Cariola, 2022).

8 The rate of carbon leakage depends both on the amount of production activity shifted abroad and on the emission intensity of that production activity. Thus, it is possible to have high leakage rates with less significant shifts in production (Keen, Parry and Roaf, 2021).

9 In the illustrative simulation experiments, the set of high-income countries are Australia, Canada, the European Union, the European Free Trade Association (EFTA), Japan, the United Kingdom and the United States. The first experiment assume that the high-income group adopt a carbon pricing scheme to reduce its emissions from no reductions (business as usual) to its NDC target levels, while the other countries and regions have no targets. In the second experiment, the same set of high-income countries is assumed to set a carbon price of US$ 75 instead of US$ 50, with the other regions setting carbon prices of US$ 25 (low-income regions) and US$ 50 (middle-income regions).

10 A large strand of the empirical literature assesses the competitiveness consequences of environmental policy by testing whether the so-called "pollution haven" hypothesis holds in practice. The pollution haven hypothesis posits that trade openness results in the relocation of pollution-intensive production from countries with stringent environmental policy to countries with lax environmental policy (see Chapter E).

11 In theory, a BCA could also be applied on products imported from a jurisdiction with a higher carbon pricing level if that jurisdiction also operates a BCA on their exports, thus implementing a "carbon tax neutrality" for traded goods.

12 As in the illustrative policy experiments described previously, if a coalition of seven developed regions introduces a carbon pricing scheme whereas the other regions do not, implementing a BCA mechanism is, on average, effective in preventing competitiveness loss. However, the effects are heterogeneous among the regions introducing the carbon pricing scheme and do not prevent competitiveness losses in all regions (Bekkers and Cariola, 2022).

13 If the simulation setting is modified by assuming that regions can impose counter-tariffs in response to a BCA mechanism, some regions would have an incentive to introduce a carbon pricing scheme, whereas other regions would prefer to impose counter-tariffs (Böhringer, Carbone and Rutherford, 2016).

14 A more detailed discussion of these choices is beyond the scope of this report and can be found, for example, in Cosbey et al. (2020).

15 See https://www.carbonpricingleadership.org/.

16 See https://icapcarbonaction.com/.

17 See https://www.g7germany.de/g7-en/current-information/g7-climate-club-2058310/.

18 See https://carbonpricingdashboard.worldbank.org/.

19 See https://www.oecd.org/tax/tax-policy/tax-and-environment.htm/.

20 Following the departure of the United Kingdom from the European Union, the United Kingdom replaced its participation in the European Union Emission Trading System with a national emission trading scheme.

21 See for instance European Union-Viet Nam RTA.

22 See for instance Chile-United States RTA.

23 See, inter alia, discussions in the Committee on Trade and Environment (WTO official document number WT/CTE/28/Rev.1, paragraph 1.19; WT/CTE/M/71, paragraphs 1.102–122; WT/CTE/M/72, paragraphs 2.95–2.115; WT/CTE/M/73, paragraphs 1.45–1.75), Committee on Market Access (WTO official document number G/MA/M/74, paragraphs 12.3–12.43) or Council on Trade in Goods (WTO official document number G/C/M/139, paragraphs 20.3–20.59; G/C/M/140, paragraphs 28.3–28.60; G/C/M/141, paragraphs 39.3–36.63). WTO official documents can be accessed via https://docs.wto.org/.

24 For instance, the Committee on Trade and Environment (CTE) discussed carbon footprint and labelling schemes on various occasions. See Summary Report of the Information Session on Product Carbon Footprint and Labelling Schemes (WTO official document number WT/CTE/M/49/Add.1); Report of the Committee on Trade and Environment (WTO official document number WT/CTE/M/55); 2017 Annual Report of the Committee on Trade and Environment (WTO official document number WT/CTE/M/55). WTO official documents can be accessed via https://docs.wto.org/.

25 For instance, the Council for Trade in Goods recently discussed the European Union's plans for a carbon border adjustment mechanism. See https://www.wto.org/english/news_e/news20_e/good_11jun20_e.htm.

E

The decarbonization of international trade

The transition to a low-carbon economy will require the transformation of many economic activities, including international trade. This chapter looks at the extent to which trade contributes to greenhouse gas emissions, but also assesses its importance for the diffusion of the technology and know-how needed to make production, transportation and consumption cleaner. Although carbon emissions associated with international trade have tended to decrease in recent years, bold steps are needed to further reduce trade-related emissions. Greater international cooperation is needed to support efforts to decarbonize supply chains and modes of international transport.

Contents

Key facts and findings

- Carbon emissions embodied in world exports are estimated to account for slightly less than 30 per cent of global carbon emissions in 2018. This share has been slowly declining since 2011.
- Emissions embodied in exports derive from both domestic and foreign inputs. From 1995 to 2018, the estimated share of CO_2 emissions with foreign origins in total trade-related emissions increased from 24 per cent to 31 per cent.
- Although trade increases global CO_2 emissions compared to a hypothetical autarky situation, simulation analysis suggests that the cost of GHG emissions associated with international trade would be outweighed by the benefits of international trade.
- Greater international cooperation on improving carbon content measurement, reducing emissions from the transport sector, and improving the sustainability of global supply chains is necessary to reduce trade-related greenhouse gas emissions.
- International support for developing countries is critical so that they can reduce their trade-related emissions, including those connected to sustainable agricultural supply chains.

1. Introduction

The transition to a low-carbon economy is likely to entail a transformation of most economic activities, including international trade. Reducing greenhouse gas (GHG) emissions will increasingly become a business imperative to remain competitive and efficient. Decarbonizing trade will require reducing carbon emissions from the production stage but also the transportation stage.

Although measuring the overall impact of trade on carbon emissions is complex, identifying carbon hotspots along the supply chains, where there is an intense generation of GHG emissions, is essential to prioritize and implement climate change mitigation strategies.

This chapter discusses how carbon emissions originating from international trade can be measured. It then reviews the channels through which international trade can increase or decrease emissions, and discusses how the level of carbon emissions and welfare would change in a counterfactual world with no international trade. The chapter concludes with a discussion on the role of international cooperation, including at the WTO, in supporting strategies that aim to reduce the carbon emission associated with international trade, such as improving carbon efficiency in transportation and ensuring the environmental sustainability of supply chains.

2. Accounting for carbon emissions originating from international trade is complex

Conceptually, the carbon emissions embedded in a traded product – sometimes referred to as carbon footprint – include all direct GHG emissions from the whole life cycle of a product, i.e., its production, assembly, packaging, shipping to the market (to consumers) and disposal. A more comprehensive measurement of embedded carbon emissions can also account for the indirect GHG emissions generated by the production and transportation of the inputs used to produce the final product or service, including the GHG emissions from the generation of the electricity used during production.

Changes in the way land is used to produce goods and services (e.g., clearing of forests for agricultural use) impact GHG emissions, and can be included in the assessment of the carbon emissions embedded in traded products. Land use change is estimated to account for 12.5 per cent of the carbon emissions associated with human activities between 1990 and 2010 (Houghton et al., 2012). The expansion of agriculture and the production of traded goods have been identified as important drivers of global land use change (Böhringer et al., 2021).

In practice, comprehensively estimating the carbon footprint of a product or an economic activity is complex and data-intensive. A common approach, known as carbon accounting, uses sectoral carbon emission data and input-output (I-O) tables, which track an economy's circular flow of goods and services, to estimate the carbon emissions associated with international trade (WTO, 2021a).[1]

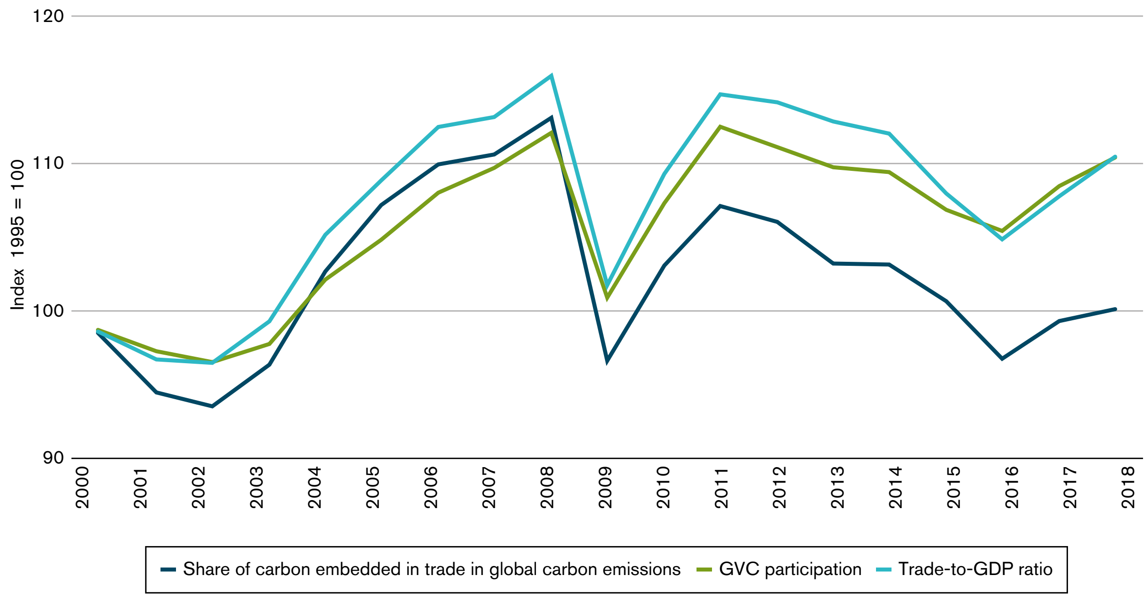
According to the most recent available estimates, the carbon emissions embedded in world exports in 2018 amounted to about 10 billion tons of CO_2, or slightly less than 30 per cent of global carbon emissions (OECD, 2022d). The share of CO_2 emissions embedded in trade in total emissions, while increasing significantly between 1995 and 2008, has been on a declining trend since 2011 (see Figure E.1). Moreover, since the financial crisis of 2008, carbon embedded in trade seems to have declined relative to trade's contribution to GDP or global value chain (GVC) participation, suggesting a decoupling of carbon emissions and trade thanks, in part, to greater energy efficiency.

Aggregate accounting results hide important regional differences. For instance, Canada, China, the European Union, India, Japan, the Republic of Korea, the Russian Federation, and the United States are found to be the main contributors to global carbon emissions embedded in international trade (see Figure E.2). Over the past decade, the growth of global carbon emissions embedded in trade has been mainly driven by a few high- and middle-income countries.

The amount of GHG emissions embedded in an economy's exports is determined by a broad range of factors, including its economic size, the sectoral composition of its foreign trade, its level of participation in global value chains, the modes of transportation used for its imports and exports and the energy efficiency of its production system, which depends in part on environmental and energy policies (WTO, 2021a). For instance, a few sectors, including energy and transportation, account for more than 75 per cent of the GHG emissions embedded in international trade (Yamano and Guilhoto, 2020).

Given that international trade separates production and consumption across space, carbon emission accounting can be analysed from a production

Figure E.1: The share of emissions embedded in international trade in total carbon emissions has been slowly decreasing in recent years



Source: Authors' calculation, based on the OECD Trade in embedded CO_2 ($TeCO_2$) database for carbon emissions embedded in trade, the World Bank's World Development Indicators for the trade-to-GDP ratio, and the OECD Trade in Value-Added (TiVA) database for GVC participation.

Note: Data have been normalized to 100 for the year 2000 to depict differences in trends. GVC participation is measured as share of foreign value-added in exports.

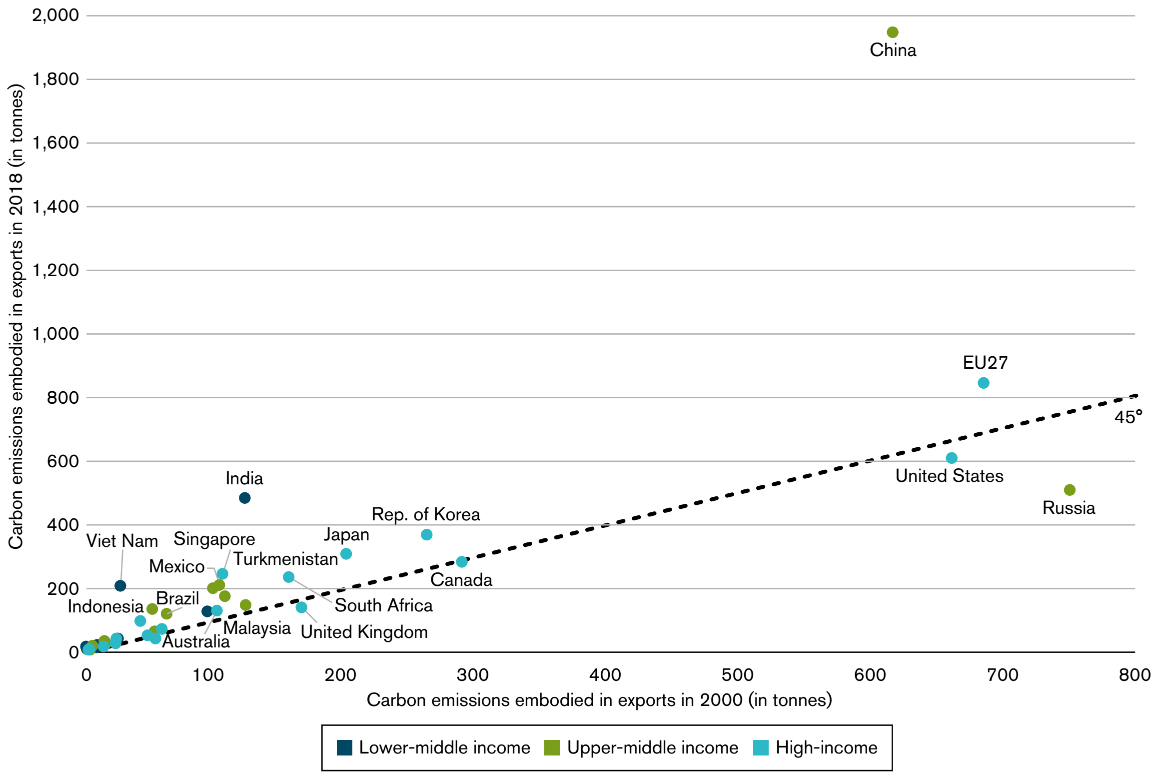
perspective (i.e., production of goods and services consumed domestically and exported) or a consumption perspective (i.e., consumption of goods and services produced domestically and imported). The difference between the production and consumption determines the trade balance in carbon emissions, namely whether economies are net importers or exporters of carbon emissions. While developed economies tend to be net importers of carbon emissions, developing economies and fossil fuel commodity dependent economies tend to be net exporters of carbon emissions (OECD, 2022d).

Although high-income economies remain more dependent on imported carbon-intensive activities than middle-income economies, the net imports of embedded carbon emissions has declined in recent years, in part thanks to improvements in energy efficiency (see Figure E.3) (Wood et al., 2020). Very few economies have, however, moved from being net importers of embedded carbon emissions to being net exporters, or vice versa (Yamano and Guilhoto, 2020).

The rise in GVCs has increased the fragmentation of production processes with the offshoring of some tasks. Emissions embedded in trade, therefore, can derive from the lifecycle of a product as well as from the embedded emissions in domestic and foreign inputs. Economies more integrated in GVCs have increased the share of carbon emissions embedded in imports of intermediate inputs, and thus the amount of carbon emissions embedded in their exports. From 1995 to 2018, the average share of carbon emissions with foreign origins in total trade-related emissions increased from 24 per cent to 31 per cent (OECD, 2022d).

While carbon emission accounting provides interesting insights on the amount and evolution of carbon emissions embedded in international trade, it is a purely descriptive analysis that cannot capture all aspects of the complex relationship between trade and carbon emissions. For instance, it does not provide any insights about the changes in carbon emissions and welfare that would arise in a counterfactual world in which trade is replaced by domestic production. More generally, carbon accounting is silent on the determinants of carbon emissions embedded in trade and on the net impact of trade on carbon emissions.

Figure E.2: The increase in carbon emissions embedded in international trade is mostly driven by a few economies



Source: Authors' calculation, based on OECD TeCO$_2$ database.

Note: The horizontal axis indicates the logarithm of carbon emissions embedded in exports in 2000, and the vertical axis indicates the logarithm of carbon emissions embedded in exports in 2018. The dashed line indicates the 45-degree line. Countries below the line have reduced the carbon emissions embedded in their exports between 2000 and 2018.

3. International trade affects carbon emissions in multiple ways, both positive and negative

The effect of trade on the environment is theoretically undetermined, because different mechanisms pulling in opposite directions are at play, and different factors determine the importance of the role of each of these mechanisms (WTO, 2013). The overall impact of trade on GHG emissions is therefore an empirical question.

(a) International trade can raise emissions through different channels

Trade-opening increases the level of production, transportation and consumption of goods and services, thus increasing carbon emissions. This is commonly referred to as the "scale effect" of trade (Antweiler, Copeland and Taylor, 2001).

Expansion of trade by GVCs, which accounts for almost half of global trade today (World Bank, 2020), also contributes to more carbon emissions from international transportation, i.e., an additional contributor to the scale effect.

Different modes of transport have different impacts on carbon emissions, which are in large part determined by the source of energy used (WTO, 2013). Air transport is the most carbon-intensive mode of transportation, followed by road transport (e.g., trucks). Rail and maritime transport are relatively less carbon-intensive.

The international transport sector is estimated to account for over 10.2 per cent of global carbon emissions in 2018 (OECD, 2022d). Although carbon emissions from the international transport sector fell by over 10 per cent in 2020 during the COVID-19 pandemic, they have been growing steadily at an average annual rate of 1.9 per cent since 1990 (ITF, 2021a).

While passenger transportation accounts for more than two-thirds of international transport emissions,

Figure E.3: Carbon emissions embedded in net imports of high-income countries have peaked in 2006

Source: Authors' calculation, based on OECD TeCO_2 database.

Note: Net exports of carbon emissions are the difference between carbon embedded in exports and carbon emissions embedded in gross imports. A negative net exports correspond to net imports of carbon emissions.

the remaining transport emissions are associated with international freight transport. International freight transport is also estimated to represent, on average, 33 per cent of the carbon emissions generated by international trade during the production and transport of goods traded internationally, the remaining 67 per cent of trade-related emissions are associated with the production of traded goods (Cristea et al., 2013).

Although the bulk of international trade continues to be transported by sea, trade-related transport activities and carbon emissions are projected to increase sharply due to the increase in air transport to deliver time-sensitive products, such as fruits and vegetables and consumer electronics.

Changes in the sectoral composition of production resulting from trade-opening can increase or reduce emissions, depending on whether or not the country has a comparative advantage in carbon-intensive industries (McLaren, 2012). This is commonly referred to as the "composition effect" (Antweiler, Copeland and Taylor, 2001).

According to the so-called "factor endowments hypothesis", trade opening will cause capital-abundant countries, typically developed economies, to specialize in the production of capital-intensive products, while developing countries specialize in labour-intensive production. The "factor endowment hypothesis" assumes that the pollution intensity of an economic sector tends to go hand in hand with its capital intensity. Accordingly, developed economies are assumed to specialize in carbon-intensive industries.

An alternative hypothesis, known as the "pollution haven hypothesis", assumes that climate policy, and implicitly the cost for firms to reduce or prevent carbon emissions, are the main source of comparative advantage. The hypothesis posits that trade opening will lead to the relocation of carbon-intensive production from countries with stringent climate policy to countries with relatively lax climate policy (Copeland and Taylor, 2004). Similarly, when firms slice up production along value chains, the carbon-intensive parts of production might be shifted from countries with stringent climate change regulations to those with weaker regulations, a phenomenon called "pollution outsourcing" (Cherniwchan, 2017; Cherniwchan, Copeland and Taylor, 2017; Cole, Elliott and Zhang, 2017).[2]

Additional scale and composition effects may arise if trade encourages or reallocates activities that lead to higher emissions, such as deforestation. Theoretically, the impact of trade-opening on deforestation can either be positive or negative (WTO, 2021c). Recent empirical studies find, however, a significant increase in deforestation in response to trade-opening (Abman and Lundberg, 2019; Faria and Almeida, 2016). It is estimated that around one-third of deforestation-related emissions were driven by international trade (Henders, Persson and Kastner, 2015; Pendrill et al., 2019).

(b) International trade can lower emissions through different channels

Trade can lower emissions by facilitating changes in production methods that reduce emissions per units of output, generally referred to as the "technique effect" (Antweiler, Copeland and Taylor, 2001). International trade facilitates the access and deployment of cleaner technologies, including carbon-friendly technologies that are not necessarily available in the importing countries. The increase in economic growth and per capita income associated with open trade can give rise to greater demand by the public for a cleaner environment.[3]

The demand for more climate-friendly solutions can result in more stringent climate policies that incentivize producers to reduce the carbon intensity of output, provided that policies are not influenced by industry lobbyists or otherwise compromised (Magnani, 2000; Nordström and Vaughan, 1999).

At the sector level, trade-opening may shift output shares to more productive and cleaner firms because firms engaged in trade tend to be more energy efficient than firms only servicing domestic markets.[4] This has been called the "pollution reduction by rationalization" hypothesis (Copeland, Shapiro and Taylor, 2022). Improved access to foreign intermediates due to input tariff liberalization can also trigger reductions in within-industry emission intensities.[5] The so-called "pollution halo hypothesis" further posits that multinational companies through foreign direct investment can transfer their environmental technology, such as pollution abatement, renewable energy and energy efficient technologies, to the host country (Eskeland and Harrison, 2003).

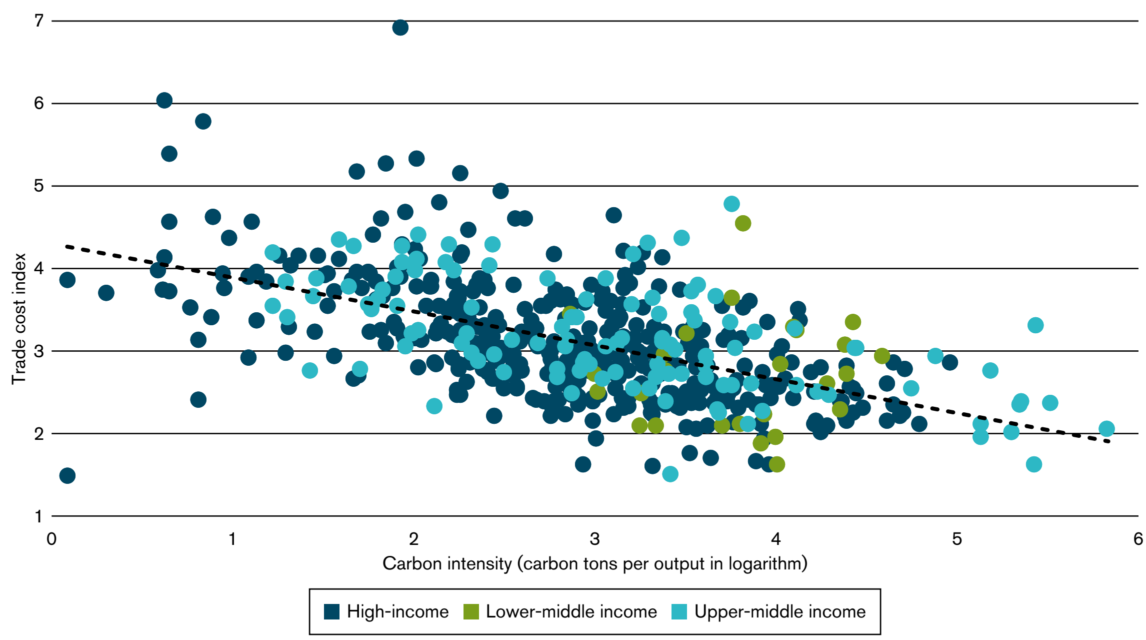
Trade openness can also stimulate innovation, including environmental innovation, through different channels (WTO, 2020a). Innovation and the adoption of energy efficient technologies can increase in response to increased competition from imports.[6] For instance, increased import competition due to tariff reductions has been found to cause Mexican production facilities to increase their energy efficiency (Gutiérrez and Teshima, 2018).[7] Similarly, export expansion due to trade liberalization in export markets can increase innovation (Bustos, 2011). For example, Indian firms exporting manufactures have been found to undergo technological upgrading in response to increased foreign demand (Barrows and Ollivier, 2021).[8]

Finally, trade policy changes also have the potential to affect emissions. Tariff and non-tariff barriers tend to be lower in carbon-intensive industries than in clean industries (see Figure E.4). Indeed, high carbon-intensive goods tend to be traded more than low carbon-intensive (Le Moigne and Ossa, 2021). This is mainly because trade barriers tend to be lower on upstream products (which are mainly used as inputs into production) than on downstream products (which are closest to the final consumption goods), and upstream products tend to be more carbon-intensive than downstream products. A recent counterfactual analysis shows that, if trade policy reform eliminated the environmental bias in trade policy by imposing the same tariff and non-tariff barrier structure in all industries, this would yield a win-win outcome: global real income would slightly increase (by 0.65 per cent), while global carbon emissions would fall by 3.6 per cent (Shapiro, 2021).[9]

(c) In the absence of international trade, welfare losses would outweigh the welfare gains due to lower carbon emissions

Several studies have empirically investigated the extent to which trade has an impact on carbon emissions through its impact on production and transport, on industry composition and on industry emission intensities (respectively, scale, composition and technique effects). Overall, the empirical literature suggests that trade-related reductions in emissions are mostly due to the technique effect, while the composition effect tends to be quite small (Copeland, Shapiro and Taylor, 2022).[10] The evidence that the composition effect is relatively small suggests that international trade driven by comparative advantage has not been responsible for a systematic relocation of pollution-intensive production out of countries with stringent environmental regulations, as would have

Figure E.4: Trade costs tend to be lower in carbon-intensive manufacturing industries



Source: Authors' calculation, based on Shapiro (2021) for carbon emission intensities in manufacturing industries and WTO Import Trade Cost Index for 2011.

Note: Each dot is an importer-industry (ISIC rev. 3.1 two-digit) combination. The trade cost index measures the cost of trading internationally relative to trading domestically.

been predicted by the "pollution haven hypothesis" (Cherniwchan and Taylor, 2022). This is because costs of abating emissions tend to represent only a small part of a firm's total operating costs, and other factors such as costs of capital, labour and proximity to the market are more important determinants of a firm's location decision.

With a relatively small composition effect, open trade may decrease or increase total carbon emissions depending on whether the technique effect overrides the scale effect. The empirical evidence on the net impact of trade on carbon emissions is mixed. The impact is sector- and country-specific and depends on a broad range of factors, including the type of pollutants, the country's level of development, energy intensity, types of energy sources used, types of products traded, modes of international transport, trading partners' location and energy and environmental policies in force.

For a global pollutant, such as carbon dioxide (CO_2), the scale effect tends to dominate, implying that trade increases emissions. However, for some local and regional pollutants such as particulate matter (PM) and sulphur dioxide (SO_2), the technique effect is likely to exceed the scale effect because governments have a greater incentive to reduce emissions of local pollutants given that the benefits of pollution abatement accrue more directly to their citizens.

In developed economies, the technique effect tends to dominate the scale effect, while the reverse is observed in developing economies because of relatively less stringent environmental regulations and limited access to pollution abatement technologies (Managi, 2006). As a result, open trade is associated with less carbon emissions in high-income economies but more carbon emissions in developing economies.

This finding corroborates the carbon accounting analysis discussed in the previous section and suggests that high income countries tend to be net importer of carbon emissions, with large amounts of carbon emissions emitted in developing countries to produce goods and services exported to high-income countries.

Several mechanisms contribute to the reduction of pollution emissions intensity underlying the technique effect. For instance, the reduction of nitrogen oxides (NOx) emissions in the manufacturing sector in the

United States has been found to be almost entirely driven by more stringent environmental regulations (Shapiro and Walker, 2018).[11] At the same time, trade can also affect emission intensity by reallocating market shares to exporting firms. Exporters in Indonesia have been found to be more energy-efficient and less reliant on fossil fuels compared with non-exporters (Roy and Yasar, 2015). In India, within-industry reallocation of market share as a result of trade produced large savings in GHG emissions (Martin, 2011).

Trade has also been found to induce a change in industry emission intensities of particulate matter (PM) and sulphur dioxide (SO_2) due to changes in the relative sizes of firms or to the entry of more productive firms and exit of less competitive firms (Holladay and LaPlue, 2021). Finally, changes in innovation activities and improved access to foreign intermediates induced by trade-opening can also contribute to reductions in industry emission intensity (Akerman, Forslid and Prane, 2021).

Given that international trade contributes to carbon emissions, there have been calls to reduce international trade by producing and consuming "locally". Such calls raise the question of what would be the level of carbon emissions if economies only produced and consumed locally while ensuring a high level of welfare. Although international trade emits GHG, it also generates trade gains and contributes to increase society's welfare by supporting economic growth, lowering prices, and increasing consumer choice and product variety, including with respect to climate-friendly goods, services and technologies.

While a situation of autarky is not observable, economists have used economic models to examine the question as a thought experiment. In a scenario where countries closed their borders to trade, domestic production of intermediate and final goods would need to rise to meet the demand for products that were previously imported. Compared with a hypothetical situation involving autarky (i.e., economic self-sufficiency) international trade would increase global CO_2 emissions by approximately 5 per cent, corresponding to 1.7 gigatons of CO_2 annually (Shapiro, 2016). This effect would be almost equally driven by production and transportation (scale effect), as, in the absence of trade, the resources used to produce goods and services for international markets would be employed in satisfying domestic demand. However, the benefits for producers and consumers from international trade, estimated at US$ 5.5 trillion, would exceed by two orders of magnitude the environmental costs from carbon emissions, estimated at US$ 34 billion.

This analysis suggests that, rather than unwinding trade integration – for example, by re-shoring production and promoting self-sufficiency – the better option would be to trade in a cleaner way, for example by reducing the carbon intensity of transportation, as well as developing and deploying environmental and carbon-friendly technologies and sourcing low-carbon inputs and products.

4. Reducing trade-related carbon emissions requires greater international cooperation

Although international trade is not the main contributor of GHG emissions, reducing trade-related GHG emissions is essential to contribute to the transition to a low-carbon economy. International cooperation is important to scale up strategies to decarbonize international trade and transport and to limit any undesired impacts that can hinder and slow down progress towards low-carbon trade.

International cooperation can contribute to a more coherent and predictable policy environment by providing a reference point for national climate change mitigation policy and help signal a more credible commitment to decarbonize international trade. Similarly, enhancing the transparency of measures aimed at reducing trade-related carbon emissions through greater international cooperation can facilitate the review and monitoring of actions and help to overcome resistance to decarbonizing some trade-related activities.

International cooperation can further help to mobilize financial and technical resources to overcome capacity constraints and facilitate access to capital and technologies that reduce trade-related carbon emissions. Technical assistance, capacity building and exchanges in knowledge and experience can also help promote a just transition to a low-carbon trade.

As discussed below, a broad range of regional and international organisations, including multilateral and regional financial institutions, address different dimensions of the decarbonization of international trade. The private sector is also active in efforts to decrease trade-related carbon emissions.

International cooperation on trade can also support efforts to reduce the carbon emissions embedded in international trade. An increasing number of regional trade agreements (RTAs) explicitly promote activities that can contribute to lower trade-related carbon emissions. Provisions explicitly promoting trade in environmental goods and services, including renewable energy and energy efficient products, are increasingly incorporated in RTAs (see Chapters C and D). A few, mostly recent, agreements specifically promote cooperation on sustainable transport, including through information and experience sharing.[12]

The WTO can also support the transition to a low-carbon trade by means of its existing framework of rules, as well as its negotiation forum, transparency requirements, monitoring system and capacity-building.

(a) Deeper international cooperation is required to facilitate carbon measurement and verification

Reducing carbon emissions associated with international trade requires accurately keeping track of the carbon emitted during the production and trade of goods and services, as well as the progress made in reducing those emissions. Different approaches have been developed to quantify the amount of carbon emissions in products and economic activities.

The scope of the carbon footprint within value chains is a particularly important criterion to define the boundary to include the full range of relevant emissions. As discussed in Chapter D, the carbon content of a product can cover the direct emissions from a production process (scope 1), the indirect emissions from the generation of purchased energy (scope 2), and the indirect upstream emissions and downstream emissions (scope 3) in a company's value chain, including investment, transportation and distribution. Relevant information, including the benchmarks of measuring carbon emissions, is essential to quantify the amount of carbon.

Several standards and guidelines have been published to provide overall guidance on calculating the carbon footprint of products and economic activities. For instance, the International Organization for Standardization (ISO) released the ISO 14067:2018, which sets out requirements and guidelines for quantification and reporting for the carbon footprint of products. The private sector has launched a number of initiatives, such as the GHG Protocol Corporate Accounting and Reporting Standard, which provides requirements and guidance for companies preparing a corporate-level GHG emissions inventory.

Although there is ongoing international cooperation on carbon measurement and verification, more global coherence is needed in this area, given the growing number of carbon measurement standards. At the national level, various standards have also been developed for carbon emissions measurement. There are also sector-specific standards that are tailored to calculate the carbon content in specific industry settings (WTO, 2022c).

As efforts to decarbonize increase, a proliferation of different standards could create unpredictability for producers and impose burdensome costs on them, and ultimately reduce the effectiveness of efforts to reduce carbon emissions. Moreover, carbon measurement methodologies should be backed by a robust system of verification. Without convergence or common understandings on carbon measurement and verification approaches, countries may encounter difficulties implementing certain trade-related climate policies aimed at decarbonizing international trade.

One important dimension of cooperation on carbon measurement and verification relates to the development and international recognition of quality infrastructure institutions. Quality infrastructure refers to the systems (both public and private), policies and practices that support and enhance the quality, safety and environmental soundness of goods that are traded. It relies on standardization, accreditation, conformity assessment, metrology and market surveillance.

The WTO supports efforts to promote a coherent carbon measurement and verification approach by providing a set of rules calling for convergence around common standards and verification procedures, and a forum where its members can cooperate to ensure that countries around the world have the quality infrastructure they need for carbon measurement and verification.

For these reasons, the manner in which international standards for measuring carbon are set will have a decisive impact on their use. The WTO supports international cooperation in this area. The use of relevant international standards is strongly encouraged under the Agreement on Technical Barriers to Trade (TBT), and the TBT Committee has developed "Six Principles for the Development of International Standards, Guides and Recommendations", namely (1) transparency, (2) openness, (3) impartiality and consensus, (4) effectiveness and relevance, (5) coherence, and (6) the development dimension, to address important areas of international standard-setting.[13] These six principles can play a significant role in the development of new international standards relating to carbon emissions quantification. For instance, observing these principles ensures that relevant information is made available to all interested parties, that sufficient opportunities for written comments are provided, that conflicting international standards are not adopted, and, importantly, that constraints facing developing countries are considered.

Aligning verification approaches with respect to the information provided by producers and exports on the carbon content of products is important to increase trust in the verification process and in carbon efficiency claims. Mutual recognition of the results of verification procedures can also contribute to a reduction in compliance costs. The TBT Agreement encourages members to accept the results of procedures adopted by other members, even if they are different from their own, if those procedures offer an equivalent assurance of conformity with applicable technical regulations or standards.

The participation of developing countries and least-developed countries (LDCs), as well as micro, small and medium-sized and enterprises (MSMEs) across the globe, in the transition to a low-emission global economy depends on their ability to measure and verify the carbon content of products. Deficient quality infrastructure in many LDCs and developing countries risks excluding them, creating bottlenecks in the decarbonization of supply chains and preventing low-carbon solutions from gaining access to the market.

Other issues that can impact developing countries include the extent to which direct and indirect land use change may have a bearing on carbon footprint calculations, as well as challenges that developing countries have in accessing accurate historical data on local land use change (Gheewala and Mungkung, 2013).

International support for developing countries is critical so that they can accurately measure and verify the carbon content of their products and participate in setting relevant international standards. A number of multilateral organizations support developing countries in improving their quality infrastructure, including in areas related to standardization and conformity assessment.[14] Further support to improve developing countries' capacities in the area of carbon standards would be beneficial.

Moreover, WTO bodies, such as the TBT Committee and the Committee on Trade and Environment (CTE) have held discussions on trade-related aspects of carbon footprint policies and methodologies.[15] In addition, the WTO could serve as a forum to hold more specific discussions at the multilateral level on trade-related aspects of carbon measurement methodologies and verification procedures, as well as on possible ways to support developing countries in this area.

(b) Reducing carbon emissions in international transport requires more international cooperation

Trade-related GHG emission abatement cannot be fully achieved without reducing carbon emissions from international transportation. As discussed above, transportation is an important contributor to the GHG emissions generated by international trade for many products (Cristea et al., 2013). Transport is also a major source of air and water pollution. Ensuring domestic and international transport is more sustainable and climate-friendly is essential to achieve a low-carbon economy.

Major decarbonization pathways for international transport include switching to lower-carbon fuels (for example, biofuels, hydrogen or renewable electricity), improving aircraft, vehicle and vessel efficiency, phasing-out high-carbon intensive vehicles and improving system-wide operational efficiency, including through the planning of efficient routes and the use of vehicle-sharing.[16] If it proves impossible to completely eliminate carbon emissions of transport at the source, remaining carbon emissions from international transport could be compensated through carbon offsets and new technologies, such as carbon capture, utilization and storage.[17]

Despite recent progress, the transition to a low-carbon international transport involves several challenges, including ensuring that the production of alternative, lower-carbon fuels does not increase emissions, managing the higher cost and lower energy density of alternative and lower-carbon fuels, and creating the necessary infrastructure such as charging facilities for electric vehicles.

Unlike domestic aviation and shipping, emissions from international aviation and shipping activities are not covered by the nationally determined contributions (NDCs) established under the Paris Agreement, because they take place, in part, beyond the territorial boundaries of states. The International Marine Organization (IMO) and the International Civil Aviation Organization (ICAO) have been tasked to find solutions to mitigate GHG emissions from international maritime and air transport, respectively.

(i) Maritime transport

Although maritime transport has relatively low carbon intensity,[18] international shipping is nevertheless estimated to be responsible for 2.9 per cent of global carbon emissions in 2018 (IMO, 2020) in large part due to the fact that it is the main mode of transport for global trade.

Annual emissions from shipping are forecast to grow by 15 per cent by 2030 in the absence of ambitious climate targets. Various commitments and initiatives to decarbonize maritime transport have been adopted and launched by both public and private actors at the international and regional levels.

At the international level, the IMO's Initial GHG Strategy, adopted in 2018, provides a policy framework and guiding principles to reduce carbon intensity of international shipping (CO_2 emissions per transport work) by at least 40 per cent by 2030 and pursuing efforts towards 70 per cent by 2050, and to reduce GHG emissions from international shipping by at least 50 per cent by 2050, compared to 2008 levels.[19] The IMO Initial GHG Strategy also seeks to strengthen the energy efficiency design requirements for ships.

The shipping industry supports the IMO's Initial GHG Strategy through a number of initiatives. For example, the Getting to Zero Coalition, an alliance of more than 150 companies across the shipping value chain supported by governments and intergovernmental organizations, aims to get commercially viable zero-emission vessels operating along deep-sea trade routes by 2030.[20]

Regional cooperation is also active in supporting the decarbonization of international maritime transport. For instance, the Pacific Blue Shipping Partnership launched by Fiji, Kiribati, the Marshall Islands, Samoa, the Solomon Islands, Tuvalu and Vanuatu, commits to a 40 per cent reduction in carbon emissions for Pacific shipping by 2030 and full decarbonization of the sector by 2050.[21] More recently, 22 developed and developing countries signed in 2021 the Clydebank Declaration with the aim of establishing six zero carbon emission maritime routes between two or more ports around the world by 2025.[22]

International cooperation is also critical to secure the large amount of financing required for decarbonizing shipping (Christensen, 2020). In this context, the IMO and Norway launched the Green Voyage 2050 project to support developing countries, including small-island developing states (SIDS) and LDCs, in meeting commitments to climate change and energy efficiency goals in shipping (IMO, 2019b).[23] Similarly, the Pacific Blue Shipping Partnership is seeking US$ 500 million from multilateral and bilateral development finance and the private sector to retrofit existing cargo and passenger ferries with low-carbon technologies and to buy zero-emission vessels.[24]

The WTO can also support the efforts to decarbonize international maritime transport, for example, by facilitating reductions in barriers to trade in goods and services involved in the production process of low-emission fuels for shipping (see Chapter F); by ensuring that trade-related regulatory changes, including energy efficiency requirements, are non-discriminatory; and by ensuring that the views of interested parties, including developing countries, are taken into account in discussions at the WTO on the trade impacts of decarbonizing shipping.

Moreover, as discussed in Chapter C, WTO rules can help to ensure that trade-related climate change mitigation measures, such as taxes, support measures and regulatory measures, applied in shipping for decarbonization purposes are transparent and do not distort the shipping market. For example, notifications under the General Agreement on Trade in Services (GATS) and the exchange of information in the Council for Trade in Services could increase regulatory transparency with respect to shipping-related decarbonization measures (e.g., tonnage and bunker taxes), and could contribute to further increase the predictability of trade policy and the credibility of policy commitments to decarbonize the sector.

(ii) Air transport

International aviation is the most carbon-intensive mode of transport and is estimated to be responsible for 1.3 per cent of global CO_2 emissions (ICAO, 2017).[25] Emissions from international aviation are expected to increase through 2050 by a factor ranging from approximately 2 to 4 times the 2015 levels, depending on the type of emissions and the scenario used (ICAO, 2019). Although decarbonizing aviation remains challenging, it has become an integral part of business strategies in the sector. Several international and regional initiatives are being introduced or implemented by both public and private stakeholders to support the transition to a low-carbon aviation industry.

The International Civil Aviation Organization (ICAO) adopted in 2016 the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to allow aircraft operators to buy emissions reduction offsets from other sectors to compensate for any increase in their own emissions above 2020 levels, thereby achieving carbon neutral growth from that year.[26] The mandatory phase of CORSIA will start in 2027. In addition, ICAO also promotes aircraft technology improvements, operational improvements and sustainable aviation fuels to contribute to the global aspirational goals of 2 per cent annual fuel efficiency improvement for the international aviation sector through 2050 and carbon neutral growth from 2020 onwards.

OPINION PIECE

By Sophie Punte
Managing Director of Policy, We Mean Business Coalition, and Founder, Smart Freight Centre

Building momentum for zero-emissions freight movement

International trade is indispensable. Yet the vital role played by freight transportation and logistics is often forgotten. Only now are leaders waking up to how vulnerable the supply of essential goods is in times of crises, whether as a result of pandemics, international conflicts, or climate-related disasters. A sector that contributes around 11 per cent of both global CO_2 emissions and global GDP and constitutes a reliable and sustainable transport system can play a critical role in the transition to a decarbonized future as well as in adaptation to the impacts of climate change.

The key to delivering a zero-emissions freight industry lies in international cooperation based on the Paris Agreement and the UN Sustainable Development Goals.

First, to reduce emissions and respond to supply chain shocks or disruptions, we need increased transparency in the logistics supply chain. Carbon emissions are an indicator that does not lie. Price can be negotiated up or down but you cannot negotiate the actual CO_2 footprint, and that makes it a more reliable indicator than prices on which to base decisions. Smart Freight Centre's Global Logistics Emissions Council (GLEC) Framework – a methodology for harmonizing the calculation and reporting of the logistics GHG footprint across supply chains – and soon the ISO 14083 standard, allow for consistent calculation and reporting of global logistics emissions. If coupled with blockchain technology, the sector could deliver a transparency revolution. This trend will go even further with the upcoming International Sustainability Standards Board (ISSB) standard, as well as and EU and US regulations requiring companies to disclose sustainability and climate information that is relevant to investors and stakeholders.

Second, we must go all out to decarbonize freight transport. Solutions range from sustainable aviation fuel and zero-emission ships and trucks, to fleet efficiency, a shift to less carbon-intensive transport modes and reducing freight demand. A complex but fortunately increasingly aligned number of initiatives is bringing stakeholders together to deliver these solutions. The 50+ companies of the First Movers Coalition, supported by initiatives such as the Mission Possible Partnership, Smart Freight Centre and Climate Group, send market demand signals for zero-emission aviation, shipping and trucking. Carbon offsetting and CO_2 removal should be used as a last resort where mitigation is not (yet) possible, but not as an alternative to action. A much-preferred service now offered by several logistics service providers is "carbon insetting": customers' emissions are reduced within the logistics sector, helping to drive investment into greener technologies and strategies.

Third, collaboration and supportive policy is critical, and can take various forms. For example, the Sustainable Trade Initiative works with 600 companies and governments on new sustainable production and trade models in emerging economies across 12 sectors, all of which involve transport. Policies that cut across trade and climate include carbon border adjustment mechanisms, fossil fuel subsidy reforms, renewable energy trading and technology transfer. The We Mean Business Coalition focuses on raising policy ambition with the backing of leading businesses that are setting science-based targets and taking action.

Governments, businesses and civil society all have every reason to work together in pursuit of carbon neutrality and sustainability in international transport. The benefits for international trade and the climate will be felt for generations to come.

The International Air Transport Association (IATA), the trade association of the world's airlines, approved in 2021 a resolution for the global air transport industry to achieve net-zero carbon emissions by 2050.[27] The financial sector is also active in supporting the decarbonization of the aviation industry. For instance, the Aviation Climate-Aligned Finance Working Group, launched in 2022 by several international lenders to the aviation sector, commits the participating financial institutions to annually disclose the degree to which GHG emissions from aircraft, airlines, and lessors they finance align with the 1.5°C climate targets.[28]

The WTO can also support the transition to a low carbon aviation industry. As noted in Chapter F, reducing barriers to trade in climate-friendly aircraft components, such as electric and hybrid-electric engines, could contribute to decarbonizing the sector and stimulate carbon-abating innovations. Improved access to software platforms, particularly if bound under the WTO Agreements, could help optimize available seats or air freight capacity in aircrafts by shifting traffic onto lower load flights by relying on real-time data to dynamically adjust prices, which would contribute to decarbonization (ITF, 2021b). Moreover, carbon emissions could also be reduced by fostering trade in digital services, such as teleconferencing, to reduce demand for business-related flights (Munari, 2020).[29]

Cooperation at the WTO could also improve the operational efficiency of the sector. Although air transport is largely excluded from the scope of the GATS,[30] the GATS does apply to measures affecting three aviation sub-sectors: aircraft repair and maintenance, computer reservation system services, and the selling and marketing of air transport services.[31] Further liberalization of aircraft repair and maintenance services could enable airlines to gain access, both domestically and in foreign destinations, to a wider range of suppliers able to deal with climate-friendly aircrafts. Similarly, opening up access to foreign airport operators and the capital injections they could potentially bring could help invest in new and retrofitted energy-efficient infrastructures, electrified ground-handling services, low-energy vehicles and equipment, and zero-cargo energy and fuel sources (ATAG, 2020; ITF, 2021b; Nieto, Alonso and Cubas, 2019).[32]

(iii) Road transport

Road freight transport is critical for the entire logistics chain. International road freight transport is estimated to account for 3.7 per cent of global carbon emissions (OECD, 2022d). Road freight is also estimated to account for 53 per cent of carbon emissions in global trade-related transport, a share that could rise to 56 per cent by 2050 if current trends continue (WEF, 2021).

Decarbonizing the road freight transport sector is particularly challenging and requires coordinated actions. For instance, no single fuel solution can meet operators' needs and therefore a variety of technologies must be pursued in parallel to achieve a decarbonization of road freight transport (IRU, 2020). International cooperation on low-carbon road transport remains, however, more fragmented than other modes of international transport.

At the 2021 United Nations Climate Change Conference (COP26), a large number of governments, vehicle manufacturers, shippers and financial institutions, signed the Glasgow Declaration on Zero-Emission Cars and Vans, committing to ensuring that new cars and vans being sold by 2035 in leading markets, and by 2040 for the rest of the world would be zero-emission.[33] In addition, 15 high-income economies signed a Global Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles to work together toward increasing sales of new zero-emission trucks and buses to 30 per cent by 2030 and to 100 per cent by 2040.[34] In 2021, the International Road Transport Union (IRU), which represents the road transport industry in over 80 countries, launched a Green Compact to achieve carbon neutrality by 2050 (IRU, 2021).

These initiatives complement other projects, such as the World Economic Forum's (WEF) Road Freight Zero initiative established in 2020 and designed to help industry leaders jointly develop solutions, including action plans for scaling up finance mechanisms and new lending and investment products.[35]

Like the decarbonization of other modes of international transport, the WTO can support efforts to reduce carbon emissions from road freight transport by facilitating the access and deployment of renewable energy and energy-efficient goods, services and technologies, including electric cars and trucks (see Chapter F), and by promoting non-discriminatory trade-related regulations, including energy efficiency requirements. Trade-related transport emissions could, to some extent, also be reduced by minimizing delays when clearing customs (Duval and Hardy, 2021; Reyna et al., 2016).[36]

In this context, the implementation of the WTO's Trade Facilitation Agreement (TFA), especially its provisions on single windows (i.e., single entry points at which traders can lodge standardized information and documents required for trade and transport), pre-arrival processing, electronic payment, and separation of release from final determination of customs duties, taxes, fees and charges, can speed up customs clearance, possibly reducing some carbon emissions from international trade.[37]

(c) International cooperation is needed to ensure that the decarbonization of supply chains limits market fragmentation

As discussed previously, decarbonizing supply chains can be achieved in different ways (see also Chapter C). However, much of the value of decarbonizing supply chains will likely come from the ability of economic operators to demonstrate and communicate their emissions reduction efforts to potential stakeholders. In that context, sustainability certification and labelling schemes can be important instruments to further incentivize firms to pursue the decarbonization of their value chains.

The multiplication of sustainability certification and labelling schemes is a visible sign of the rapidly expanding global market for sustainable products. In recent decades, many governments, producers, retailers and non-governmental organizations around the world have promoted such schemes to strengthen the market incentives for producers to opt for more sustainable production, while cultivating consumer awareness of environmental and social issues. For instance, in agriculture, the use of sustainability certification and labelling schemes has increased markedly. The value of the global organic food market has more than quadrupled since 2000, exceeding 120 billion Euros in 2020 (FiBL, 2022).

However, the proliferation of sustainability schemes in recent years has raised concerns about their effect on trade costs and possible impacts on market access for exporters, particularly from developing countries. Costs increase when the schemes multiply across geographic or thematic areas, fail to converge or recognize each other's equivalence, or when they do not include opportunities for collaboration in areas such as training or inspection (WTO and UNEP, 2018).

Trade could play an important role in strengthening the markets for sustainable products and in expanding related economic opportunities. For trade to do so, it must, however, be underpinned by an open, transparent, rules-based and inclusive trading system. As part of this, it is important to ensure that sustainability requirements are transparent, and are based on relevant international standards, while not creating any unnecessary barriers to trade (WTO and UNEP, 2018).

Thus, while vigorous action is needed to improve the sustainability of global supply chains, it is also important to take into account the concerns of various stakeholders, including in developing countries.

The WTO plays an important role in contributing to a better understanding of the trade impact of environmental policies, sustainability certification and labelling schemes and can help to identify best practices. For example, the CTE has been an important forum for members, including developing ones, to present and comment on recent climate proposals related to various sectors, including agriculture and forestry.[38] Other aspects of sustainable supply chains have also been discussed in the CTE, such as the need to enhance the availability of comparable and reliable information on the environmental impact of products.[39]

Ongoing initiatives at the WTO could further contribute to support the decarbonization of supply chains. For instance, the Trade and Environmental Sustainability Structured Discussions (TESSD), launched in 2021, intend to identify and compile best practices and explore opportunities to ensure that trade and trade policies contribute to promoting sustainable supply chains and addressing the challenges and opportunities arising from the use of sustainability standards, particularly for developing members. The Informal Dialogue on Plastics Pollution and Environmentally Sustainable Plastics Trade could also promote low carbon supply chains by contributing to efforts to reduce plastics pollution and promoting the transition to more environmentally sustainable trade in plastics.

5. Conclusion

Trade, like any economic activity, generates GHG emissions. Carbon emissions released by the production and transport of traded products are estimated to represent about one-third of global carbon emissions, a share that has been slowly declining in recent years. While estimating the amount of carbon emissions associated with international trade is important to identify climate mitigation priorities, it is also important to determine what impacts trade actually has on GHG emissions.

International trade affects GHG emissions in several different ways. Trade generates GHG emissions through the production, transportation, distribution and consumption of traded products, and it increases emissions by stimulating economic activity through increased income. On the other hand, trade can facilitate changes in production methods that reduce emissions per units of output, and modify the sectoral composition of the economy by allowing the production and consumption of goods and services to take place in different regions.

Overall, international trade has been found to lead to a relatively limited net increase in carbon emissions relative to a counterfactual "autarky" situation which would be associated with a significantly lower welfare level. Decarbonizing international trade is, however, essential to support the transition to a low carbon economy.

A successful decarbonization pathway for international trade requires adequately measuring and verifying carbon emissions resulting from trade, improving carbon efficiency in production and transportation, and developing environmentally sustainable supply chains. International trade cooperation, including through the WTO, can play an important role in supporting and scaling up these efforts.

Endnotes

1 Due to a lack of data, available estimates of carbon emissions embedded in international trade cover mostly high- and upper-middle-income countries. Estimates are only available for a few lower-middle income countries. Estimates for LDCs are not available (OECD, 2022d).

2 The literature distinguishes between the "pollution haven effect" and the "pollution haven hypothesis". The pollution haven effect assumes that an increase in environmental standards reduces exports (or increases imports) of carbon-intensive goods. The "pollution haven hypothesis" assumes a reduction in trade costs results in production of carbon-intensive goods shifting towards countries with lower environmental standards. The existence of "pollution haven effects" is a necessary, but not a sufficient condition, for the "pollution haven hypothesis" to hold. While some studies find evidence of "pollution haven effects", there is no empirical evidence of the "pollution haven hypothesis" (Copeland, Shapiro and Taylor, 2022).

3 The relationship between environmental pollution and income level might not be linear, but inverted U-shaped, as described by the Environmental Kuznets Curve. See Stern (2017b) for recent evidence of a decoupling of emissions and GDP growth in many advanced economies over recent decades, consistent with the Environmental Kuznets Curve.

4 Evidence that exporters have lower emission intensities than other firms is provided by Richter and Schiersch (2017) for German manufacturing firms, and by Banerjee, Roy and Yasar (2021) for Indonesian firms.

5 Evidence that becoming an importer of foreign intermediates boosts energy efficiency is provided by Imbruno and Ketterer (2018) for the Indonesian manufacturing sector in the period between 1991 and 2005. Similarly, an analysis of the impact of China's accession to the WTO shows that a 1 per cent reduction in input tariffs decreased the sulphur dioxide (SO_2) emission intensity of Chinese firms by 6 to 7 per cent (Cui et al., 2020).

6 A large body of literature has shown that this mechanism is relevant in developing countries (Gorodnichenko, Svejnar and Terrell, 2010; Shu and Steinweider, 2019), but also in EU countries in response to Chinese import competition (Bloom, Draka and Van Reenen, 2016). These studies, however, do not explicitly focus on environmental innovation.

7 Gutiérrez and Teshima (2018), however, also find evidence of a reduction in Mexican production facilities' investments in pollution abatement.

8 Barrows and Ollivier (2021) find that, while foreign demand growth increased carbon emissions growth rates for Indian firms exporting manufactures over the period between 1998 and 2011, technological upgrading in response to increased foreign demand mitigated roughly half of this increase.

9 Shapiro (2021), however, also shows that eliminating the environmental bias in trade policy would imply substantial carbon emissions increases in Europe and very slight increases in China, while other regions would see their emissions decrease.

10 See Antweiler, Copeland and Taylor (2001), and subsequent contributions including Cole and Elliott (2003), Grether, Mathys and de Melo (2009), Levinson (2009, 2015), Managi, Hibiki and Tsurumi (2009), and Shapiro and Walker (2018).

11 Conversely, trade liberalization following the North American Free Trade Agreement (NAFTA) was found to decrease particulate matter (PM) and sulphur dioxide (SO_2) intensities of production in the United States through within-plant changes, including the adoption of new technologies and fragmentation of production in response to differences in environmental regulation across the United States and Mexico (Cherniwchan, 2017).

12 For example, United States-Mexico-Canada RTA and European Union-United Kingdom RTA.

13 See "Decisions and Recommendations Adopted by the WTO Committee on Technical Barriers to Trade since 1 January 1995", WTO official document number G/TBT/1/Rev.14, pages 62-64, which can be consulted at https://docs.wto.org/.

14 A list of the organizations operating at the international and regional levels in promoting quality infrastructure and that are part of the International Network on Quality Infrastructure can be found here: https://www.inetqi.net/about/members/.

15 See, for instance, Minutes of the Meeting of the Committee on Trade and Environment, November 2020, WT/CTE/M/70, para 2.24; and Minutes of the Meeting of the Committee on Technical Barriers to Trade, November 2021, G/TBT/M/85: paras 2.171- 2.175, which can be consulted at https://docs.wto.org/.

16 Although not discussed in detail here, international cooperation on international rail transport is also important to decarbonize part of international trade.

17 Carbon offsetting allows airlines and passengers to compensate for the carbon released by the aircraft by investing in carbon reduction projects in other areas (e.g., planting trees). Direct air carbon capture is a new technology which can remove carbon emissions directly from the ambient air.

18 Maritime transport emits other types of air pollution, including nitrogen oxides (NOx), sulphur oxides (SOx) and particulate matter, and contributes to marine pollution, such as oil spills and littering.

19 See https://www.imo.org/en/MediaCentre/HotTopics/Pages/Cutting-GHG-emissions.aspx.

20 See https://www.globalmaritimeforum.org/getting-to-zero-coalition.

21 See https://www.councilpacificaffairs.org/news-media/pacific-blue-shipping-partnership/.

22 See https://www.gov.uk/government/publications/cop-26-clydebank-declaration-for-green-shipping-corridors/cop-26-clydebank-declaration-for-green-shipping-corridors/.

23 See https://greenvoyage2050.imo.org/.

24 See https://www.mcttt.gov.fj/decarbonising-domestic-shipping-industry-pacific-blue-shipping-partnership/.

25 According to the IEA, CO_2 emissions from domestic and international aviation accounted for about 2.8 per cent of global CO_2 emissions from fossil fuel combustion in 2019.

26 Only emissions from international flights, which account for around 65 per cent of the aviation industry's CO_2 emissions, are covered by ICAO, whereas emissions from domestic aviation are covered by national pledges under the 2015 Paris Agreement (https://www.un.org/en/climatechange/paris-agreement).

27 ICAO's plan is to abate CO_2 as much as possible from in-sector solutions such as sustainable aviation fuels, new aircraft technology, more efficient operations and infrastructure, and the development of new zero-emissions energy sources such as electric and hydrogen power. Any remaining emissions would be addressed through carbon capture and storage and carbon offsets.

28 See https://climatealignment.org/.

29 While digitalization acts as an important driver of decarbonization, digital technologies contribute to between 1.4 per cent to 5.9 per cent of GHG emissions (The Royal Society, 2020). This figure is expected to rise given the increasing internet use. Improving energy efficiency in data centers and data transmission network and switching to renewable energy sources can contribute to low-carbon digitalization.

30 For example, the GATS does not cover traffic rights (i.e., the right for airlines to operate and/or to carry passengers, cargo and mail from, to, within, or over the territory of a WTO member) and services directly related to the exercise of traffic rights.

31 Moreover, developments in the sector are meant to be kept under regular review, with a view to «considering the possible further application of the Agreement» (GATS Annex on Air Transport Services, paragraph 5, available at https://www.wto.org/english/docs_e/legal_e/26-gats_02_e.htm#annats).

32 Some WTO members are of the view that the coverage of the GATS should extend to ground-handling and airport management services. See, for instance, "Review of the GATS Annex on Air Transport Services - Communication by the European Union and its Member States" (WTO official document number S/C/W/280, accessible via https://docs.wto.org/.).

33 See https://www.gov.uk/government/publications/cop26-declaration-zero-emission-cars-and-vans/cop26-declaration-on-accelerating-the-transition-to-100-zero-emission-cars-and-vans/.

34 See https://globaldrivetozero.org/mou-nations/.

35 See https://www.weforum.org/projects/decarbonizing-road-freight-initiative/.

36 It should be emphasized, however, that reducing delays in clearing customs could also increase trade (a scale effect) and therefore trade-related transport emissions.

37 Other complementing trade-related initiatives include the United Nations Economic Commission for Europe (UNECE) Customs Convention on the International Transport of Goods under Cover of TIR (International Road Transport) Carnets which provides a global transit system that streamlines procedures at borders and reduces administrative burdens for international road transport and logistics firms.

38 Various climate proposals have been discussed recently in the CTE, including the Forest, Agricultural and Commodity Trade (FACT) Initiative co-chaired by the United Kingdom and Indonesia, which seeks to break the links between commodity production and net deforestation globally (see Minutes of the Meeting of the Committee on Trade and Environment, October 2021, WT/CTE/M/73, para. 1.77); and the European Union's new strategy to reduce habitat loss and promote deforestation-free supply chains (see Minutes of the Meeting of the Committee on Trade and Environment, November 2020, WT/CTE/M/70, para 1.73). Paraguay also shared experiences on its agricultural system of soil rotation and biotechnology, which increased agricultural productivity without modifying land use, thereby preserving forests (see Minutes of the Meeting of the Committee on Trade and Environment, November 2020, WTO official document number WT/CTE/M/70, para 1.60, accessible via https://docs.wto.org/).

39 See, for instance, the discussion of the European Union's Single Market for Green Products Initiative (see Minutes of the Meeting of the Committee on Trade and Environment, October 2014, WTO official document number WT/CTE/M/58, para 1.1, accessible via https://docs.wto.org/).

F

The contribution of trade in environmental goods and services

The transition to a low-carbon economy depends, among other things, on the development, adoption and diffusion of environmental goods, services and technologies. This chapter looks at the extent to which trade in environmental goods and services can contribute to the low-carbon transition. Although international trade in environmental goods is uneven across regions, the sector is very dynamic. While the WTO agreements ensure that trade in environmental goods and services flows as smoothly, predictably and freely as possible, the WTO could make an even greater contribution to the development and deployment of environmental technologies by addressing relevant trade barriers and improving data quality on trade and trade policy of environmental goods and services.

Contents

Key facts and findings

- Environmental goods and services cover a broad range of products used to measure, prevent, limit, minimize or correct environmental damages, including those related to climate change.
- Although high-income countries are the main exporters and importers of environmental goods, exports of environmental goods from middle-income countries increased tenfold between 2000 and 2020.
- Although tariffs on environmental goods are, on average, lower than those for other goods, they remain relatively high in low-income countries.
- The elimination of tariffs, together with the reduction in non-tariff measures, on a subset of energy-related environmental goods and environmentally preferable products could increase total exports by 5 and 14 per cent above the baseline, respectively, by 2030. It could further reduce carbon emissions by 0.6 per cent through improvements in energy efficiency.

1. Introduction

Climate change mitigation can be enhanced by developing, adopting and deploying environmental technologies (ET). International trade in environmental goods and services (EGS) can enable access to ET embodied in environmental products, and can help diffuse these technologies. Opening up trade in EGS further could potentially benefit the environment.

This chapter presents available information on the latest trend in trade in EGS and related trade barriers, pointing to a number of data-related issues and challenges. It then reviews the various mechanisms through which trade in EGS can reduce environmental harm, including mitigating carbon emissions. Simulation results quantifying the effect of opening up trade in environmental goods (EG) on trade, gross domestic product (GDP) and carbon emissions are also presented. The chapter concludes by outlining how international cooperation and the WTO can further boost trade in EG and access to ET.

2. There is scope for intensifying trade in environmental goods and services

Although the environmental industry is still emerging in many developing countries, it is a very dynamic and fast-growing sector providing important job opportunities. While there is no publicly available statistics on the size of the environmental industry, the environmental technology market is estimated at US$ 552.1 billion in 2021 and could reach US$ 690.3 billion by 2026 (MarketsandMarkets, 2022). The environmental industry remains highly segmented between well-established and new cutting-edge environmental technologies. Despite the fact that many new environmental technologies are developed in high income economies, the production of many environmental goods and services is spread across developed and developing countries, forming regional or global value chains (GVCs).

(a) Environmental goods and services serve to improve environmental outcomes

EGS have been defined as goods and services used to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and eco-systems (OECD and Eurostat, 1999). They include cleaner technologies, products and services that reduce environmental risks and minimize pollution and resource use.

While the concept of EGS is rather intuitive, defining the scope of EGS has proven to be a complex exercise, in particular in the context of trade negotiations (see Section F.4). The environmental objective and the main end-use purpose of EGS are two of the main criteria that have been considered to delimit the scope of EGS. Over the years, various classifications and lists of EGS have been developed for different purposes, including statistical analysis and trade negotiations.

For instance, the so-called "OECD list of EG" (OECD list), stemming from joint work by the OECD and Eurostat, illustrates the scope of the environment industry for analytical and statistical purposes (OECD, 1999).[1] The list is broad, as it was not compiled with a view to being used for negotiations, and distinguishes between three broad categories of products.

(i) **Pollution management technologies and products** comprise goods and services that are clearly supplied for an environmental purpose and have a significant impact in reducing polluting emissions.[2] They include technologies and products supplied for air pollution control; wastewater management; solid wastewater management; remediation and clean-up; noise and vibration abatement; and environmental monitoring, analysis and assessment.

(ii) **Cleaner technologies and products** comprise goods and services that reduce or eliminate negative environmental impacts, but which are often supplied for other purposes than environmental ones.[3] They are directly related to the efficiency criteria, as well as to the reduction of environmental impacts during their end use.

(iii) **Resources management technologies and products** include the design, construction, installation or provision of technologies and products related to reducing the impact of intensive natural resource extraction on various ecosystems.[4] In particular, these EGS address indoor air pollution control; water supply; recycled materials; renewable energy plant; heat/energy savings and management; sustainable agriculture, fisheries and forestry; natural risk management and eco-tourism.

While EGS can cover ET, whose main (and often sole) purpose is to address or remedy an environmental problem, they can also cover products stemming from eco-innovation. Eco-innovation encompasses all forms of technological and non-technological innovation whose main purpose might be unrelated to the environment, but which possesses certain environmental benefits arising during the production (e.g., organic production), consumption and use (e.g., efficient cars) or disposal stage (e.g., jute), compared to substitutes or like products.

Products that, over their entire life cycle, including production, processing, consumption and disposal, cause significantly less environmental harm than alternatives are commonly known as environmentally preferable products (EPP). In that context, the United Nations Conference on Trade and Development (UNCTAD) identified several products that are more environment-friendly than their petroleum-based competitors, or whose production and sales contribute significantly to the preservation of the environment (UNCTAD, 1995).

Environmental services (ES) often complement EG, and in many cases, the provision and trade of ES drive the growth of trade in EG (Steenblik, Drouet and Stubbs, 2005). Environmental services have been estimated to represent more than 65 per cent of the market value of the environmental industry (EBI, 2017). Yet, ES are often overshadowed by EG despite the documented synergies existing between EG and ES. Measuring trade in ES and barriers to trade in ES is particularly challenging. Indeed, both the quality and the availability of data vary significantly, depending on the mode through which ES are traded (Sauvage, 2014). WTO members define ES according to the so-called Services Sectoral Classification List (W/120), based on the Provisional Central Product Classification[5] (CPC), which distinguish between sewage services; refuse disposal services; sanitation services; and other ES, including cleaning services of exhaust gases; noise abatement services, and nature and landscape protection services.[6]

In addition to ES, numerous ancillary services, such as business services, research and development (R&D), consulting, contracting and engineering, construction, distribution, transport, and repair and maintenance are essential to the sales, delivery, installation, functioning and maintenance of environmental plants, equipment and other goods (Nordås and Steenblik, 2021; Sauvage and Timiliotis, 2017).

The Asia-Pacific Economic Cooperation (APEC) economies recently endorsed a Reference List of Environmental and Environmentally Related Services that identifies both ES and relevant ancillary services based on the CPC 2.1 classification (APEC, 2021).[7]

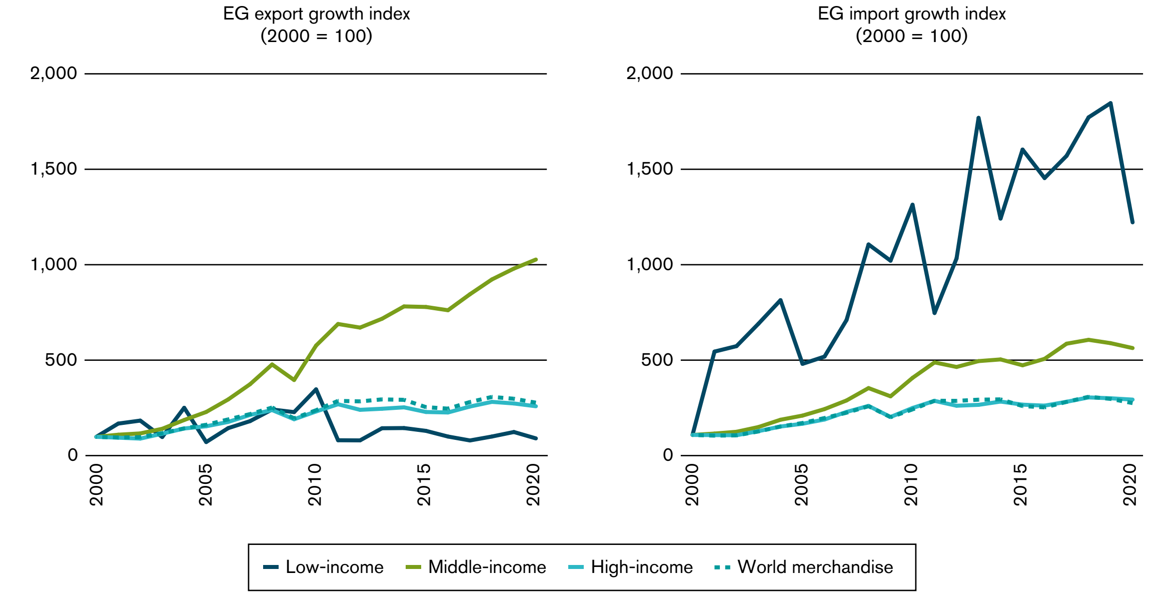
(b) Trade in environmental goods has been dynamic, but not equally so in all regions

Measuring trade in EG can be a difficult task, in particular when the purpose is to generate internationally comparable statistics. Trade-flow data on goods are collected and organized according to Harmonized System (HS) codes,[8] but few of the HS's six-digit subheadings (HS6) specifically cover goods that are mainly used for environmental purposes. A large share of EG is classified under generic subheadings, and is not separately identified, making it difficult to measure the size and pattern of world trade in the relevant goods. Photovoltaic (PV) cells and modules, for example, have been lumped together under the same HS subheading as light-emitting diodes (LEDs), the trade of which is also large and growing rapidly. As a result, it has been impossible to get internationally consistent information on actual trade in these solar energy technologies. Also, because of the difficulty in separating EG from other goods, and because some of these products can both benefit and harm the environment depending on their use (i.e., dual use), most trade data actually result in an overestimation of trade in EG. Nevertheless, the situation should improve, as the 2022 revisions to the HS include several amendments that separate EG from previous subheadings that covered other goods as well, often not of environmental interest (Steenblik, 2020).

Trade in EG, as defined in the OECD list and covering 124 HS-6 tariff lines, accounted for 5 per cent of global trade in 2020. High-income countries accounted for the largest share of EG exports (69.82 per cent), followed by middle-income countries (30.16 per cent) and low-income countries (0.02 per cent). For the period 2000-20, available statistics suggest that both exports and imports of EG increased relatively quickly for middle-income countries, while for low-income countries, exports mostly remained at the same level and imports increased at variable speeds (see Figure F.1). As for high-income countries, both their exports and imports increased, but only modestly.

As regards trade in ES, the availability and quality of data is even more limited, which prevents a comprehensive assessment of the evolution of international trade in ES. Preliminary WTO estimates

Figure F.1: Trade in environmental goods has grown in most regions, but at different speeds



Source: Authors' calculation, based on trade figures from the UN Comtrade database.

Note: The coverage of EG is based on the OECD list, which covers 124 tariff lines at the six-digit HS level. Income groups follow the World Bank classification.

suggest that some US$ 20 billion of traditional ES, including waste disposal, recycling, sanitation and cleaning of pollution, were traded in 2017, accounting for just 0.2 per cent of world services trade (WTO, 2019).

However, growing environmental concerns are boosting demand for ES worldwide. World trade in ES has grown by 4 per cent on average annually since 2005. Establishment of a commercial presence abroad (e.g., locally-established affiliate, subsidiary, or representative office of a foreign-owned and -controlled company) is the most important mode of supply in ES, as many traditional ES are highly dependent on infrastructure and require a continuous and long-term local presence. Case studies examining certain ES, for example ecotourism, have also shown that trade in ES can provide economic opportunities and incentivize the conservation of natural resources in developing countries (see Box F.1).

(c) Barriers to trade in environmental goods and services are still significant

On average, tariffs for EG are lower compared to tariffs for other goods (see Figure F.2). While average applied tariffs on EG are around 1.4 per cent in high-income countries, they go up to 7.3 per cent in low-income countries.

EG trade is also affected by various non-tariff measures (NTMs). The use of technical barriers to trade (TBT) measures is of particular relevance to EG, as EG are often subject to technical regulations and conformity assessment procedures. The intensity of TBT measures tends to be higher in high-income economies. High-income economies apply, on average, 11 TBT measures on EG imports, middle-income economies apply five TBT measures and low-income economies apply two TBT measures (see left panel of Figure F.3). The number of TBT measures applied to EG tends to be, on average, similar to these applied on other goods.[9]

Accounting for the share of imported EG affected by NTMs, 81 per cent of EG tariff lines at the six-digit HS level imported in high-income countries are, on average, affected by at least one TBT measure, as opposed to an average of 45 per cent in middle-income countries and 36 per cent in low-income countries, respectively (see right panel of Figure F.3).

It is important to note, however, that metrics based on the count of NTMs applied, such as the intensity and frequency indices of NTMs, are imperfect measures of the trade restrictiveness of NTMs, as they only provide an indication of the prevalence of NTMs, without accounting for the effect of different measures on trade, which may be more or less

Box F.1: Ecotourism as an economic incentive to preserve nature in Costa Rica

Ecotourism is a form of tourism that emphasizes the maintenance and preservation of nature and puts fauna, flora and cultural heritage at the centre of attractions for tourists. While ecotourism is a promising industry, its success hinges on conserving and protecting fragile natural areas while providing benefits to tourists and contributing to community development.

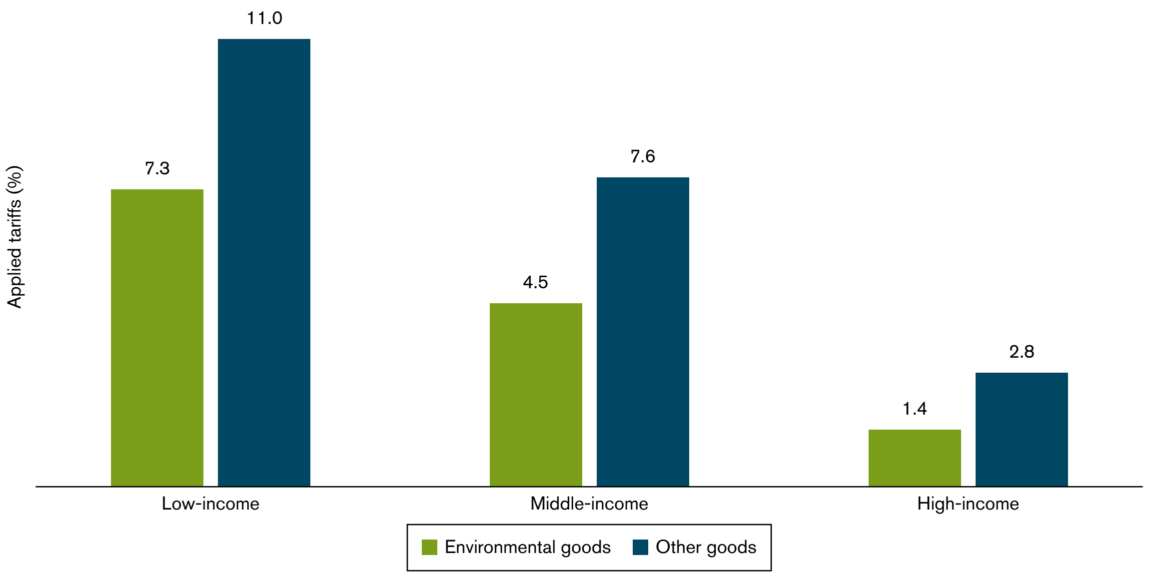
Widely known for its rich biodiversity, Costa Rica has developed a diversified economy that includes ecotourism. General tourism makes up 17-18 per cent of the country's value of exports and contributes up to 8 per cent of its GDP (Costa Rican Tourism Board, 2022a). Foreign tourist visits grew 43 per cent to over 3 million between 2011 and 2019, a substantial number given that the country's population is 5 million. Although the COVID-19 pandemic has taken a heavy toll on the tourism industry, the number of foreign visitors rebounded to 1.3 million in 2021 (Costa Rican Tourism Board, 2022b).

Because it can generate important revenues, ecotourism can serve as an economic incentive to preserve natural resources. Since Costa Rica designated its first natural reserve in 1963, 26 per cent of the national territory has been allocated to natural reserves. More than 70 per cent of tourists entering the country partake in ecotourist activities, such as hiking or wildlife observation in national parks or biological reserves (Costa Rican Tourism Board, 2022c).

Ecotourism can also promote the restoration of ecosystems that have been degraded, damaged or destroyed. For example, in the 1980s, the Costa Rican government began to focus on the development of international ecotourism and thereby took action to reverse deforestation, as in the 19th century and the first half of the 20th century, there had been a significant decline in forest cover due to ranching and agriculture. Government incentives to increase both forest cover and protected areas have allowed Costa Rica's ecotourism sector to thrive (Tafoya et al., 2020).

By means of the revenues generated by natural reserves, visitors help to protect the species inhabiting these ecosystems and to contribute to the conservation of the country's national parks and the development of local communities. For local residents, ecotourism often represents a better livelihood than existing alternatives such as construction, transportation and small-scale agriculture (Hunt et al., 2015). Costa Rica's experience has shown that ecotourism can be a major force for promoting natural resource conservation and respect for local communities.

Figure F.2: Tariffs on environmental goods are low compared to those for other goods, but remain significant in low-income countries



Source: Authors' calculation, based on 2019 tariff data from the WTO Integrated Database (IDB) and 2019 trade figures from the UN Comtrade database.

Note: The coverage of EG is based on the OECD list, which covers 124 tariff lines at the six-digit HS level. Income groups follow the World Bank classification.

restrictive, or may even be trade-promoting (WTO, 2012).

The number of specific trade concerns (STCs) raised and discussed by WTO members in WTO committees also provides a useful indication of the number of measures taken by members that are sources of concern for exporters (WTO, 2012). Between 2005 and 2020, some 126 STCs relating to EG were raised in the WTO Technical Barriers to Trade (TBT) committee, an average of eight STCs per year. Measures underlying TBT-related STCs on EG potentially affect a large value of trade. Over the period 2005 to 2020, STCs covered an annual average of US$ 42 billion in imports of EG.

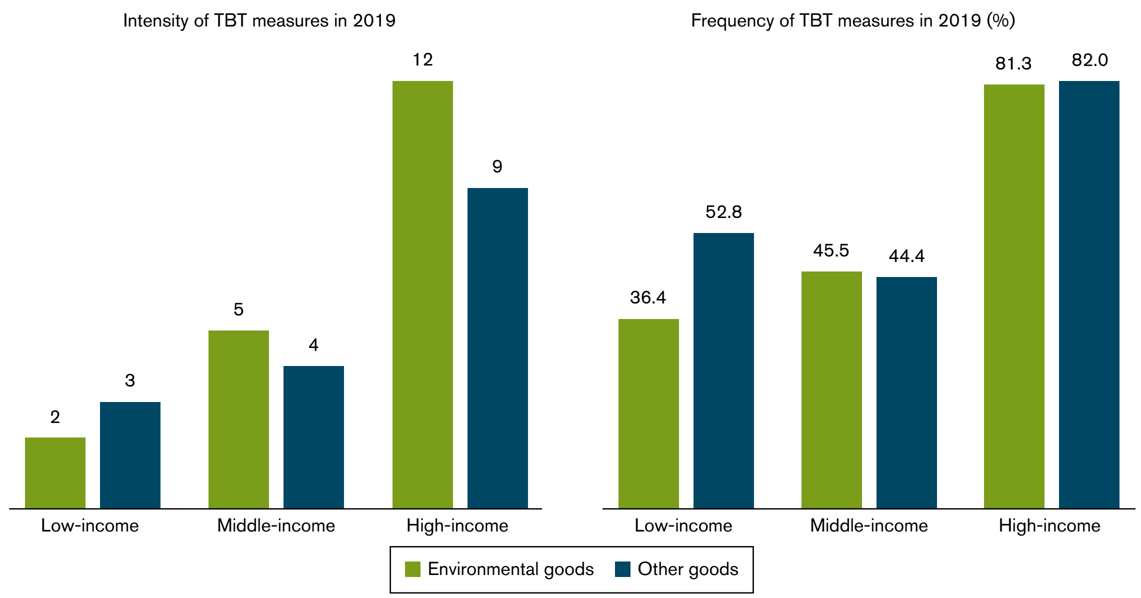
In recent years, an increasing number of trade remedies have also been applied to some EG, such as solar panels and wind turbines. These antidumping duties and countervailing measures can be substantial, often over 100 per cent of the value of the EG.[10]

Given the limited information on applied measures restricting trade in ES, the commitments of WTO members in the General Agreement on Trade in Services (GATS) give an idea of the willingness of members to open their market for ES. ES are one of the least-committed sectors under the GATS.[11] Only 59 WTO members (counting the European Union as one member) have undertaken specific commitments in at least one of the seven provisional CPC sub-sectors. Several members have limited their commitments to consulting and/or advisory services in relation to ES, either across the entire range of committed sectors or with respect to some sub-sectors only.

On average, only 38 per cent of members committed not to impose any new measures that would restrict entry into the market or the operation of the ES (GATS mode 1).[12] There is a high proportion, averaging 71 per cent, of full commitments for consumption of ES abroad (GATS mode 2). The proportion of full commitments for the establishment of a commercial presence abroad to supply an ES (GATS mode 3) is, on average, 57 per cent, with a relatively higher share of full commitment (71 per cent) for sanitation and similar services. Finally, 13 per cent of members have taken full commitments for the temporary movement of natural persons to supply ES (GATS mode 4).

The relatively modest level of binding commitments in ES under the GATS stands in contrast with levels of bindings on ES that have been achieved by various WTO members in bilateral and regional trade

Figure F.3: The intensity of NTMs for environmental goods is higher for high-income countries than for middle and low-income countries



Source: Authors' calculation, based on 2019 TBT data from the UNCTAD TRAINS database.

Note: The coverage of EG is based on the OECD list, which covers 124 tariff lines at the six-digit HS level (HS-6). The left panel displays the average number of TBT measures imposed by countries within an income group targeting a given EG or another good. The right panel displays the average share of HS-6 lines that a country import subject to at least one TBT measure, among all the EG and other goods HS-6 lines they import. The analysis covers 57 countries, encompassing 11 high-income countries (with the European Union counted as one), 36 middle-income countries and 10 low-income countries. Income groups follow the World Bank classification.

agreements. Parties to services trade agreements tend, on average, to go well beyond the commitments they had undertaken in the GATS (WTO, 2019). This is in part a reflection of the fact that most GATS commitments date from 1995.

Trade-opening commitments on ES are, in part, limited because the provisions of many traditional ES, like sewage and refuse disposal, are natural monopolies where only a single firm, typically a public operator, supplies the ES with limited competition with other companies. Natural monopolies tend to be prevalent in traditional ES markets because some of these ES, like the cleaning of roads and beaches, have the characteristics of public goods.[13] Unless special measures are taken, no single firm has an economic incentive to provide the adequate level of service and capture the economic returns. Some traditional ES, like sewage services, also require high levels of investment to build special distribution or collection networks, which often create significant barriers to entry. Governments are often reluctant to allow private or foreign ownership of essential services for fear that they would exploit consumers (WTO, 2010). Other ancillary services, which facilitate the provision of ES, but which are also used for other purposes are also subject to numerous restrictions (USITC, 2013).

3. Trade in environmental goods and services can contribute to climate change mitigation

A broad range of EGS is particularly relevant to climate change mitigation. For instance, energy-related EG (EREG), including clean and renewable energy, energy-efficiency and resource-efficiency goods, can contribute to reducing greenhouse (GHG) emissions.[14] Clean and renewable energy goods cover all products required for the generation of electricity, for example wind turbines, by methods that are environmentally preferable to conventional methods. Energy-efficiency goods help to manage and restrain growth in energy consumption.[15] Resource-efficiency goods help to improve the efficiency with which resources are used, and are, by nature, close to energy-efficiency goods and to clean and renewable energy goods, as they operate through the same channels and aim to reduce energy consumption.

Another category of environmental products highly relevant in the fight against climate change is goods and services essential to help to adapt to climate change (see Chapter B). Examples of such goods and services relevant to the agricultural sector include stress-tolerant cultivars (i.e., cultivated varieties of plants specifically developed and bred for distinct traits), pesticides for weed control, early warning weather systems, equipment for renewable off-grid power generation, irrigation technology and related engineering and technical services, as well as agricultural extension services (GCA, 2021).[16]

(a) Trade in EGS can contribute to climate change mitigation through three main channels

Because EGS affect the environment in distinctive ways, removing barriers to trade in such products and facilitating the diffusion of ET can contribute to climate change mitigation and adaptation and other environmental objectives, including pollution control, wastewater treatment, recycling, and organic agriculture.

As with the general effects of trade on carbon emissions (see Chapter E), the effects of trade in EGS can be decomposed into scale, composition and technique effects.

First, increased trade in EGS, all else being equal (i.e., maintaining a constant mix of goods produced and production techniques), would mean more economic activity and more transport, and this would increase emissions (**scale effect**). Opening trade in EGS would lower their domestic price, raise real income and increase demand for environmental products, trade and economic activity.

Second, maintaining a constant scale of the economy and constant carbon emissions intensities, the lowering of tariffs and NTMs on imports of EGS would lead to changes in countries' allocation of resources towards activities with either higher or lower emission intensities depending on their respective comparative advantages (**composition effect**).

Third, holding scale and composition constant, improved access to EGS would encourage a switch to low-carbon production techniques, and this would reduce emissions (**technique effect**). This positive trade effect on climate change mitigation captures various channels. For instance, international trade can accelerate the cross-country diffusion of ET, making local production processes more efficient and environmentally sound (Garsous and Worack, 2021). Trade provides an opportunity for developing countries to adopt cleaner technologies and, in some instances, to leapfrog the stage of intensive fossil fuel energy use. Opening up trade in EGS can also stimulate innovation spillovers through the diffusion of knowledge embodied in intermediate EGS. Reducing trade barriers has been found to be associated with a boost in environmental innovation globally (Dechezleprêtre and Glachant, 2014).

Trade in EGS could also contribute to sustainable development by supporting and creating additional employment in the renewable energy sector and in sectors implementing climate-friendly technologies, including those promoting energy efficiency and conservation. In particular, trade in EG can increase demand for ES and ancillary services, including those related to the sales, delivery, installation and maintenance of EG and ET. Given that jobs in the EGS industry tend to be higher-skilled, better paid and more gender-inclusive, trade in EGS can contribute to supporting a more just and inclusive low-carbon economy (see Chapter C).

(b) Opening up trade in energy-related environmental goods would reduce emissions and raise GDP in all regions

Despite an extensive literature on trade in EGS, the effect of trade in EGS to address specific environmental issues has been less investigated and is still not well understood. This is in part because there is a lack of internationally comparable data on trade in EG, with even fewer data available on trade in ES, and in part because the mechanisms through which trade in EGS affects carbon emissions and other environmental outcomes are complex to capture and to quantify.

Only a few empirical studies have focused on the effect of opening up trade in EG on different types of pollutions (de Alwis, 2015; Zugravu-Soilita, 2018, 2019) and on EG exports (He et al., 2015; Tamini and Sorgho, 2018), and have found mixed results. For instance, trade intensity in EG relative to GDP has been found to reduce carbon dioxide (CO_2) emissions but to increase water pollution with no impact on sulphur dioxide (SO_2) (Zugravu-Soilita, 2018).[17] However, trade in EG has also been shown to have no impact on total carbon dioxide and sulphur dioxide emissions, although trade in EG improved the emission efficiency of both pollutants (Zugravu-Soilita, 2019).

Several studies also use modelling techniques to assess the potential effects of opening up trade in EG (Dijkstra and Anuj, 2016; Hu et al., 2020; Nimubona, 2012; Wan, Nakada and Takarada, 2018). However, the large number of channels through which trade in EG can affect economic and environmental outcomes makes the overall effect difficult to model.

The WTO Global Trade Model (GTM) was used to fill part of the gap in the literature and analyse how opening further trade in a subset of specific EG could affect their trade, GDP and carbon dioxide emissions (Bacchetta et al., 2022).[18] The model captures two mechanisms through which trade in EG can affect carbon emissions: improvements in energy efficiency (mainly a technique effect) and the replacement of non-renewable with renewable energy (a combination of a technique and a composition effect). The simulations focus on EREG, namely energy-efficiency, resource-efficiency and clean and renewable energy goods, that are most relevant to reducing carbon emissions.[19] The set of EG is subsequently extended to EPP because of their potential export interest for a broad range of countries, including developing economies and LDCs.[20]

Four scenarios combining reductions in tariffs and NTMs for EREG and EPP are considered:

(1) elimination of tariffs on EREG;

(2) elimination of tariffs and a 25 per cent reduction in the *ad valorem* equivalent of NTMs on EREG;[21]

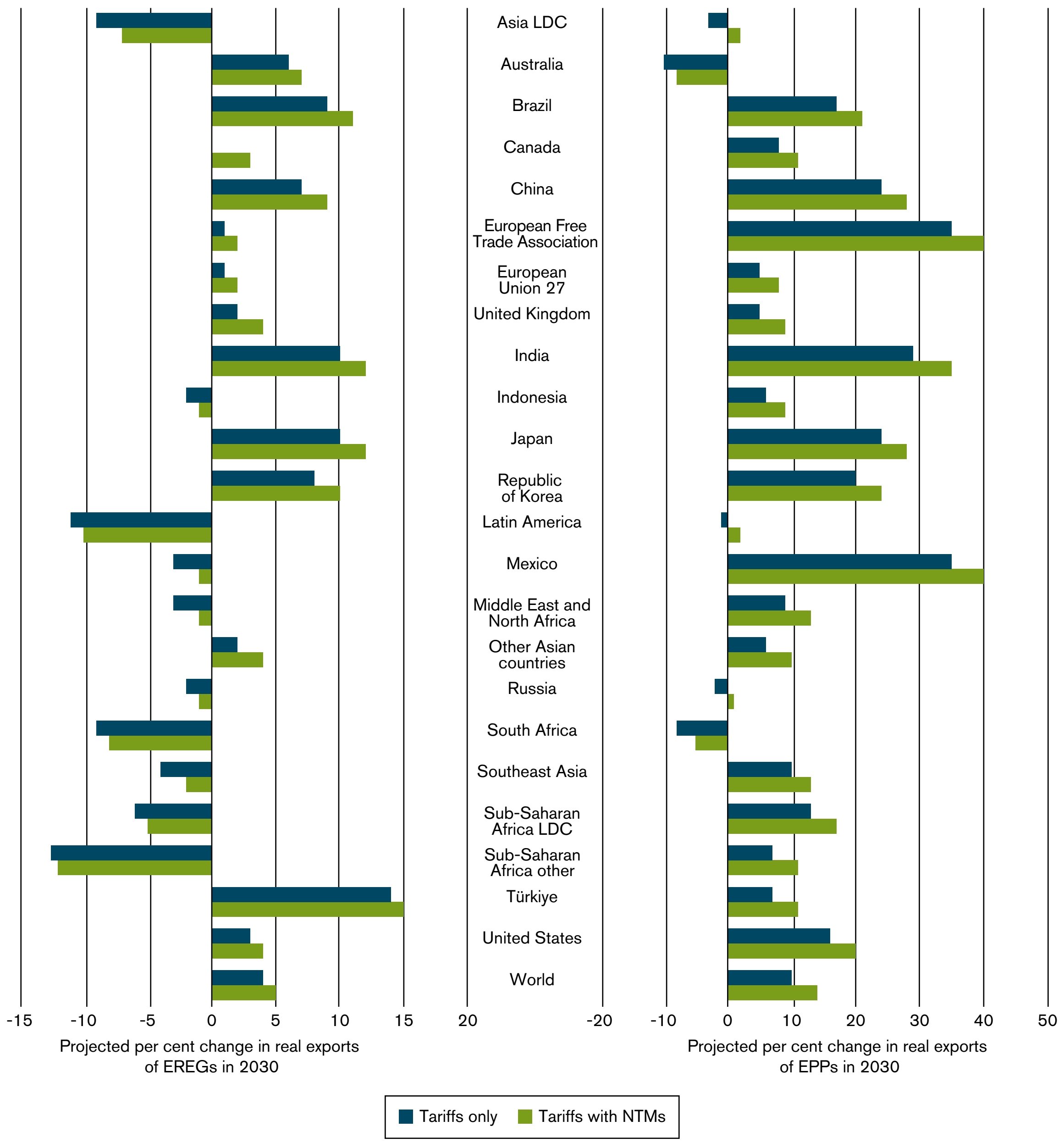
(3) elimination of tariffs on EREG and EPP and a 25 per cent reduction in the *ad valorem* equivalent of NTMs on EREG; and

(4) elimination of tariffs and a 25 per cent reduction in the *ad valorem* equivalent of NTMs on EREG and EPP.

The elimination of tariffs and the reduction in NTMs on EREG and EPP (as per scenario 4) would raise global exports (expressed in real terms) of EREG and EPP in 2030 by 5 per cent and 14 per cent above the baseline, respectively. While the percentage increase in exports would be larger for EPP than for EREG, the value of trade in EREG would be much greater. Total exports are projected to rise for all regions, as the fall in trade costs of EREG and EPP and the implied increase in energy efficiency would both raise GDP, leading to an increase in import demand. This positive effect would dominate the negative effect of trade diversion for EREG in some regions.

While exports of EPP from most regions are expected to increase, mainly due to larger decreases in trade costs compared to current values, exports of EREG are projected to rise only in slightly more than half of the regions, due to trade diversion effects (see Figure F.4). Market access would be improved for important exporters of EREG, whereas for EPP the gain would be rather shared among all regions,

Figure F.4: Opening up trade in environmentally preferable products would raise exports in most regions



Source: Bacchetta et al. (2022).

Note: The figure displays the percentage changes in exports of EREG and exports of EPP projected with the WTO Global Trade Model for 2030. The left panel shows the projected percentage change of real exports of EREG with only a reduction in tariffs under scenario (1) and a reduction in both tariffs and NTMs under scenario (2). The right panel shows the projected percentage change of real exports of EPP with only a reduction in tariffs under scenario (3) and a reduction in both tariffs and NTMs under scenario (4). The percentage change of exports for the World corresponds to a trade weighted average over all regions.

with low-income regions projected to expand trade of EPP for which they have a comparative advantage.

Besides trade flows, the removal of tariffs and reduction of NTMs on EREG and EPP (per scenario 4) would raise global GDP (expressed in real terms) by 0.8 per cent relative to the baseline in 2030.[22] GDP would rise in all regions, including those where exports of EREG and EPP are projected to fall (relative to baseline) due to two effects. First, lowering barriers to trade would reduce distortions. Second, productivity would increase owing to lower costs of compliance with NTMs and lower prices for goods that facilitate the more efficient use of energy and materials.[23] Most of the projected increase in GDP is driven by trade-opening of EREG, since the projected change in trade in EPP is smaller than the projected change in trade of EREG.

The elimination of tariffs and the reduction of NTMs on EREG and EPP (scenario 4) would reduce global CO_2 emissions by 0.58 per cent in 2030, relative to the baseline. About half of this reduction in emissions would be the result of tariff liberalization, while the other half could be attributed to the reduction of NTMs. The total effect can be broken down into three components along the lines discussed in Section F.3(a).

First, opening trade in EREG and EPP would stimulate trade and GDP, and thereby raise the demand for energy, thus raising emissions by 0.034 per cent in 2030 (a form of scale effect).[24] Second, the scale effect would be more than offset by increased energy efficiency in both production and consumption due to higher imports of energy efficiency and clean and renewable energy goods (a form of technique effect). Combined with the scale effect, the energy-efficiency effect is projected to result in a reduction of annual CO_2 emissions by 0.58 per cent in 2030. The third effect achieved through the shift towards renewable energy (a form of composition effect) would be negligible[25] because, in order for an economy to switch to sectors that produce using clean technologies, large investments in fixed costs are needed, so it is expected that opening up trade in EG alone would not be enough to result in large composition effects.[26]

As explained previously, the simulations only capture two mechanisms through which trade in EG can affect carbon emissions. At least three additional channels through which trade in EG could reduce carbon emissions are not modelled. First, increased trade in EG can promote the diffusion of environmental innovation, which would likely reinforce the energy-efficiency effect through another form of technique effect. Second, detailed effects related to ES, for example better environmental monitoring or waste management, are not considered. Modelling such channels would require extensive study of the role of imported capital goods in the adoption and diffusion of sustainable environmental management. Third, opening up trade in EPP can lead to a shift in consumption and production towards EPP and help reduce carbon emissions as well as address other environmental issues.[27]

For some EG, such as solar panels, substantial declines in price have, in the recent past, been accompanied by large trade flows. At the same time, installed capacity in solar panels increased about 15-fold from 2010 to 2019, during which the levelized cost of energy plummeted in most countries (IEA, 2022a).

A recent study suggests that trade liberalization in solar PV power generation technologies might bring considerable reductions in carbon emissions by helping to stimulate production, reduces price and application costs, and increases solar PV power capacity. Eliminating half of the trade barriers on solar cells and modules could reduce global emissions by 4 to 12 gigatonnes of CO_2 ($GtCO_2$) between 2017 and 2060, corresponding to a cumulative reduction of global emissions of 0.3 to 0.9 per cent.[28]

The contribution of trade in EGS to the transition to a low-carbon economy could be significantly larger if the opening of EGS markets were accompanied by relevant complementary policies. As discussed in Chapter C, ambitious, credible and timely climate policy strategies are essential to signal the market, investors and consumers to make more low-carbon investment and consumption decisions, including with respect to the development, adoption and deployment of EGS.[29] Climate change policy can also affect how responsive agents are to price changes in EGS and high-carbon products (i.e., price elasticity of demand).[30]

A wide adoption of EGS is likely to only take place when the price drop of EGS caused by the reduction in trade barriers in EGS is sufficient to render them as affordable as, or cheaper than, high-carbon goods. When the level of trade barriers on EGS is already relatively low, the liberalization of trade in EGS might not necessarily lead to a price drop large enough to make EGS price competitive. In addition, other factors besides the price of EGS can influence the decision to replace high-carbon technologies with low-carbon ones. For instance, the choice of a given energy technology can also depend, among other things, on its life cycle and reliability, as well as the marginal cost of the electricity generated, installation cost, grid infrastructure, storage capacity, and structure of the electricity market. Well-targeted and adequately financed energy and infrastructure policies are important to make EGS and ET investable by reducing uncertainty and improve investment risk management.

A well-functioning quality infrastructure system – comprising legal and regulatory frameworks responsible for standardization, accreditation, metrology and conformity assessment – is also key to guarantee the supply of high quality EGS and keep deficient, sub-standard quality products from entering the supply chain (WTO and IRENA, 2021). Setting up and upgrading the quality infrastructure can also contribute to reduce trade costs, increase the likelihood that domestic companies participate in the value chains of EGS and ultimately build an EGS sector that delivers economic, social and environmental benefits.

4. The development and deployment of environmental goods and services require greater international cooperation

The transition to a low-carbon economy will not be possible unless ET are developed, deployed and diffused quickly. International cooperation on EGS, and in particular on trade in EGS, can play a major role in supporting the development and in scaling up the adoption of EGS.

Addressing, through cooperation, the trade barriers that hinder the adoption and diffusion of ET can improve market access to more efficient, diverse and cheaper EGS and stimulate innovation. This is particularly relevant for economies that do not necessarily possess the know-how and manufacturing capacity to produce ETs. However, this does not mean that these and other economies cannot contribute to the production of EGS, given that ET are often produced in GVCs, in which many economies participate in the supply of parts and services.

Facilitating access to EGS through trade can also provide economies with greater opportunities to adapt ET to their local needs, spurring potentially greater environmental innovation. When there is little or no international trade cooperation on ET, the level of development, deployment and use of EGS is likely to be less than optimal from a global perspective, resulting in a slower transition to a low-carbon economy.

While trade and trade policy on EGS are particularly relevant, other issues that hinder the development, adoption and diffusion of EGS have to be addressed to ensure that trade in EGS contributes to the fullest to the transition to a low-carbon economy. Some of these barriers include inadequate infrastructure, skills, and environmental and energy policies. Addressing trade barriers faced by EGS through trade agreements could also contribute to making climate policies more credible by signalling to the market and investors in ET that governments are seriously committed to improving the ET industry. Such signalling could also increase transparency and predictability.

(a) Facilitating trade and investment in environmental goods and services is essential

Although international cooperation on EGS is attracting attention, it is not a recent phenomenon. Multilateral negotiations to reduce or eliminate tariffs and non-tariff barriers (NTBs) on EGS were launched in 2001 as part of the Doha Development Agenda.[31] The lack of progress in the Doha Development Agenda negotiations ultimately led 46 WTO members to launch the negotiations of a plurilateral Environmental Goods Agreement in 2014.[32] The Environmental Goods Agreement negotiations then stopped in 2017 and have not resumed since.

Multilateral and plurilateral trade negotiations on EGS have faced a number of challenges. While trade negotiations do not seek to identify the full range of EGS, negotiations on the criteria defining the scope of EGS have faced significant hurdles. While some products, such as wind turbines or solar panels, may seem to be intrinsically environmental, there are many other products that may not come across as being environmental *per se*, but which are nevertheless essential when carrying out environmental activities or implementing ET. A product may be used for both environmental and non-environmental purposes. While manufacturing goods received the most attention in trade negotiations, there has been discussion about whether some agricultural goods, such as organic fruits and vegetables, may be considered as EG. The rapidly evolving nature of ET also raises the question of how to address obsolete EGS technologies in the future, and how to ensure that the latest environmental innovations are considered.

The difficulty in reaching consensus at the multilateral and plurilateral level has led regional trade cooperation to become the main avenue to promote trade in EGS. The 2012 Vladivostok APEC Leaders' Declaration marked the first time a group of economies agreed to a set of EG (i.e., 54 EG), with a view to reducing their respective applied tariff rates to 5 per cent or less by the end of 2020. The APEC list includes solar panels, wind turbines and bamboo flooring, as well as environmental monitoring, analysis and assessment equipment.[33]

In parallel to these initiatives, an increasing number of regional trade agreements (RTAs) explicitly address trade in EGS (see Figure F.5). Although the inclusion of provisions on EGS in RTAs is not a recent trend, the number of these provisions in any given agreement has increased significantly over the years.

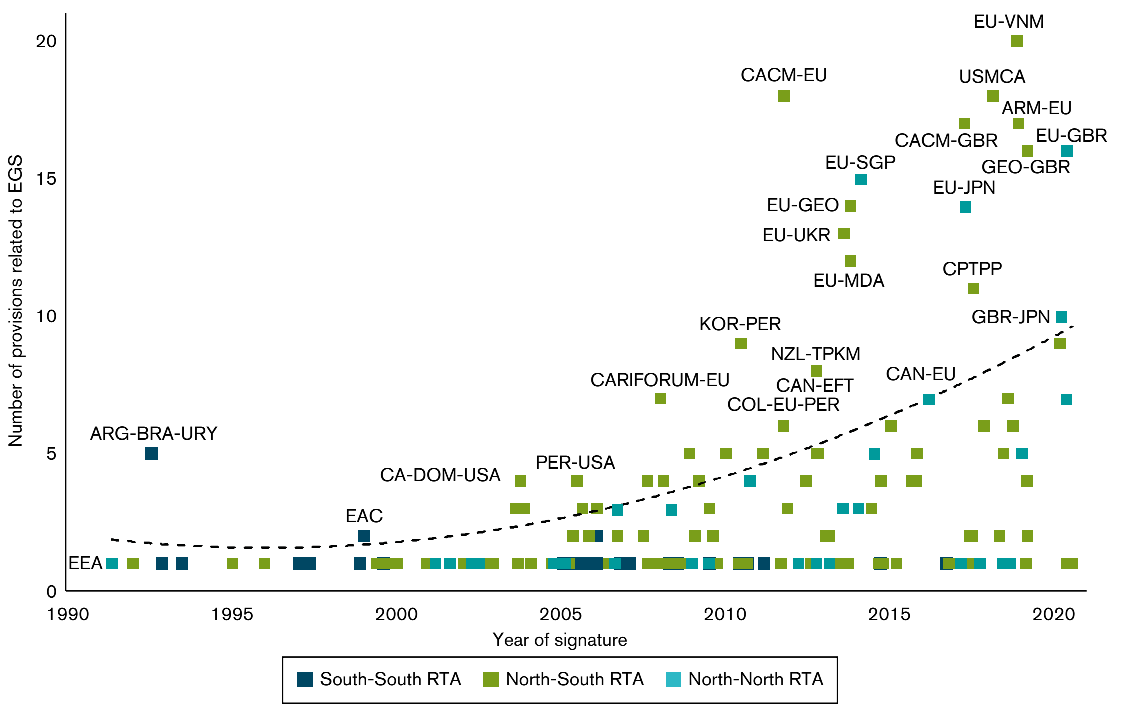
Environmental provisions are known to be heterogenous across RTAs, and provisions on EGS are no exception (Monteiro, 2016; 2022b). They differ in terms of structure and location in RTAs, as well as in language and scope. While some provisions refer to EG, ES or technologies in general, other provisions address specific categories of EGS, such as goods and services related to sustainable renewable energy and energy efficiency, or goods and services subject to eco-labelling and fair trade schemes. A few more recent provisions explicitly refer to climate-friendly goods, services and technologies. Provisions on EGS complement other environmental provisions, including those promoting voluntary environmental performance mechanisms, such as private-public-partnerships and voluntary environmental auditing and reporting, found in a limited number of RTAs. Similarly, provisions on EGS complement provisions on trade in natural resource-based products obtained through a sustainable use of biological resources and provisions on sustainable management of fish and forests, and on trade in fish and timber products, found in an increasing number of RTAs.

Provisions committing parties to endeavour to facilitate and promote trade and, in some agreements, foreign direct investment in EGS are the most common type of provisions on EGS. Most other provisions on trade in EGS are only specific to a single or a few RTAs.

While many RTAs include different market access and national treatment commitments for ES (mostly related to waste management and treatment), only a couple of agreements establish explicit tariff reductions or eliminations for specific EG.[34] The 1992 Partial Cooperation and Trade Agreement between Argentina, Brazil and Uruguay was one of the first trade agreements to eliminate tariffs and NTMs on an agreed list of EG (58 tariff lines at the 10-digit national product classification level). More recently, the RTAs negotiated by New Zealand with Chinese Taipei and the United Kingdom include a list of EG (132 and 298 tariff lines, respectively, at the six-digit HS level), whose tariffs are to be eliminated. An alternative market access approach, only found in the RTA between Indonesia and Switzerland, establishes a preferential tariff rate quota access for palm oil produced sustainably in Indonesia.

Besides tariffs, some recent RTAs explicitly call on the parties to address potential NTMs on EG. Many

Figure F.5: Provisions on environmental goods and services are increasingly included in RTAs



Source: Monteiro (2022b).

Note: Analysis based on RTAs notified to the WTO. "North" is defined as high-income countries, whereas "South" is defined as middle- and low-income countries according to the World Bank's country classification.

of these provisions add clarifications or expand some of the disciplines set out in the WTO TBT Agreement. A few provisions promote good regulatory practices when designing standards and technical regulations relating to EG in general. Other provisions establish regulatory commitments on specific categories of EG, such as listing relevant international standard-setting bodies for the design of domestic standards on products related to renewable energy;[35] harmonizing energy performance standards and test products;[36] acceptance of the other party's technical regulations, standards or conformity assessment procedures related to the production, processing or labelling of organic products;[37] and mutual acceptance of conformity assessment procedures for products related to renewable energy.[38]

While most detailed provisions on EGS in RTAs focus on EG, only a few detailed provisions explicitly address trade barriers on ES, such as facilitating the movement of businesspersons involved in the sale, delivery or installation of EG or the supply of ES.[39] Provisions on support measures related to EGS are also limited. For instance, a recent provision commits each party to refrain from adopting local content requirements or any other offset affecting the other party's products, service suppliers or establishments related to energy generation from renewable and sustainable non-fossil sources.[40]

The remaining types of provisions on EGS in RTAs are mostly about cooperation. While some cooperation provisions refer to cooperation on EGS in general, other cooperation provisions focus on specific categories of EGS or specific issues. Some provisions encourage cooperation between enterprises in relation to goods, services and technologies beneficial to the environment. A few other provisions call on the parties to cooperate in international fora to support trade and investment in EGS.

Although progress in trade negotiations on EGS in the WTO has been limited, the multilateral trading system ensures that trade in EGS flows as smoothly, predictably and freely as possible through its disciplines, which limit members' discretion to adopt policies unjustifiably, thereby causing negative cross-border spillovers. Tariffs on manufacturing goods, including many EG, were, on average, significantly reduced with the conclusion of the Uruguay Round (1986-94). The General Agreement on Tariffs and Trade (GATT) and the GATS ensure that trade policies, including those related to EGS, are non-discriminatory and transparent. The TBT Agreement also aims to ensure that technical regulations, standards and conformity assessment procedures on goods, including those related to EG, do not create unnecessary obstacles to trade and are based on relevant internationally agreed standards. The TBT Agreement further promotes the harmonization, equivalence and mutual recognition of technical regulations and conformity assessment procedures. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement) also supports the development and dissemination of ET by establishing a set of minimum standards for the protection and enforcement of intellectual property rights.

The WTO could make an even greater contribution to promoting trade in EGS by advancing a couple of initiatives currently being pursued by several WTO members at the plurilateral level.[41] The Trade and Environmental Sustainability Structured Discussions (TESSD) explore opportunities and possible approaches for promoting and facilitating trade in EGS. The TESSD intends to broaden the scope beyond tariff liberalization and cover NTMs, the dissemination of technology and ES – including those that can facilitate the uptake and use of EG – and technical assistance. Potential outcomes of the TESSD could include identifying and compiling best practices, as well as exploring opportunities for voluntary actions and partnerships to promote and facilitate access to EGS, including new and emerging low-emission technologies, and other climate-friendly technologies.[42]

Efforts to support trade in EGS could also be reinforced by promoting sustainable trade in plastics, including low-carbon alternatives, a topic currently under discussion in the Informal Dialogue on Plastics Pollution and Environmentally Sustainable Plastics Trade at the WTO. Similarly, rationalizing and phasing out the use of fossil fuel subsidies, under the Fossil Fuel Subsidy Reform initiative,[43] could promote low-carbon energy sources, including renewable energy equipment.

(b) Inclusive participation in developing and deploying environmental goods and services is important

A just transition to a low-carbon economy requires giving particular attention to the challenges and opportunities faced by developing countries and vulnerable groups when they engage or seek to participate in trade in EGS.[44] Given that the ET sector is only just emerging in most developing countries and LDCs, reducing tariff barriers and NTMs to EGS is only one way of reducing the costs and increasing the availability of and access to ET. Additional efforts could ensure that effective transfer of ET takes place in practice. In the context of climate change, the Intergovernmental Panel on Climate Change (IPCC) defines technology transfer "as a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NGOs) and research/education institutions" (IPCC, 2000).

Technology transfers through cross-border partnerships can facilitate manufacturing scale-ups and innovation in multiple contexts. Firms can manufacture an environmental product that was successfully developed by an originator firm under some form of licence or production contract that encompasses the transfer of know-how along with formal intellectual property and access to the regulatory dossier. Alternatively, the transfer of technology can help competitors to modify and improve existing ET. A transfer of technology can also be used, irrespective of the type of ET, to develop and produce new ET.

Technology transfers can come from both private and public sources. In the case of climate change, such aid often involves international cooperation (Popp, 2011). For example, the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP) and the World Bank jointly implement the Global Environment Facility (GEF),[45] which provides grants for projects in developing countries to address global environmental issues, including those related to climate change.

Another example is the Clean Development Mechanism (CDM),[46] defined in Article 12 of the Kyoto Protocol, which offers developed countries the opportunity to earn credits (called saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO_2), in return for financing projects in developing countries that reduce emissions, thus enabling the transfer of climate-friendly technologies (Dechezleprêtre, Glachant and Ménière, 2008). The CDM's underlying infrastructure and remaining funds will largely be repurposed to implement Article 6.4 of the Paris Agreement that establishes a new mechanism for parties to cooperate in achieving their NDCs.

Another international initiative is the Climate Technology Initiative (CTI), operating under the International Energy Agency (IEA), which works to accelerate the development and diffusion of climate-friendly and environmentally sound technologies and practices and to strengthen the capacity of developing countries to employ them. In addition, the World Intellectual Property Organization (WIPO) has established WIPO GREEN, an online database and network that connects owners of new technologies with individuals or companies who might be looking to commercialize, license or otherwise distribute ET.

A very limited but increasing number of RTAs include specific cooperation provisions aimed at facilitating the transfer of ET. Some provisions refer, in general, to the promotion of ET development, innovation, transfer and application.[47] Other provisions specifically cover the promotion of measures at the domestic, regional and international levels, related to R&D, demonstration, deployment, transfer and diffusion of new, innovative, safe and sustainable low-carbon and climate adaptation technologies.[48]

As discussed in Chapter C, the TRIPS Agreement also helps to facilitate the transfer of technology, including of ETs, through developed-country members' commitments under TRIPS Article 66.2 to provide incentives for enterprises and institutions in their territories to encourage technology transfer to LDCs. The Aid for Trade Initiative could also contribute to the transfer of ET by supporting developing countries, in particular LDCs, in building low-carbon and climate-resilient trade capacity and infrastructure (see chapters B and C).

(c) More detailed data on trade and trade policy on EGS are needed

The need for more detailed data on trade and investment in EGS is becoming pressing as governments strive to unlock trade in ET. Different statistical classifications or nomenclatures, including the HS, have been used to identify EG and ES separately. The lack of disaggregated and comparable data on trade in EGS and related trade policies continues to hold back research and can hinder trade negotiations in EGS. Several international organizations have attempted to define and classify EGS.

As discussed above, the OECD/Eurostat Informal Working Group has developed a list based on the six-digit HS intended to illustrate the scope of the "environmental industry" (Steenblik, 2005). UNCTAD (1995) identified several EPP that are more environment-friendly than petroleum-based competitors, produced in an environment-friendly way or that contribute to the preservation of the environment. More recently, the World Customs Organization (WCO) released the 2022 version of the HS, which includes new commodity codes specific to several technologies that use solar energy and energy-efficient light-emitting diodes. These changes should facilitate the monitoring of trade in specific EG. The United Nations' CPC, released in 1991, identifies several types of ES (WTO, 2010). Several international organizations, including APEC and the OECD Secretariat, have also worked to update the list of ES (APEC, 2021; Sauvage and Timiliotis, 2017).

The WTO provides access to official tariff and trade data at the tariff-line level, which often means eight, or sometimes even 10, digits, including in some cases for specific EG for some countries. WTO agreements also promote transparency in trade measures via formal, publicly available notifications of all laws and regulations affecting trade, including those related to EGS. Notifications explicitly related to EGS are reported in the WTO Environmental Database (EDB).

The WTO could further improve the quality and availability of its data on EGS by strengthening its collaboration with statistical agencies and other government offices, as well as with other international organizations, including the WCO. Ongoing plurilateral initiatives, including TESSD, could also play an important role in improving transparency of relevant measures, offering an opportunity for sharing experiences and best practices.

5. Conclusion

The transition to a low-carbon economy will require the development, deployment and diffusion of ET at an unprecedented pace, and trade in EGS can contribute to this process. However, EGS trade flows and trade policies differ across regions: exports of EGS from middle-income countries have been growing dynamically over the past two decades, whereas those of low-income countries have remained almost constant. Conversely, low-income countries' imports of EGS have been increasing faster than those of other countries, suggesting a strong demand for EGS in those countries.

Simulations using the WTO GTM suggest that the elimination of tariffs, together with the reduction in NTMs on a specific subset of EG, could make a contribution to reducing carbon emissions while contributing to an increase in exports and GDP in all regions. These simulations, however, only account for two of the various mechanisms through which trade in EG can affect emissions, suggesting that the actual effects of opening up trade in EGS could potentially be considerably more significant with a broader set of EGS, if all effects were taken into account and if relevant complementary policies accompanied the liberalization of trade in EGS.

International cooperation on trade in EGS can play a major role in supporting the development and in scaling up the adoption of EGS. The multilateral trading system ensures that trade in EGS flows as smoothly, predictably and freely as possible. The WTO agreements can also support the transfer of ET to developing countries, in particular to LDCs. The difficulty in reaching consensus in multilateral and plurilateral trade negotiations has, however, led regional trade cooperation to become the main avenue to promote trade in EGS.

The WTO could make a greater contribution to promoting trade in EGS. Several plurilateral initiatives currently being pursued by subsets of WTO members could play an important role in promoting and facilitating trade in EGS. The WTO could also further improve the quality and availability of data on EGS by strengthening its collaboration with national statistical agencies and other international organizations.

Endnotes

1 The OECD list of EG contains 164 tariff lines at the six-digit Harmonized System (HS) level organized according to three main categories and 18 sub-categories. The list covers, however, 132 unique HS-6 tariff lines after eliminating multiple listings across various sub-categories of some tariff lines. The tariff classification is based on the 1992 version of the HS nomenclature.

2 According to the OECD list, pollution management technologies and products include goods and services that are easily identifiable statistically (OECD, 1999).

3 According to the OECD list, cleaner technologies and products include some goods and services whose statistical assessment remains disputed, difficult or expensive (OECD, 1999).

4 Although environmental protection is excluded from the coverage of resource management, inevitably some products associated with environmental protection may be included, although their prime purpose is not environmental protection.

5 The CPC, prepared under the auspices of the United Nations and other international bodies, provides a classification structure for goods and services based on a set of internationally agreed concepts, definitions, principles and classification rules. The first version of the CPC, the Provisional Central Product Classification, was published in 1991.

6 National and regional statistical classifications of the EGS sector (i.e., EGS sector account) have also been expanded over the years. See for instance Eurostat (2009, 2016).

7 The specific services relevant to the environment are identified within sub-classes of the CPC 2.1 classification at the five-digit level through the use of "ex out" (which indicates that the identified service is extracted from the five-digit subclass) (Nordås and Steenblik, 2021).

8 International trade in goods is classified using the World Customs Organization (WCO) Harmonized Commodity Description and Coding System (HS). The HS classifies all products using six-digit codes that are organized by chapter (two digits), heading (four digits), and subheading (six digits).

9 Notifications of environment-related countervailing measures can be found in the WTO Environmental Database (EDB), which can be consulted at https://edb.wto.org/.

10 The TRAINS database covers 57 countries, encompassing 11 high-income countries (with the European Union included as a country group), 36 middle-income countries and 10 low-income countries.

11 See the Note by the WTO Secretariat on "experiences in the promotion and facilitation of environmental goods and services" (WTO official document number INF/TE/SSD/W18, accessible via https://docs.wto.org/).

12 For more information about the GATS modes of supply, see https://www.wto.org/english/tratop_e/serv_e/gatsqa_e.htm.

13 Public goods are a special case of positive externalities for which the cost of extending the service to an additional person is zero and which it is impossible to exclude individuals from enjoying.

14 GHG comprise carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphurhexafluoride (SF_6). Although carbon dioxide is the primary GHG emitted through human activities, methane has become an emerging GHG given its more potent heat-trapping ability.

15 For example, using LED light instead of filament lamps would reduce energy consumption, as the former is more energy-efficient.

16 Some climate change adaptation solutions can exacerbate some environmental issues in the absence of complementary actions. For instance, artificial snow might help keep slopes snowy at higher temperatures, but its production can be energy- and water-intensive. The chemicals or biological additives used to enhance artificial snow's quality and slow down its melting can also impact the environment, including biodiversity (Rixen, Stoeckli and Ammann, 2003).

17 Trade intensity is defined as the ratio of exports plus imports over GDP.

18 See Aguiar et al., (2019) for a technical description of the WTO GTM, a recursive dynamic computable general equilibrium model. The energy and electricity version of the WTO Global Trade Model was used to generate a baseline projection until 2030 for the global economy with the path for global CO_2 emissions close to the emissions projected by the International Energy Agency (IEA) as reported in Böhringer et al. (2021). Bilateral tariff rates are from the Market Access Map (MAcMap) database, provided by the International Trade Centre (ITC). Ad valorem equivalents of NTMs are taken from Cadot, Gourdon and van Tongeren (2018), based on count data on NTMs from the UNCTAD TRAINS database. The elasticity of carbon emissions with respect to trade in EG were estimated econometrically (Bacchetta et al., 2022).

19 The list of EREG is derived from the OECD list of EG (OECD, 1999).

20 The list of EPP is based on the list reported in Tothova (2005).

21 NTMs are modelled as iceberg costs (i.e., some of the product is lost between the buyer and the seller). A 25 per cent reduction in NTMs is in line with empirical estimates of the effect of a regional trade agreement on NTMs (Benz and Yalcin, 2013), as well as with the literature on regulatory convergence (Vanzetti, Knebel and Peters, 2018).

22 The higher projected global GDP level by 2030 is the result of a higher projected GDP growth trajectory between 2021 and 2030.

23 For the products modelled, the NTMs concern mostly TBT, which require firms to allocate extra resources to comply with them.

24 Part of the effect is also driven by increased demand for transportation services, which generates additional CO_2 emissions.

25 This is the case with or without end-use control. Under the scenario without "end-use control", all energy producing sectors would benefit from the lower prices of clean and renewable energy goods, so that the increase in electricity

produced by fossil fuels would increase emissions. Conversely, under the scenario with "end-use control", only sectors producing electricity with renewables would benefit from the lower prices of clean and renewable energy goods, which would reduce emissions.

26 The estimated effects, based on the WTO GTM, are an order of magnitude smaller than those found by Hu (2020), due to differences in the models used to determine the price of clean and renewable energy goods and the impact on emissions, and different assumptions concerning the decline in the price of domestic clean and renewable energy goods.

27 In particular, a lack of emissions data at the detailed sectoral level makes it difficult to evaluate the emissions effects of trade in EPP.

28 The estimated cumulative reduction of global emissions of between 0.3 per cent and 0.9 per cent between 2017 and 2060 assumes that emissions remain constant at the level of 2020 (31.5 $GrCO_2$) until 2060 (Wang et al., 2021).

29 For instance, following a reduction in trade barriers on EG, a government which used to extract tariff revenue with tariffs on EG, might be tempted to respond by strategically lowering the level of environmental protection to stimulate domestic production. Depending on the marginal pollution rate associated with the production of the high-carbon product, the reduction in trade barriers on EG could lead to an increase (or decrease) in pollution when the marginal pollution rate is significantly high (or low) (Nimubona, 2012).

30 The price elasticity of demand itself largely depends on the choice and implementation of environmental policy instruments (David and Sinclair-Desgagné, 2005).

31 The WTO Special Session of the Committee on Trade and Environment (CTESS) was established to conduct negotiations on trade and environment. The reduction or elimination of tariffs on EG was also discussed in the context of the WTO's Negotiating Group on Market Access, but without addressing the specific issues that were debated in the CTESS. In addition, the Special Session of the Council for Trade in Services is in charge of the negotiations on services, including ES.

32 The Environmental Goods Agreement discussion initially built on the 54 EG set out in the 2012 Leaders' Declaration of the Asia-Pacific Economic Cooperation (https://www.apec.org/meeting-papers/leaders-declarations/2012/2012_aelm).

33 More recently, APEC economies have been considering updating the list of EG and advancing trade in ES, including by identifying different types of ES (https://www.apec.org/meeting-papers/sectoral-ministerial-meetings/trade/2021_mrt).

34 The tariff reduction and elimination of goods covered in the WTO and in RTAs can apply to EG without explicitly singling out any specific EG.

35 For example, European Union-Singapore and European Union-Viet Nam RTAs.

36 For example, United States-Mexico-Canada (USMCA).

37 For example, Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP).

38 For example, European Union-Singapore RTA.

39 For example, Chinese Taipei-New Zealand RTA.

40 For example, European Union-Singapore and European Union-Viet Nam RTAs.

41 These WTO initiatives complement other initiatives, such as the one led by Costa Rica, Fiji, Iceland, New Zealand, Norway and Switzerland that seeks to negotiate tariff elimination on EG and binding commitments for ES in an Agreement on Climate Change, Trade and Sustainability.

42 See TESSD Ministerial Statement on Trade and Environmental Sustainability (WTO official document number WT/MIN(21)/6, viewable via https://docs.wto.org/).

43 See Ministerial Statement on Fossil Fuel Subsidies (WTO official document number WT/MIN(21)/9/Rev.1, viewable via https://docs.wto.org/).

44 A number of international initiatives support micro, small and medium-sized enterprises (MSMEs) in introducing innovations to their operations and scaling them for trade across borders. For instance, the World Banks's Climate Technology Program (CTP) supports the private sector in developing countries, and in particular small and medium-sized enterprises and entrepreneurs, to use new technologies and business models to address local climate challenges.

45 See https://www.thegef.org/.

46 See https://cdm.unfccc.int/index.html.

47 See for instance the European Union-East African Community (EAC) RTA.

48 See for instance the European Union-Armenia RTA.

G. Conclusion

Climate change is having a damaging effect on people, the environment and the economy globally. Major economic investment and ambitious policy actions will be required to steer the economy towards a sustainable, low-carbon growth trajectory, which is necessary to mitigate climate change and adapt to its disruptive and costly consequences. Thus, both climate change and climate policies will have significant consequences for international trade and trade policies.

Although the interlinkages between climate change and international trade are complex and multifaceted, much of the debate on climate change and trade is based on oversimplifications and misconceptions. Two basic but misleading assumptions still underlie much of the current debate: that trade clearly contributes to climate change; and that WTO rules prevent governments from adopting ambitious climate policies.

The first misleading assumption – that trade, and in particular international transportation, is one of the main contributors to climate change – has led to calls to limit imports in favour of producing and consuming goods and services locally. In reality, international trade affects greenhouse gas (GHG) emissions in many different ways. It is true that trade activities emit GHG emissions through the production, transportation, distribution and consumption of traded products, and, in this way, trade increases emissions by stimulating economic activity through increased income. Trade also affects the type of goods and services that each country produces, and can therefore affect climate change positively or negatively depending on whether a country has a comparative advantage in GHG emission-intensive sectors.

At the same time, however, trade contributes to the reduction of GHG emissions in several important ways. Trade provides access to low-carbon goods, services and technologies at lower prices. The increased income associated with trade openness can also lead to rising environmental awareness, as well as to more stringency in terms of environmental regulations, which spurs the incorporation of environmental technologies into production processes. Trade can help to diffuse environmental innovations, and provides firms with the opportunity to reap higher profits from integrating those innovations into production processes, thereby increasing their incentives to continue creating, diffusing and integrating environmental technologies. In addition, trade in cleaner energy can further enable countries, including developing ones, with large endowments in renewable energy sources to lever their comparative advantage in clean energy generation and contribute to the low-carbon transition.

Trade can also help countries to protect themselves against, and adapt to, some of the consequences of climate change by helping to prevent, reduce and prepare for climate risks, as well as to respond to and recover from climate disasters. Recovery from climate disasters via the timely availability of critical goods and services, such as food, healthcare, transportation and communication, is enabled by trade. By helping countries to adjust to shifts in agricultural production caused by long-term changes in climate conditions, trade can also contribute to food security. Facilitated access to technologies that minimize some of the costs and the economic effects of climate change is also supported by trade.

The positive contribution of trade to the fight against climate change is, however, not necessarily automatic. Building economic and trade resilience to climate change requires an understanding of economic challenges and opportunities, as well as the ability to anticipate, evaluate and manage climate risks. Trade policies need to be integrated into climate adaptation strategies, including policies to enhance resilience of supply chains to climate-related disruptions. Similarly, giving producers and consumers incentives to factor climate risks into their decisions, so that they choose to limit or compensate their GHG emissions, requires relevant and well-designed climate and energy policies.

The second misleading assumption about trade and climate change is that WTO rules prevent governments from adopting ambitious climate policies. In reality, although the term "climate change" does not appear in WTO agreements, the WTO supports the fight against climate change by helping to ensure efficient and effective trade-related climate policies. While not all climate change policies have a trade dimension, WTO rules govern taxes, tariffs, support measures, regulatory measures and other trade-related instruments that are relevant for implementing climate policies.

Climate and trade regimes do not operate in isolation. For instance, the United Nations Framework Convention on Climate Change (UNFCCC) provides that measures taken to combat climate change should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade, and should be implemented so as to minimize adverse effects, including on international trade, and social, environmental and economic impacts on other parties.

At the same time, the WTO framework contributes to the fight against climate change by supporting policies that create or expand positive cross-border spillover effects; for instance, climate measures adopted in one country may facilitate the diffusion of environmental technologies to other countries. WTO rules also help to limit the use of policies that can lead to trade tensions and cause income and welfare losses for other countries, and that thereby ultimately undermine efforts to tackle climate change.

Through its committees, the WTO provides a unique forum for members to discuss their efforts to mitigate and adapt to climate change, and the trade implications of those efforts. WTO transparency mechanisms, including the notification requirements for trade measures and periodic trade policy reviews for WTO members, provide information about climate-related trade measures. WTO technical assistance and capacity-building initiatives, including Aid for Trade, contributes to the efforts towards mobilizing investments in low-carbon and climate-resilient trade infrastructure.

The international trade of critical and environmental-friendly goods and services is enabled by the transparent and predictable trading environment underpinned by WTO rules, which also helps economies to diversify so that they are less reliant on single exporters and suppliers when an extreme weather event hits.

Nevertheless, while trade rules play an important role in climate mitigation and adaptation, the WTO can certainly do more to advance work on environmental and sustainability issues, including greater information-sharing and transparency in the context of trade-related climate change policies, and by addressing trade barriers to environmental goods and services. In that context, the ongoing WTO initiatives on trade and environmental sustainability, on sustainable trade in plastics and on fossil fuel subsidies reforms could lead to both pragmatic and creative results. The WTO could be an appropriate forum for discussions on opening up trade in environmental goods and services to further facilitate access to and diffusion of climate technologies. Strengthening cooperation between the WTO and regional and international climate organizations would further support understanding of the interlinkages between climate change and trade.

This report has underlined how international trade and trade rules can play a positive, constructive role in adapting to climate change and supporting a just transition to a low-carbon economy. Given the cross-cutting nature of climate change, trade and climate change policies need to be mutually supportive. This requires coordination, coherence and transparency.

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World Trade Organization
154, rue de Lausanne
CH-1211 Geneva 2
Switzerland
Tel: +41 (0)22 739 51 11
www.wto.org

WTO Publications
Email: publications@wto.org

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World Trade Report 2022

Climate change is having a profound impact on people's lives across the world. Mitigating and adapting to climate change will require major economic investment and coordinated action to transition to a sustainable, low-carbon economy. The *World Trade Report 2022* explores the complex interlinkages between climate change, international trade, and climate and trade policies.

Although international trade generates greenhouse gas emissions which contribute to climate-related natural disasters, it can also play an essential role in helping countries reduce emissions by increasing the availability and affordability of environmental goods, services and technologies. International trade can also play a key role in helping countries adapt to the impacts of climate change and build future resilience.

The *World Trade Report 2022* shows how international trade and trade rules can contribute to addressing climate change. Ensuring trade and climate change policies are mutually supportive requires global coordination and transparency about government measures. The WTO already plays an important role in helping countries tackle climate change by maintaining a predictable trading environment underpinned by WTO rules that allow for international trade in critical goods and services needed to cope with the consequences of climate change and to reduce emissions. Further international cooperation at the WTO could strengthen the mutual supportiveness of trade and climate change policies so that the world is better equipped to transition to a low-carbon economy.

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