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

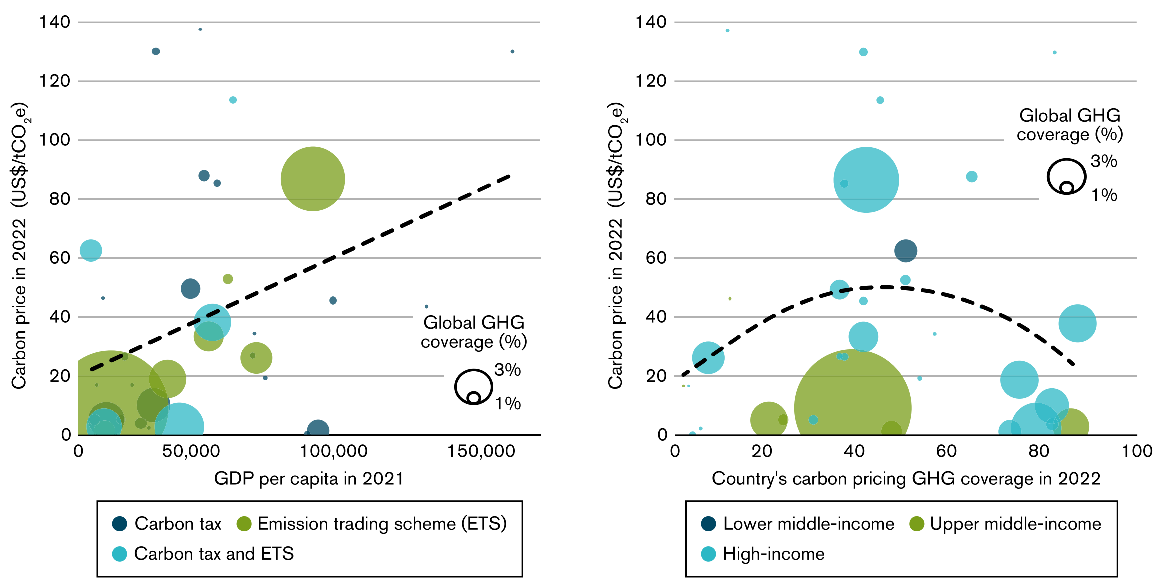
In adopting the Paris Agreement, countries committed collectively to limit the average global temperature rise to well below 2°C and to pursue efforts to limit warming to 1.5°C by the end of the century. To achieve that objective, each government chose its own national determined contribution (NDC) to 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

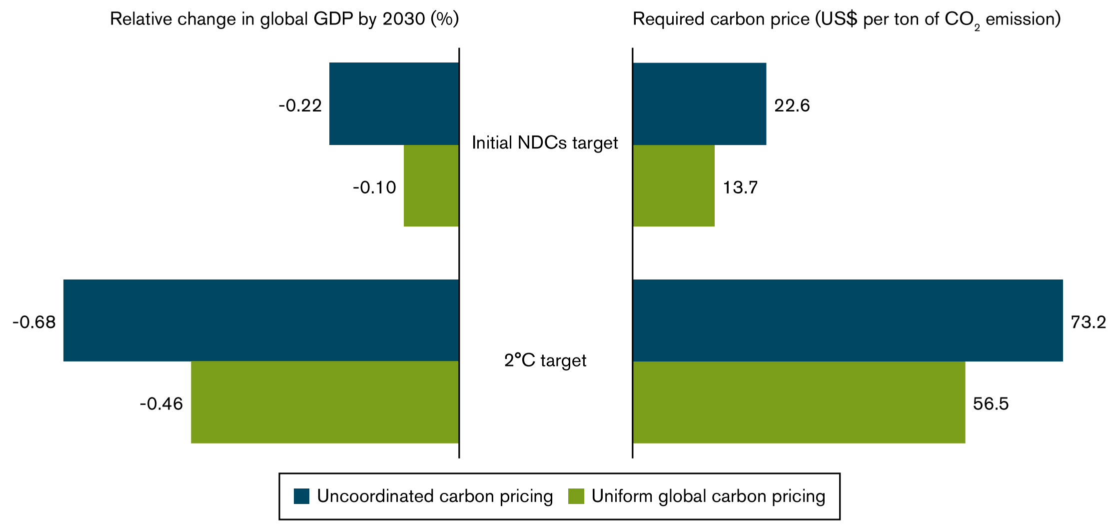
While a well-designed global carbon pricing scheme could support a low-carbon transition, its adoption and implementation at a global scale face a number of important challenges. In particular, two main challenges are associated with promoting a global agreement on carbon pricing: (i) free-riding and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

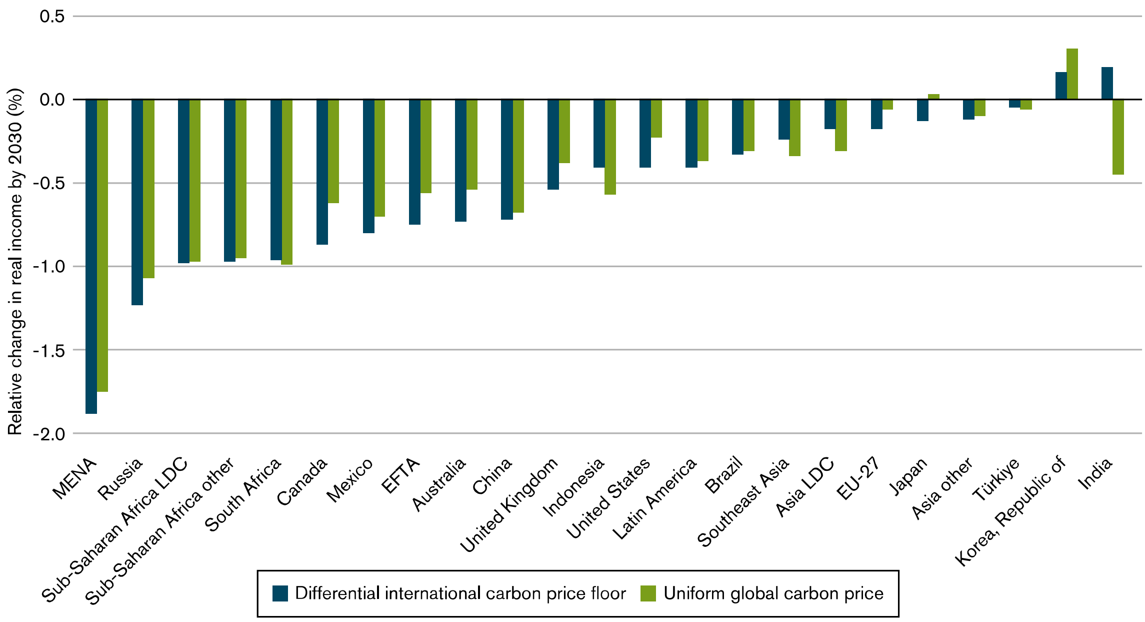
(iii) Technical challenges in global carbon pricing

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).

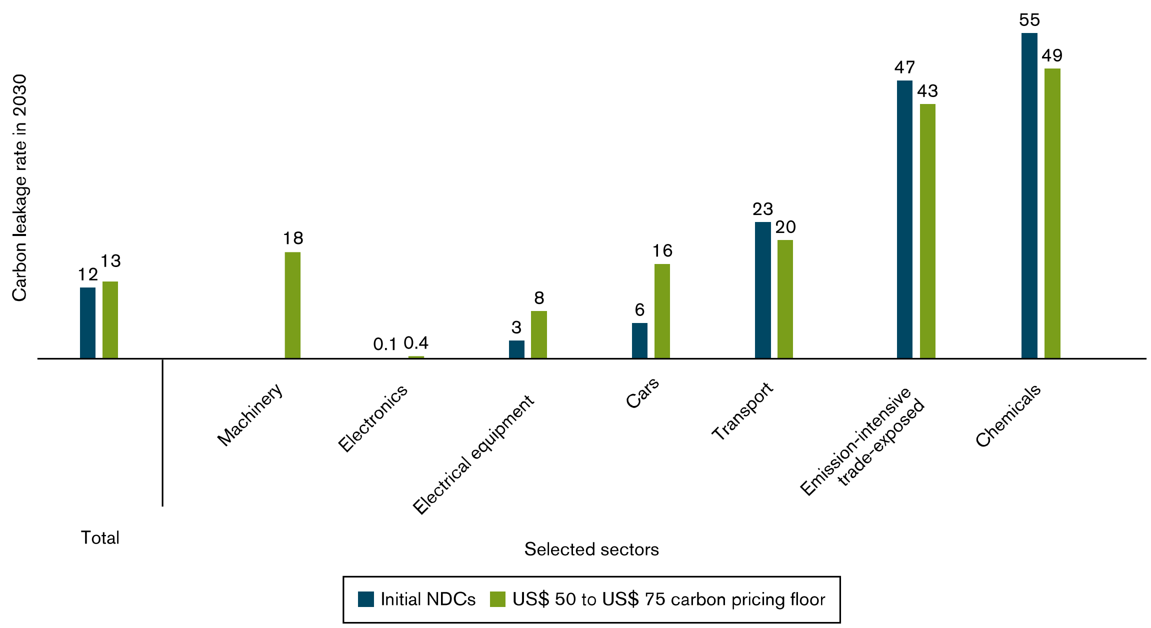
According to the WTO GTM simulation analysis, the estimated aggregate carbon leakage rates seem to be relatively limited and do not exceed 13 per cent (Bekkers and Cariola, 2022).[9] However, the magnitude of the estimated carbon leakage rates differs significantly by sector, with the chemical and EITE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

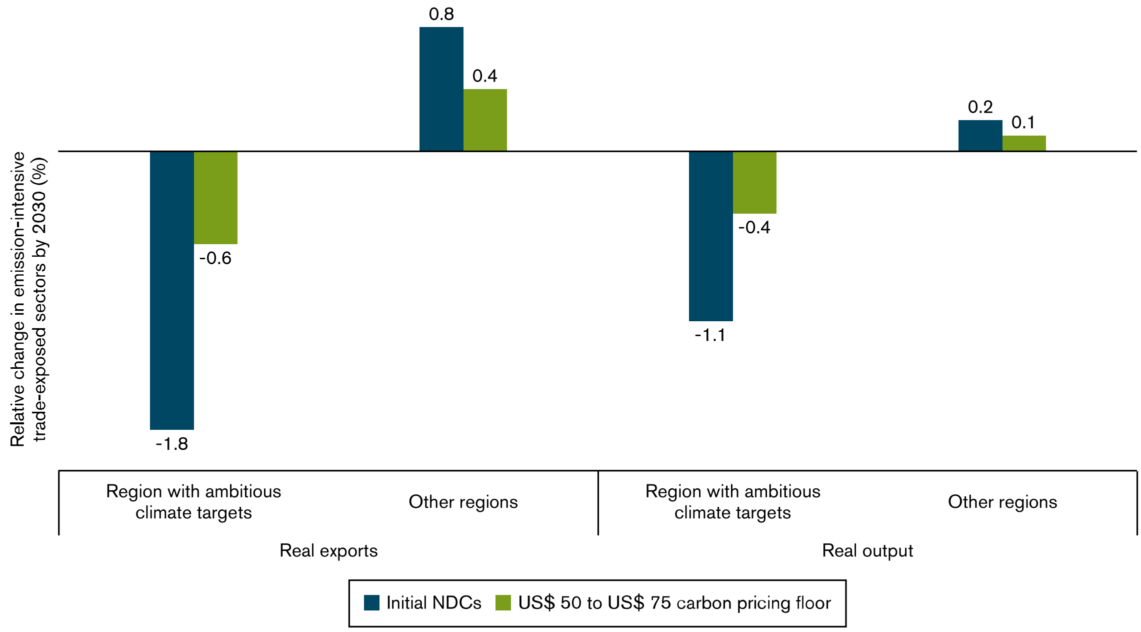
In addition to empirical analysis, simulation studies have been used to analyse the risk of competitiveness loss associated with carbon pricing. For instance, unilateral carbon pricing has been found to lead to competitiveness losses in EITE industries (Carbone and Rivers, 2020). The WTO GTM simulation 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
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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]

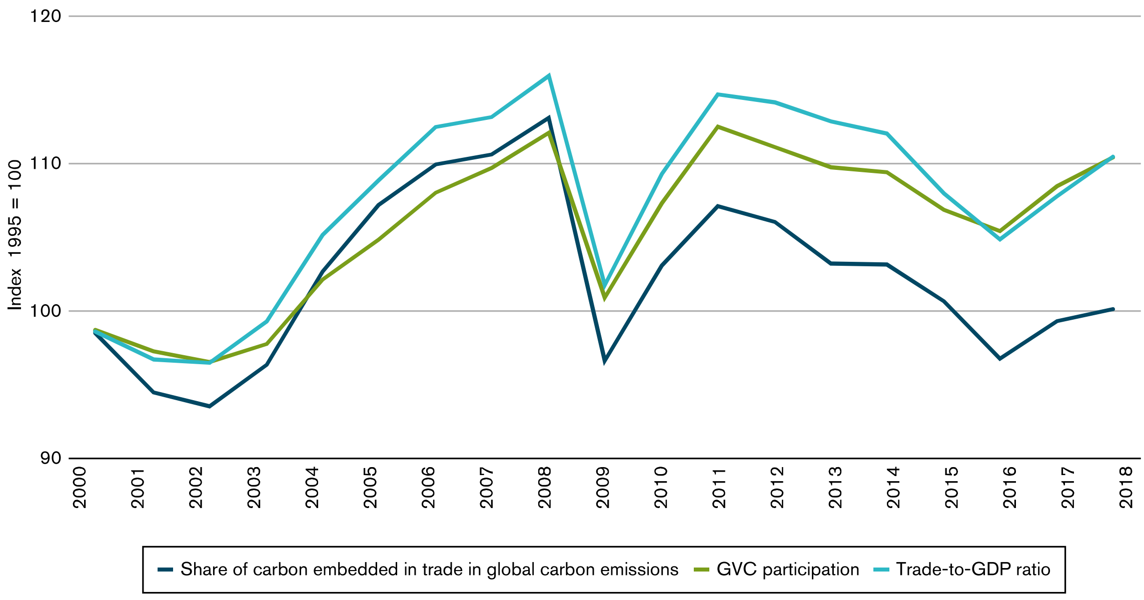
According to the most recent available estimates, the carbon emissions embedded in world exports in 2018 amounted to about 10 billion tons of CO_2, or slightly less than 30 per cent of global carbon emissions (OECD, 2022d). The share of CO_2 emissions embedded in trade in total emissions, while increasing 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.

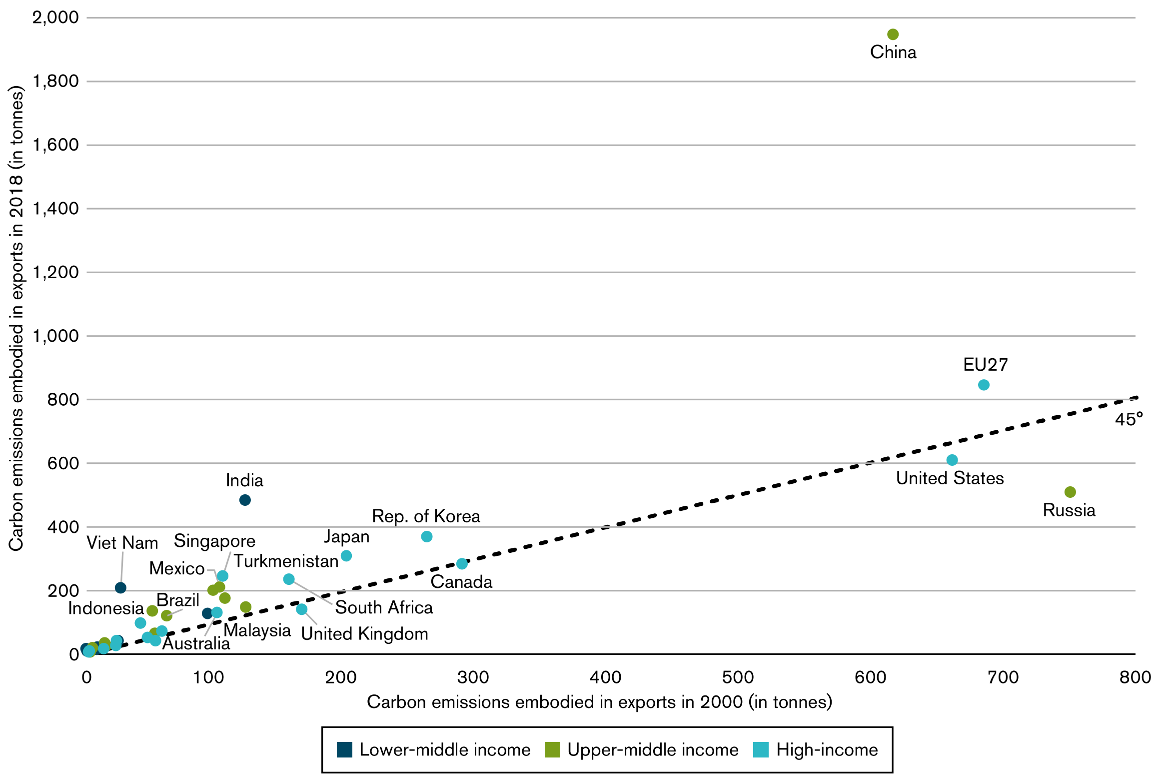
perspective (i.e., production of goods and services consumed domestically and exported) or a consumption perspective (i.e., consumption of goods and services produced domestically and imported). The difference between the production and consumption determines the trade balance in carbon emissions, namely 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).

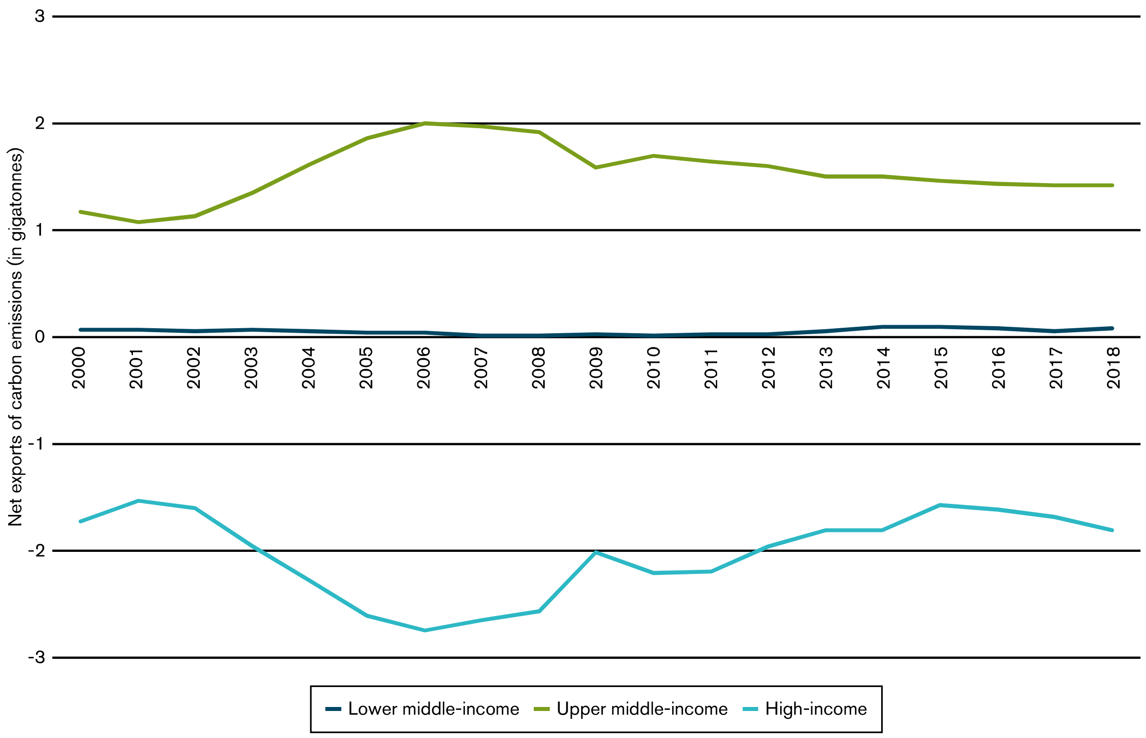
Expansion of trade by GVCs, which accounts for almost half of global trade today (World Bank, 2020), also contributes to more carbon emissions from international transportation, i.e., an additional contributor to the scale effect.

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).

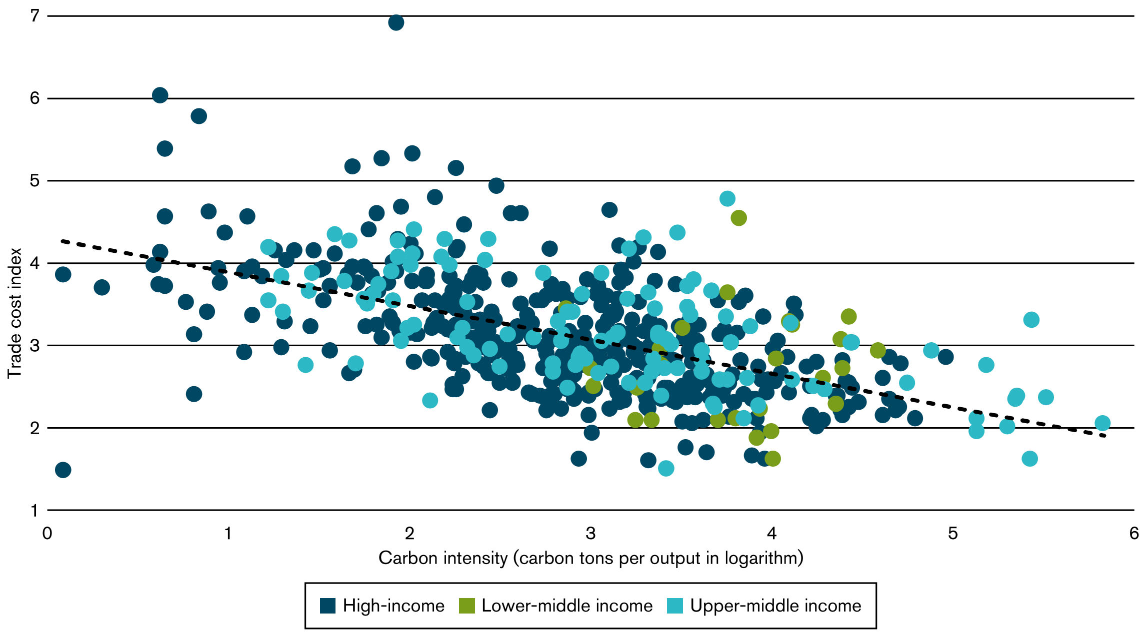
Trade openness can also stimulate innovation, including environmental innovation, through different channels (WTO, 2020a). Innovation and the adoption of energy efficient technologies can increase in response to increased competition from imports.[6] For instance, increased import competition due to 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/).