Policy Research Working Paper 9955

Pandemic, Climate Mitigation, and Reshoring

Impacts of a Changing Global Economy on Trade, Incomes, and Poverty

Maksym Chepeliev
Maryla Maliszewska
Israel Osorio-Rodarte
Maria Filipa Seara e Pereira
Dominique van der Mensbrugghe

WORLD BANK GROUP
Macroeconomics, Trade and Investment Global Practice
March 2022

Policy Research Working Paper 9955

Abstract

The resilience of global value chains has been put to the test by the COVID-19 pandemic, extreme weather events, and trade tensions spurred by growing economic nationalism and protectionism. Shocks in production and trade can be transmitted from one country to another by global value chains, although they can also help to lessen the blow of a domestic shock, such as a lockdown, and drive economic recovery. What shocks to global value chains should be anticipated in the coming years? Is it possible to design policies that can enhance resilience to trade shocks in developing countries without endangering growth? This paper explores simulations from the ENVISAGE global computable general equilibrium model to enhance understanding of the potential longer-term impacts of COVID-19 and the policy responses it engenders in developing countries. The paper assesses the likely impacts of measures designed to reshore production and reduce reliance on imports. It also evaluates other key factors shaping the global economy, including stylized scenarios to capture the essential elements of policies to achieve carbon emission reductions that will have an impact on trade.

This paper is a product of the Macroeconomics, Trade and Investment Global Practice. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/prwp. The authors may be contacted at mchepeli@purdue.edu and mmaliszewska@worldbank.org.

Pandemic, Climate Mitigation, and Reshoring: Impacts of a Changing Global Economy on Trade, Incomes, and Poverty

Maksym Chepeliev, Maryla Maliszewska, Israel Osorio-Rodarte, Maria Filipa Seara e Pereira, and Dominique van der Mensbrugghe[1,2]

Keywords: economic growth of open economies; measurement and analysis of poverty; computable general equilibrium modeling; distributional impacts of trade; trade agreements; trade and environment.

JEL Classification: F16, F17, F18, I32, F63, O53, C68.

[1] Maksym Chepeliev and Dominique van der Mensbrugghe are with the Purdue University. Maryla Maliszewska, Israel Osorio-Rodarte, Maria Filipa Seara e Pereira are with the World Bank. We are grateful to Paul Brenton, Michael Ferrantino and Antonio Nucifora for their guidance and to the participants of the 23rd Annual Conference on Global Economic Analysis (Virtual Meeting) for their useful comments.

2 This paper is a product of the staff of the Trade and Regional Integration Unit at the International Bank for Reconstruction and Development/the World Bank. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://www.worldbank.org/prwp. The authors may be contacted at mchepeli@purdue.edu and mmaliszewska@worldbank.org.

1. Introduction: Shift from globalized to localized world would slow recovery

The resilience of global values chains (GVCs) has been put to the test by the COVID-19 pandemic, extreme weather events, and trade tensions spurred by growing economic nationalism and protectionism. The sudden drop in global trade in the first half of 2020 was massive by historical standards (WTO 2020). Econometric evidence shows that shocks in production and trade can be transmitted from one country to another by GVCs, though participation in GVCs may help to lessen the blow of a domestic shock such as a lockdown (Espitia et al. 2021). But GVCs can also drive recovery, spreading the benefits, for example, as countries come out of lockdowns at different times. In light of this experience, is it possible to design policies that can enhance resilience to trade shocks in developing countries without endangering growth?

The past three decades of globalization have lifted international trade to new heights while helping to drive extreme poverty to new lows (World Bank 2020a). GVCs have lengthened and strengthened to provide countries and consumers worldwide with vital goods and services, from vaccines to vacuum cleaners. The evidence from the scenarios in this chapter on the economic and social benefits of GVCs is emphatic: globalization will strengthen a recovery while localization will weaken it. Moreover, localization could drive more people into extreme poverty while globalization could lift millions above the poverty line by 2030. In short: developing and developed countries are better off in a globalized world.

In the public debate, the recent disruptions of the supply chains have cast doubt on whether the gains of GVCs outweigh the associated risks of transmission of shocks. Consequently, a new array of literature continues to appear with the goal of gaining a better understanding of the benefits of globalization and resilience of GVCs. Furthermore, one of these most recent disruptions, the Covid-19 pandemic, offers a rare opportunity to understand the role that GVCs play in making countries more resilient. Bonadio et al. (2020) and Espitia et al. (2021) both illustrate this role in their work. They show that in a pandemic-style labor supply shock, if countries try to artificially weaken the entry of foreign inputs by means of a renationalization, this will only result in a higher level of exposure to domestic shocks, more fragility and would not mitigate contractions in GDP.

A re-localization of supply chains as a possible solution to fight uncertainty seems also destined to fail. Not only would this increase costs for firms and consumers, but it also hardly protects countries from external shocks. The OECD (2020b), using its METRO computable general equilibrium (CGE) model, finds that in a localized system, with reduced GVCs, economies would have significantly lower levels of economic activity and lower incomes, making countries more – not less – vulnerable to shocks. When looking into a more specific example of the impact of a China lockdown on the US economy, Eppinger et al. (2021), using a multi-country, multi-sector trade model, reinforce the conclusion that repatriating supply chains does little to mitigate the welfare losses caused by a China shock, and the policy itself carries substantial welfare costs.

GVCs, on the other hand, not only play a role in offering to countries some protection against external and domestic shocks, but also, they have been shown to be resilient and thus offer some security to businesses and consumers. GVCs display resilience when confronted with shocks, such as natural disasters. The largest earthquake ever recorded, which occurred in Japan in 2011, had no long-term consequences on the reconfiguration of the GVCs and did not lead to reshoring nor import diversification (Freund et al. 2021).

Few studies exist that analyze the impact of climate change mitigation measures, and more specifically the Carbon Border Adjustment Mechanism (CBAM), on GVCs. It has been shown that the implementation of carbon pricing measures consistent with reaching the Paris Agreement targets can have negative impacts on economic growth, a higher incidence of poverty, but result in progressive income distribution (Chepeliev et al., 2021). But little has been written on mitigation policies' impacts on trade and GVCs. Our paper tries to fill this gap and lead the way in a better understanding of the impact of CBAM on GVCs, and how supply chains can play a role in mitigating the adverse effects of climate policies.

Policies that are "friendly" rather than "hostile" to GVCs could prove critical to the strength of the economic recovery from the pandemic. Developing countries stand to gain the most from strengthening GVCs. Three scenarios examining the potential impact of "GVC friendly" and "GVC hostile" policies in 2020-2030 show that shortening supply chains through reshoring or localization would short-change developing and developed countries. The first scenario, *Reshoring Leading Economies*, examines a case in which high-income economies and China raise barriers to imports and increase subsidies to agriculture and manufacturing in an attempt to achieve reshoring. The second scenario, *Reshoring All*, looks at the impact of even wider localization and diminished globalization when developing countries join the reshoring efforts. The third scenario, *GVC Friendly Liberalization + Trade Facilitation (TF)*, examines a case in which developing countries seek to reduce trade costs and make it easier to use imports in domestic production. These scenarios are evaluated for the year 2030 against a baseline in which the economic recovery from COVID-19 is L-shaped; that is, pre-COVID growth rates are achieved but the loss of potential output suffered in 2020 is permanent. The main messages would, however, remain the same under different post-COVID-19 recovery pathways.

In a world where major countries try to reshore their production through subsidies and tariffs, global income declines by 1.5 percent and global exports decline by 17 percent relative to the baseline in 2030. If developing countries join in attempting to reshore, global income drops by 2.2 percent and global exports drop by 21.4 percent relative to the baseline. By contrast, when developing countries move to lower trade costs, global income increases by 0.4 percent relative to the baseline. A "hostile" environment with a shift toward global reshoring could drive an additional 51.8 million people into extreme poverty, while a more "friendly" one could lift 21.5 million additional people out of poverty by 2030 relative to the baseline.

The post-COVID-19 recovery in developing countries will be much stronger in a globalized world. Our simulations indicate that the overall increase in real income in developing countries between 2019 and 2030 could be 7 percentage points higher in a globalized world. While between 2019 and 2030 in a localized world real income in developing countries grows by 48 percent, in a globalize world the corresponding increase could reach 55 percent.

We examine three main trends with potential implications for GVCs, impact on economic growth and poverty reduction. Firstly, we delve into the impact of shocks, such as COVID-19, and how that plays out in terms of economic growth, poverty reduction, and resilience. Secondly, we look at the impact of protectionism, economic nationalism, and reshoring. Finally, we analyze the impact of changes in climate change mitigation policies, including carbon pricing.

First, the COVID-19 crisis is having significant impact on GVCs and government policies to support domestic industry and reshoring efforts, will have impacts on jobs, income, and poverty. Given the

complexity of the policy and economic environment in which firms and governments are responding to COVID-19, a CGE model can be a useful tool. It provides an assessment of the impacts of COVID-19 and various policy changes on economic growth, sectoral trade flows, output, and employment.

Second, trade tensions have thrown up new challenges and uncertainties. These include recent US-China trade barriers and challenges to the legitimacy of the World Trade Organization (WTO). The unprecedented step back by the United States from the multilateral approach to trade governed by the WTO has seen significant bilateral trade restrictions imposed on U.S.-China trade. This in turn has led to swift changes to bilateral trade flows.

Third, new regulations on greenhouse gas (GHG) emissions to combat climate change are throwing up new complexities and competitive challenges for some industries changing the comparative advantage of countries. As part of attempts to limit climate change and meet obligations under the Paris Agreement, several countries are developing domestic regulations to reduce GHG emissions, that can dramatically alter comparative advantages of countries, as well as taxation of imported goods that could have significant effects on their trading partners. For example, the European Commission has announced that a carbon border adjustment mechanism (CBAM) will be part of the ambitious European Green Deal (European Commission 2019). This scheme will be the first in which a major border tax adjustment is to be used in climate policy.

The CGE tool can inform an understanding of the medium to long-term implications of the recalibration of GVCs. The analysis designs forward-looking scenarios to anticipate medium run impacts of COVID-19 and potential policy changes on trade in goods and services, employment and wages by sector, skill, and gender, as well as on poverty and income inequality. The analysis builds on a global dynamic CGE model i.e. the multi-regional input-output (MRIO) version of the ENVISAGE model, and the global microsimulation framework Global Income Distribution Dynamics (GIDD). The ENVISAGE-GIDD top-down assessment approach allows for the analysis of global development and structural transformation, incorporating the complex interactions of productivity differences at the country, sector, or factor level, shifts in demand as income changes, demographic and skill dynamics in factor markets, and changes in comparative advantage. This application includes an extension of the standard modeling framework by incorporating MRIO tables that distinguish between imports of intermediate, final, and investment goods to better capture the nature of trade typical for GVCs. The CGE model relies on the GTAP 10 Data Base with a 2014 reference year and runs until 2030. The analysis covers 27 sectors and 21 countries/regions.

The CGE tool goes hand-in-hand with the GIDD microsimulation tool which translates the CGE results into implications for poverty and income distribution. This includes impacts on employment and wages of female and male workers. The GIDD simulations are based on a Global Micro Database, which covers over 80 percent of the global population and GDP. It includes harmonized household surveys for 130 countries. This study presents scenarios of globalized or segmented worlds and analyzes the implications of various shocks, such as future trade policy changes, disruptions in production, and climate mitigation policies. Their impacts on patterns of international trade, including GVCs, along with their implications for poverty and distribution, are the key questions addressed.

2. Methodological framework and scenarios

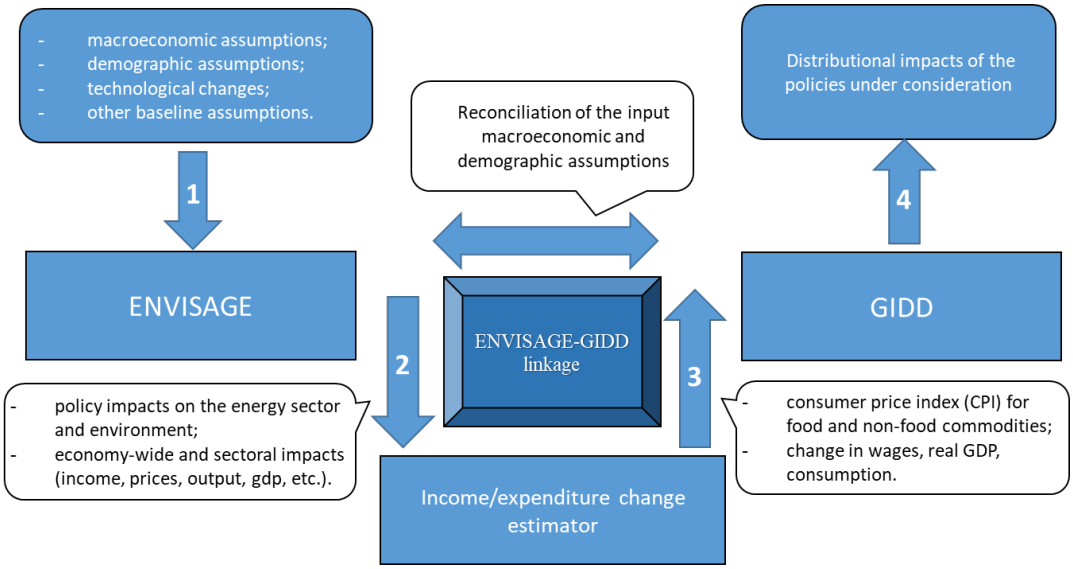
To provide a quantitative assessment of the policy scenarios, we rely on a soft linkage between the global recursive dynamic CGE model ENVISAGE (van der Mensbrugghe 2019) and the GIDD microsimulation framework (Bussolo et al. 2010). First, the ENVISAGE model is run to provide an assessment of policy scenarios under consideration. Next, selected indicators from this assessment are transferred to the GIDD model. These are further implemented as an external shock relative to the baseline scenario within the GIDD modeling framework to estimate the distributional impacts of the considered set of policies. Such soft-linking approach does not incorporate any backward linkages from the GIDD to ENVISAGE and can be considered as a decomposition of the aggregate ENVISAGE results using the microsimulation framework.

Key data input to the ENVISAGE model for the reference year representation is the Global Trade Analysis Project (GTAP) 10 MRIO Data Base with 2014 as the reference year (Aguiar et al. 2019; Carrico et al. 2020). Relying on the MRIO data, which distinguishes agent-based demand for imports by region of origin, selected manufacturing sectors in the ENVISAGE model are represented using the MRIO specification, while all other sectors use the standard Armington assumption, treating imports as imperfect substitutes with domestically produced commodities—and sourcing is done at the national level. The model is solved as a sequence of comparative static equilibria where the factors of production accumulate over time. Nested constant-elasticity-of-substitution (CES) functions are used to represent production technologies. 141 regions and 65 sectors of the GTAP 10 Data Base have been aggregated to 21 countries/regions and 27 sectors for the current assessment. Annex A reports sectoral and regional mappings, as well as provides identification of the sectors of the model that are represented using the MRIO specification. Annex B provides technical details of the modeling framework.

The GIDD is a top-down macro-micro simulation framework that exploits heterogeneity observed in household surveys to distribute macroeconomic shocks obtained from the CGE model. Transferred shocks are distributed in a predefined set of linkage aggregate variables that communicate between the two models. The GIDD model relies on a collection of 130 nationally representative household surveys with harmonized variables on demographics, education, labor, welfare and consumption. The sample covers more than 10.5 million individuals from countries constituting 83.4% of global GDP and 86.3% of global population. The data is described with more detail in Ahmed et al. (2020). Additional details regarding the GIDD microsimulation framework can be found in Bussolo et al. (2010).

The ENVISAGE-GIDD model linking process is performed in a sequence of steps, where the two models are pre-calibrated to the same demographic and macroeconomic baseline assumptions. ENVISAGE and GIDD models are connected through changes in labor supply, skill formation, and real earnings. In terms of labor supply, the macro and micro models incorporate projections for skilled and unskilled labor over time. The GIDD framework, in addition, reallocates workers across sectors based on aggregate general equilibrium conditions. After reallocation, the GIDD simulates impacts on real earnings, income growth, and changes in relative prices for food and non-food expenditures. The shocks are transmitted through a set of linkage variables that connect the macro and micro models. Figure 1 provides an overview of the general approach. For additional details on the model linkage implementation an interested reader is referred to Chepeliev et al. (2021).

Figure 1. Overview of the general approach to the ENVISAGE-GIDD linkage



Source: Reprinted by permission from Elsevier: Chepeliev et al. (2021), Copyright (2021).

3. Scenarios: COVID-19, climate change, and protectionist shocks to GVCs

For the implementation of the baseline scenario, we rely on World Bank Macro and Poverty Outlook (MPO) projections from World Bank (2021). For the pre-COVID baseline scenario, we use pre-COVID MPO projections from World Bank (2020b). We further extend the GDP forecasts post period reported in each version of the MPO using per capita GDP growth rates from the Shared Socioeconomic Pathways database relying on the SSP2 scenario (IIASA 2016). Several COVID-specific shocks are introduced into the baseline scenario (pre-COVID baseline does not have these shocks) partially relying on Maliszewska et al. (2020), who simulated impacts of COVID-19 in a comparative static CGE framework. All COVID-specific shocks discussed below are implemented in the model for 2020 as the simulated year.

- *First,* we assume a 5 percent increase in the costs of imports across all sectors and regions. This is captured in the model via a so-called iceberg parameter. The assumed increase in transport and transactions costs in foreign trade is driven by additional inspections, reduced hours of operation, road closures, border closures, increases in transport costs, etc.

- *Second,* we simulate a sharp drop in international tourism. This is represented via a 50 percent consumption tax on international tourism-related services, including transportation and recreational services. A typically small revenue generated by such taxes is rebated back to households in the corresponding region in a lump-sum. The World Travel and Tourism Council (WTTC) estimated that domestic visitor spending decreased by 45 percent, while international visitor spending declined by 69.4 percent. The implemented tax on the export of trade-related services results in a decline in exports of tourism services at the global level of about 25 percent.

- *Third,* we implement a shift in household demand away from services that require close in-person interactions, such as hotels, restaurants, public transport, etc., toward other goods and services.

The consumption patterns under home-based work and lockdowns have changed with consumers decreasing spending on services requiring human interaction.[3] We assume that the demand for the former category of services drops by 15 percent.

- *Fourth,* we introduce a food supply shock, to simulate a post-harvest loss in food producing sectors. The measures put in place by many governments to contain the spread of COVID-19 can have a disruptive effect on the availability of agro-food products to consumers.[4] Therefore, to take into consideration this disruption of the logistics of food distribution, we assume that the cost of agricultural and food commodities production increases by 3 percent.[5]

- *Fifth* is the shift toward communication technologies in the service sectors and away from transportation activities, particularly air transportation. To represent the shift from (air) transportation toward communication services used by service sectors we decrease by 20 percent a share of air transport activity in the cost structure of services production and increase the share of communication input to the services cost structure by 20 percent.

- *Finally,* we introduce a reduction in global oil prices (in 2020 relative to 2019) by increasing the supply of oil. We further assume that in the post-2021 period oil prices would rebound to the 2019 levels in the next several years and exceed 2019 prices by 2030 – in line with International Energy Agency (IEA) price projections (IEA 2020). All these shocks are implemented for the 2020 simulated year together with the GDP target consistent with the GEP 2021 forecast (World Bank 2021).

Our baseline scenario also includes implementation of the trade frictions between the United States and its trading partners (mainly China) implemented in the model via increases in import tariffs based on the detailed tariff line data from the CARD database (Li 2018). We assume that these trade policy shocks stay in the model throughout the entire simulated timeframe, i.e. until 2030. We also include all existing and ongoing trade agreements with a pre-defined set of tariff changes based on the published tariff schedules reported by the International Trade Center (ITC 2020). We refer to this scenario as the globalized world, as it represents the continuation of past trends.

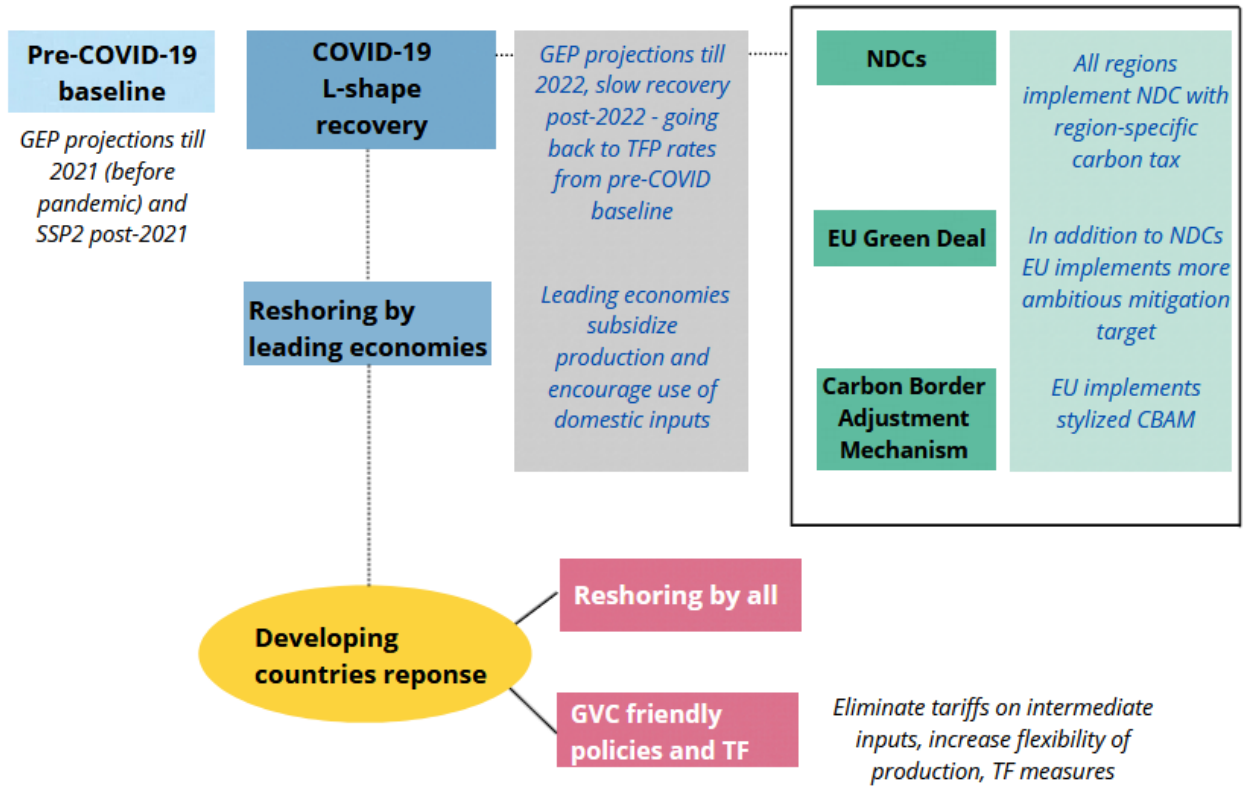
Policy scenarios

Introducing two scenarios that are "hostile" to GVCs and one that is "friendly."

Our scenarios examine the impact of changes in trade and climate policies, including reshoring and carbon taxes, on the pace of economic recovery from the COVID-19 pandemic (Figure 2). We further explore how developed and developing countries are impacted by such polices and what actions developing countries can take to cushion the impact of policy shocks. In this section, we discuss the construction of the corresponding policy shocks. A summary of the scenarios is provided in Annex C.

[3] U.S. retail sales data https://www.census.gov/retail/index.html
[4] See OECD (2020a).
[5] World Bank's Food Price Index increased by 3 percent in 2020 according the October 2020 edition of World Bank's Commodity Markets Outlook.

Figure 2. Overview of the scenario set up



Source: Developed by authors.

Our first scenario examines the impact of reshoring by the world's leading economies: *The Reshoring Leading Economies scenario.* In this scenario, leading economies (high income countries and China) implement policies to reshore production. This scenario assumes a subsidy to local production of agricultural and manufacturing products amounting to 1 percent of GDP in the corresponding region (through capital and labor subsidies), putting up barriers to imports—a 25 percentage point surcharge—and making it harder to substitute domestic production for imports by, for example, tightening the product standards (reducing trade elasticities by 50 percent). These shocks are phased in over five years, from 2022 to 2026, and are implemented by leading economies.[6]

The second scenario examines the impact of developing countries responding in kind by implementing their own reshoring efforts: *The Reshoring All scenario.* This scenario is also referred to as the localized world (cf. OECD 2020b).

The third scenario is "friendly" rather than "hostile" to globalization*: The GVC Friendly Liberalization + Trade Facilitation (TF) scenario.* This scenario assumes that developing countries implement three sets of policies to become more GVC-friendly (leading economies continue their reshoring policies). Firstly, they eliminate tariffs on all intermediate inputs (MRIO sectors are identified in Annex A). Secondly, they take steps to increase flexibility of their production by making it easier to substitute domestic for imported inputs by, for example, loosening product standards. We implement these policies by increasing the trade

[6] The group of leading economies includes Western Europe, United States, China and Rest of high-income countries.

substitution elasticity by 50 percent. Finally, developing countries reduce costs to trade by implementing trade facilitation measures in line with the implementation of the WTO Trade Facilitation Agreement, which according to estimates by Moise and Sorescu (2013) and WTO (2015), reduces trade costs by between 14-16 percent.[7] As in the case of reshoring, these policies are phased in between 2022 and 2026.

Another set of policy options that we investigate deals with climate change mitigation, which has significant implications for the comparative advantage of countries. These polices may be viewed as slow-acting shocks to GVCs. There is a lot of uncertainty over the exact shape these policies will take and how they are going to be implemented. In order to explore their potential consequences for GVCs, we include a stylized interpretation of the Paris Accord and the EU Green Deal including CBAM. First, we implement the so-called Nationally Determined Contributions (NDCs), which refer to emission reduction targets under the Paris Accord, following Chepeliev et al. (2021) and Böhringer et al. (2020). These targets are specified in the form of CO_2 emission reductions in 2030 relative to the pre-COVID baseline scenario levels. We assume that countries implement carbon pricing policies to reach the NDC commitments. The model estimates the carbon price level (for each region) consistent with these emission reduction targets. Corresponding 2030 carbon prices range from less than US$5/t$CO_2$ in Sub-Saharan Africa countries, India, and Malaysia to more than US$30/t$CO_2$ in Brazil, Turkey, the EU, and some other high-income countries.

In addition to NDC targets, we consider more ambitious climate mitigation efforts by the EU in a stylized EU Green Deal scenario. This effort is consistent with the recently announced EU Green Deal mitigation plans to cut emissions by 55 percent in 2030 relative to 1990 levels (EC 2019). This more ambitious emission reduction policy in the EU is achieved by further increases in carbon prices in the model. We first explore the impact of the EU Green Deal without implementation of a Carbon Border Adjustment Mechanism (CBAM)[8] and then add the latter policy measure to our assessment. In the assessment, we implement CBAM as an excise tax imposed on region- and commodity-specific carbon content of imports to the EU. The carbon price level that is used to determine the CBAM rate is estimated as the difference between the carbon price in the EU and the carbon price in the country/region of the imported commodity origin. Only imported commodities that correspond to the EU's Emissions Trading Scheme (ETS) sectors are assumed to be covered by the CBAM.

To provide an accounting of the CO_2 emissions embodied in bilateral trade,[9] we follow an approach outlined in Peters (2008). Country-specific CO_2 emissions per unit of output by sector are used to estimate emissions associated with bilateral trade flows. For every commodity, the total CO_2 emissions associated with fossil-fuels combustion and embodied in trade flows from region r to region s (f_{rs}) are estimated as $f_{rs} = F_r(E - A_r)^{-1}e_{rs}$, where F_r is a vector of region-specific CO_2 emissions per unit of output by industries, E is an identity matrix, A_r is the technological matrix, which represents the industry requirements of domestically produced products in region r, and e_{rs} corresponds to the bilateral trade flow from region r

[7] The decline amounts to 14 percent in East Asia, South Asia, Europe and Central Asia, and Middle East, and to 16 percent in Sub-Saharan Africa and Latin America and the Caribbean. In the model, these measures are implemented as a reduction in Iceberg parameter.

[8] CBAM is one of the policy measures discussed in the European Green Deal (EC 2019; EC 2021). It is aimed to protect domestic industries, create incentives for other countries to adopt carbon taxes, avoid carbon leakage, and limit the reallocation of the EU-based industries to the countries with less stringent climate regulations.

[9] Only CO_2 emissions from fossil-fuel combustion are considered in this study. Under the implemented approach, we cover Scope 1, Scope 2 and Scope 3 emissions under. This implementation of CBAM is different from the recent proposal of the Euro Commission (EC 2021). The latter has more narrow emission scope and commodity coverage.

to region *s*. Essentially the role of the CBAM is to bring the level of emissions per unit of imported output to the average sectoral level in the domestic economy, in this case of the EU.

4. The risks of GVC reshoring

The COVID-19 shock and recovery in a post-pandemic world

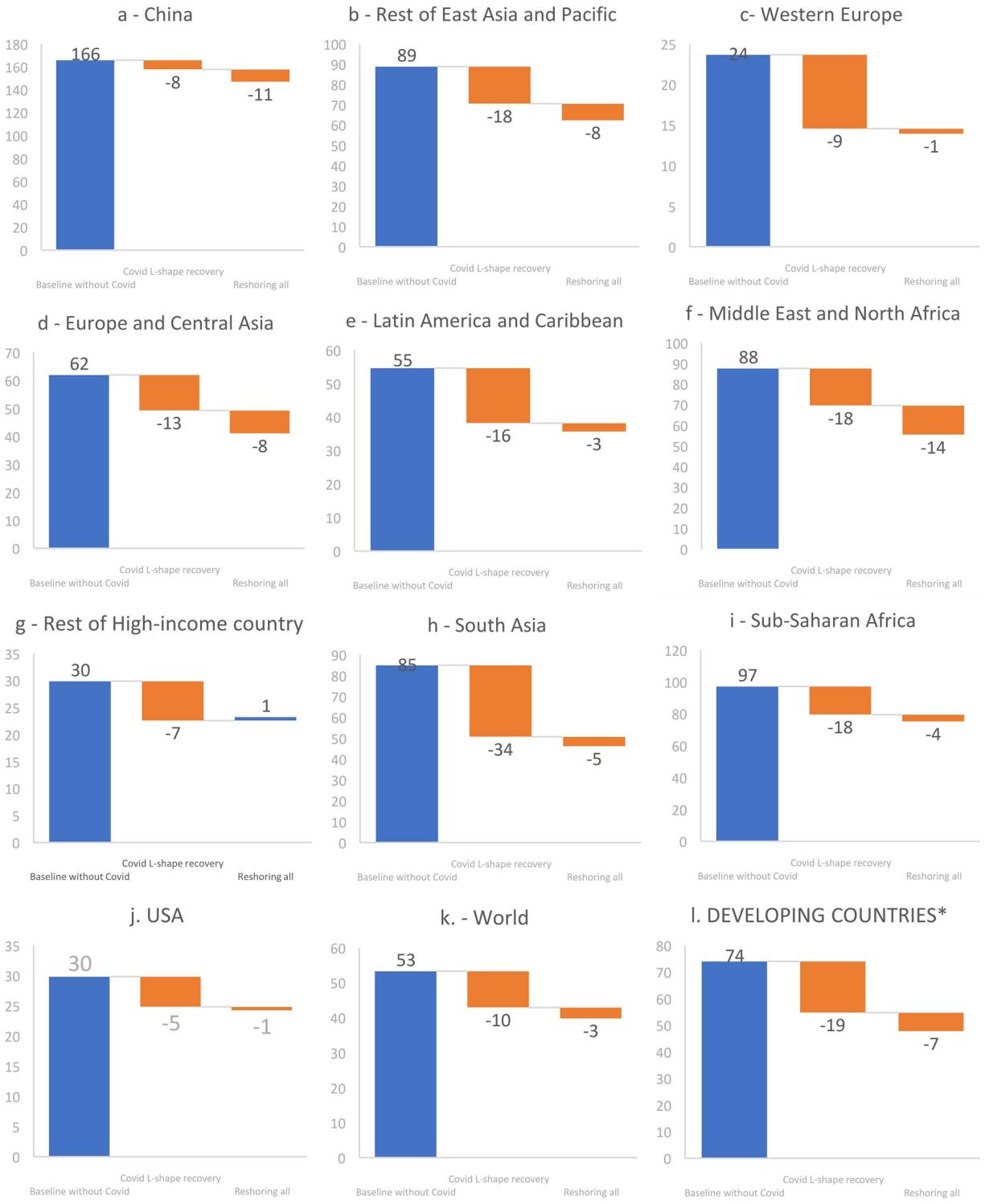
The COVID-19 pandemic has been both a supply and a demand shock. The supply shock was sparked by lockdowns shutting down production. The demand shock was caused by a drop in the ability and willingness of consumers to consume, shifting expenditures away from services that required human interaction and toward goods necessary to work from home. Looking at the long run impacts of COVID-19, it is the developing countries that are the most affected in the COVID L-shape recovery scenario, with South Asia showing the slowest recovery (a difference of 31 percentage points between real income growth between 2019 and 2030 in the no-COVID-19 baseline and an L-shape recovery from COVID-19). Developed countries also see their real income levels reduced in an L-shape recovery scenario, with China and the United States losing respectively 8 and 5 percentage points (Figure 3.a and 3.j), but still doing better than Western Europe (with a drop of 9 percentage points by 2030) (Figure 3.c).

Welfare in the Middle East and North Africa, China, Rest of East Asia and Pacific, and Europe and Central Asia is hit the hardest by reshoring of production.[10] Developing countries are the most negatively affected in a reshored world, with the Middle East and North Africa, Rest of East Asia and Pacific, and Europe and Central Asian regions being hit the most severely. In the case of the Middle East and North Africa, the real income growth between 2019 and 2030 would amount to 70 percent in an L-shape recovery, compared to a 56 percent increase in a reshored world. Developing countries also stage a slower recovery in a reshored world, with China's real income growth rate reduced by 11 percentage points in a world where all countries attempt to reshore. In the rest of East Asia and Pacific (EAP), the decline in real income could be even more dramatic, dropping from an increase of 71 percent under an L-shape recovery to 62 percent under reshoring. This is due to much higher levels of openness and integration in GVCs in the EAP region.

In terms of exports, reshoring would see South Asia suffer the biggest export drop with China recording the biggest drop in imports (Figure 4). When all countries reshore their production, the region of South Asia sees the highest reduction of exports (a 45 percentage points drop from a global world with COVID to a reshored world), followed by China (37 percentage points reduction), and the rest of East Asia and Pacific (34 percentage points difference). These are all regions that are deeply integrated in the GVC network. The highest reductions of imports between a globalized and reshoring world would be seen in China (42 percentage points drop), Rest of East Asia and Pacific (35 percentage points reduction), and Sub-Saharan Africa (33 percentage points decrease). In a world where all countries attempt to reshore their production, both global exports and global imports go down by 27 percent, changing from 25 percent growth in the COVID-19 scenario without reshoring, to a 2 percent decrease in the scenario with reshoring.

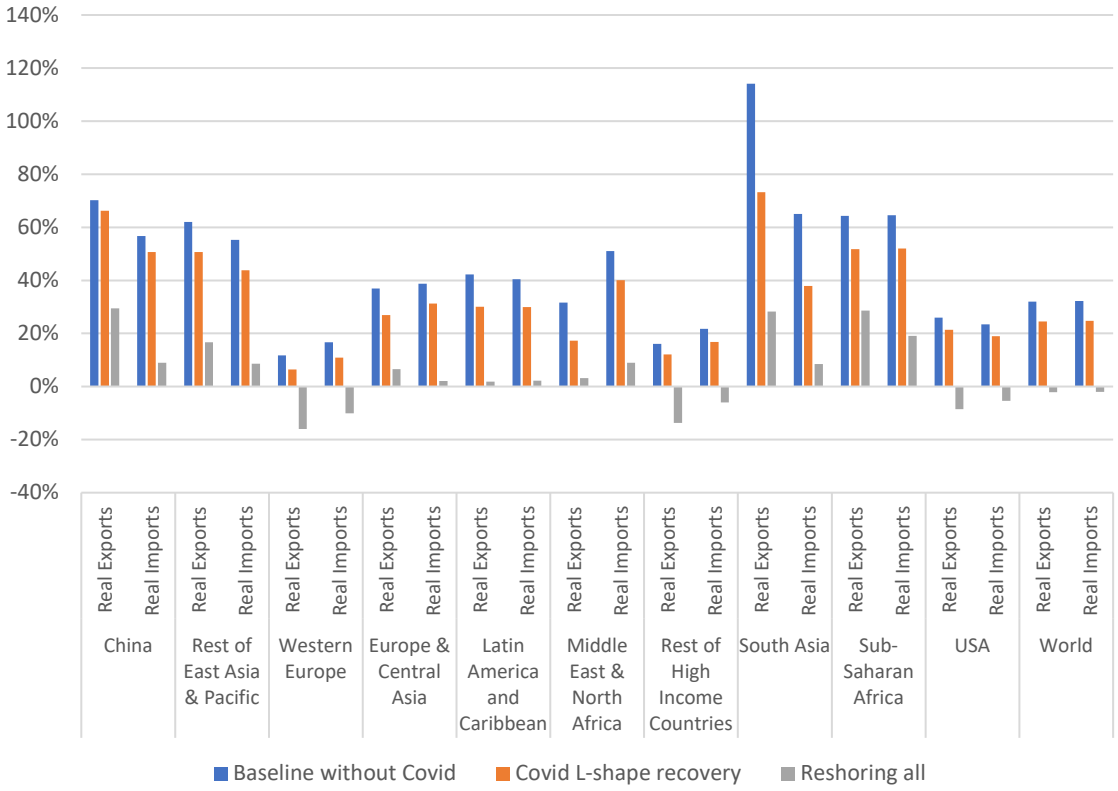
[10] All percentage changes in this and the following paragraph are stated relative to the 2019 baseline without COVID-19.

Figure 3. Change in real income in 2030 relative to 2019 (percent)



* Includes all developing regions
Source: ENVISAGE simulations.

Figure 4. Real exports and real imports in 2030 w.r.t 2019 following reshoring(%)



Source: ENVISAGE simulations.

Rethinking GVC restructuring

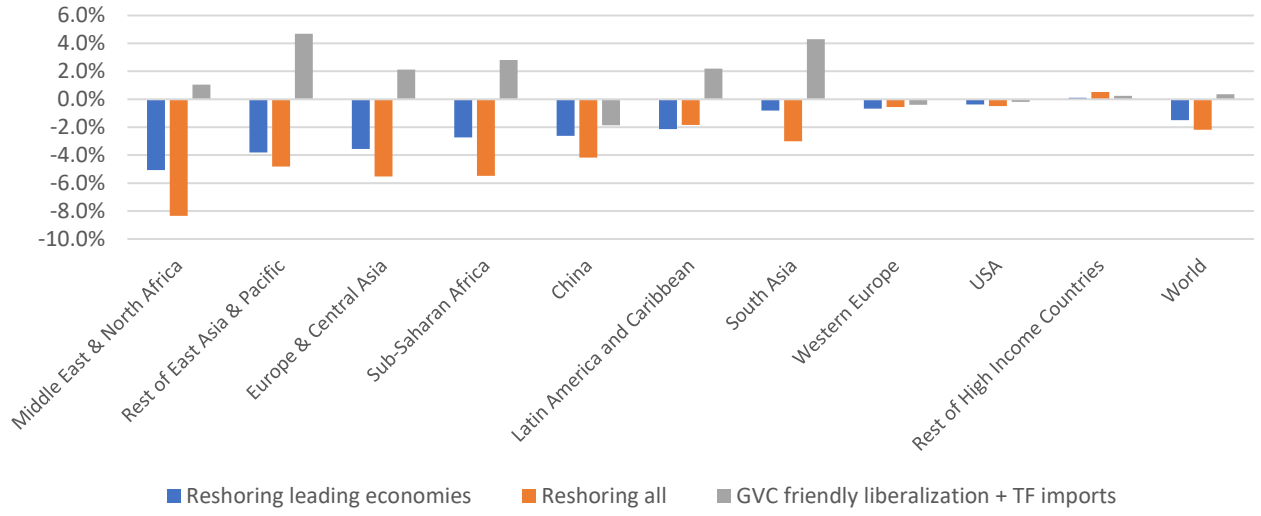
The economic impact of COVID-19 has fueled an already heated debate about the benefits and costs of global supply chains, yet reshoring would have a negative impact in most regions. The pandemic has highlighted the role of GVCs as channels for the faster spread of shocks, resulting in higher risks and vulnerabilities to external disruptions. With this assumption in mind, countries might be tempted to restructure their GVCs. A possible scenario is a reshoring of production by the leading economies and China, which would have a noticeably negative impact in most regions, particularly in developing regions, leaving them more vulnerable. Global real income would decrease by 1.5 percent, compared with the COVID L-shape recovery. China sees its real income falling by 2.6 percent. The regions that are more negatively affected are the Middle East and North Africa, with a drop in real income of 5.1 percent, followed by East Asia and Pacific with 3.8 percent, and Europe and Central Asia with 3.5 percent.

The best policy response to reshoring by leading countries is to make developing economies more GVC-friendly rather than responding in kind. To counter this sharp negative impact on regions that are highly dependent and integrated in the GVC, countries may be tempted to respond in kind by pursuing their own reshoring policies. Or they can follow a more GVC-friendly liberalization approach. As our analysis indicates, having all economies reshore would compound the damage done by leading economies reshoring their production. In fact, global real income would drop by 2.2 percent, versus 1.5 percent if only leading economies reshore. China would suffer a decrease of 4.2 percent in real income, a further loss of 1.6 percentage points compared to the previous scenario. The most negatively affected regions

are once more the developing regions, with the Middle East and North Africa decreasing up to 8.3 percent in a global reshoring war. The rest of the high-income countries would see a slight increase in real income, due mainly to the terms of trade effect.

Closer integration in the global economy would pay dividends for developing countries. Eliminating input tariffs and implementation of trade facilitation measures would strengthen the integration of developing countries in regional and global value chains. An alternative response by developing countries to the reshoring of production by the leading economies would be to alleviate its negative impacts with more GVC-friendly policies and support for more integration. The gains would be evident in all developing regions. In global terms, real income increases by 0.4 percent compared to the COVID L-shape recovery. East Asia and Pacific and South Asia are the regions which stand to benefit the most, with real income increasing 4.7 percent and 4.3 percent, respectively. In other words, GVC-friendly policies could reverse the real income losses inflicted by the reshoring efforts of the leading economies (Figure 5).

Figure 5. Real income compared with COVID L-shape recovery – 2030 (%)



Source: ENVISAGE simulations.

Reshoring by the leading economies would drastically reduce exports and imports for most regions (Table 1). Global exports and global imports both see a decrease of 17 percent in this scenario in 2030. The deepest declines in trade would be for the countries engaging in the reshoring policies, with declines in export for China, the United States, and Western Europe, ranging from 20 to 25 percent. Developing regions would suffer collateral damage, with exports declining in the range of 1 to 5 percent. But in the scenario in which developing countries also attempt to reshore, losses in trade for the developing countries are much larger. Compared to a scenario in which only leading economies reshore, losses in exports in the case where developing countries also reshore increase from 4.3 percent to 26.0 percent for South Asia, from 2.9 percent to 22.7 percent in Latin America, and from 1.3 percent to 12.1 percent in MENA.

However, if developing regions choose to follow the GVC-friendly path, the global exports and global imports reduction is less pronounced. As compared with doing nothing or reshoring, both of which would lead to declining trade for developing countries, a policy of GVC-friendly liberalization would actually lead

to increases in trade in developing regions, ranging from an increase of about 12 percent in imports and exports for MENA, to an increase of 18 percent for exports and more than 25 percent for imports in South Asia. Similarly, developing regions enjoy increases in real incomes in the *GVC Friendly Liberalization and Trade Facilitation* scenario. This illustrates dramatically that despite choices made by the high-income economies and China, developing countries can be in control of their own trade outcomes rather than passive victims of the decisions of others.

Table 1**.** Real income, real exports and real imports compared with COVID L-shape recovery – 2030 (%)

	Real Income			Exports			Imports		
%	Reshoring leading economies	Reshoring all	GVC friendly liberalization + TF imports	Reshoring leading economies	Reshoring all	GVC friendly liberalization + TF imports	Reshoring leading economies	Reshoring all	GVC friendly liberalization + TF imports
Middle East & North Africa	-5.1	-8.3	1.1	-1.3	-12.1	11.6	-9.9	-22.2	12.3
Rest of East Asia & Pacific	-3.8	-4.8	4.7	-4.7	-22.6	14.2	-9.4	-24.4	20.4
Europe & Central Asia	-3.5	-5.5	2.1	-0.8	-16.1	12.0	-8.4	-22.2	14.2
Sub-Saharan Africa	-2.7	-5.5	2.8	-3.0	-15.2	11.3	-9.0	-21.6	15.8
China	-2.6	-4.2	-1.9	-20.8	-22.1	-20.4	-22.8	-27.7	-20.5
Latin America and Caribbean	-2.1	-1.8	2.2	-2.9	-21.7	12.6	-8.2	-21.4	17.1
South Asia	-0.8	-3.0	4.3	-4.3	-26.0	18.3	-6.7	-21.3	25.5
Western Europe	-0.7	-0.6	-0.4	-22.2	-21.1	-22.8	-19.7	-19.0	-19.7
United States	-0.4	-0.5	-0.2	-24.9	-24.7	-25.2	-20.1	-20.5	-19.4
Rest of High Income Countries	0.1	0.5	0.3	-24.2	-23.0	-25.0	-20.9	-19.5	-21.0
World	-1.5	-2.2	0.4	-17.0	-21.4	-12.6	-16.9	-21.5	-9.2

Source: ENVISAGE simulations.

Reshoring by leading economies hits developing countries hard, but selected sectors could see their exports expand as trade is diverted from leading economies to the rest of the world (Table 2). When leading economies reshore their production, some sectors see expansion of their exports, even in regions that were badly hit, such as MENA, which sees its computer and electronics sector expanding by 43 percent compared to the COVID L-shape recovery (highest increase within the region). Some of the biggest increases are recorded in the livestock sector in South Asia (103 percent) and in China (51 percent), and in the computer and electronics sector in Sub-Saharan Africa (51 percent).

Sectoral exports are hit hard when developing countries reshore. When developing economies respond in kind to reshoring by leading economies, this aggravates the impact on exports. Developing countries, which before enjoyed expansion in certain sectors, now suffer contraction. In East Asia and Pacific, where

motor vehicles exports were increasing by 17 percent in the reshoring by leading economies are now contracting by 18 percent. In Europe and Central Asia where computer and electronics were expanding 45 percent before, they are now decreasing by 1 percent.

Table 2. Sectors with top three increases in exports for the "Reshoring leading economies" scenario. Exports compared with COVID L-shape scenario

Country/region	Sector	Reshoring leading economies	Reshoring all	GVC friendly liberalization + TF imports
China	Livestock	51	101	51
	Accommodation, food and service activities	2	4	-1
	Meat products (inc. fisheries) and other food	2	20	-4
Rest of East Asia & Pacific	Motor vehicles, parts and transport equipment	17	-18	57
	Refined oil	16	-19	36
	Computer, electronic and optical products	7	-27	41
Western Europe	Electricity	-3	-5	-6
	Communications	-4	-6	-5
	Natural resource products	-4	-2	-6
Europe & Central Asia	Computer, electronic and optical products	45	-1	97
	Motor vehicles, parts and transport equipment	15	-14	35
	Other manufacturing	15	-14	39
Latin America and Caribbean	Computer, electronic and optical products	21	-12	41
	Air transport	18	3	22
	Wood and paper products	13	-12	36
Middle East & North Africa	Computer, electronic and optical products	43	-7	123
	Metals	11	-13	17
	Motor vehicles, parts and transport equipment	9	-17	29
Rest of High-Income Countries	Natural resource products	7	5	5
	Air transport	0	3	-4
	Electricity	0	-3	-3
South Asia	Livestock	103	129	103
	Motor vehicles, parts and transport equipment	26	-26	71
	Computer, electronic and optical products	26	-31	124
Sub-Saharan Africa	Computer, electronic and optical products	51	5	115
	Motor vehicles, parts and transport equipment	18	-12	70
	Refined oil	14	-20	25
United States	Natural resource products	3	2	0
	Electricity	-1	-4	-5
	Non-metallic minerals	-4	-9	-5
World	Natural resource products	-2	-5	-4
	Electricity	-3	-7	-6
	Metals	-3	-9	-6

Source: ENVISAGE simulations.

Eliminating intermediate input tariffs and implementation of trade facilitation measures under *GVC-friendly* scenario leads to faster integration of developing countries into regional and global value chains. Exports of several sectors deeply integrated into GVCs expand such as motor vehicles and transport equipment in Sub-Saharan Africa, or computer, electronic, and optical products in South Asia. Table 3 displays percentage increases as compared to the COVID L-shape recovery scenario. Often these impressive export growth rates apply to a very small base. In value terms, the fastest increase of exports

is likely to occur in different sectors, e.g. metals and metal products, motor vehicles, textiles and apparel in Sub-Saharan Africa, or other manufacturing, chemical products, motor vehicles, crops, and textiles in South Asia.

Table 3. Top 3 import sectors for the Reshoring leading economies scenario. Exports compared with COVID L-shape scenario

Country/region	Sector	Reshoring leading economies	Reshoring all	GVC friendly liberalization + TF imports
China	Electricity	5	-1	2
	Natural resource products	1	-2	-1
	Air transport	1	-5	-1
Rest East Asia & Pacific	Oil extraction	5	-25	-2
	Metals	4	-12	-8
	Computer, electronic and optical products	3	-25	8
Western Europe	Electricity	-4	-6	-6
	Metals	-4	-3	-8
	Non-metallic minerals	-6	-8	-8
Europe & Central Asia	Metals	7	-6	-11
	Natural resource products	3	-10	-11
	Non-metallic minerals	0	-11	-13
Latin America and Caribbean	Oil extraction	5	-35	23
	Metals	3	-10	-15
	Computer, electronic and optical products	3	-14	-9
Middle East & North Africa	Metals	3	-9	-14
	Natural resource products	0	-6	-17
	Water transport	-2	-11	-1
Rest of High-Income Countries	Natural resource products	-3	-2	-7
	Electricity	-4	-6	-7
	Livestock	-6	-9	-7
South Asia	Gas extraction and distribution	3	-22	-7
	Oil extraction	1	-17	-15
	Natural resource products	0	-7	-11
Sub-Saharan Africa	Metals	3	-10	-17
	Gas extraction and distribution	3	-9	-15
	Non-metallic minerals	1	-10	-18
United States	Metals	1	-1	-2
	Electricity	-1	-4	-4
	Non-metallic minerals	-3	-6	-5
World	Natural resource products	-1	-5	-6
	Electricity	-3	-7	-6
	Metals	-3	-9	-10

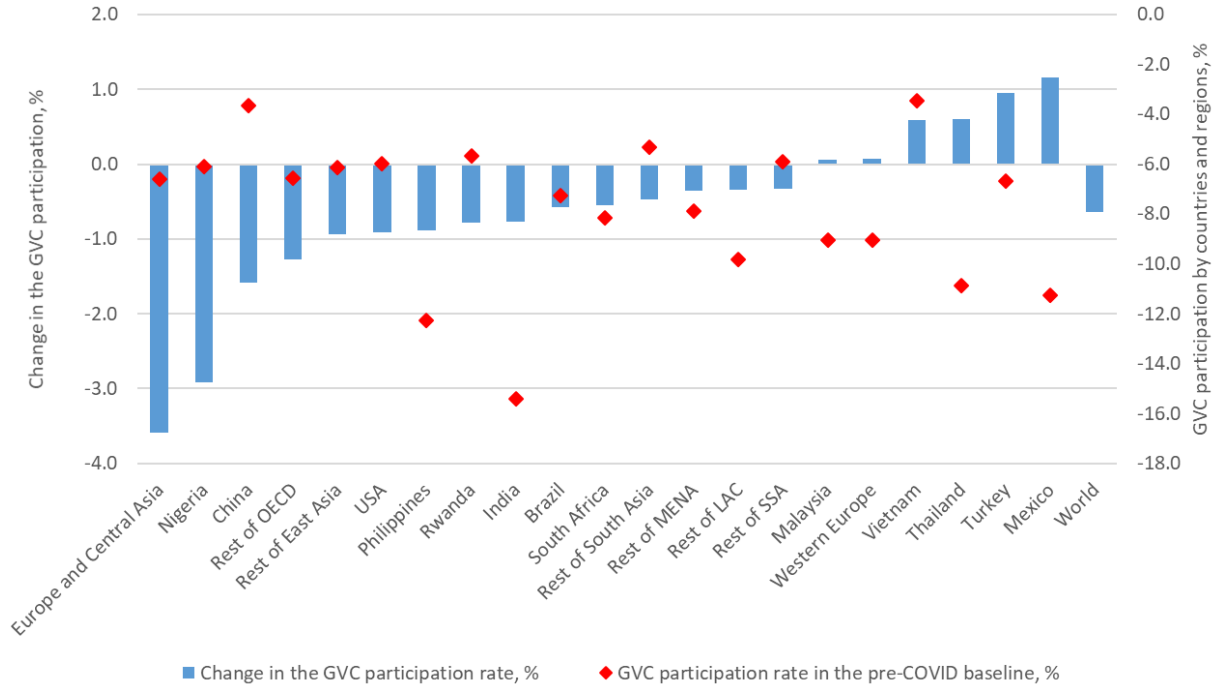
Source: ENVISAGE simulations.

Implications for GVC participation

With the reduction in the level of the economic activity due to the COVID-19 pandemic, overall trade participation rate by countries is also decreasing. While results suggest that due to the changes in trade

patterns, some countries might experience moderate increase in the GVC participation rate,[11] global average GVC participation decreases by around 0.6% in 2020 compared to the pre-COVID baseline (Figure 6) Europe and Central Asia (ECA) and Nigeria experience the largest reduction in the GVC participation. As discussed below, transportation, accommodation and recreation services are the activities that are impacted the most by to the COVID-19 pandemic and thus are driving the observed results for the regions. Looking at the aggregate GVC participation rate across these three activities by countries and regions,[12] both ECA and Nigeria are at the top of this list, with a corresponding indicator for ECA being 3.3% and for Nigeria 4.7%. High involvement in trade in these service activities explains why these two regions are impacted the most adversely.

Figure 6. Impacts of the COVID-19 on the GVC participation by countries and regions, % change in 2020 relative to the the pre-COVID baseline



Source: ENVISAGE simulations.

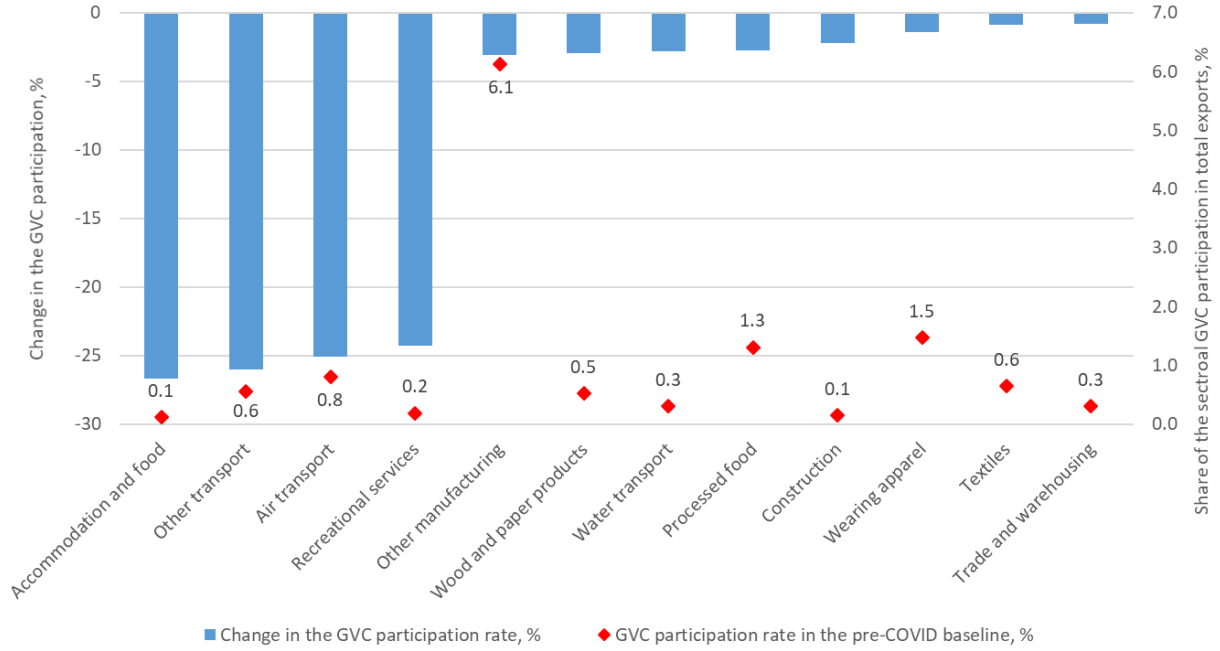
At the sectoral level, accommodation and food activities, road, rail and air transport, as well as recreational services are impacted the most and face a reduction in the GVC participation rate of around 25% in 2020 relative to the pre-COVID baseline (Figure 7). Recreation and accommodation services both require in-person interactions that have been significantly limited by the COVID pandemic. Demand for the transportation services has been impacted both by the reduction in the business travel and lower demand for the international tourism-related travel, as well as lower public transport demand and commuting in general due to the teleworking. Among these four activities, air transportation services have the highest involvement in GVCs (0.8% global average share in the aggregate exports), while accommodation and recreation services have a corresponding share of 0.1% and 0.2% respectively. The latter two even with a significant reduction in the GVC participation rate do not have a major overall impact.

[11] GVC participation rate is calculated as the sum of domestic value added in the foreign export (forward participation) and foreign value added in domestic export (backward participation) (Koopman et al. 2010).

[12] GVC participation rate as a share of aggregate exports by the corresponding country or region.

Among the most impacted sectors in terms of the GVC participation rate, other manufacturing has the highest global average share in total exports, which equals 6.1% (Figure 7). Relatively significant impact of the COVID-19 on this sector can explain larger reduction in the total GVC participation rate for such large economies like China and United States (Figure 6), where other manufacturing plays a significant role in their trade and production structures.

Figure 7. Impacts of the COVID-19 on the GVC participation by sectors (global average), % change in 2020 relative to the pre-COVID baseline for the most impacted sectors



Source: ENVISAGE simulations.

Changes in the post-COVID GVC participation rate would largely depend on the type of policies that countries implement. Under the scenario, where both leading economies and developing countries choose to reshore their production by increasing trade barriers and providing subsidies to the domestic producers (Reshoring all scenario), global average GVC participation rate for the sectors highly involved into GVCs (MRIO sectors)[13] could fall by over 6% in 2030 relative to the post-COVID baseline. If only leading economies would implement the reshoring policies and developing countries would not respond in-kind, this would have a positive impact on the GVC participation rate for the latter group of economies, with such GVC-integrated countries like Malaysia, Thailand and Vietnam experiencing at least a 5% increase in their GVC participation rate (aggregate over MRIO sectors).

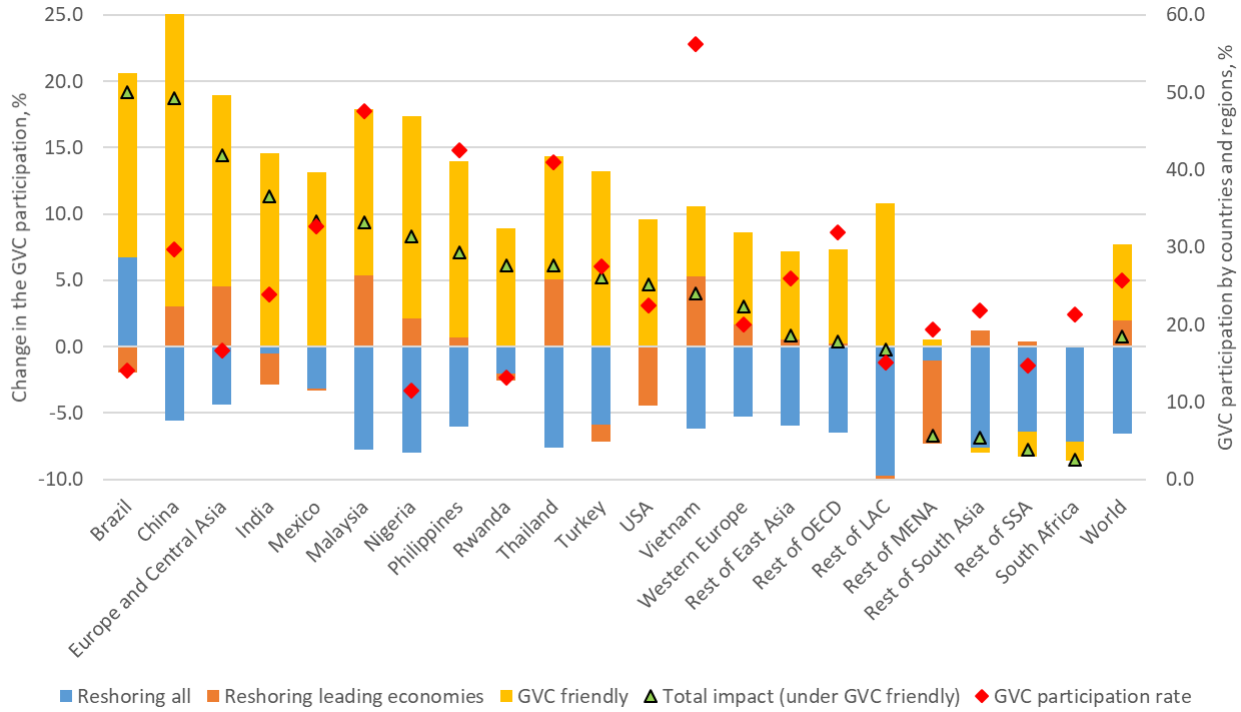
Most of the leading economies would benefit from the non-implementation of reshoring efforts by developing countries, with China benefiting the most as its GVC participation for the MRIO sectors increases by around 3% (Figure 8). Implementation of the GVC friendly liberalization and trade facilitation efforts by the developing countries would have a major positive impact on the GVC participation for the MRIO sectors. For most developing countries, corresponding change is above 10%. Implementation of the GVC friendly policies by developing countries even overweighs negative impacts of the reshoring by

[13] MRIO sectors are identified in Table A.2 (Annex A). These sectors mostly cover manufacturing activities that have a high participation rate in GVCs.

leading economies in terms of the global average GVC participation rate for the MRIO sectors, so that the latter one moderately increases by around 0.8%.

Even under the GVC friendly scenario some developing countries experience reductions in the GVC participation rate for the MRIO sectors (Figure 8). In particular, these include some South Asian, African and MENA countries. All these countries are not heavily involved into the trade in manufacturing goods (MRIO sectors), while most of their exports include agricultural and energy commodities that face lower participation in the GVC, as the GVC friendly policies in our simulations have a focus on the MRIO sectors.

Figure 8. Change in the GVC participation for the MRIO sectors by regions compared with post-COVID baseline decomposed by scenarios in 2030, percent

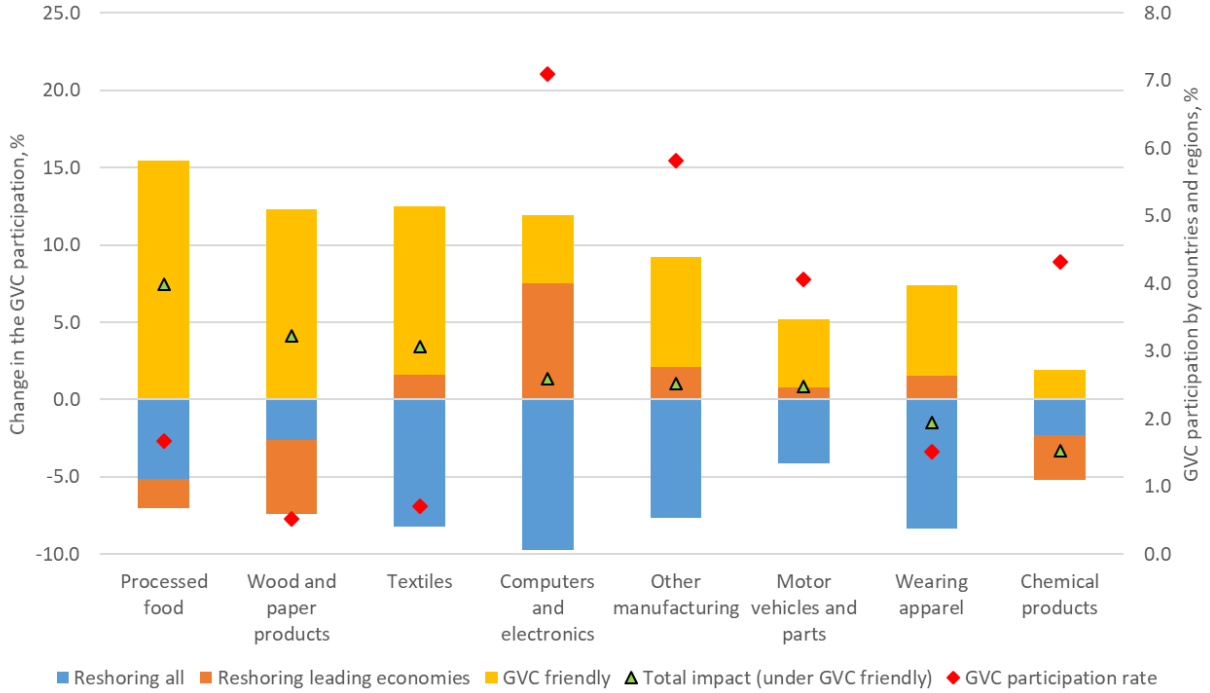


Notes: Columns on the figure report a decomposition of the trade policy impacts. "Reshoring all" case provides impacts relative to the post-COVID baseline; "Reshoring leading economies" case reports impacts relative to the "Reshoring all" case; and "GVC friendly" option measures impacts relative to the "Reshoring leading economies" case. "Total impact" reports the sum over all three bars and corresponds to the impact of the "GVC friendly" scenario relative to the post-COVID baseline case. Countries and regions on the chart are sorted based on the aggregate impact of the "GVC friendly" scenario in the descending order.
Source: ENVISAGE simulations.

Trade liberalization and GVC friendly policies also tend to increase the GVC participation rate at the sectoral level (Figure 9). If all countries implement reshoring efforts, GVC participation falls for all MRIO sectors, with textiles, wearing apparel, electronics and other manufacturing being impacted the most (reduction of 8%-10%) (Figure 9). On the other hand, if developing countries do not implement reshoring policies, GVC participation increases in most MRIO sectors with computers and electronics being impacted the most. The latter result is in line with the distribution of the regional impacts of this scenario, where largest producers of electronics in Asia (China, Thailand, Malaysia, Vietnam) were main benefiters (Figure 8). Implementation of the GVC friendly policies boosts GVC participation rate in all sectors (Figure 9), benefiting not only those with a high involvement into GVC (e.g. computers, electronics, other

manufacturing), but also sectors with a lower rate of the GVC participation (processed food, wood products and textiles).

Figure 9. Change in the global average GVC participation for selected sectors compared with post-COVID baseline decomposed by scenarios, percent



Notes: Columns on the figure report a decomposition of the trade policy impacts. "Reshoring all" case provides impacts relative to the post-COVID baseline; "Reshoring leading economies" case reports impacts relative to the "Reshoring all" case; and "GVC friendly" option measures impacts relative to the "Reshoring leading economies" case. "Total impact" reports the sum over all three bars and corresponds to the impact of the "GVC friendly" scenario relative to the post-COVID baseline case. Sectors on the chart are sorted based on the aggregate impact of the "GVC friendly" scenario in the descending order.
Source: ENVISAGE simulations.

Country focus

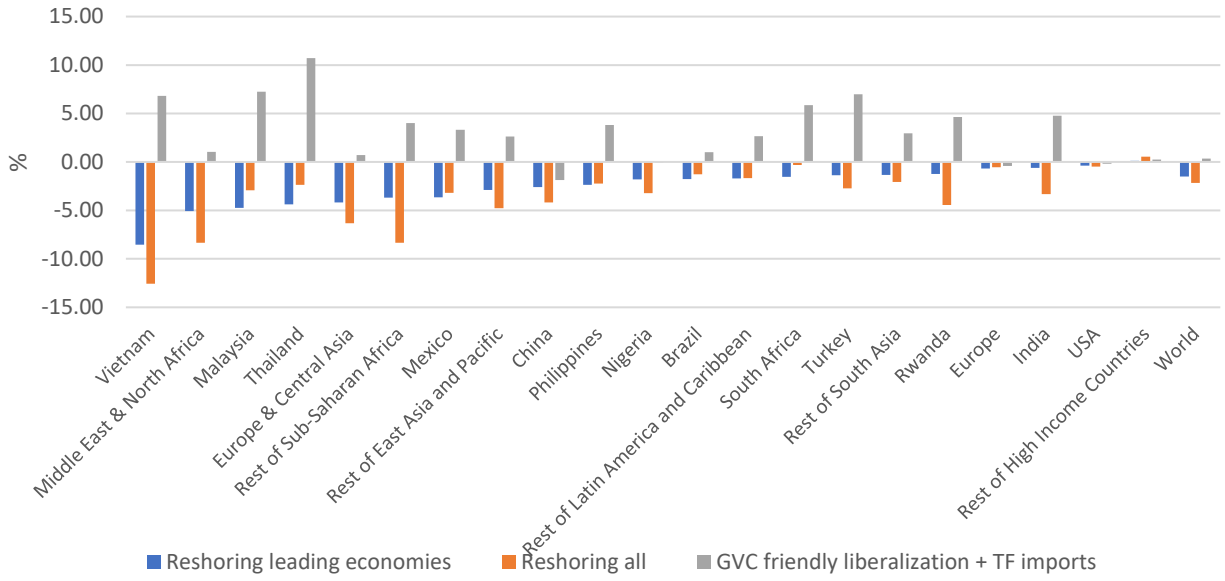
When leading economies reshore their production, the impact on real income is going to be uneven across countries, with most of the losses falling in countries that are the most deeply integrated into GVCs. Vietnam and other countries in the East Asia and Pacific (EAP) region are hit the most because they are deeply integrated in the network of GVCs, with most of their final demand still coming mainly from developed economies. The reshaping of GVCs by the developed economies translates into heavy losses in real income in Vietnam (-9 percent), Malaysia (-4.7 percent), and Thailand (-4.4 percent) (Figure 10). The Middle East and North Africa (-5.1) also sees a high reduction of real income due to a reduction of exports of oil and a reduction in oil prices. The United States (-0.4 percent), India (-0.6 percent) and Europe (-0.7 percent) are also worse off and register modest reductions in real income.

Own reshoring efforts hurt the poorest and least integrated regions as well as those that are highly integrated. Sub-Saharan Africa's real income further drops by 4.7 percentage points, becoming one of the regions that suffers the highest reductions of real income (with an overall income reduction of 8.3 percent), illustrating the damaging effects of reshoring production in developing countries. In this scenario, Vietnam, a country that has emerged as an Asian manufacturing powerhouse, is hit the most by this global reshoring, seeing its real income drop by 12.6 percent relative to the COVID L-shape recovery

scenario (a reduction of 4.1 percentage points from the reshaping leading economies scenario). A small number of countries see their real income decrease less in this scenario. For example, Thailand, where real income was expected to decline by 4.4 percent in the *Reshoring leading economies* scenario, now in the *Reshoring All* scenario sees its real income decrease by 2.4 percent (a positive difference of 2 percentage points – the highest increase between *Reshoring leading economies* and *Reshoring All* from all countries and regions). This relative gain in income is driven by terms of trade effects as real GDP decline is still higher under *Reshoring All* scenario.

Implementing GVC-friendly policies reverses the losses due to reshoring by leading economies in all regions. Instead of reshoring their production, developing countries have the option to counteract reshoring policies, by generating a more GVC-friendly environment, which leads to faster growth of trade and income and deeper integration into GVCs in line with their comparative advantages. Countries that were previously already deeply integrated are the ones expected to see the highest gains, with Thailand (10.7 percent), Malaysia (7.2 percent), Turkey (7 percent), and Vietnam (6.8 percent) benefiting the most from this approach (Figure 10). On the other hand, the only countries showing losses in terms of real income are the countries reshoring their production, i.e. China (-1.9 percent), followed by Europe (-0.4 percent), and the United States (-0.2 percent). However, it is noteworthy that each of these losses are smaller than in each of the previous scenarios. In fact, developed countries and China are better off in a scenario where developing countries implement GVC-friendly measures.

Figure 10. Real income compared with COVID L-shape recovery under reshoring by leading economies, by all countries and in the GVC-friendly scenario in 2030 (deviations from the L-shape COVID recovery, percent)



Source: Envisage simulations.

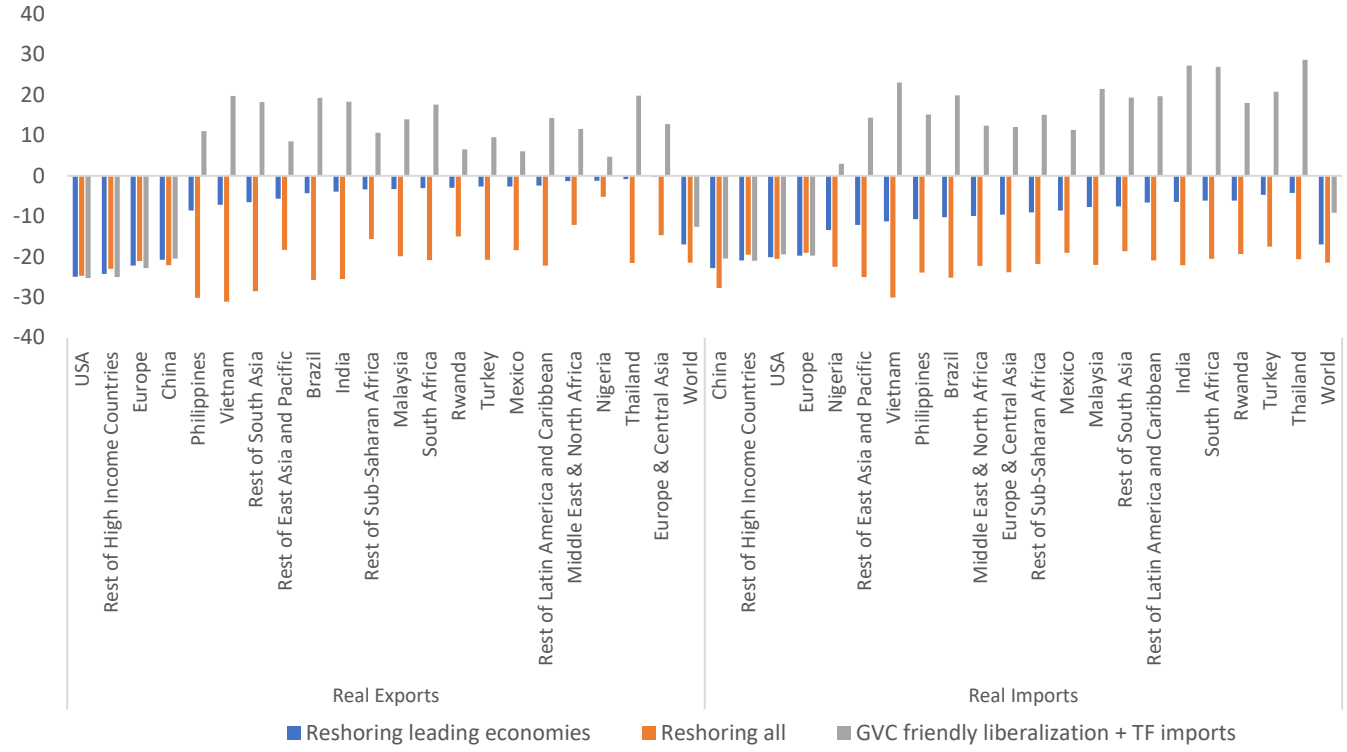
The reshoring of production by the leading economies will inevitably lead to a decrease in global trade by 17 percent. Highest losses are concentrated in developed countries. The countries suffering the highest reduction in exports are the United States (-24.9 percent), rest of high-income countries (-24.2 percent), Europe (-22.2 percent) and China (-20.8 percent) (Figure 11). Developing countries also suffer a reduction in exports, albeit to a lesser degree. The Philippines, the developing country that has the highest reduction

of exports, sees its exports going down by 8.6 percent relative to the COVID L-shape recovery scenario. In terms of imports, all the developed regions including China (-22.8 percent), rest of high-income countries (-20.9 percent), the United States (-20.1 percent) and Europe (-19.7 percent), register the highest reductions. The developing country with the highest reduction is Nigeria, where imports drop by 13.4 percent.

Reshoring production leads to a significant drop in global trade flows. Developing countries register the highest reductions, with Vietnam (-30.1 percent), the Philippines (-30.1 percent), and rest of South Asia (-28.5 percent) (Figure 11) expected to see the highest reductions of exports. In terms of imports, Vietnam (-30.1 percent), China (-27.7 percent), and Brazil (-25.1 percent) register the biggest declines. The destructive consequences of this scenario are illustrated in the case of a country like Vietnam, where GVCs play an essential role in the economy, helping boost economic growth and reduce poverty. Such massive reductions in trade, a direct consequence of countries shifting their production home, have a devastating impact on welfare.

Where developing countries implemented GVC-friendly policies, all developing countries see their exports and imports increase relative to the COVID L-shape recovery scenario. The only reductions observed are in developed countries, with the United States experiencing the biggest decrease in exports (-25.2 percent), and the rest of high-income countries in imports (-21 percent). The countries with the highest increases of exports are Thailand (19.8 percent), Vietnam (19.8 percent), and Brazil (19.3 percent), while the highest increases of imports are expected in Thailand (28.6 percent), India (27.2 percent), and South Africa (26.9 percent). In terms of trade, the implementation of policies that follow a more GVC-friendly approach not only counteracts the negative impact that a reshoring by leading economies may bring, but also generates gains that go beyond the COVID L-shape recovery scenario, helping to mitigate the damaging effect that the pandemic has had in developing countries.

Figure 11. Real exports and real imports compared with COVID L-shape recovery – 2030 (%)



Source: Envisage simulations.

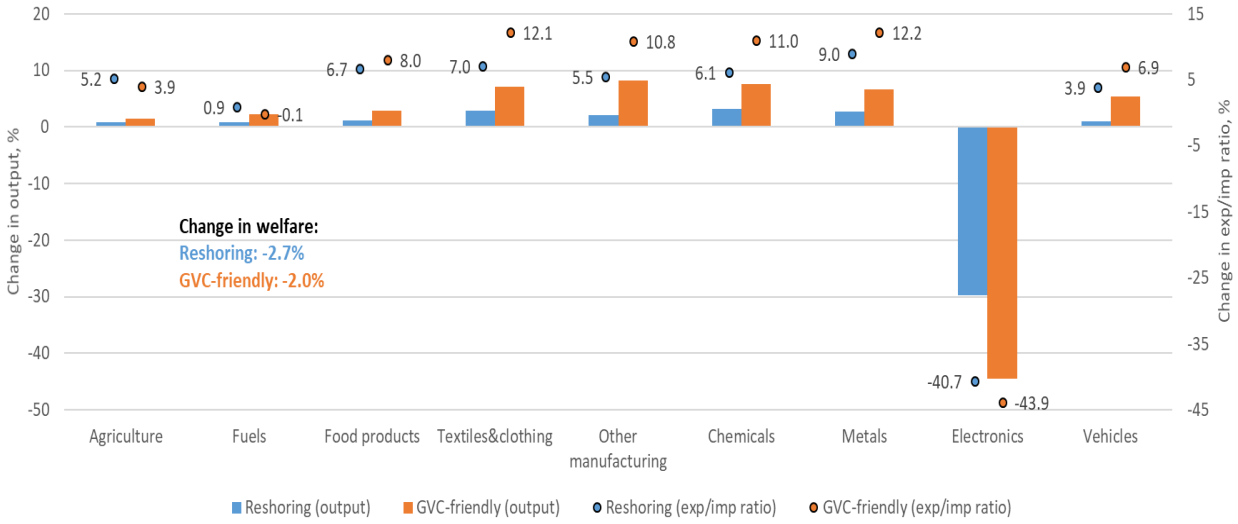
Resilience to supply shocks and reshoring efforts

Becoming more GVC-friendly makes developing countries more resilient to supply shocks. In the *Reshoring All* scenario and the *GVC-friendly* scenario countries have different abilities to adapt to external shocks. In the *Reshoring All* world, countries face higher trade barriers and have less ability to substitute between domestic and imported commodities, as well as choose between different import sources. At the same time, in the *GVC-friendly* world both developed and developing regions are more resilient in the face of disruptions in production or supply chains.

A *GVC-friendly* world provides better shock absorbers than the localized world. In this section we showcase such difference by looking into a stylized experiment where we estimate impacts of a hypothetical supply shock in Thailand and its disruption to the supply chain of electronics in a similar way in which the floods impacted the output of electronics in Thailand in 2010 (e.g. Haraguchi and Lall 2015). We assume a 10 percent negative shock to the total factor productivity of Thailand's computer, electronic and optical products industry in 2027 and explore how this shock impacts both domestic and global supply chains under the *Reshoring All* and *GVC-friendly* world assumptions. In terms of the impacts on Thailand's domestic economy, in the *GVC-friendly* world, the country's real income falls by 26 percent less compared to the case when the same shock is implemented in the *Reshoring All* scenario (-2 percent vs -2.7 percent respectively) (Figure 12). Due to the lower trade barriers and higher trade substitution possibilities, output of Thailand's electronics is impacted more negatively in the *GVC-friendly* world. At the same time, output of all other sectors increases substantially (compared to the *Reshoring All* scenario), as there is a partial reallocation of resources away from electronics production towards other sectors of the economy. As a

result, while exports of electronics are hit more in the *GVC-friendly* world, exports of other commodities increase and the export-to-import ratio also grows at a higher pace for these sectors in the *GVC-friendly* world.

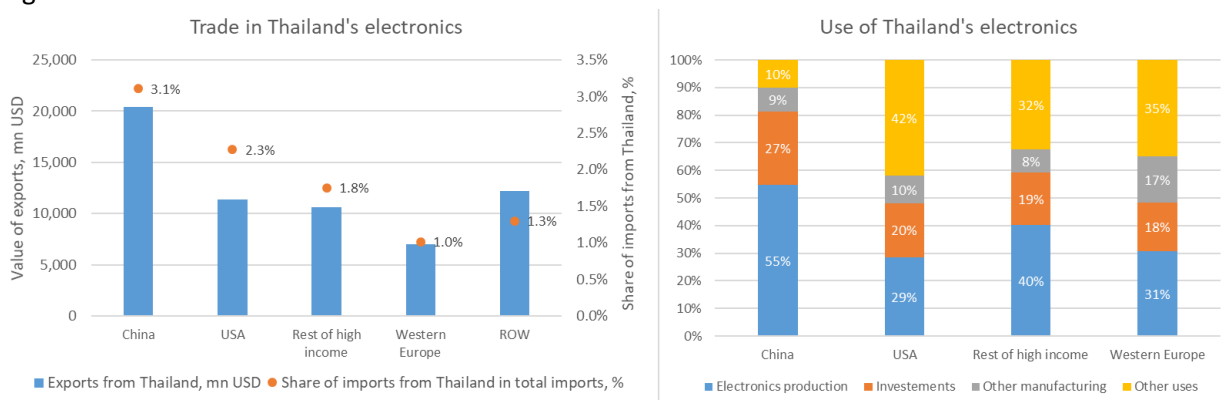
Figure 12. Impact on the economy of Thailand in 2027, % change relative to the corresponding scenario without shock



Notes: Clustered columns show changes in Thailand's output by sectors. Scatter plots show changes in the exports-to-imports ratio. All changes are shown relative to the corresponding scenario without shock to Thailand's electronics production.
Source: ENVISAGE simulations.

Reductions in electronics production in Thailand disrupt global supply chains, especially impacting large importers of Thailand's computer and electronic products, including China, the United States, Western Europe, and other high-income countries (Figure 13). On average, the share of electronics imports from Thailand in the total imports of electronics in the corresponding countries and regions is not high – reaching 3.1 percent in the case of China. The largest share of electronics imports from Thailand is used as an intermediate input in domestic electronics production. In the selected countries and regions, this share varies from 29 percent in the United States to 55 percent in China. A reduction in exports of electronics from Thailand due to supply chain disruption would be expected to hit electronics industries in the destination countries most.

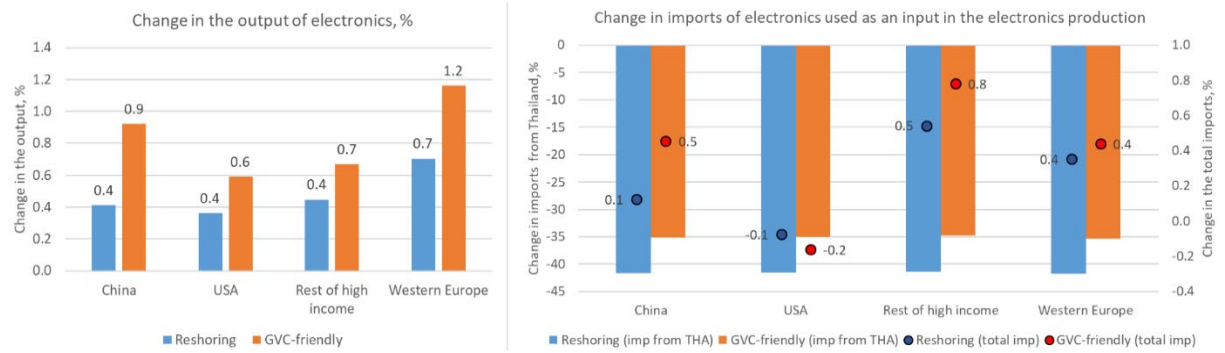
Figure 13. Trade and use of Thailand's electronics



Notes: All estimates are reported for the baseline scenario in 2030. On the right panel stacked bars indicate shares of the electronics imported from Thailand split by uses in the selected countries and regions. These uses include use of electronics as an input to the domestic electronics production (Electronics), use of electronics as an investment good (Investments), use of electronics as an input to other manufacturing (Other manufacturing) and other uses, including intermediate and final demand (Other uses).
Source: ENVISAGE simulations.

Reduced exports of electronics from Thailand would prompt its key trading partners to increase domestic production. They would do so to expand their market share, as well as to compensate for lost imports from Thailand used as intermediate inputs in the domestic electronics production process (Figure 14). In the *GVC-friendly* world though, increases in the electronics output by key producers are higher – from 50 percent (in the case of the United States) to 120 percent (in the case of China). This expansion in output under the *GVC-friendly* scenario is supported by increasing imports of electronics used as an intermediate input in the corresponding countries, but especially in China. In the *GVC-friendly* world, Thailand's economy does better than in the reshoring world. Key producers of electronics also adapt much better in a GVC-friendly future, due to lower trade barriers and better substitution opportunities.

Figure 14. Change in the output of electronics by key importers of electronics from Thailand (left panel) and change in the imports of electronics used as an input in the electronics production in selected countries and regions (right panel)



Notes: All estimates are reported for 2027 relative to the corresponding scenario without shock to Thailand's electronics production. In the right panel stacked bars indicate changes in the imports of electronics from Thailand that are used as an intermediate input for electronics production in the corresponding country. Scatter plots show changes in the aggregate imports of electronics further used as an intermediate input in domestic electronics production.
Source: ENVISAGE simulations.

5. Distributional impacts of reshoring

Before COVID-19, additional efforts were needed to put the world on track to eradicate poverty by 2030. According to our estimates, in the baseline scenario, without the effect of COVID-19, the number of people living in extreme poverty would have fallen to 375 million by 2030 – down from 663 million in 2018. This is equivalent to halving the poverty headcount ratio from 9.0 percent to 4.5 percent in 12 years. Despite the sustained trend of poverty reduction in the baseline scenario (without the effect of COVID-19), it still falls above the global target of 3 percent in the extreme poverty headcount ratio. In fact, an additional 125 million people must be lifted from extreme poverty to reach that target – as stated in the World Bank goals of ending poverty and promoting shared prosperity.

The effect of COVID-19 sent 122 million into extreme poverty, and a quarter of them will not be lifted out of extreme poverty by 2030. Our estimates under the COVID L-shape recovery indicate that extreme poverty increases to 738 million in 2020 and, as economic activity resumes, it declines to 405 million by 2030 – equivalent to a global poverty headcount ratio of 4.9 percent. Further, 122 million people fell into extreme poverty as a result of the economic and health consequences of the pandemic, and one in four of them will remain living in extreme poverty by 2030[14] (Figure 15.a). Low- and middle-income countries in South Asia will constitute the majority of the new COVID-19 induced poor, with 71 million additional people living in extreme poverty in 2020, followed by Sub-Saharan Africa with 27.7 million (Figure 15.b). By 2030, 14.4 million in South Asia and 13 million in Sub-Saharan Africa would still be living in extreme poverty as a result of the pandemic.

Reshoring production could impair recovery by increasing the number of people living in extreme poverty by 51.8 million (Figure 15.c). In the *Reshoring Leading Economies* scenario, poverty reduction resumes at a lower rate than in the L-shape recovery. By 2030, reshoring efforts by leading economies would lead to an increase in the number of people living in extreme poverty by 19.4 million. Under the *Reshoring All* scenario by 2030, 51.8 million additional people would fall into extreme poverty, the equivalent to an increase in 0.6 percent in the global extreme poverty headcount ratio. Figure 15.d shows that in both cases, under reshoring by leading or all economies, Sub-Saharan Africa is the most affected region, contributing to around 80 percent of the new poor caused by reshoring, followed by South Asia and the Middle East and North Africa region.

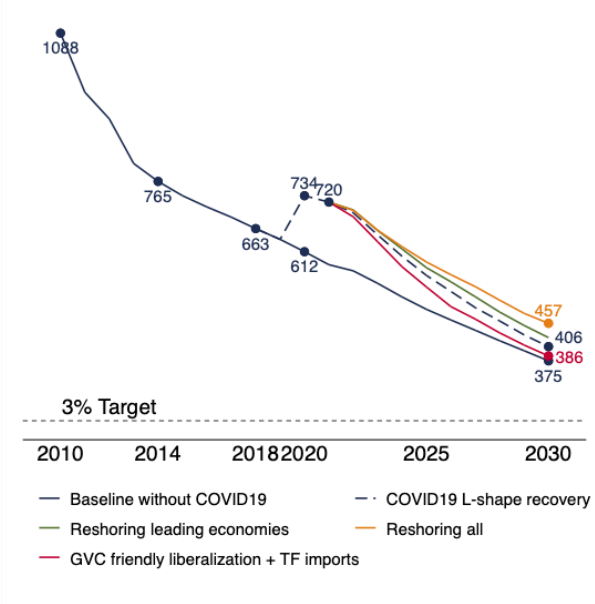
But a GVC-friendly liberalization could lift 21.5 million people from extreme poverty. The *GVC-friendly* scenario accelerates poverty reduction and brings the world close to full recovery from the effects of COVID-19. Extreme poverty would be reduced by 21.5 million people by 2030 with respect to the COVID L-shape recovery, and the global poverty headcount ratio would be 4.6 percent or 10.5 million above the baseline without the effect of COVID-19. A *GVC-friendly* scenario would help to reduce extreme poverty, particularly in South Asia, which was the region very heavily affected by the effects of COVID-19 (Figure 16). Under this scenario, 56.2 million would graduate into global middle-class status, measured as individuals with a per capita consumption of more than PPP$10.00 a day. Table 4 shows that more than half of the new entrants in the global middle-class, or 30.9 million, would be in South Asia and between 6.3 and 7.2 million would come from each of the regions of East Asia and Pacific, Latin America and Caribbean, and Sub-Saharan Africa. It is important to highlight that high-income countries would see a

[14] This is in line with the COVID-19 induced new poor presented in Lakner et al. (2020). For a useful discussion see: https://blogs.worldbank.org/opendata/updated-estimates-impact-covid-19-global-poverty-looking-back-2020-and-outlook-2021

decline of half-a-million in the number of people in middle-class status, with respect to the L-shape recovery. Therefore, high-income countries are better off if they do not implement any reshoring efforts at all.

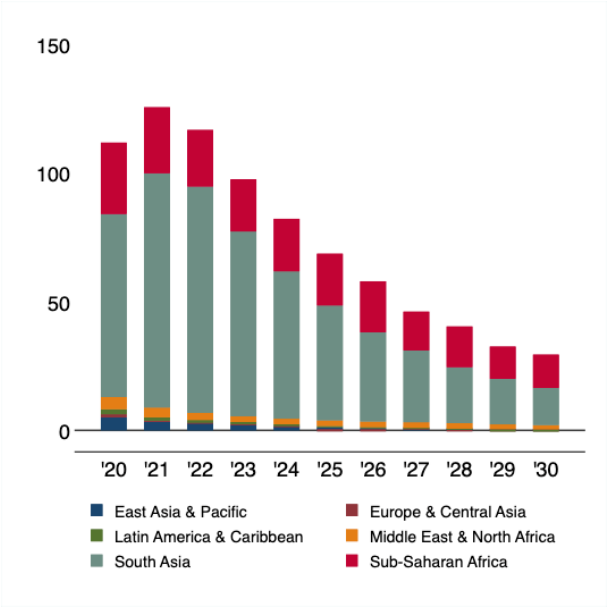
Figure 15. Distributional Impacts

a – People living in extreme poverty
by scenario, millions



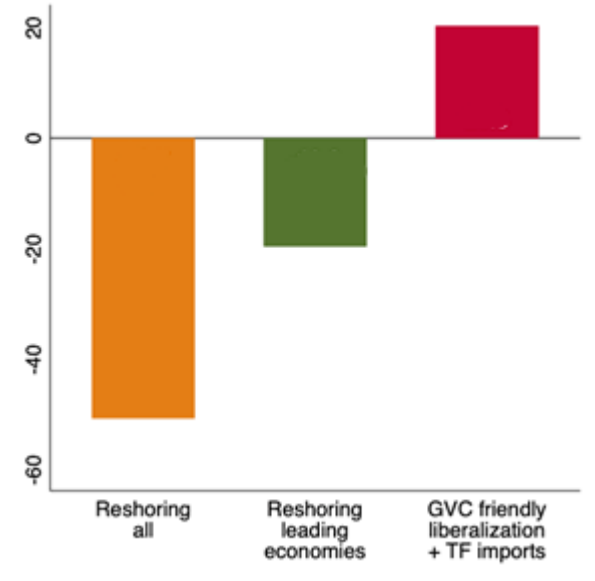
Source: WB staff estimates.

b – COVID-19 induced new poor, with respect to the baseline without COVID-19
by region, millions



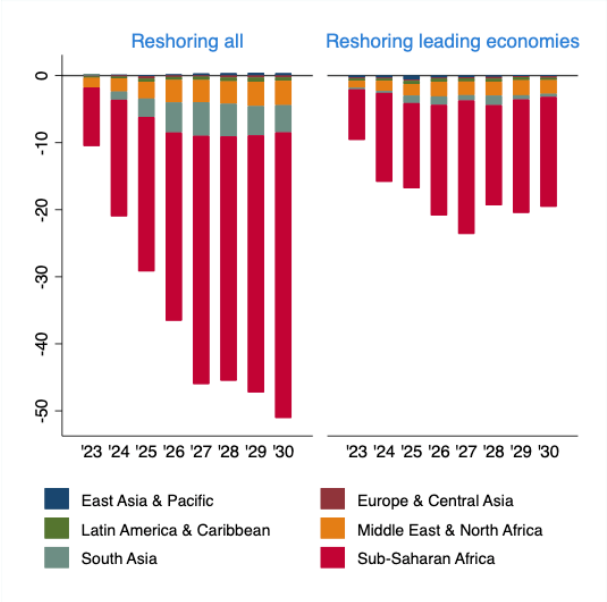
Source: WB staff estimates.

c – People lifted from extreme poverty, with respect to COVID L-shape recovery
millions



Source: WB staff estimates.

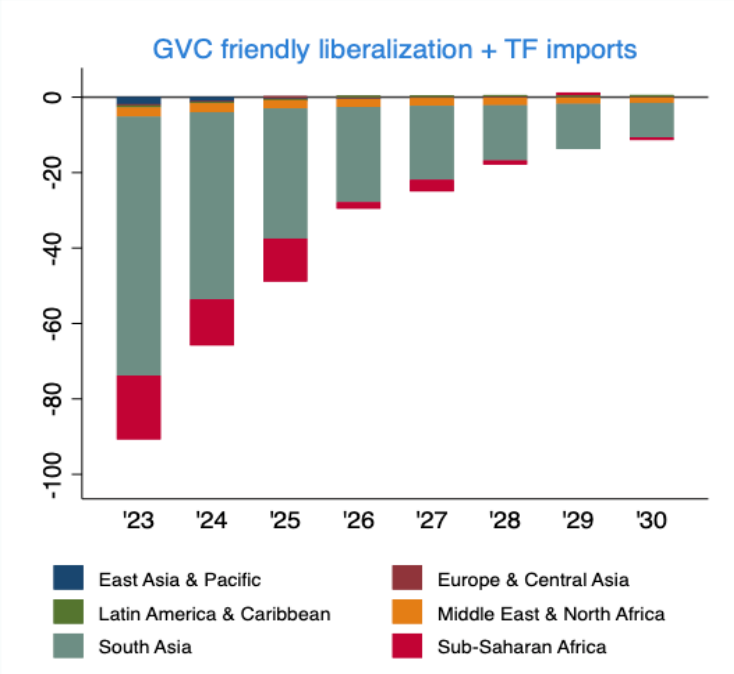
d – People lifted from extreme poverty, with respect to COVID-19 L-shape recovery
by region and scenario, millions



Source: WB staff estimates.

In line with the World Bank goal of shared prosperity, a GVC-friendly liberalization helps raise the income of the bottom-40 percent. In the *Reshoring Leading Economies* and *Reshoring All* scenarios, the population in the bottom 40 percent of income distribution (by region) loses the most vis-à-vis the top 60 percent of the population. Figure 17 shows that in the East Asia and Pacific region, the bottom 40 percent sees its income decline by 4 percent under the *Reshoring Leading Economies* scenario and by -4.8 percent if they respond in kind. The top 60 percent experience a decline, but at a lower rate, by -2.4 and -2.8 percent respectively. Nevertheless, the GVC-friendly liberalization increases the welfare gains for the bottom-40 faster than those of the top-60. By 2030, the bottom-40 would increase their welfare by 3.3 percent with respect to L-shape recovery, 1.6 percentage points above the growth of the top-60. Figure 17 shows the same pattern across regions, with the exception of the MENA region.[15] It is also important to highlight that while GVC-friendly liberalization can lead to sustained poverty reduction and increase in the income of the bottom-40 percent (by region), it does not guarantee that wages for unskilled females would necessarily grow faster than those of the rest of the economy. This situation is particularly acute in Sub-Saharan Africa, where even with GVC-friendly liberalization, wages for unskilled females do not keep pace with the growth of wages in the rest of the economy (Figure 18).

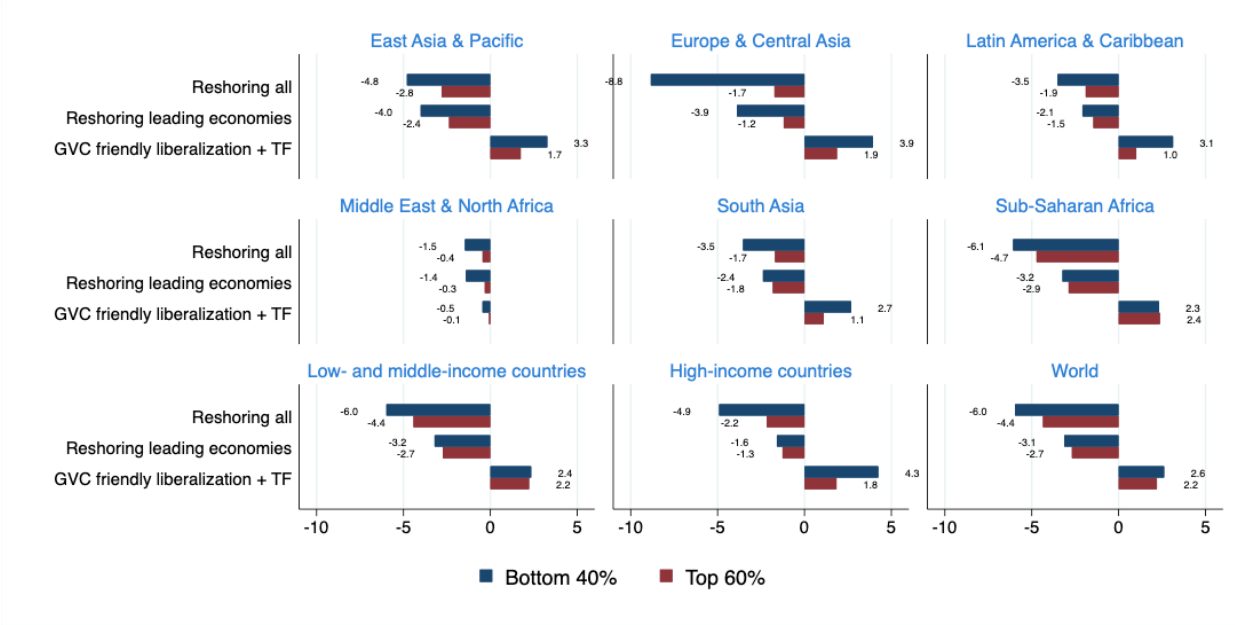
Figure 16. Extreme poverty reduction in GVC-friendly scenario, with respect to pre-COVID-19 conditions, *by region, millions*



Source: WB staff estimates.

[15] These estimations on the evolution of welfare of the bottom-40 and top-60 percent consider the entire population in each region as a single entity. It is entirely possible that this trend follows a different pattern within countries in the same region, especially in small countries located at either side of the tails of the region's distribution. Nevertheless, the general trend shows a pattern of regional convergence at the regional level.

Figure 17. Income of bottom 40 and top 60, by scenario and region
% change with respect to COVID L-shape recovery



Source: WB staff estimates.

Figure 18. Wages for unskilled females
Percentage point difference with respect to rest of wages, by 2030

Source: WB staff estimates.

Table 4. People lifted from extreme poverty and joining the global middle class, by scenario
Change with respect to COVID L-shape recovery, millions

Region	Extreme Poverty PPP$1.90/day (scenarios)			Global Middle Class PPP$10.00/day (scenarios)		
	Reshoring all	Reshoing leading economies	GVC friendly +TF imports	Reshoring all	Reshoing leading economies	GVC friendly +TF imports
East Asia & Pacific	-0.06	-0.19	0.41	-29.48	-22.65	6.34
Europe & Central Asia	-0.26	-0.22	0.02	-7.21	-5.22	2.66
Latin America & Caribbean	-0.54	-0.38	0.59	-6.99	-6.99	6.96
Middle East & North Africa	-3.47	-2.06	0.27	-16.90	-10.59	2.11
South Asia	-4.95	-1.04	6.10	-20.54	-5.91	30.90
Sub-Saharan Africa	-42.54	-15.44	14.10	-12.66	-6.38	7.19
Low and middle income countries	-51.82	-19.33	21.49	-93.78	-57.73	56.15
High-income countries	-0.02	-0.02	-0.01	-0.76	-0.96	-0.53
World	**-51.84**	**-19.35**	**21.48**	**-94.54**	**-58.69**	**55.62**

Source: WB staff estimates.

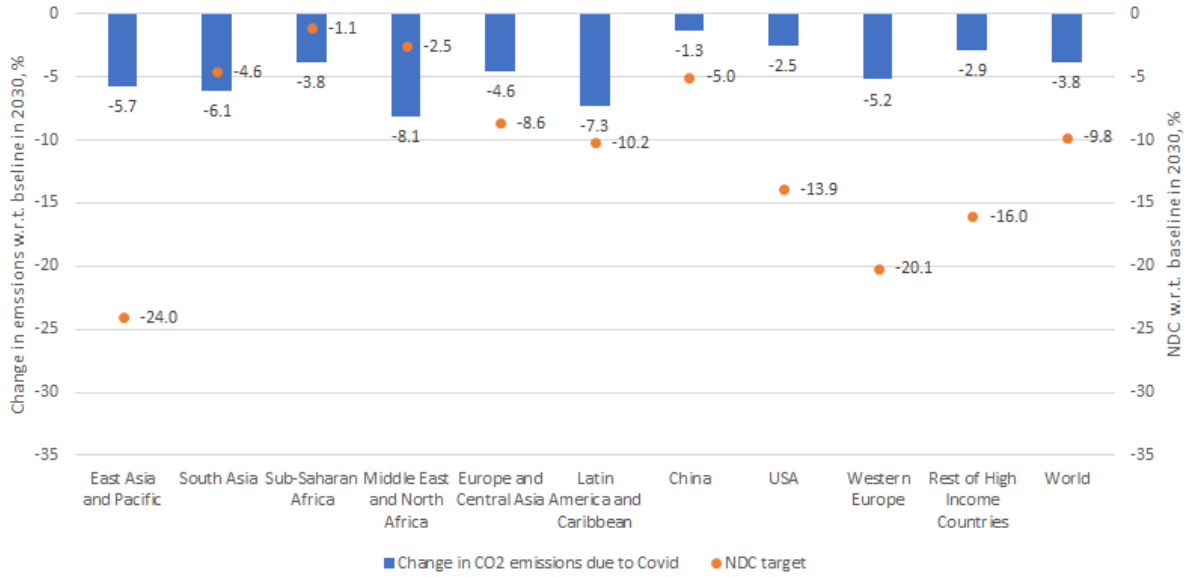
6. Climate change mitigation policies reshaping comparative advantage of countries

The COVID-19 pandemic is estimated to have reduced global CO_2 emissions, but its impact on achieving climate change goals is expected to be limited. The pandemic has shifted down the 'current policy' emissions trajectory in almost all countries and regions. Global CO_2 emissions are estimated to have decreased by around 7 percent in 2020 relative to 2019 (Friedlingstein et al. 2020). These short-term emissions reduction trends are expected to have a limited impact on long-term emission pathways (Forster et al. 2020).

Our simulations suggest that by 2030 global CO_2 emissions would fall by around 3.8 percent relative to the pre-COVID-19 baseline if the Paris Accord were fully implemented. The global average unconditional NDC emissions reduction target,[16] according to our interpretation of NDCs, is around 10.8 percent relative to the baseline in 2030. In the case of three aggregate regions – South Asia, Sub-Saharan Africa, and Middle East and North Africa, COVID-19-induced CO_2 emissions reduction overreaches the NDC target (Figure 19). These regions have the least-ambitious NDC emissions reduction targets and are also among the most adversely impacted by the pandemic.

[16] In the current assessment only unconditional NDC targets are taken into consideration. If a country has specified only conditional NDC targets in its Paris Agreement contribution, then the unconditional target is assumed to be "0".

Figure 19. Change in CO_2 emissions in 2030 relative to the pre-COVID baseline – impact of the COVID pandemic and NDC targets, %



Source: ENVISAGE simulations.

Each region and sector will be affected differently as countries strive to reach their NDC targets, with coal hardest hit. Focusing on the top three sectors in each region with the largest reduction in output following stylized NDCs implementation, one key outcome is that the coal sector is the most impacted in all regions (Table 5). An increase in carbon prices under the NDC scenario leads to a reduction in global coal demand. Coal production drops significantly: anywhere from 6-7 percent in MENA and China, to more than 20-30 percent in Latin America, Europe, the United States, and the Rest of High-Income Countries. All other sectors experience much less significant reductions in output. Natural gas extraction is the second most impacted activity in almost half of the analyzed regions. Due to an increase in fuel prices following carbon taxes implementation, transportation, including air, water, and ground transport, is also hard hit.

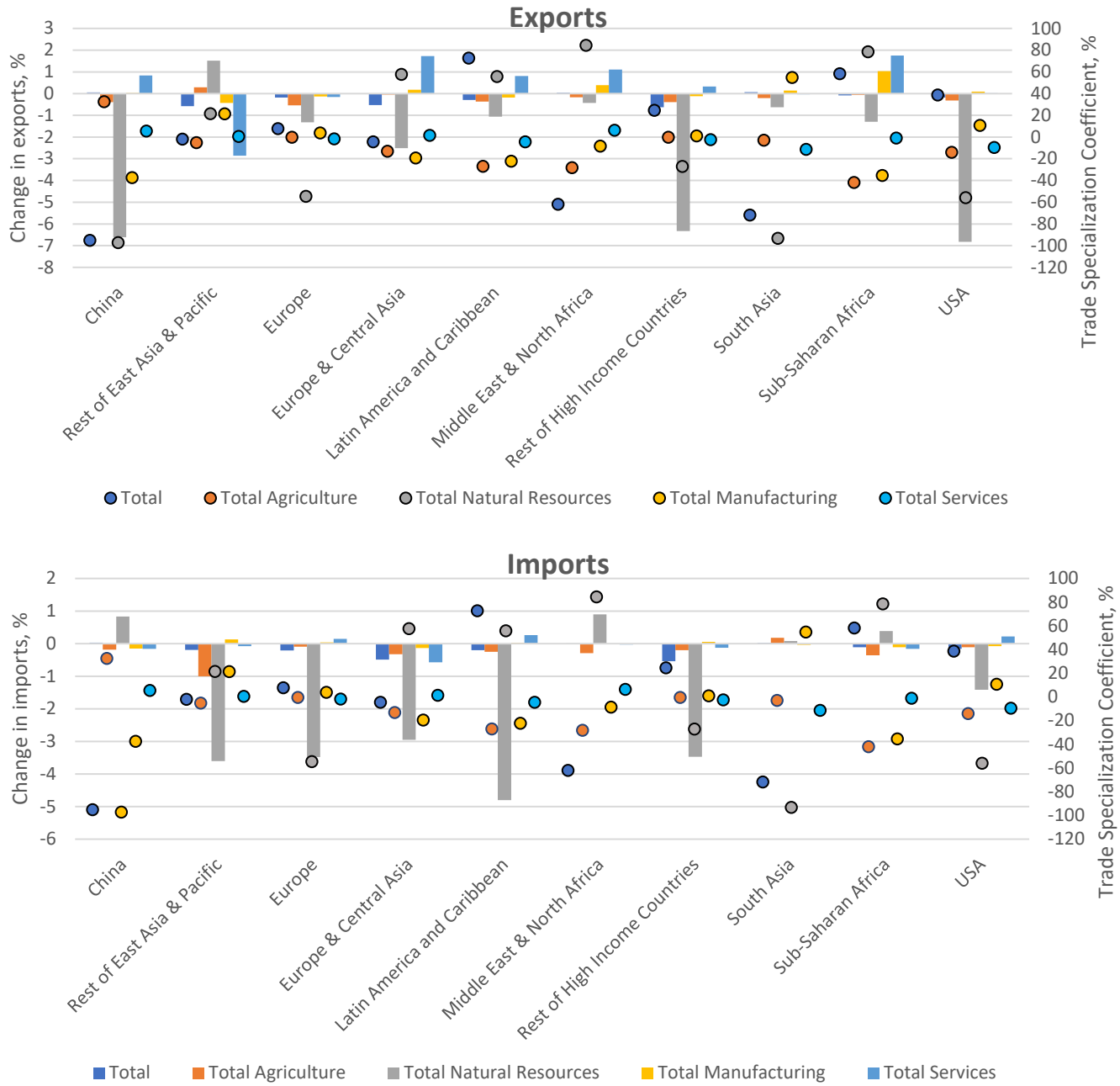
Table 5. Changes in output by sector and region following NDC implementation (top three sectors with the largest output reduction in each region are reported), % change w.r.t. post-COVID baseline in 2030

Region\most impacted sector	Top 1		Top 2		Top 3	
	Sector	Change, %	Sector	Change, %	Sector	Change, %
China	Coal extraction	-6.0	Gas extraction and distribution	-3.0	Wearing apparel and leather products	-0.2
Rest of East Asia & Pacific	Air transport	-10.6	Coal extraction	-8.6	Other transport	-5.8
Europe	Coal extraction	-33.2	Air transport	-2.5	Gas extraction and distribution	-2.2
Europe & Central Asia	Coal extraction	-15.7	Gas extraction and distribution	-1.1	Non-metallic minerals	-0.6
Latin America and Caribbean	Coal extraction	-18.3	Gas extraction and distribution	-3.3	Refined oil	-1.3
Middle East & North Africa	Coal extraction	-5.7	Gas extraction and distribution	-0.3	Wearing apparel and leather products	-0.2
Rest of High Income Countries	Coal extraction	-18.5	Gas extraction and distribution	-3.3	Textiles	-1.2
South Asia	Coal extraction	-6.1	Wearing apparel and Leather products	-0.4	Gas extraction and distribution	-0.4
Sub-Saharan Africa	Coal extraction	-8.9	Gas extraction and distribution	-0.2	Meat products (inc. fisheries) and other food	-0.2
United States	Coal extraction	-25.0	Gas extraction and distribution	-4.9	Other transport	-0.5
World	Coal extraction	-10.9	Gas extraction and distribution	-2.2	Air transport	-0.9

Notes: Top three sectors with the largest reduction in output are reported for each region. Numbers in brackets indicate corresponding change in output. Source: ENVISAGE simulations

Consistent with the observed changes in production patterns, exports and imports of fossil fuels are impacted the most (Figure 20). With lower global demand for fossil fuels, volumes of trade for these commodities are expected to decline, accompanied by a moderate reallocation of trade to places with less stringent environmental regulations. China, as the world's largest net importer of fossil fuels with a relatively low carbon price consistent with its NDC target, increases imports of fossil fuel commodities. Both Sub-Saharan Africa and East Asia, being large net energy exporters, suffer reductions in exports of fossil fuels. In the case of Sub-Saharan Africa, reduction in exports of fossil fuels is compensated for by an increase in exports of other goods and services, including agricultural commodities.

Figure 20. Change in exports and imports due to the NDC policies implementation, % change in 2030 relative to the post-COVID baseline



Notes: Trade Specialization Coefficient (TSC), plotted with circles in the figure, represents the ratio of net exports to total trade (exports + imports); TSC>0 indicates that the region is a net exporter of the specific commodity, while TCF<0 indicates a net importing commodity-region pair. Fossil fuel commodities are aggregated within the natural resources category.
Source: ENVISAGE simulations.

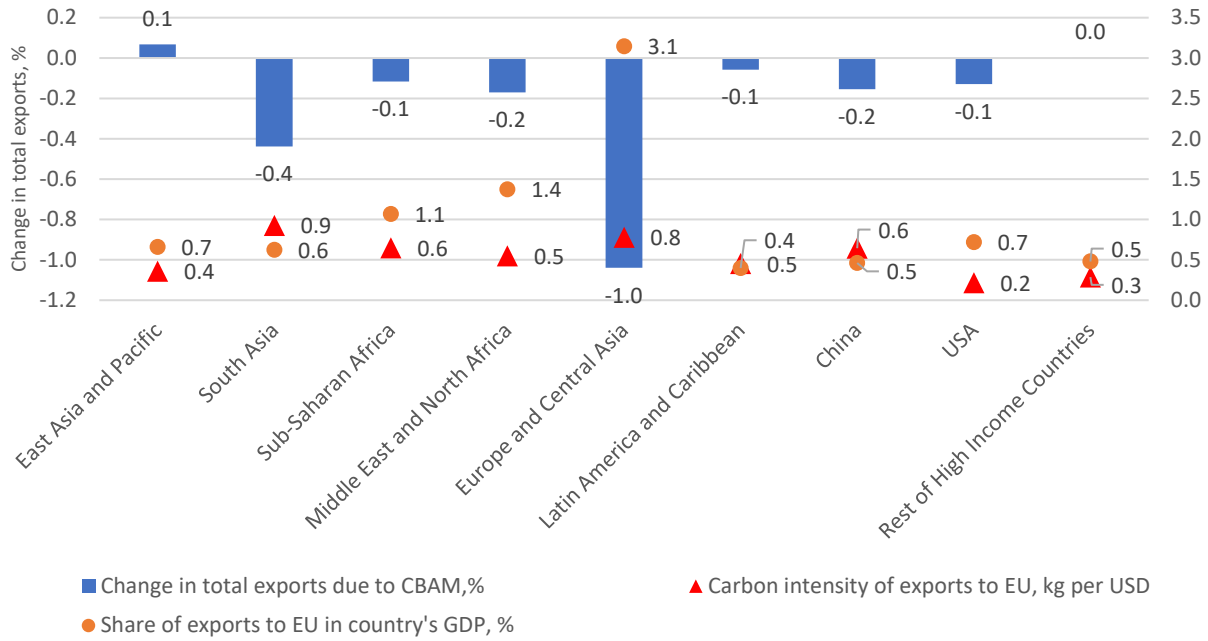
Climate policies and Carbon Border Adjustment Mechanism

We split the impact of the stylized EU Green Deal into two parts: more ambitious emissions reductions by the EU and implementation of the Carbon Border Adjustment Mechanism (CBAM), a charge on imports into the EU of some raw materials from "less climate ambitious countries." The impacts of the EU Green Deal are measured relative to the scenario with NDC-consistent climate mitigation. These impacts are

driven through two key channels. Firstly, due to the increasing carbon price in the EU (from US$39/tCO$_2$ under the NDC target to US$213/tCO$_2$ under the EU Green Deal target), there is lower demand for fossil fuels within the bloc. This has an adverse impact on regions like MENA and Central Asia, including the Russian Federation, as the EU is one of their primary destinations for fossil fuel exports. Secondly, due to the increasing price of carbon in the EU, production becomes more expensive, which negatively impacts key destinations of EU energy-intensive exports, such as neighboring European countries. Unlike the EU carbon tax, which mainly impacts demand and prices for fossil fuels, CBAM puts more pressure on energy-intensive goods, such as metals, chemical products, non-metallic minerals (cement, lime, etc.), and electricity. As a result, main exporters of these commodities to the EU (ECA – chemicals, metals, electricity; China and MENA– chemicals) are among the regions that experience lower exports following CBAM implementation.

The impact of climate policies on other countries will depend on the degree of their carbon intensity and reliance on related exports (Figure 21). Separating macro impacts of the CBAM on EU trading partners from domestic EU mitigation policies (within the EU Green Deal), we can observe that the impacts correlate with the carbon intensity (in kg per US$1 of exports) and magnitude (share of exports to the EU in a country's GDP) of exports to the EU. For estimating both carbon intensity and the share of exports in a country's GDP we focus on commodities that correspond to the EU ETS sectors and thus face the CBAM in our simulations. The top three regions most impacted by the CBAM – Europe and Central Asia, Middle East and North Africa, and Sub-Saharan Africa – have high carbon intensity of exports per US$1 and at least 1 percent of the EU-designated export share in country GDP. At the same time, high-income countries, including the United States, having the lowest carbon intensity of exports to the EU, experience negligible impacts from the CBAM.

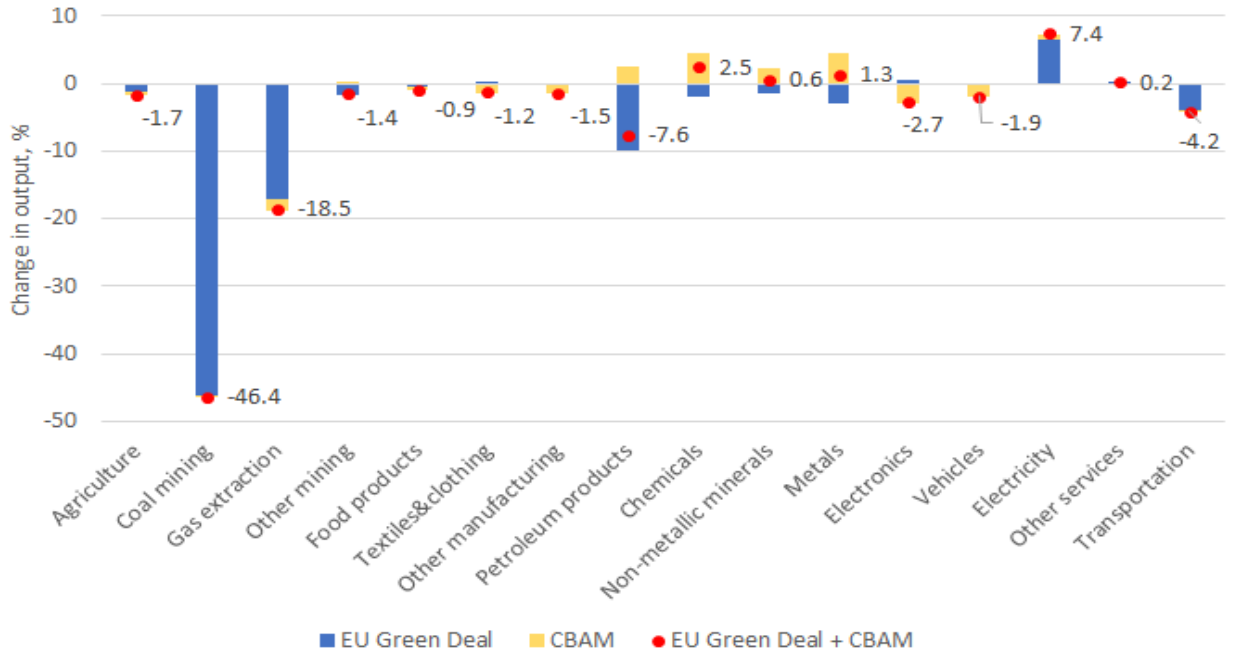
Figure 21. Impacts of the Carbon Border Adjustment Mechanism on total exports by EU trading partners and carbon intensity of exports to EU, % change in 2030 relative to the EU Green Deal implementation scenario



Source: ENVISAGE simulations.

Imposition of the CBAM only partially compensates European producers for the potential reduction in output from a more ambitious climate mitigation target under the EU Green Deal (Figure 22). At the EU aggregate level, CBAM has virtually no impact on output, while the EU Green Deal implementation itself results in total output reduction of around 0.4 percent. Fossil fuels, petroleum products, metals, and transportation are impacted the most. While most EU energy-intensive sectors (petroleum products, non-metallic minerals, metals, electricity) benefit from the CBAM roll out, this is not the case for some other producers that rely on imported intermediate inputs. With CBAM being imposed on imports of all commodities (an assumption made in this assessment), increasing costs of the imported intermediate inputs lead to a reduction in domestic EU production in a number of manufacturing sectors – electronic equipment, machinery, and motor vehicles.

Figure 22. Impacts of the EU Green Deal and Border Carbon Adjustment Mechanism on output by sectors in EU, % change in 2030 relative to the baseline with implemented NDCs

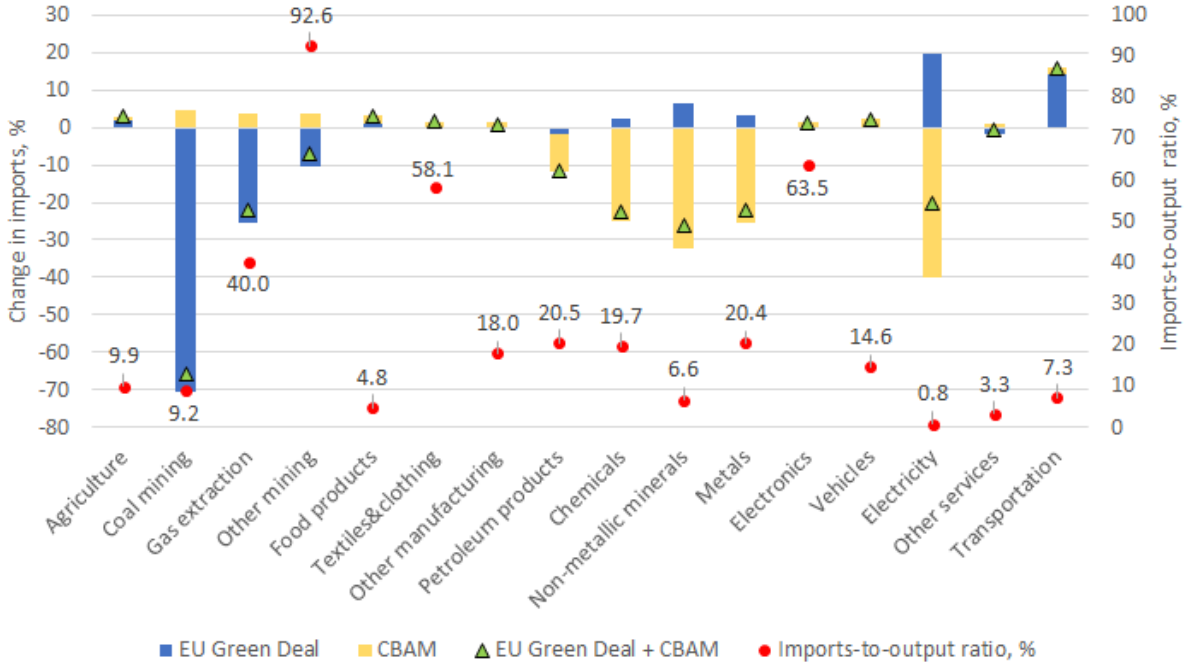


Source: ENVISAGE simulations.

The EU Green Deal is likely to reduce imports of fossil fuels and petroleum products due to lower EU-wide demand. It does not have any significant impact on imports of other commodities (Figure 23). A partial shift toward increased imports of electricity and non-metallic minerals to the EU occurs, representing a carbon leakage channel if CBAM is not implemented. Implementation of the CBAM leads to reversed trade patterns, compared to the EU Green Deal impacts. Imports of fossil fuels moderately increase, while imports of commodities covered by the EU ETS sectors fall significantly – anywhere from 11 percent in the case of petroleum products to 40 percent in the case of electricity. The import-to-output ratio for the latter is only 0.8 percent. CBAM does not have a major impact on the EU's domestic electricity producers, unlike in the case of other EU ETS sectors, for which the imports-to-output ratio varies from 6.6 percent for non-metallic minerals to 20 percent for petroleum products, chemicals, and metals. These high shares of import dependence explain a relative significant impact of CBAM on EU energy-intensive manufacturing industries as the substitution from imported to domestic production takes place. It should also be noted

that the share of the intra-EU trade in many goods, including such energy intensive commodities like electricity, is relatively high and thus the CBAM does not affect their output significantly.

Figure 23. Impacts of the EU Green Deal and Border Carbon Adjustment Mechanism on EU imports by sectors, % change in 2030 relative to the baseline with implemented NDCs



Notes: Intra-EU trade is excluded from the reporting. Imports-to-output ratio is estimated for 2030 based on the baseline with implemented NDCs.
Source: ENVISAGE simulations.

When it comes to commodities, imports of coal are impacted the most – with a potential 65.8 percent reduction (Figure 23). This reduction in imports is largely due to shrinking US exports to the EU. Imports of electricity from Europe and Central Asia are the second most impacted flow. But while the reduction in coal exports from the United States to the EU is 70.8 percent, the reduction of aggregate coal exports from the United States is only 19.7 percent, due to the reallocation of exports to other destinations and toward domestic markets. The pattern of export reallocation, away from the EU, partially compensates for the negative impacts of the EU Green Deal and CBAM on EU trading partners. In almost all cases, the reduction in total exports (by commodities and regions) is much smaller than the reduction of exports to the EU. Additional re-allocation toward domestic markets further smooths out negative impacts on production in general. Europe and Central Asia, together with China, are regions with the largest number of sectors heavily involved in trade with the EU and that are adversely impacted by the EU Green Deal and CBAM. Commodities affected include electricity, gas, oil, and metals for Europe and Central Asia, and non-metallic minerals, wood products, and chemicals in the case of China.

Table 6. Impacts of the EU Green Deal and CBAM on selected sectors in EU trading partners

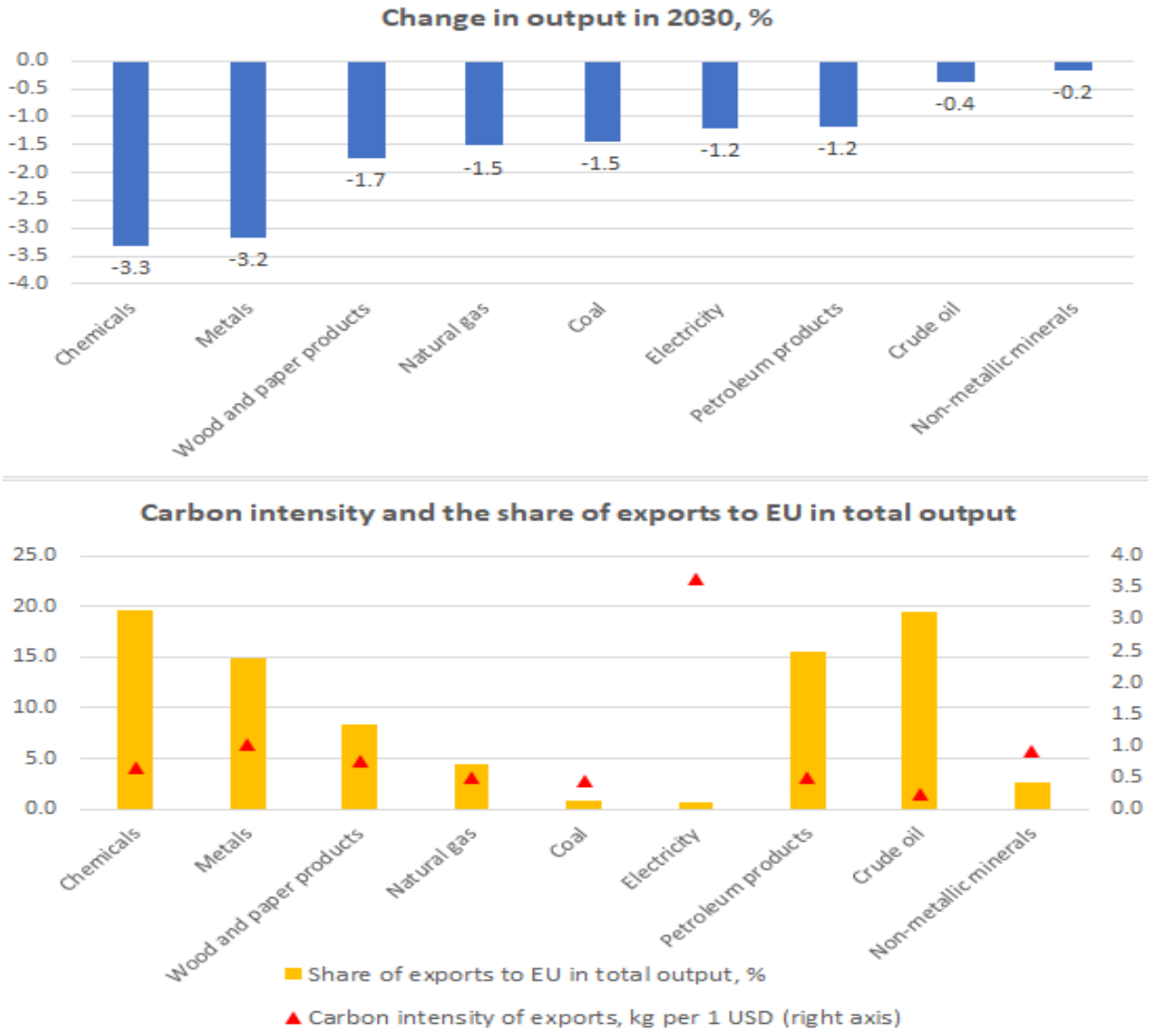
Sector	Change in EU imports, %	Key source region (share in total imports)	Change in exports to EU for key source region, %	Change in total exports for key source region, %	Change in output for key source region, %
Coal	-69.1	United States (38.9%)	-70.8	-19.7	-5.4
Electricity	-28.2	Europe and Central Asia (58.2%)	-34.3	-15.6	-1.2
Non-metallic minerals	-28.0	China (48.7%)	-33.8	-4.2	-0.2
Wood and paper products	-28.0	China (33.9%)	-37.5	-7.4	-0.6
Chemicals	-23.2	China (18.4%)	-38.4	-5.8	-0.7
Metals	-23.0	Europe and Central Asia (26.6%)	-38.7	-9.2	-3.2
Natural gas	-22.8	Europe and Central Asia (45.9%)	-20.9	-9.1	-1.5
Petroleum products	-11.5	Europe and Central Asia (47.1%)	-12.6	-5.4	-1.2
Crude oil	-9.3	Europe and Central Asia (52.5%)	-5.6	-1.6	-0.4

Notes: Share in total imports for key source region is estimated for total imports excluding intra-EU trade. For the case of chemical products (CHM), the second most important EU trading partner is reported (i.e. CHN), as for the first most important partner (United States), observed changes in flows were non-significant. Selected sectors with the largest reduction in EU imports are reported. Source: ENVISAGE simulations.

EU trade with the rest of Europe and Central Asia are likely to be hardest hit by the CBAM, with carbon-intensive sectors most vulnerable. The most impacted sectors in terms of output changes are reported in Figure 24. The impact of the CBAM on changes in the output of the exporting country depends on two key drivers – carbon intensity of exports and the share of total output that is exported to the EU. ECA commodities that have both high carbon intensity and a large share of production that is exported to the EU (metals and chemicals) suffer the largest reductions in output. At the same time, output of highly carbon-intensive commodities, like electricity, is not impacted significantly due to the low share of exports to the EU in total output.

The potential negative impacts on output of selected sectors in developing countries can be mitigated by own policy responses. By pursuing more ambitious climate mitigation policies themselves, developing countries could transform potential income losses into income gains by supporting the use of more efficient and cleaner technologies, and facilitating the green transition. In addition, developing countries would benefit from the environmental and health co-benefits of more stringent climate action. Even in the case of energy exporters, a group of countries that is substantially hit by the EU Green Deal implementation due to the reduction in the global prices of fossil fuels, transition from a traditional diversification to proactive asset diversification (with increasing R&D investments) within ambitious climate mitigation scenarios, could be an important welfare-improving channel, as shown by Peszko et al. (2020).

Figure 24. Impacts of CBAM on Europe and Central Asia



Source: ENVISAGE simulations.

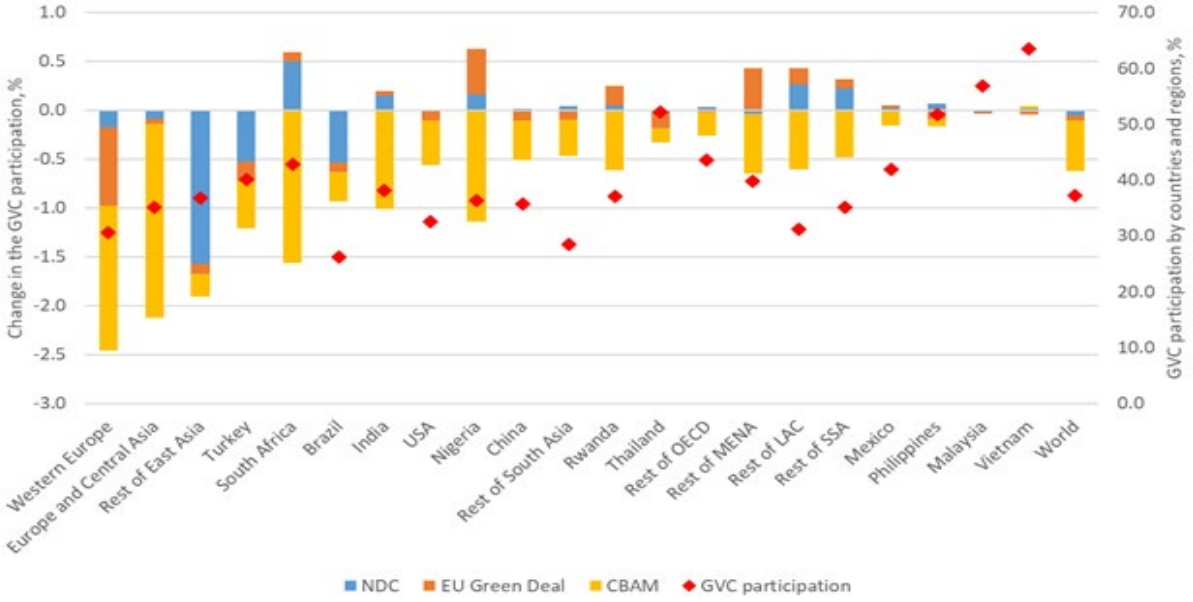
Impacts of climate mitigation policies on GVC participation

Implementation of climate mitigation policies leads to the reshaping of GVCs both at the regional and sectoral levels. Decomposing the impact of these stylized climate mitigation measures on the GVC participation rate, an overall trend of declining GVC participation is observed by country and region (Figure 25). Impacts are rather moderate and range from around -2.5 percent in Western Europe – a region with the most stringent mitigation policies in our scenarios – to essentially no impact in some countries with a high GVC participation rate in low carbon-intensive commodities, such as, the Philippines, Malaysia, and Vietnam.

Despite minor impacts of NDC targets on GVC participation, some countries and regions increase their participation in GVCs. This is the case of countries which benefit from changes in the trade patterns – this group includes India, South Africa, the Philippines, and several countries from Latin America (Figure 25). Moderate negative impacts are experienced by countries such as e.g. EU, Turkey, Brazil, and the Rest of East Asia.

Implementation of the EU Green Deal reduces GVC participation for Western Europe. Integration into GVCs declines by around 0.8 percent. At the same time, with the redirection of trade flows and an increasing trade intensity outside of the EU, GVC participation rate for most other countries and regions increases. Only the closest EU trading partners experience minor reductions in GVC participation due to the EU Green Deal implementation. Among considered climate policy measures, CBAM has the most adverse impacts on GVC participation. With increasing taxes applied to carbon intensive EU imports, not only do Western European countries observe a decline in GVC participation (-1.5 percent), a more substantial reduction is experienced by some EU trading partners, with Europe and Central Asia seeing a decline of 2 percent.

Figure 25. Impacts of climate mitigation policies on GVC participation by countries and regions, % change in 2030 relative to the post-COVID baseline

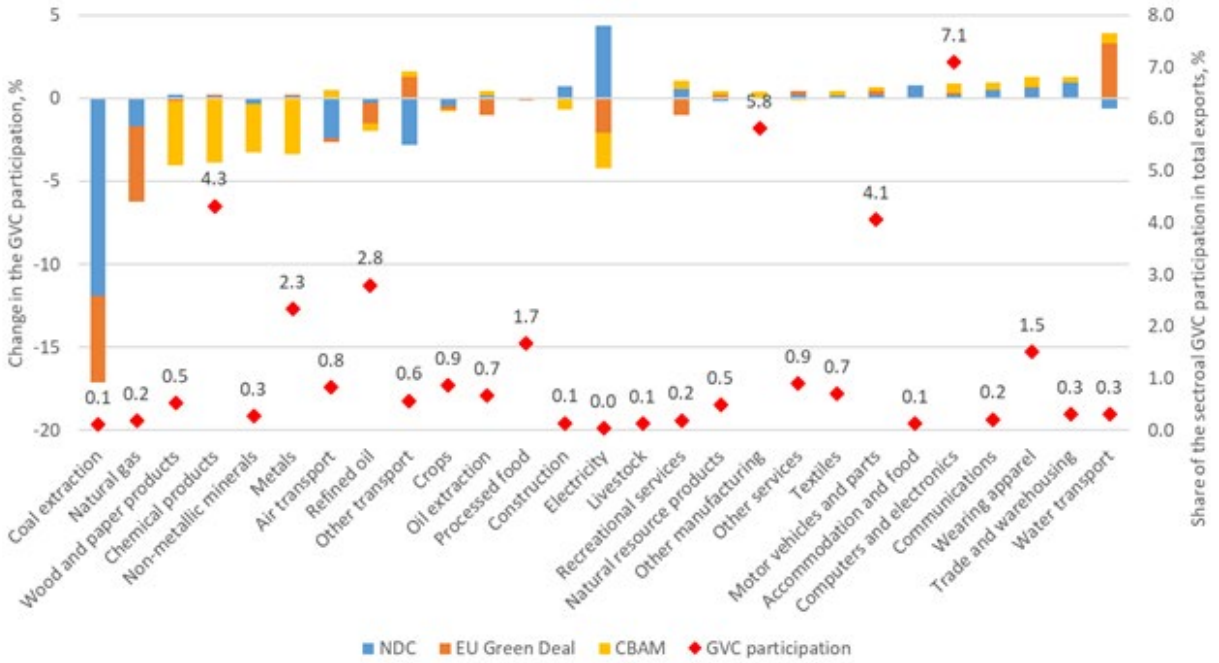


Source: ENVISAGE simulations.

At the commodity level, not surprisingly, trade in fossil fuels is impacted the most adversely due to the NDC policies, with coal at the top of the list (Figure 26). Implementation of the EU Green Deal mitigation efforts further reduces trade in fossil fuels, commodities that are not heavily involved in forward and backward GVC linkages. CBAM, on the other hand, targets selected energy-intensive sectors with relatively higher participation in GVCs, with chemical products at the top of this list. Under CBAM, participation in GVCs shrinks with chemicals, wood and paper products, non-metallic minerals, and metals all experiencing a reduction of 3 to 4 percent.

New opportunities will arise for countries that are relatively carbon efficient in key tasks along GVCs. While fossil fuels and energy-intensive sectors experience a reduction in GVC participation rates, service sectors and light manufacturing activities experience a moderate increase. These include highly GVC-integrated sectors like computers and electronics, motor vehicles and parts, and other light manufacturing. Climate mitigation policies stimulate both trade and GVC participation for these commodities, making them even more integrated in GVCs.

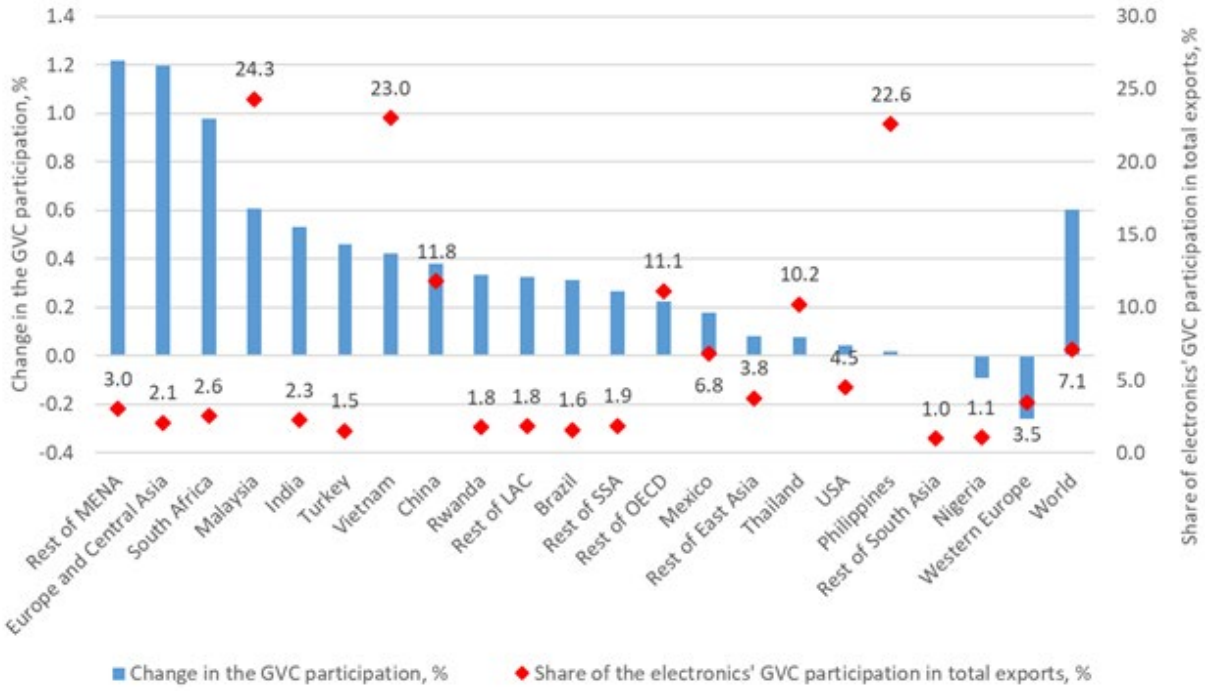
Figure 26. Impacts of climate mitigation policies on GVC participation by sectors (global average), % change in 2030 relative to the post-COVID baseline



Source: ENVISAGE simulations.

Sectors with the strongest backward and forward linkages in GVCs become even more integrated. Focusing on the CBAM impacts on computers and electronics – a sector with the highest rate of GVC participation – all EU trading partners experience an increase in GVC participation rate (Figure 27). As the trade barriers for heavy manufacturing increase, producers of electronics observe an increasing demand for their goods worldwide with a global average increase in GVC participation for electronics of around 0.6 percent. Key exporters of electronics, such as Malaysia, Vietnam, and China, also strengthen their integration into GVCs due to the border carbon adjustment measures. Thus, the climate mitigation policies not only lead to the decarbonization of the economy, but also stimulate a higher integration into GVCs of the low carbon-intensive commodities.

Figure 27. Impacts of the CBAM on GVC participation for the electronics sector by countries and regions, % change in 2030 relative to the EU Green Deal baseline



Notes: GVC participation rate is calculated as the sum of domestic value added in the foreign export (forward participation) and foreign value added in domestic export (backward participation) (Koopman et al. 2010).
Source: ENVISAGE simulations

7. Conclusions

The COVID-19 pandemic, trade tensions, extreme weather events, and ambitious climate mitigation policies all test the resilience of GVCs. Serving both as transmitters and buffers of external shocks, GVCs can endanger future economic growth by transferring negative production and trade shocks from one country to another. They can also drive growth by spreading the benefits of the recovery policies across countries. But what are the likely impacts of the adverse shocks on developing economies and is it possible to design policies that would enhance resilience to such shocks without endangering growth?

To address this point, we consider a set of policy shocks that have already occurred or could be anticipated in the upcoming years and provide quantification of their impacts on developing countries. We use a global CGE model to enhance the understanding of potential longer-term impacts of COVID-19 and the policy responses it engenders on developing countries. We assess the likely impacts of measures designed to reshore production and reduce reliance on imports, as well as other key factors shaping the global economy, including stylized climate mitigation scenarios and carbon border adjustment measures.

Our simulations suggest that while the COVID-19 pandemic has put a heavy toll on the world economy, fueling an already heated debate around the benefits and costs of global supply chains, GVC restructuring in the form of reshoring is not the solution to alleviate impacts of external disruptions. If on a post-COVID recovery path leading economies and China would decide to reshore their production, this would have a noticeable negative impact in most countries, particularly in developing regions, leaving them more

vulnerable. The impact on real income is going to be uneven across countries, with most of the losses falling in countries that are the most deeply integrated into GVCs.

In such situation, the best policy response to reshoring by leading countries is to make developing economies more GVC-friendly rather than responding in kind. As our analysis indicates, having all economies reshore would compound the damage done by leading economies reshoring their production. On the other hand, elimination of input tariffs and implementation of trade facilitation measures would strengthen the integration of developing countries in regional and global value chains. The gains would be evident in all developing regions through the increase in real incomes. We also find that becoming more GVC-friendly makes developing countries more resilient to supply shocks. We showcase this point by looking into a stylized experiment where we estimate impacts of a hypothetical supply shock in Thailand and its disruption to the supply chain of electronics.

Before COVID-19, additional efforts were needed to put the world on track to eradicate poverty by 2030. The COVID pandemic has further sent 122 million into extreme poverty, and a quarter of them will not be lifted out of extreme poverty by 2030. Low- and middle-income countries in South Asia will constitute the majority of the new COVID-19 induced poor, followed by Sub-Saharan Africa. Reshoring production by leading economies could only impair the recovery by increasing the number of people who leave in extreme poverty by 19.6 million. At the same time, the GVC-friendly scenario accelerates poverty reduction and brings the world close to full recovery from the effects of COVID-19. Furthermore, our estimates suggest that in line with the World Bank goal of shared prosperity, a GVC-friendly liberalization helps raise the income of the bottom-40 percent.

Reducing the level of economic activity and shifting the production patterns, the COVID-19 pandemic has lowered the global environmental pressure. While sharp reduction in the CO_2 emissions observed during 2020 was a short-term trend, it would also have a limited longer-term implications. Our simulations suggest that by 2030 global CO_2 emissions would fall by around 3.8 percent relative to the pre-COVID-19 baseline if the Paris commitments were fully implemented.[17] In the case of some aggregate regions – South Asia, Sub-Saharan Africa, and Middle East and North Africa, COVID-19-induced CO_2 emissions reduction could even be enough to overreach their NDC targets.

We find that while in general climate mitigation policies lead to declining GVC participation, some countries benefit from changes in trade patterns and become more integrated into GVCs. This group includes India, South Africa, the Philippines, and several countries in Latin America. Among considered climate policy measures, CBAM has the most adverse impacts on GVC participation. With increasing taxes applied to carbon intensive EU imports, not only do Western European countries observe a decline in GVC participation (-1.5 percent), a more substantial reduction is experienced by some EU trading partners, with Europe and Central Asia seeing a decline of 2 percent. At the same time, new opportunities arise for countries that are relatively carbon efficient in key tasks along GVCs. While fossil fuels and energy-intensive sectors experience a reduction in GVC participation rates, service sectors and light manufacturing activities experience a moderate increase. These include highly GVC-integrated sectors like computers and electronics, motor vehicles and parts, and other light manufacturing. Climate mitigation

[17] The global average unconditional NDC emissions reduction target, according to our interpretation of NDCs, is around 10.8 percent relative to the baseline in 2030.

policies stimulate both trade and GVC participation for these commodities, making them even more integrated in GVCs.

While we believe that our approach allows to develop a qualitatively robust policy message, a study with such a broad focus cannot avoid limitations and potential for further improvements. First of all, it should be noted that our scenarios are of a stylized and exploratory nature and can be further improved along multiple dimensions. In particular, this includes a more refined implementation of the climate mitigation policies with a better specification of the technological mitigation potentials and a more accurate design of the CBAM implementation. In addition, our understanding of the COVID-19 impacts evolves rapidly, as country-specific recovery paths are updated almost real-time. While in this paper we provide a longer-term look on the impacts of recovery policies and quantitatively support our conclusions, we first of all would like to stress the qualitative interpretation of our results.

References

Aguiar, A., M. Chepeliev, E.L. Corong, R. McDougall, & D. van der Mensbrugghe (2019). The GTAP Data Base: Version 10. Journal of Global Economic Analysis. v. 4, n. 1, p. 1-27, June 2019. ISSN 2377-2999. https://www.jgea.org/ojs/index.php/jgea/article/view/77

Ahmed, A., Bussolo, M., Cruz, M., Go, D.S, Osorio-Rodarte, I. (2020). Global Inequality in a more educated world. 2020. Journal of Economic Inequality. https://doi.org/10.1007/s10888-020-09440-z

Böhringer, C., S. Peterson, T.F. Rutherford, J. Schneider & M. Winkler (2020). Climate policies after Paris: Pledge, Trade and Recycle: Insights from the 36th Energy Modeling Forum Study (EMF36). Energy Economics, Volume 103, November 2021, 105471. https://doi.org/10.1016/j.eneco.2021.105471

Bonadio, Barthelemy, Zhen Huo, Andrei A. Levchenko & Nitya Pandalai-Nayar (2020) Global Supply Chains in the Pandemic. *NBER*, Working paper no. 27224. http://www.nber.org/papers/w27224.

Bussolo, M., R. De Hoyos & D. Medvedev (2010). Economic growth and income distribution: linking macroeconomic models with household survey data at the global level. International Journal of Microsimulation, pages 92-103, 2010.

Carrico, C., E. Corong, & D. van der Mensbrugghe (2020). The GTAP version 10A Multi-Region Input Output (MRIO) Data Base. GTAP Memorandum 34. Center for GlobalTrade Analysis, Purdue University. https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=6164

Chepeliev, M., I. Osorio-Rodarte, & D. van der Mensbrugghe (2021). Distributional Impacts of Carbon Pricing Policies under the Paris Agreement: Inter and Intra-Regional Perspectives. *Energy Economics* 102 (105530). https://doi.org/10.1016/j.eneco.2021.105530.

Devarajan, S., P.D. Go, C. Lakatos, S. Robinson & K. Thierfelder (2018). Traders' Dilemma: Developing Countries' Response to Trade Disputes, *World Bank Policy Research Working Paper* No. 8640.

Eppinger, P., G. Felvermayr, O. Krebs & B. Kukharskyy (2020). COVID-19 Shocking Global Value Chains. *CESifo*, no. Working paper No. 8572.

Espitia, Alvaro, Aaditya Mattoo, Nadia Rocha, Michele Ruta & Deborah Winkler (2021). Pandemic Trade: COVID-19, Remote Work and Global Value Chains. *World Bank*, Policy Research working paper no. WPS 9508.

European Commission (EC) (2021). Proposal for a regulation of the European Parliament and of the Council establishing a carbon border adjustment mechanism, COM(2021) 564 final.

European Commission (2019). The European Green Deal. Communication from the European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1576150542719&uri=COM%3A2019%3A640%3AFIN

Forster, P.M., H.I. Forster, M.J. Evans, *et al.* (2020). Current and future global climate impacts resulting from COVID-19. *Nat. Clim. Chang.* **10,** 913–919 (2020). https://doi.org/10.1038/s41558-020-0883-0

Freund, Caroline, Aaditya Mattoo, Alen Mulabdic, & Michele Ruta. (2021). Natural Disasters and the Reshaping of the Global Value Chains. *World Bank Policy Research Working Paper*, no. 9719.

Friedlingstein, P. *et al*. (2020). Global Carbon Budget 2020. *Earth Syst. Sci. Data* **12**, 3269–3340, https://doi.org/10.5194/essd-12-3269-2020

Haraguchi, M. and Lall, U. (2015). Flood Risks and Impacts: A Case Study of Thailand's Floods in 2011 and Research Questions for Supply Chain Decision Making. International Journal of Disaster Risk Reduction, 14, pp. 256-272.

International Energy Agency (IEA) (2020). *World Energy Outlook 2020*, IEA, Paris https://www.iea.org/reports/world-energy-outlook-2020

International Institute for Applied Systems Analysis (IIASA) (2016). SSP Database (Shared Socioeconomic Pathways) – Version 1.1. https://tntcat.iiasa.ac.at/SspDb/dsd?Action=htmlpage&page=about

International Trade Center (ITC) (2020). Market Access Map (MACMAP). Trade Agreements. https://www.macmap.org/en/query/trade-agreement

Koopman, R., Powers, W., Wang, Z., & Wei, S.-J. (2010). Give credit where credit is due: Tracing value added in global production chains. NBER Working Paper, 16426, Retrieved from http://www.nber.org/papers/w16426.

Lakner, C., Gerszon Mahler, D., Nerge, M., Beer Prydz, E. (2020). How Much Does Reducing Inequality Matter for Global Povery? Global Poverty Monitoring Technical Note. https://documents1.worldbank.org/curated/en/765601591733806023/pdf/How-Much-Does-Reducing-Inequality-Matter-for-Global-Poverty.pdf

Li, M. (2018), CARD Trade War Tariffs Database. https://www.card.iastate.edu/china/trade-war-data/

Maliszewska, M., A. Mattoo, & D. van der Mensbrugghe (2020). The Potential Impact of COVID-19 on GDP and Trade: A Preliminary Assessment. World Bank Policy Research Working Paper 9211. http://documents1.worldbank.org/curated/pt/295991586526445673/pdf/The-Potential-Impact-of-COVID-19-on-GDP-and-Trade-A-Preliminary-Assessment.pdf

Mao, Haiou & Holger Gorg (2019). Friends like This: The Impact of the US-China Trade War on Global Value Chains. *Kiel Centre for Globalization (KCG)*, no. KCG working paper, No17.

Moïsé, E. & Sorescu, S. (2013). Trade Facilitation Indicators: The Potential Impact of Trade Facilitation on Developing Countries' Trade, OECD Trade Policy Papers 144, OECD Publishing.

OECD (2020a). "COVID-19 and the Food and Agriculture Sector: Issues and Policy Responses." OECD. https://read.oecd-ilibrary.org/view/?ref=130_130816-9uut45lj4q&title=Covid-19-and-the-food-and-agriculture-sector-Issues-and-policy-responses.

OECD (2020b). Shocks, Risks and Global Value Chains: Insights from the OECD METRO Model. OECD: OECD. https://www.oecd.org/trade/documents/shocks-risks-gvc-insights-oecd-metro-model.pdf

Peszko, G., van der Mensbrugghe, D., Golub, A. (2020). Diversification and Cooperation Strategies in a Decarbonizing World. Policy Research Working Paper; No. 9315. World Bank, Washington, DC. World Bank. https://openknowledge.worldbank.org/handle/10986/34056 License: CC BY 3.0 IGO.

Peters, G.P. (2008). From production-based to consumption-based national emission inventories. Ecological Economics, 65(1): 13 – 23. doi:https://doi.org/10.1016/j.ecolecon.2007.10.014.

van der Mensbrugghe, D. (2019). The Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model. Version 10.01. Center for Global Trade Analysis, Purdue University. https://mygeohub.org/groups/gtap/envisage-docs

World Bank (2021). Global Economic Prospects. January 2021. A World Bank Group Flagship Report. https://www.worldbank.org/en/publication/global-economic-prospects

World Bank (2020a). World Development Report 2020: Trading for Development in the Age of Global Value Chains. Washington, DC: World Bank. doi:10.1596/978-1-4648-1457-0.

World Bank (2020b). Global Economic Prospects. January 2020. A World Bank Group Flagship Report. https://www.worldbank.org/en/publication/global-economic-prospects

World Trade Organization (WTO) (2020). Trade Falls Steeply in First Half of 2020. Trade Statistics and outlook - Press release 858. *World Trade Organization*.

World Trade Organization (WTO) (2015). World Trade Report 2015. Speeding up Trade: Benefits and Challenges of Implementing the WTO Trade Facilitation Agreement. 2015. World Trade Organization.

Annex A. Regional and sectoral aggregations in CGE analysis

No.	Region code	Region description	GTAP 10 regions
1.	WER	Western Europe	Austria (AUT), Belgium (BEL), Bulgaria (BGR), Croatia (CRO), Cyprus (CYP), Czech Republic (CZE), Denmark (DNK), Estonia (EST), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Hungary (HUN), Ireland (IRL), Italy (ITA), Latvia (LVA), Lithuania (LTU), Luxembourg (LUX), Malta (MLT), Netherlands (NLD), Poland (POL), Portugal (PRT), Romania (ROU), Slovak Republic (SVK), Slovenia (SVN), Spain (ESP), Sweden (SWE), Switzerland (CHE), United Kingdom (GBR), Norway (NOR), Rest of EFTA (XEF), Rest of Europe (XER), Rest of the World (XTW)
2.	USA	United States	United States (USA)
3.	CHN	China	China (CHN)
4.	BRA	Brazil	Brazil (BRA)
5.	MEX	Mexico	Mexico (MEX)
6.	IND	India	India (IND)
7.	TUR	Turkey	Turkey (TUR)
8.	ZAF	South Africa	South Africa (ZAF)
9.	RWA	Rwanda	Rwanda (RWA)
10.	NGA	Nigeria	Nigeria (NGA)
11.	VNM	Vietnam	Vietnam (VNM)
12.	PHL	Philippines	Philippines (PHL)
13.	THA	Thailand	Thailand (THA)
14.	MYS	Malaysia	Malaysia (MYS)
15.	XSS	Rest of Sub-Saharan Africa	Benin (BEN), Burkina Faso (BFA), Cameroon (CMR), Côte d'Ivoire (CIV), Ghana (GHA), Guinea (GIN), Senegal (SEN), Togo (TGO), Rest of Western Africa (XWF), Central Africa (XCF), South-Central Africa (XAC), Ethiopia (ETH), Kenya (KEN), Madagascar (MDG), Malawi (MWI), Mauritius (MUS), Mozambique (MOZ), Tanzania (TZA), Uganda (UGA), Zambia (ZMB), Zimbabwe (ZWE), Rest of Eastern Africa (XEC), Botswana (BWA), Namibia (NAM), Rest of South African Customs Union (XSC)
16.	XHY	Rest of high-income	Australia (AUS), New Zealand (NZL), Canada (CAN), Hong Kong SAR, China (HKG), Japan (JPN), Republic of Korea (KOR), Taiwan, China (TWN), Singapore (SGP)
17.	XLC	Rest of Latin America & Caribbean	Argentina (ARG), Bolivia (BOL), Colombia (COL), Ecuador (ECU), Venezuela RB (VEN), Chile (CHL), Paraguay (PRY), Peru (PER), Uruguay (URY), Rest of South America (XSM), Costa Rica (CRI), Guatemala (GTM), Honduras (HND), Nicaragua (NIC), Panama (PAN), El Salvador (SLV), Rest of Central America (XCA), Dominican Republic (DOM), Jamaica (JAM), Puerto Rico (PRI), Trinidad and Tobago (TTO), Rest of Caribbean (XCB), Rest of North America (XNA)
18	XEA	Rest of East Asia	Rest of Oceania (XOC), Mongolia (MNG), Rest of East Asia (XEA), Brunei Darussalam (BRN), Cambodia (KHM), Indonesia (IDN), Lao PDR (LAO), Rest of Southeast Asia (XSE)
19.	XSA	South Asia	Bangladesh (BGD), Nepal (NPL), Pakistan (PAK), Sri Lanka (LKA), Rest of South Asia (XSA)

No.	Region code	Region description	GTAP 10 regions
20.	ECA	Europe & Central Asia	Albania (ALB), Belarus (BLR), Russian Federation (RUS), Ukraine (UKR), Rest of Eastern Europe (XEE), Kyrgyzstan (KGZ), Tajikistan (TJK), Rest of Former Soviet Union (XSU), Armenia (ARM), Georgia (GEO), Kazakhstan (KAZ), Azerbaijan (AZE)
21.	XMN	Middle East & North Africa	Bahrain (BHR), Islamic Republic of Iran (IRN), Kuwait (KWT), Oman (OMN), Jordan (JOR), Qatar (QAT), Saudi Arabia (SAU), United Arab Emirates (ARE), Rest of Western Asia (XWS), Israel (ISR), Rest of North Africa (XNF), Arab Republic of Egypt (EGY), Morocco (MAR), Tunisia (TUN)

Table A.2. Sectoral aggregation mapping

No.	Sector code	Sector description	GTAP 10 sectors
1.	CRP	Crops	Paddy rice (pdr), processed rice (pcr), wheat (wht), cereal grains (gro), oil seeds (osd) sugar cane and beet (c_b), sugar (sgr), vegetable, fruit, nuts (v_f), plant-based fibers (pfb), other crops (ocr)
2.	LVS	Livestock	Cattle (ctl), other animal products (oap), raw milk (rmk), wool (wol)
3.	NRS	Natural resource products	Forestry (frs), other extraction (oxt)
4.	COA	Coal extraction	Coal (coa)
5.	OIL	Oil extraction	Oil (oil)
6.	GAS	Gas extraction and distribution	Gas (gas), gas distribution (gdt)
7.	PMT*	Meat products (incl. fisheries)	Fishing (fsh), bovine meat products (clt), other meat products (omt), dairy products (mil)
8.	OFD*	Other food	Vegetable oils and fats (vol), food products (ofd), beverages and tobacco products (b_t)
9.	TEX*	Textiles	Textiles (tex)
10.	WAP*	Wearing apparel	Wearing apparel (wap)
11.	LEA*	Leather products	Leather products (lea)
12.	WDP*	Wood and paper products	Wood products (lum), paper products (ppp)
13.	P_C	Refined oil	Petroleum, coal products (p_c)
14.	CHM*	Chemical products (incl. rubber and plastics)	Chemical products (chm), basic pharmaceutical products (bph), rubber and plastic products (rpp)
15.	NMM	Non-metallic minerals	Non-metallic minerals (nmm)
16.	MET	Metals	Ferrous metals (i_s), non-ferrous metals (nfm)
17.	ELE*	Computer, electronic and optical products	Computer, electronic and optical products (ele)
18.	OME*	Other machinery and equipment	Electrical equipment (eeq), other machinery and equipment (ome)
19.	MVH*	Motor vehicles and parts	Motor vehicles and parts (mvh)
20.	OTN*	Other transport equipment	Other transport equipment (otn)
21.	XMN*	Other manufacturing	Metal products (fmp), other manufacturing (omf)
22.	ELY	Electricity	Electricity (ely)
23.	CNS	Construction	Construction (cns)
24.	TRD	Trade incl. warehousing	Trade (trd), warehousing and support activities (whs)
25.	AFS	Accommodation, food and service activities	Accommodation, food and service activities (afs)
26.	WTP	Water transport	Water transport (wtp)
27.	ATP	Air transport	Air transport (atp)
28.	XTP	Other transport	Other transport (xtp)
29.	CMN	Communications	Communications (cmn)

No.	Sector code	Sector description	GTAP 10 sectors
30.	ROS	Recreational and other services	Recreational and other services (ros)
31.	XSV	Other services	Water (wtr), other financial services (ofi), insurance (ins), real estate activities (rsa), other business services (obs), public administration and defense (osg), education (edu), human health and social work activities (hht), dwellings (dwe)

Notes: "*" indicate sectors that are treated as MRIO sectors in the model, allowing agent-based demand for imports by region of origin.

Annex B. Technical description of the ENVISAGE model

The Environmental Impact and Sustainability Applied General Equilibrium (ENVISAGE) Model (van der Mensbrugghe 2019) at its core is a recursive dynamic and global computable general equilibrium (CGE) model. It follows the circular flow of an economy paradigm. Firms purchase input factors (for example labor and capital) to produce goods and services. Households receive the factor income and in turn demand the goods and services produced by firms. Equality of supply and demand determine equilibrium prices for factors, goods, and services. The model is solved as a sequence of comparative static equilibria where the factors of production are linked between time periods with accumulation expressions. Production is implemented as a series of nested constant-elasticity-of-substitution (CES) functions, the aim of which is to capture the substitutability across all inputs.

Income accrues from payments to factors of production and is allocated to households (after taxes). The government sector accrues all net tax payments and purchases goods and services. The model incorporates multiple utility functions for determining household demand—for this paper, the constant-differences-in-elasticities (CDE) utility function was chosen. Trade is modeled using the so-called Armington specification that posits that demand for goods is differentiated by region of origin. The model allows for domestic/import sourcing at the aggregate level (after aggregating domestic absorption across all agents), or at the agent-level. For this paper, a select number of production activities source imports by region of origin using the so-called MRIO specification.

The model has two fundamental markets for goods and services: Domestically produced goods sold on the domestic market, and domestically produced goods sold by region of destination. All other goods and services are composite bundles of these goods. Two market equilibrium conditions are needed to clear these two markets.

The model incorporates five types of production factors: 1) labor (of which there can be up to five types); 2) capital; 3) land; 4) a sector-specific natural resource (such as fossil fuel energy reserves); and 5) (optionally) water. The labor market is allowed to be segmented (though not required). The model allows for regime switching between full and partial wage flexibility. Capital is allocated across sectors so as to equalize rates of returns. If all sectors are expanding, *Old* capital is assumed to receive the economy-wide rate of return. In contracting sectors, *Old* capital is sold on secondary markets using an upward sloping supply curve.

ENVISAGE incorporates the main greenhouse gases—carbon, methane, nitrous oxides, and fluorinated gases, though in the current study we focus only on CO_2 emissions from fossil fuels combustion. A number of carbon control regimes are available in the model. The incidence of the carbon tax allows for partial or full exemption by commodity and end-user. The model allows for emission caps in a flexible manner—where regions/sectors can be segmented into coalitions. For the current assessment only CO_2 emissions from fossil fuels combustion were considered.

Dynamics involves three elements. Labor supply (by skill level) grows at an exogenously determined rate. The aggregate capital supply evolves according to the standard stock/flow motion equation, i.e. the capital stock at the beginning of each period is equal to the previous period's capital stock, less depreciation, plus the previous period's level of investment. The third element is technological change. The standard version of the model assumes labor augmenting technical change—calibrated to given assumptions about GDP

growth and inter-sectoral productivity differences. Detailed documentation of the ENVISAGE model is provided in van der Mensbrugghe (2019).

Annex C. Modeled scenarios

Scenario	Description
Pre-Covid baseline	Pre-COVID MPO projections from World Bank (2020), includes trade war tariffs and existing FTAs, after 2022 - SSP2
Covid L-shape recovery	GEP projections till 2022, slow recovery post 2022 – going back to the TFP growth rates from pre-COVID baseline (emissions consistent with IEA forecast, so used as the new baseline) 5 percent increase in the costs of imports Sharp drop in international tourism (World Travel and Tourism Council) Shift in household demand away from services that require close in-person interactions (U.S. retail sales data) Food supply shock (World Bank's Commodity Markets Outlook - October 2020) Shift toward communication technologies in the service sectors and away from transportation activities, particularly air transportation Reduction in global oil prices (IEA 2020)
Reshoring Leading Economies	Subsidy to local agriculture and manufacturing production (amounting to 1 percent of GDP in the corresponding region) Barriers to imports (25 percentage point surcharge) Harder to substitute domestic production for imports (reducing trade elasticities by 50 percent)
Reshoring all	As above but all countries (similar to OECD 2020b)
GVC Friendly Liberalization + Trade Facilitation (TF)	Tariff elimination on all intermediate inputs Easier to substitute domestic for imported inputs (increasing trade substitution elasticity by 50 percent) Reduce costs to trade by implementing trade facilitation measures (Moise and Sorescu 2013 & World Trade Report 2015)
Nationally Determined Contributions (NDCs)	Emissions reduction targets under the Paris Accord (Chepeliev et al. 2021 & Böhringer et al. 2020)
EU Green Deal	Cut emissions by 55 percent in 2030 relative to 1990 levels (EC 2019)