B The role of trade in adapting to climate change

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

Contents

Key facts and findings

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

1. Introduction

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

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

2. Why does climate change adaptation matter?

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

OPINION PIECE

By Danae Kyriakopoulou

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Climate inaction: implications for international trade

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

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

Continuing with "business as usual" is becoming visibly more costly, not only in terms of the natural environment, but also in the global economic, financial and trade system. The trade implications of more frequent and intense extreme weather events (EWEs), of gradual climatic changes and of policy adjustments, such as climate-driven taxes and regulation, are already manifesting through multiple channels.

EWEs, such as hurricanes and floods, are directly damaging critical infrastructure, including roads, bridges, ports, railway tracks and airports. More frequent disruptions hurt both goods and services trade, such as tourism. Food and agriculture trade is particularly exposed to heatwaves and droughts that can affect crop yields and tempt countries to restrict exports. In May 2022, India – a major wheat producer – banned exports on the grounds of national food security amid a heatwave.

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

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

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

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

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

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

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

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

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

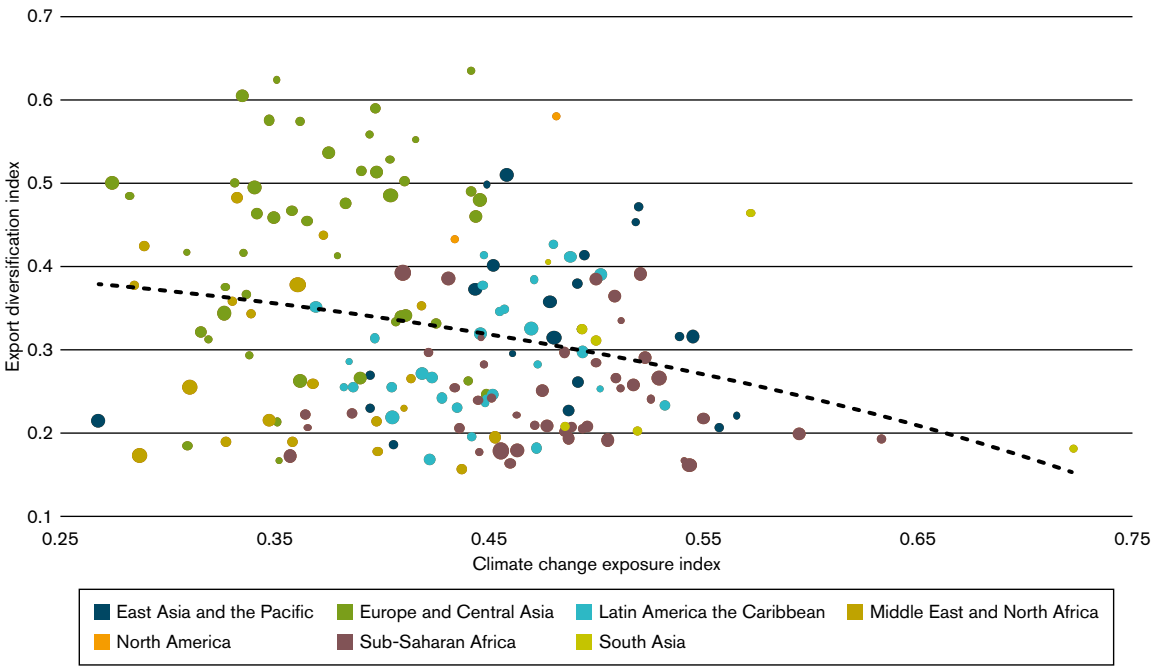
Transport infrastructure is dangerously at risk of damage both from gradual climatic changes and from EWEs (Koks et al., 2019; WTO, 2019). Increasing temperatures can cause roads, bridges, runways and railway tracks to depreciate faster. Transport infrastructure and inland waterways can become partially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

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

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

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

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



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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

In this context, international trade, as a driving force for sustained economic prosperity,[9] can indirectly help economies steer some of their financial resources towards climate change adaptation

strategies. Developing economies that opened up to trade have, on average, enjoyed a 1 to 1.5 per cent higher rate of growth, culminating in 10 to 20 per cent higher growth after a decade (Irwin, 2019). Higher economic growth can, in turn, provide financial support and material preparation for essential climate change adaptation, such as investment in climate-resilient infrastructure.

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

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

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

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

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

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

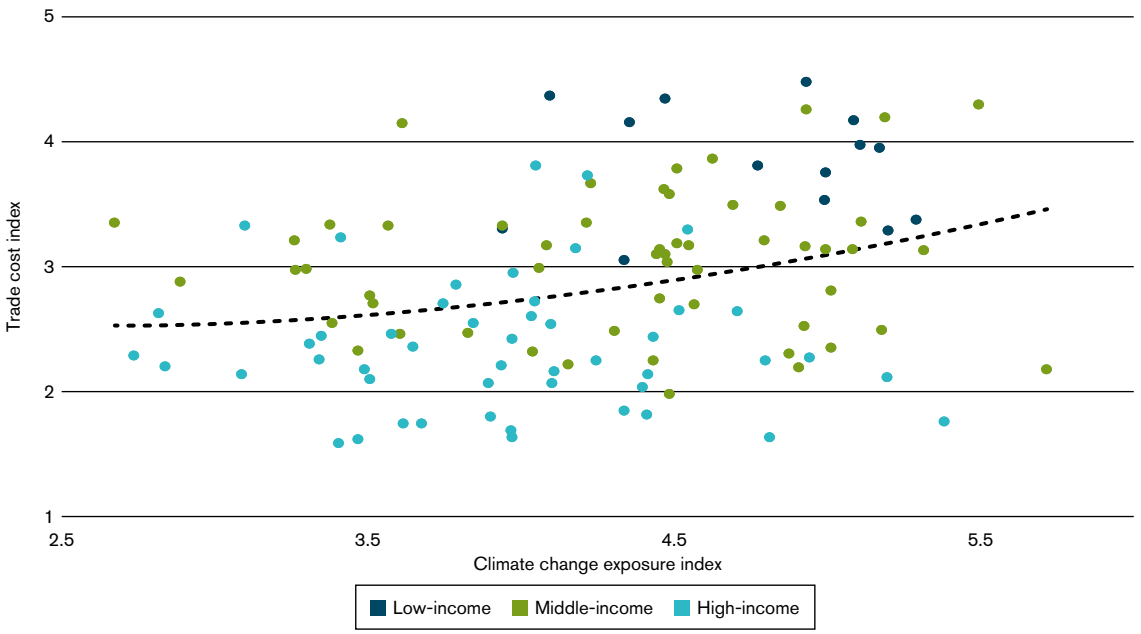
Policies aimed at reducing trade costs can support part of the adjustment caused by changes in comparative advantages due to climate change, while minimizing changes in patterns of consumption through imports, and thus potentially minimizing welfare losses. Simulations suggest that reducing trade costs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

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

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

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

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



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

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

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

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

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

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

A review of all explicitly environment-related trade measures notified by members to the WTO between 2009 and 2020 shows that, while a large majority of notified climate change-related trade measures relate to mitigation, only 3 per cent of all notified climate-related trade measures (161 out of 4,629) can be explicitly linked to climate change adaption.[12] Trade-related climate change adaptation measures predominantly take the form of support measures, with more than three-quarters of notified measures

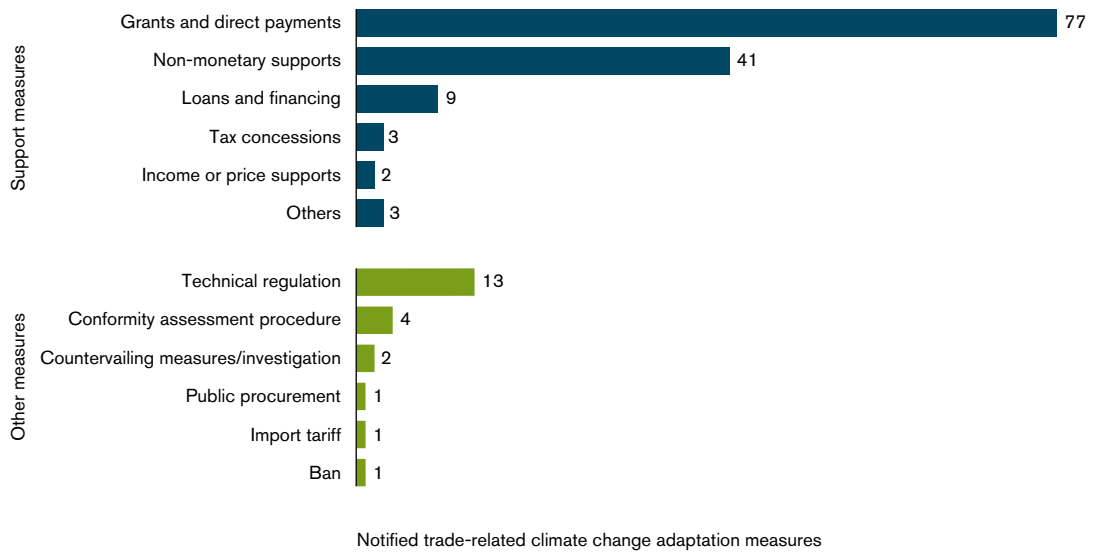
covering grants and direct payments, non-monetary support and/or loans and financing. Technical regulations and conformity assessment measures are other common types of adaptation measures (see Figure B.3). More than half of the notified climate change adaptation measures cover the agricultural sector, illustrating its vulnerability to climate change and its need to adapt.

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

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

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

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



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

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

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

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

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

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

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

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

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

Certain vulnerable groups, such as micro, small and medium-sized enterprises (MSMEs) and women in certain socio-economic groups, face even greater difficulties in adjusting due to social, economic and cultural reasons (IPCC, 2014a; Nellemann, Verma and Hislop, 2011) (see Box B.3). For example, in low- and lower-middle-income countries, 52 per cent of the female workforce is employed in agriculture (World Bank and WTO, 2020), and as climate change puts a strain on agricultural sectors, social norms or

household responsibilities may prevent these women from seeking employment in other sectors – especially if this means having to move to a different area – and this can negatively affect both households and economies at large. In addition, the consequences of climate change may cause some individuals to lose their means of livelihood permanently. However, social policies, such as education and compensation policies, like lump sum payments, can support the groups most exposed to the economic consequences of climate change.

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

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

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

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

Box B.3: Climate change impacts on MSMEs

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

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

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

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

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

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

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

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

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

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

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

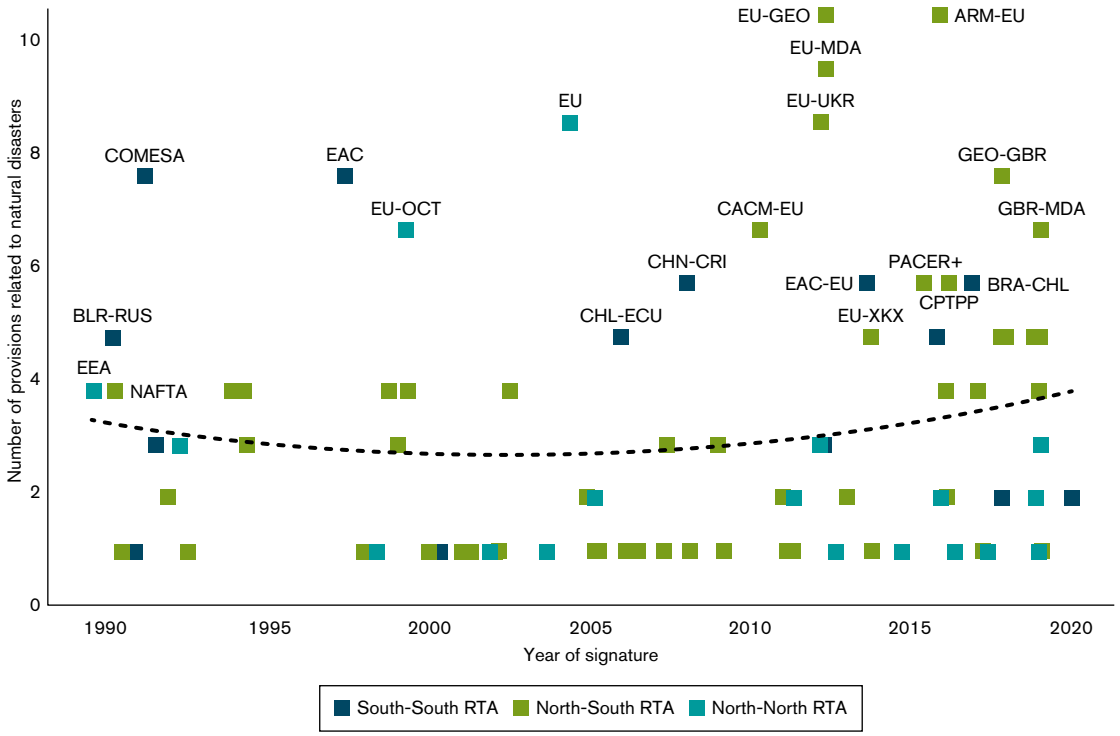
International cooperation on trade and trade-related policies can help support different dimensions of climate change adaptation, from climate risk prevention, reduction and preparedness to climate disaster response and recovery. International cooperation on trade policies can assist governments in reducing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

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

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

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

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



Source: Monteiro (2022a).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Table B.1: Selected examples of resilience policies under WTO agreements and decisions

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

who thereby face more obstacles to benefitting from open markets.

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

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

members, and to notify the Committee on Agriculture before instituting such measures.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

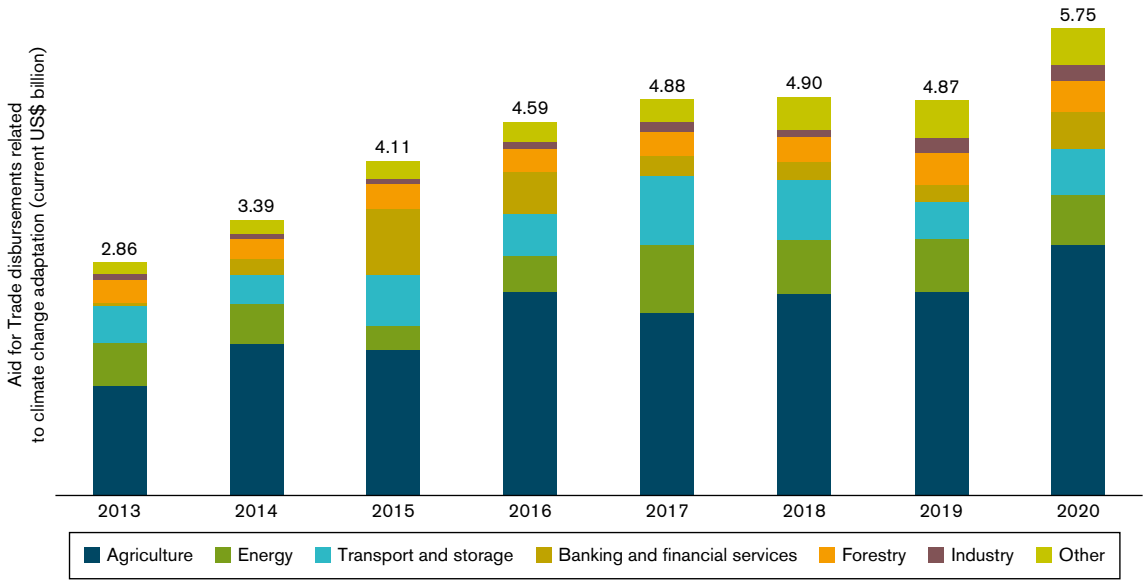
The WTO can also help countries mobilize support and build trade-related capacities for adaptation. For example, the WTO surveys LDCs' evolving technology needs and priorities and supports them by monitoring developed countries' programmes for transferring relevant technologies to LDCs in line with their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

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

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

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

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



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

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

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

5. Conclusion

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

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

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

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

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

Endnotes

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

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

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

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

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

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

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

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

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

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

11 See for instance https://corporate.walmart.com/esgreport 2019/environmental#climate-change.

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

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

14 For example, Korea-Peru RTA.

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

16 For example, Canada-Chile RTA.

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

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

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

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

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

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