INTERNATIONAL MONETARY FUND

EXTERNAL SECTOR REPORT

Pandemic, War, and Global Imbalances

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CHAPTER 2

CLIMATE POLICIES AND EXTERNAL ADJUSTMENT

Understanding the effects of climate mitigation policies not only on the global economy but on different regions and countries is critical to forging a consensus on how to combat global warming and moving that process forward. This chapter contributes to the assessment of the economic effects of climate policies on different regions and countries. Drawing on model-based analysis of a "net-zero emissions by 2050" scenario, the chapter finds that a range of announced climate policies could have substantially different impacts on external balances over the next decade. A credible and globally coordinated carbon tax would decrease current account balances in greener advanced economies and increase current accounts in more fossil-fuel-dependent regions, reflecting a disproportionate decline in investment for the latter group. Green supply-side policies—green subsidy and infrastructure investment—would increase investment and saving but would have a more muted external sector impact, either because of the constrained pace of expansion for renewables or because of the symmetry of the infrastructure boost. Ultimately, country characteristics, such as initial carbon intensity and net fossil fuel exports, determine the current account responses. For the global economy, a coordinated climate change mitigation policy package would shift capital toward advanced economies and reduce global current account balances. The global interest rate, following an initial rise, would fall over time with increases in the carbon tax. These external sector effects, however, depend crucially on the degree of international policy coordination and on credibility. A unilateral carbon tax in Europe would reverse that region's current account response—negatively impacting competitiveness—and increase global balances. Policies such as burden sharing of carbon emission reductions between advanced and developing economies and accelerating the pace of investment in renewables in developing economies could moderate the external sector impact of the climate change mitigation efforts.

The authors of this chapter are Rudolfs Bems and Luciana Juvenal, in collaboration with external consultants Warwick McKibbin and Weifeng Liu for modeling simulations. Xiaohan Shao provided research support and Jane Haizel editorial assistance. The chapter also benefited from comments by Fernanda Nechio, internal seminar participants, and reviewers.

Introduction

As global warming continues, there has been increasing interest in understanding the effects of climate mitigation policies on the macroeconomy. Leveraging the objective to eliminate carbon emissions by 2050, studies have focused on the impact of mitigation policies on economic activity, employment, and international trade as well as their distributional effects (see Chapter 3 of the October *2020 World Economic Outlook* [WEO]; Chateau, Jaumotte, and Schwerhoff 2022b; OECD 2022). Other recent topics of interest are the implications of mitigation policies for global commodity markets and financial markets, as well as for fiscal and monetary policies (see the October 2019 *Fiscal Monitor*; April 2020 *Global Financial Stability Report;* October 2021 WEO; McKibbin, Konradt, and Mauro 2021; and IEA 2021). The literature discusses mitigation policy choices and design, given the recommended limits on temperature increases and the need to avoid catastrophic consequences of climate change (Parry, Black, and Roaf 2021; Jaumotte and Schwerhoff 2021).

A potentially important gap in this literature is the external sector impact of mitigation policies. The green transition will induce a major economic transformation. Comparable past episodes of energy transitions, such as oil discoveries, have led to large external sector adjustments in the affected economies (Box 2.1). A global green transition would not impact the external sector if countries and mitigation policies were identical. However, there are significant structural differences across countries—for example, the degree of fossil fuel dependence and the role of renewables in energy generation—that can induce and magnify external sector responses. Differences in the content and pace of implementation of mitigation policies are another source of cross-country asymmetries that could trigger external sector adjustments.

To address this gap in the literature, this chapter examines the effect of mitigation policies on the external sector using a model-based approach. The chapter builds on the net-zero emissions by 2050 scenario analyzed in the October 2020 WEO, based on the G-Cubed global macroeconomic model (McKibbin and Wilcoxen 2013; Liu and others 2020). Taking as given the set of mitigation policies from the scenario analyzed in the October 2020 WEO—a carbon tax with a compensatory transfer to households to ensure inclusion, a green subsidy to the renewables sector, and green infrastructure investment—the chapter examines the following questions:[1]

- What are the consequences of climate mitigation policies on countries' external sectors?
- How do the resulting external sector outcomes depend on the countries' (sectoral) structural characteristics?
- How does the coordination of mitigation policies across countries impact external sector outcomes?
- What effect does burden sharing of emission reductions between advanced and developing economies have on the external sector adjustment?
- What are the implications of mitigation policies for global current account balances, capital flows, and global interest rates?[2]

The analysis is limited to a specific climate change mitigation scenario. Research on climate change and associated policies is still nascent. The literature on the topic continues to debate many of the important aspects underlying the construction of the scenario, including the economy's response to carbon pricing policies and the role of technological progress in the green transition. Furthermore, economic consequences of climate policies can vary significantly with the assumed long-run input substitutability or the mobility of production factors. Therefore, the findings of this chapter need to be interpreted in the context of the scenario being considered. Global current account balances in the chapter are used as a descriptive concept, not carrying policy or normative implications.

The investigation focuses on medium-term outcomes for the global economy partitioned into the largest economies and key regions. Specifically, the chapter restricts attention to external sector impacts over the next decade, because the longer-term climate change outcomes and their economic consequences are highly uncertain. Coverage of the largest economies and aggregated regions that together constitute the global economy allows the scenario to account for the global general equilibrium effects of climate policies.

The chapter finds that, while ensuring the paramount objective of addressing climate change, a range of future climate mitigation policy choices could have a substantially different medium-term impact on current account balances by changing current investment and saving decisions.

- A credible and globally coordinated carbon tax decreases the current account in the greener advanced economies and increases it in the more fossil-fuel-dependent developing countries. On the investment side, the tax permanently reduces the return on carbon-intensive investment. In response, investment falls globally, more so in fossil-fuel-dependent economies, bringing about significant differences in the investment response across countries.[3] On the saving side, the global decline in investment reduces the global interest rate, which decreases saving across countries in a relatively uniform manner. As a result, current account movements are driven by the investment response, which is ultimately determined by country characteristics such as the initial intensity of carbon emissions and the net fossil fuel exports.
- Globally coordinated supply-side policies—a green subsidy for renewables and infrastructure investment—boost investment and saving and increase the global interest rate. Compared with the carbon tax, these policies have a more limited impact on the external sector, either because of the limited pace of sectoral expansion for renewables or because of the imposed identical size of the boost to the green infrastructure, which leads to comparable investment and saving responses within countries, leaving the current account broadly unchanged.
- For the global economy, a coordinated climate change mitigation policy package reduces global current account balances by 25 percent by 2027, while capital flows shift toward the greener advanced economies. The global interest rate, following an initial green-infrastructure-induced rise, falls over time as the persistently increasing carbon tax reduces investment globally, shifting economic activity toward more labor-intensive sectors.
- Partial implementation of mitigation policies can reverse or magnify external sector effects relative to

[1]The carbon tax assumed in this chapter may differ from the way carbon pricing is implemented. Alternative instruments and policies such as emissions trading systems, adjustments to preexisting taxes or subsidies, and nonpricing approaches based on regulations can be translated into a carbon price equivalent policy (Black and others 2022; Chateau, Jaumotte, and Schwerhoff 2022a).

[2]Global current account balances are defined as the sum of absolute current account balances across all countries.

[3]In support of the model scenario, the April 2022 WEO estimates that, in part as a result of anticipated and implemented climate policies, investment in gas and oil sectors declined globally by 40 percent between 2014 and 2019.

globally coordinated implementation, depending on the type of policy and the country implementing it. For example, a unilateral carbon tax in Europe increases the current account in that region (instead of a decrease in the current account under coordinated implementation), because the tax reduces domestic investment and shifts capital abroad.[4] By contrast, a unilateral green subsidy in Europe magnifies the external sector response in that region by further reducing the current account balance. However, a critical shortcoming of partial implementation is the failure to address climate change.

- Increased burden sharing in emission reductions, consistent with the proposed internationally coordinated carbon price floor (October 2022 *Fiscal Monitor*), could reduce the size of the climate-policy-induced external sector adjustment between advanced and developing economies by a third. A further moderation of the external sector response could result from policies that accelerate the pace of investment in developing economies with less developed renewables sectors.

The Approach: The Model-Based Mitigation Scenario

This section summarizes the model and the climate change mitigation scenario featured in the October 2020 WEO, emphasizing aspects that are particularly relevant for studying the external sector impact.

The G-Cubed Model

The chapter's findings are based on simulations of the G-Cubed global macroeconomic model. This large intertemporal general equilibrium model partitions the world economy into 10 countries and regions, separating out major economies as well as fossil-fuel-producing countries and regions (Table 2.1). The model includes 20 sectors, with rich sectoral detail on energy sectors and power generation, including three key fossil fuel sectors—oil, gas, and coal—as well as renewables-based electricity generation sectors (Table 2.2).

The model's sectoral detail captures key asymmetries central to the analysis of the external sector. First, regions differ in the carbon intensity of economic activity (Figure 2.1, panel 1). Carbon intensity

[4]"Europe" throughout the chapter refers to the EUW group of countries, as defined in Table 2.1.

Table 2.1. Regions in the G-Cubed Model

Region/Country Code	Region or Country
AUS	Australia
CHN	China
EUW	EU and selected other European Countries
IND	India
JPN	Japan
OEC	Rest of the advanced OECD
OPC	Selected oil exporters and other economies
ROW	Rest of the world
RUS	Russia
USA	United States

Sources: McKibbin and Wilcoxen (1999, 2013); Liu and others (2020).
Note: EUW comprises the European Union (EU), Norway, Switzerland, and the United Kingdom; OEC comprises Canada, Iceland, Liechtenstein, and New Zealand; OPC comprises Algeria, Angola, Bahrain, the Democratic Republic of the Congo, Ecuador, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Nigeria, Oman, the West Bank and Gaza, Qatar, Saudi Arabia, Syria, the United Arab Emirates, Venezuela, and Yemen; ROW comprises all countries not included in the other groups. OECD = Organisation for Economic Co-operation and Development.

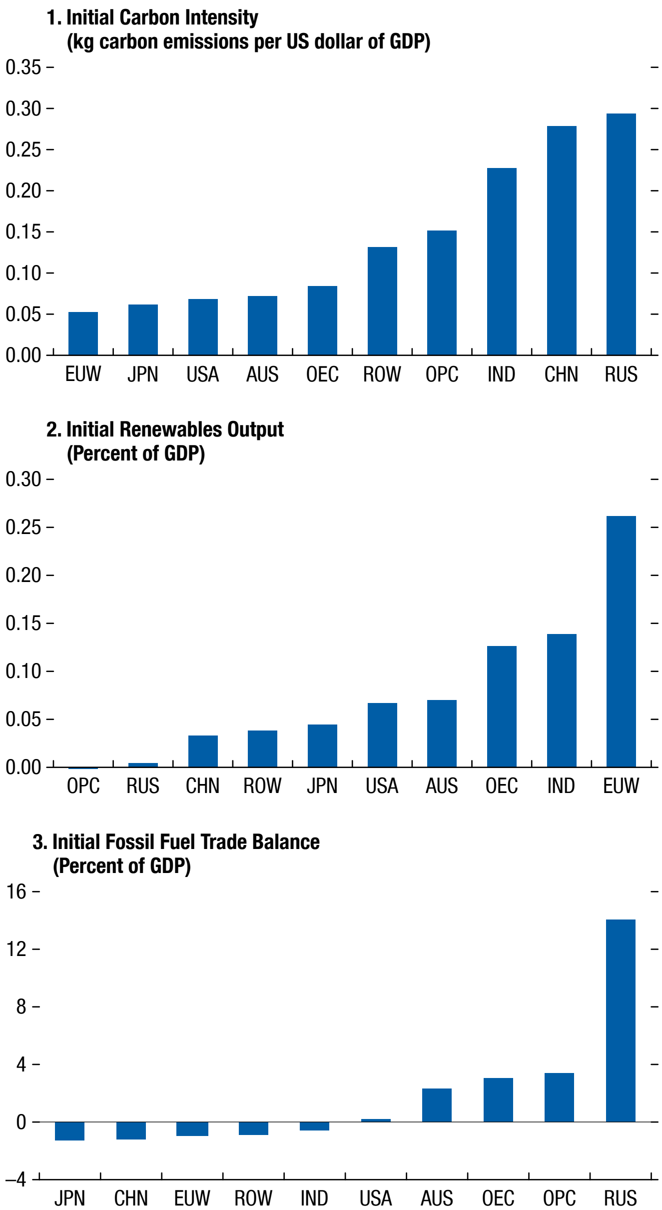
Table 2.2. Sectors in the G-Cubed Model

Number	Sector Name	Note
1	Electricity delivery	Energy sectors other than generation
2	Gas extraction and utilities	
3	Petroleum refining	
4	Coal mining	
5	Crude oil extraction	
6	Construction	Goods and services
7	Other mining	
8	Agriculture and forestry	
9	Durable goods	
10	Nondurable goods	
11	Transportation	
12	Services	
13	Coal generation	Electricity generation sectors
14	Natural gas generation	
15	Petroleum generation	
16	Nuclear generation	
17	Wind generation	
18	Solar generation	
19	Hydroelectric generation	
20	Other generation	

Sources: McKibbin and Wilcoxen (1999, 2013); Liu and others (2020).

Figure 2.1. Structural Asymmetries

Countries differ in terms of their initial level of carbon intensity, the initial size of their renewables sectors, and the initial size of their fossil fuel trade balances. This heterogeneity plays a role in the response to mitigation policies.



Source: IMF staff calculations.
Note: The panels show the baseline characteristics used to run the simulation in the G-Cubed global macroeconomic model in the October 2020 *World Economic Outlook* (WEO). See Online Annex 3.4 in that WEO for a description of the baseline assumptions. The fossil fuel sector includes coal, natural gas, and petroleum. The renewables sector includes wind, solar, and other renewable electricity-generating sectors. See Table 2.1 for a list of region and country codes. kg = kilograms.

is higher in fast-growing emerging market economies such as China and India, as their fossil energy structures rely more heavily on coal. These economies also rely more on carbon-intensive industries. Less carbon-intensive advanced economies rely relatively more on gas and oil for energy generation. Second, regions differ in the importance of renewable energy for electricity generation (Figure 2.1, panel 2). The renewables sector is dominated by Europe, which accounts for 62 percent of global renewable energy (including solar, wind, and other renewables). This sector magnifies differences in carbon intensities across countries and regions. While renewables account for about 20 percent of energy generation in Europe and the OEC (see Table 2.1 for an explanation of the region codes), they represent less than 5 percent of the total in all fossil fuel exporters. Third, regions and countries differ in energy trade (Figure 2.1, panel 3). Russia and the OPC group are the main fossil fuel exporters, while other countries, such as Japan, are fossil fuel importers, especially of oil and gas.

The G-Cubed model includes standard features of large macro models, including several that are worth highlighting:

- Intertemporal general equilibrium with standard optimization.
- Rigidities, such as limits on the pace of investment, that prevent economies from moving quickly from one equilibrium to another.
- Cross-border capital and trade flows and bilateral cross-border input linkages.
- Heterogeneous households and firms—besides conventional forward-looking agents, a fraction of households simply consume their current income, and a fraction of firms make backward-looking investment decisions.
- Monetary and fiscal policy rules.

The model, discussed in detail in McKibbin and Wilcoxen (1999, 2013), Liu and others (2020), and Online Annex 3.4 of the October 2020 WEO, has been applied to study a wide range of macroeconomic policy questions.

Importantly, the model incorporates a full-fledged external sector. Intertemporal decisions of households and firms determine both saving and investment in response to the change in government policies. The gap between aggregate saving and investment determines the current account. A key variable that affects national saving, investment, and current accounts is the real interest rate, which directly affects both saving and investment decisions as well as human wealth through a discounting channel.[5] Flexible exchange rates and open capital accounts are assumed for the model's 10 countries and regions.

Climate Change Mitigation Scenario

The October 2020 WEO climate change mitigation scenario brings net carbon emissions to zero by 2050 with the help of a policy package that consists of carbon taxes, accompanied by compensatory transfers to households, and green supply policies—infrastructure investment and a subsidy to renewables—designed as follows:[6]

- *Carbon tax:* Carbon prices are calibrated to achieve an 80 percent reduction in emissions in each region by 2050 relative to 2018, after accounting for emission reductions from the infrastructure investment and the green subsidy are accounted for.[7] The carbon tax consists of an initial tax rate followed by an annual increase of 7 percent. A quarter of the resulting carbon tax revenue is transferred back to households to help protect the purchasing power of the poorest households from the increase in energy prices. The remaining three-quarters of the revenue is recycled to reduce government debt.
- *Green subsidy:* Output of renewables—solar and wind electricity generation sectors—is subsidized by 80 percent. The subsidy is financed by government debt.
- *Low-carbon infrastructure investment:* An initial green public infrastructure investment of 1 percent of GDP gradually declines to zero over 10 years. Public investment is assumed to occur in the renewables and other low-carbon energy sectors, transport infrastructure, and services.[8] In line with the analysis in Calderón, Moral-Benito, and Servén (2015), it is assumed that for every 10 percent increase in the aggregate stock of infrastructure capital, productivity in private sector output rises by 0.8 percent. The new infrastructure, once in place, is sustained by spending an additional 0.2 percent of GDP to offset depreciation, which locks in the productivity gains of the sectors that benefit from the green infrastructure.

The three mitigation policies play distinct roles in reducing emissions and supporting economic growth. The carbon tax by 2050 accounts for 80 percent of emission reductions, but negatively impacts economic growth (Figure 2.2). Meanwhile, the green supply-side policies provide limited contributions to the emission reductions but ensure that the green transition is growth neutral.[9]

The assumption that all countries and regions reduce emissions to the same extent imposes a disproportionate and inequitable burden of economic adjustment on developing economies. To address such concerns, the chapter complements the baseline scenario with one of increased burden sharing in mitigation efforts between advanced and developing economies. This alternative scenario highlights the external sector impact of switching from uniform emission reduction targets to income-differentiated mitigation efforts.

Mechanisms

The mitigation policy package affects carbon emissions and the macroeconomy through two main channels. First, the carbon tax increases the relative price of fossil fuel energy, encouraging energy efficiency and discouraging energy usage. This is the scenario's main channel for reducing carbon emissions, with important implications. As economies reduce energy

[5]Note that the precautionary saving motive is absent from the model. Given uncertainties associated with climate change and the green transition, precautionary considerations could provide an additional motive for saving.

[6]The G-Cubed model baseline without the climate mitigation policies relies on country-specific projections for labor force, country- and sector-specific projections of productivity growth rates as well as projections of energy efficiency improvements based on historical experience. Regions and countries are assumed to gradually catch up with the worldwide productivity frontier, and a catch-up in energy efficiency is assumed for China and India. The baseline scenario abstracts from the 2020 COVID-19 pandemic-related fall in output and emissions, assuming that the subsequent rebound brings output and emission levels in 2021 close to their 2019 level—the most recent year for which the model has been calibrated. The baseline projects that global carbon emissions will continue rising at an average annual pace of 1.7 percent, reaching 57.5 gigatons by 2050 (Figure 2.2). Improvements in energy efficiency and growth in renewables cannot offset the forces of population and economic growth that are driving emissions. Projected economic growth over the next 30 years determines the expected growth of future emissions and hence the scale of efforts needed to keep temperature increases at 1.5°–2°C. For further details on the model baseline scenario, see Jaumotte, Liu, and McKibbin (2021).

[7]The October 2020 WEO scenario assumes that the remaining 20 percent of carbon emission reductions would come from factors not captured by the model, such as natural emission sinks and carbon removal technologies.

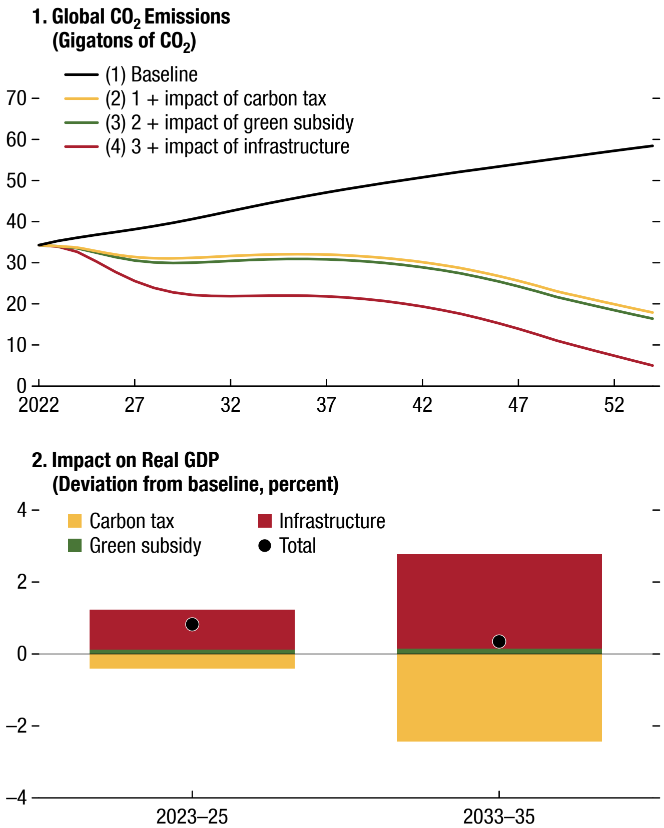
An exception is made for the OPC region, for which emissions are kept at the initial level because of an outsized negative economic impact from the global decline in demand for fossil fuels.

[8]The latter aims to capture the higher energy efficiency of buildings.

[9]The scenario is also designed to be employment-neutral and public-debt-neutral for the global economy.

Figure 2.2. Policy Package

The reduction in emissions is achieved through a carbon tax, a green subsidy, and infrastructure investment. Infrastructure investment and the green subsidy are growth friendly, while the carbon tax has a negative impact on growth but generates the bulk of emission reductions. Initially there is a boost in global activity, followed by a decline.



Source: IMF staff calculations.
Note: The simulations are run using the G-Cubed global macroeconomic model of the October 2020 *World Economic Outlook* (WEO). The climate change mitigation policy package is calibrated to reduce gross emissions by 80 percent in every country/region by 2050 and is composed of (1) gradually rising carbon taxes, (2) a green fiscal stimulus consisting of green infrastructure investment, and (3) a subsidy for renewables production. See Online Annex 3.4 of the October 2020 WEO for more details on the implementation of the simulation. CO_2 = carbon dioxide.

usage, economic activity shifts from capital-intensive high-carbon sectors to more labor-intensive low-carbon sectors. Hence, the impact of decarbonization is more negative for investment than it is for output and employment. Less energy-intensive aggregate economic activity also limits the size of carbon tax revenues that can be raised. Second, both the carbon tax and the green supply policies increase the price of fossil fuel energy relative to that of renewables-based energy, contributing to the growth and investment in the renewables sector. However, this shift in energy composition is a slow-moving process because of limits to the pace of sectoral expansion, with a potential role for targeted policies to facilitate the growth of the sector. Importantly, the credibility and anticipation of the mitigation policies, implemented over the next three decades, are crucial for generating the outcomes of the climate change mitigation scenario. Credible carbon tax policy can trigger large changes in immediate economic outcomes, including investment responses and dynamic effects, even if the initial size of the tax is small.

Two additional considerations are worth noting. First, the global economic transformation entailed by the mitigation scenario studied in the October 2020 WEO is gradual and orderly, avoiding abrupt adjustments in fossil fuel prices, which increase persistently over the scenario's horizon. There are also no technological breakthroughs, including technology leapfrogging, assumed that would facilitate the green transition, beyond the spillovers from the green infrastructure investment. Second, the results presented in this chapter abstract from long-term climate damages. A model extension that incorporates climate damages suggests a very limited economic and external sector impact for the global economy over the next decade (Fernando, Liu, and McKibbin 2021).

External Sector Impact

To investigate the external sector impact of the net-zero emissions by 2050 scenario, this section analyzes the three mitigation policies individually, followed by an analysis of the full policy package. The section also examines alternative policy scenarios, including partial implementation of climate mitigation policies and burden sharing of emissions reductions and explores the implications of climate change mitigation policies for the global economy.

Carbon Tax

The carbon tax policy resembles a negative productivity shock that varies by sector and country, depending on the current and anticipated path of carbon dependence. Greener countries are the least affected, while fossil fuel extraction activities are permanently reduced. The economic impact of the policy is backloaded, with tax levels gradually increasing until 2050 to achieve the emission targets (see Online Annex 3.4 of the October 2020 WEO).

The internal investment-saving balance approach is adopted to gauge the external sector response to the tax, distinguishing between (1) global intertemporal implications and (2) cross-country variation in response to the tax. To focus on the responses over the first decade, results are reported in terms of average deviations from the baseline growth path for the first 10 years of the simulation.

The carbon tax decreases aggregate investment globally as the anticipated return on fossil-fuel-linked investment is permanently reduced.[10] The global interest rate falls, shifting income toward consumption and reducing global saving until the global investment-saving balance is restored.[11] The economic magnitude of the adjustment is sizable, with investment and saving declining by 2 percent of global GDP over the first decade, reflecting the high capital intensity of fossil-fuel-dependent economic activity. Meanwhile, the global interest rate declines by 0.25 percentage point.

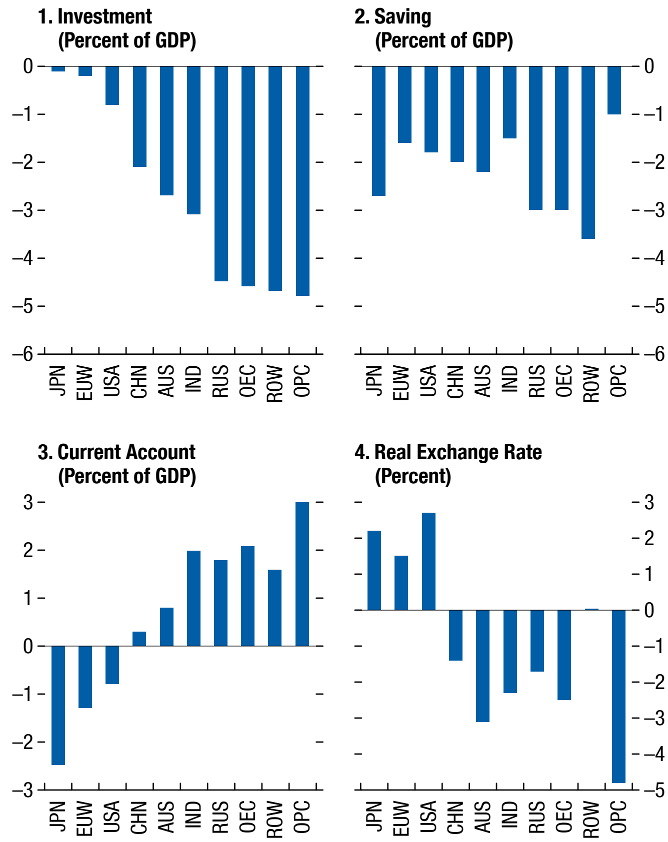
Results reveal a large variation in the investment response across countries. To examine such cross-country differences, Figure 2.3 reports results for all 10 of the model's countries and regions, ordered by the size of the investment response. The contraction in investment is most pronounced in the fossil-fuel-producing countries and regions (Russia, OEC, ROW, OPC), while relatively greener advanced economies and regions (Japan, EUW) are affected the least (Figure 2.3. panel 1). China and India are more negatively affected than advanced economies because of their carbon-intensive manufacturing activities.[12] Saving declines more evenly across countries, dominated by the decline in the global interest rate, while other underlying drivers vary less (Figure 2.3, panel 2).[13]

The response of the current account is driven by heterogeneity in the investment response across countries (Figure 2.3, panel 3). The current account decreases where investment contracts the least and increases in countries where the carbon tax decreases investment the most, as capital is relocated toward greener economies. The dominant role of aggregate investment in driving external sector responses is captured by a strong negative cross-country correlation (–0.94) between investment and current account responses and an absence of correlation between the current account and aggregate saving (0.01). A stylized

Figure 2.3. Impact of a Coordinated Carbon Tax on the External Sector

(Deviations from baseline; 2023–33 average)

Following a carbon tax, investment falls globally. The external sector response is determined by the heterogeneity in the decline in investment. In countries where investment contracts least, the current account decreases, while in countries with the largest decline in investment, the current account increases relative to the baseline. To facilitate the adjustment, the real exchange rate depreciates in countries where the current account increases, decreasing imports and increasing exports.



Source: IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. See Table 2.1 for a list of region codes.

[10]This overall decline in investment relies importantly on the investment response in the expansion of renewables.

[11]Public sector surpluses stemming from carbon tax revenues are more than offset by private dissaving, resulting in decreased aggregate saving.

[12]Using a different computable general equilibrium model–based climate change mitigation scenario, the OECD (2022) reports a similar higher cost of decarbonization, in terms of the investment response, for China and India.

[13]The overall saving is also impacted by the intertemporal consumption smoothing motive, as income declines in response to the persistently increasing carbon tax. More of the income is saved in the initial decade in economies and regions in which the income decline is anticipated to be the steepest. However, the variation in this saved income share plays a limited role quantitatively.

two-country graphic illustration of these economic forces is presented in Box 2.2.

The real exchange rate (RER) plays a shock absorber role for the most affected countries and regions. In response to the carbon tax, the RER depreciates in countries with the most negative economic impact—with the largest declines in investment and capital outflows (Figure 2.3, panel 4). For such economies the RER facilitates the external sector adjustment through the expenditure switching channel, as the demand at home shifts from imported to domestic goods and services and exports are boosted. Reverse economic forces are at work in countries that are the least affected by the carbon tax, exhibiting capital inflows and current account deficits relative to the baseline. The strong link between the current account and the RER adjustment is captured by a –0.86 cross-country correlation for responses.

The external sector impact of the carbon tax is sizable. The absolute value of the 10-year average current account response ranges from 0.3 to 3 percent of GDP. The absolute value of the RER adjustments, relative to the baseline path, ranges from 0 to 4.8 percent, with an outsized response in initial years.

Increased current accounts in the fossil-fuel-dependent economies contrast with the historically observed positive relationship between carbon revenues and current account balances. This result is due to the permanent nature of the carbon tax increase. While the negative economic impact of a temporary fall in the carbon price can be absorbed by reducing the current account, a credible and anticipated permanent decrease in carbon revenues requires a structural adjustment as aggregate investment declines and countries transition away from investment-intensive carbon-based economic activity. It is also important to note that the model does not capture intergenerational equity considerations stemming from the exhaustible nature of fossil fuels, which could decrease the current account of fossil-fuel-exporting countries in response to a globally coordinated carbon tax.[14] The overall current account response would need to reflect both the necessary structural adjustment and the fall in aggregate investment captured by the model, as well as the impact of the carbon tax on intergenerational equity considerations.

Which Country Characteristics Shape the External Sector Response to the Carbon Tax?

Country-specific determinants of carbon emissions drive the cross-country differences in the external sector response. One key characteristic, discussed earlier, is initial carbon intensity (Figure 2.1, panel 1). In addition, long-run growth of carbon emissions will be higher in countries with higher projected labor force and productivity growth rates and in sectors with a more limited scope for reducing reliance on carbon-intensive inputs. Each of these carbon-emission-inducing factors necessitates a higher carbon tax to reach the 2050 emission targets. Cross-country differences in the role of these factors can be summarized with the collected carbon tax revenues, which exhibit a strong positive correlation with the change in the current account. In countries or regions where the revenues collected from the tax (and projected carbon emissions) are the highest, the current account increases the most (Figure 2.4, panel 1), suggesting a form of twin surpluses. Conversely, countries and regions with relatively low carbon tax revenues exhibit current account decreases.

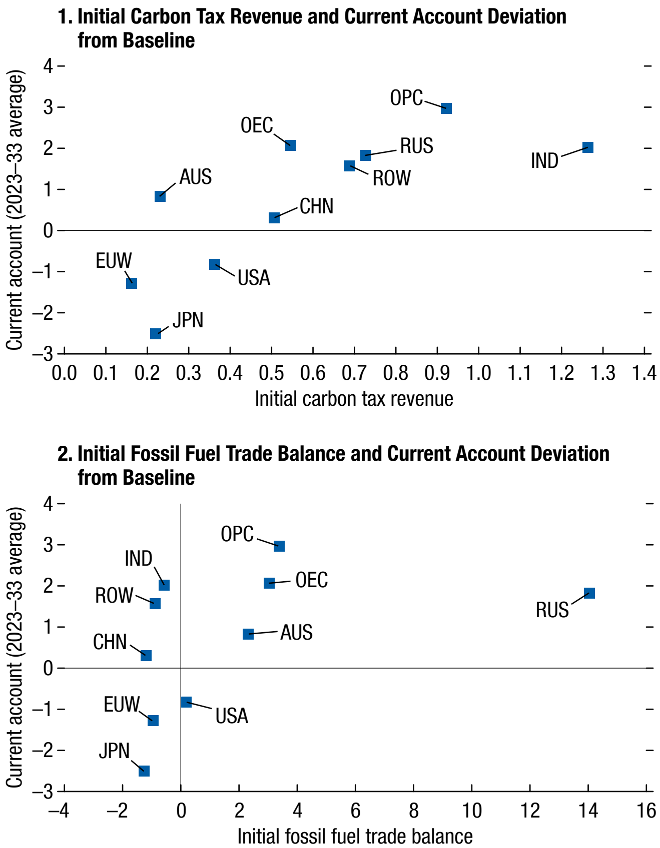
A country's status as a net fossil fuel exporter is an important additional determinant of the current account response. Net fossil-fuel-exporting countries face a reduced demand for fossil fuel from abroad, which further depresses investment and increases the current account (Figure 2.4, panel 2). This channel operates and exerts an economically significant impact on the external sector even if the fossil-fuel-exporting country does not impose a carbon tax.[15] More generally, the nature of this cross-border demand spillover could differ drastically across net resource-exporting countries. While net exporters of fossil fuels are negatively affected, the demand for metals critical for green energy transition could surge (Box 2.3). However, the G-Cubed model does not incorporate sufficient detail on mineral resources to explore such additional considerations.

[14]As fossil fuel exports fall permanently in response to a carbon tax, saving and the current account would decrease, reflecting the reduced income from the exhaustible resource.

[15]See panel 2 of Figure 2.8 for a simulation of this external sector spillover effect on net fossil fuel exporters from a carbon tax imposed in Europe only.

Figure 2.4. Country Characteristics and External Sector Impact of the Carbon Tax
(Percent of GDP)

Country characteristics such as the initial carbon intensity, labor force, and productivity growth rates and substitutability of carbon-intensive inputs—proxied with the carbon tax revenue—drive investment and current account responses in the model. For net fossil fuel exporters, cross-border spillovers from permanently reduced foreign demand also contribute to the decline in investment and the increase in current accounts.



Source: IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. See Table 2.1 for a list of region codes.

Green Subsidy

The green output-based subsidy to the renewables sector—that is, solar and wind energy generation—is reminiscent of a positive sector-specific productivity shock. The subsidy complements the carbon tax in stimulating a shift in energy generation from fossil fuels to renewables.

For the global economy, the green subsidy triggers an intertemporal adjustment familiar from the discussion of the carbon tax, but operating in reverse. The subsidy boosts investment in renewable activities, which leads to an increase in the global interest rate and saving until the global investment-saving balance is restored. Despite the large subsidy, the magnitude of the response is limited when compared with the carbon tax. Investment (and saving) increase globally by 0.1 percent of GDP, while the interest rate rises by 0.11 percentage point. The muted response is explained by the small initial size of the renewables sector—at a mere 0.1 percent of the global output—and by the limits on the pace of investment.[16]

There are stark differences in the investment response across countries and regions (Figure 2.5, panel 1). Europe, with its abundant renewable energy generation, has the strongest investment boom because limits to the pace of investment provide an advantage to regions with capital for renewables already in place (Figure 2.1, panel 2). At the other end of the spectrum, for fossil-fuel-producing countries and regions with small renewables sectors (RUS, OPC), the increased relative price of fossil-fuel-based energy reduces demand for fossil fuels, decreasing investment in the sector. While the renewables sector is attracting investment and growing rapidly, the sector's small size limits investment's macroeconomic impact. Saving increases in all regions in tandem with the rise in the global interest rate (Figure 2.5, panel 2).

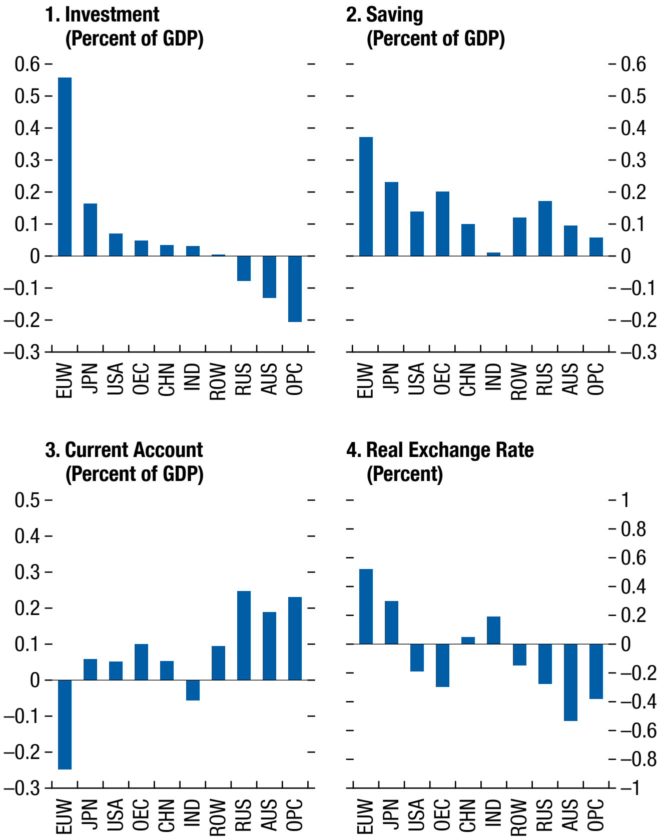
Changes in the current account are driven mainly by the heterogeneity in the investment response across countries and regions. There is an outsized decrease in Europe, reflecting the investment boom, while current accounts increase the most in fossil-fuel-dependent countries (Figure 2.5, panel 3).[17] The cross-country correlation between investment and current account responses is –0.91. As in the case of the carbon tax, the RER response facilitates the current account adjustment, with the largest appreciation in Europe and depreciations for fossil fuel exporters (Figure 2.5, panel 4). Reflecting investment responses, current account and RER adjustments are a fraction of those generated by the carbon tax.

[16]The model includes quadratic investment adjustment costs. As a result, countries that have smaller initial capital stocks in renewable activities experience a higher cost of adjustment per unit of capital investment because their marginal costs rise faster, constraining the pace of sectoral expansion.

[17]The stylized two-country graphic illustration of the model's forces in Box 2.2 can be modified to capture the investment-saving and current account impacts of the green subsidy. The key change is that a green subsidy shifts the investment curve outward, rather than inward, and the shift is larger for the green region.

Figure 2.5. Impact of the Green Subsidy on the External Sector
(Deviations from baseline; 2023–33 average)

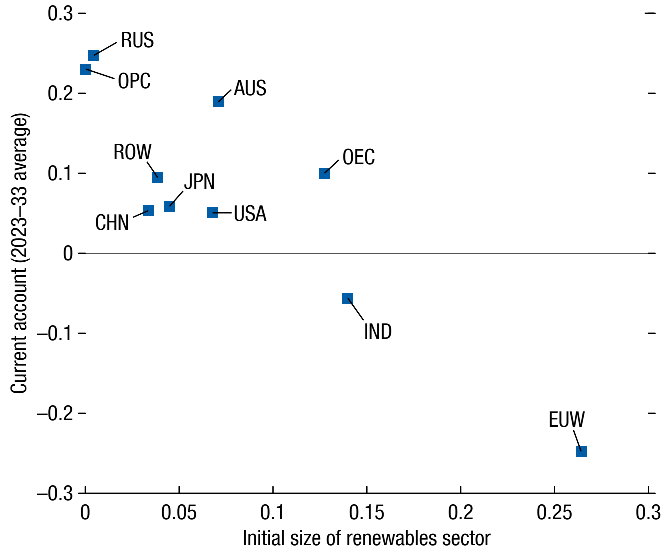
The green subsidy stimulates investment in the renewables sector and decreases the relative price of renewables-based energy. The resulting investment boom is most pronounced in Europe, where the renewable sector is the largest. Fossil fuel exporters see a decline in investment due to an increase in the relative price of fossil fuels. The impact on the external sector is determined by the heterogeneity in the response of investment. An investment boom decreases the current account and appreciates the real exchange rate.



Source: IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. See Table 2.1 for a list of region codes.

Figure 2.6. Country Characteristics and External Sector Impact of the Green Subsidy
(Percent of GDP)

With limits to the pace of expansion in the renewables sector, the initial size of the renewables sector determines the size of the fiscal subsidy and, hence, the investment and current account responses in the model.



Source: IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. See Table 2.1 for a list of region codes.

Which Country Characteristics Shape the External Sector Response to the Green Subsidy?

The external sector impact of the subsidy is ultimately driven by the cross-country variation in the initial size of the renewables sector. Given the constrained pace of sectoral expansion, in countries and regions where the initial size of the renewables sector is the smallest (RUS, OPC), the average size of the output-based green subsidy over the first decade remains below 0.04 percent of GDP, and the current account increases the most (Figure 2.6). Meanwhile, Europe provides the largest subsidy—at 0.3 percent of its GDP and 57 percent of the global green subsidy—and exhibits the largest decrease in the current account.

Policies accelerating the adoption of green energy in countries with less developed renewables sectors could moderate the external sector responses to the green subsidy and counter the impact of the globally coordinated carbon tax. For example, in developing economies it might be difficult to attract the financing necessary for renewables-related investment, which could boost the growth of the sector, reducing the cross-country dispersion of current account responses to the green subsidy. A targeted recycling of the carbon tax could be one financing source for the investment, while international financing could also contribute. Support could also come in the form of technology transfers, allowing for technology leapfrogging in developing countries that would increase their contributions to global emission reductions.

Infrastructure Investment

The green public infrastructure component of the mitigation policy package amounts to a sizable and front-loaded fiscal expansion that aims to counter the negative growth impact of the carbon tax. An additional economic boost stems from the assumed private sector productivity spillover, induced by the increased public infrastructure capital stock (Calderón, Moral-Benito, and Servén 2015).[18] Importantly, the aggregate size of both components of the infrastructure investment policy—temporary fiscal expansion and private sector productivity spillover—is assumed to be identical across countries.

The symmetric and coordinated nature of the infrastructure investment policy limits its impact on the external sector.[19] This finding should come as no surprise, as what matters for the current account response is the fiscal policy action (and productivity gains) relative to those in the rest of the world, as well as country-specific characteristics, such as the degree of openness. Intuitively, when policy-induced shifts in the investment curve are identical across countries, the resulting increase in investment and saving broadly offsets, increasing the interest rate but leaving the current account unchanged (Box 2.2). However, these external sector findings need to be interpreted with caution. First, they depend crucially on the assumed symmetric size of the infrastructure investment across countries. Second, the external sector results could be sensitive to the assumed symmetry in productivity spillovers as well as to their sectoral distribution.

Mitigation Policy Package

The mitigation policy package is designed to be growth and public debt neutral by 2050. Its external sector impact is equal to the sum of the impacts of the three individual mitigation policies—carbon tax, green subsidy, and infrastructure investment (Figure 2.7). Several takeaways are worth highlighting.

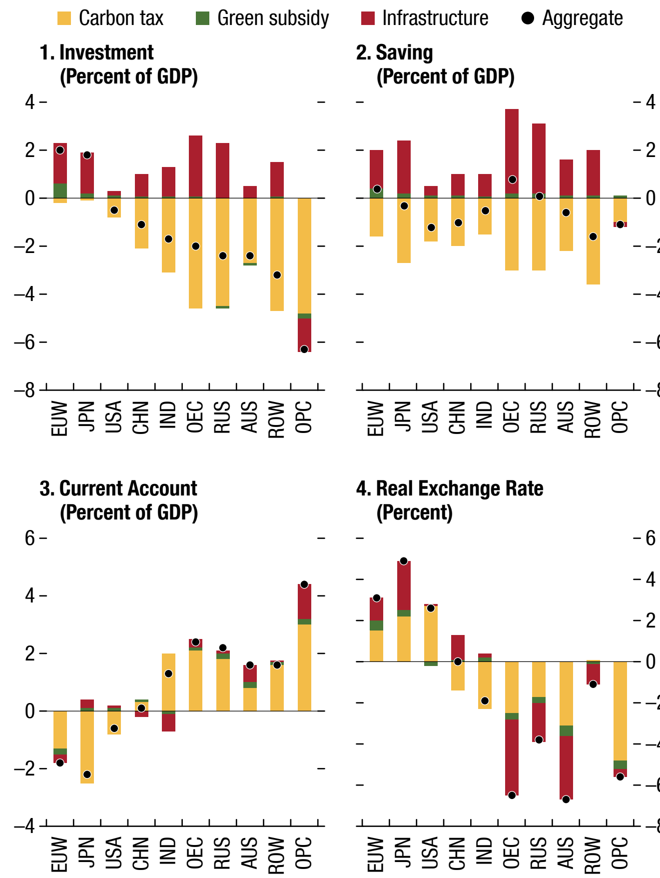
First, despite the policy package delivering positive output growth globally during the initial decade, aggregate investment falls in all but the least carbon-intensive economies (Figure 2.7, panel 1). The public infrastructure boost offsets approximately half of the carbon-tax-induced decline in investment globally. The remaining negative impact on investment is mainly due to the higher capital intensity of fossil-fuel-producing sectors, the role of which declines significantly in the global economy as carbon emissions are reduced, shifting economic activity toward more labor-intensive sectors.

Second, the external sector impact is dominated by the carbon tax, while the other policies have much

Figure 2.7. Impact of Mitigation Policy Package on the External Sector

(Deviations from baseline; 2023–33 average)

The overall external sector impact is dominated by the carbon tax. The relatively small initial size of the renewables sector—and any resultant subsidy to the sector—constrains the subsidy's external sector impact. The sizable infrastructure investment is symmetric across countries, limiting the external sector response.



Source: IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. See Table 2.1 for a list of region codes.

[18]For details on the modeling of the private sector productivity spillover, see Jaumotte, Liu, and McKibbin (2021).

[19]Figure 2.7 reports the impact of the infrastructure investment policy on the external sector and compares it with that of the other mitigation policies.

smaller effects, as discussed earlier. For the model's median region, the carbon tax accounts for 91 percent of the total current account response to the mitigation policy package (Figure 2.7, panel 3). The carbon tax is also the main driver of the RER response, accounting for 46 percent of the overall adjustment. In the greener advanced countries and regions (JPN, EUW), the sizable current account and RER adjustments that occur as investment increases while saving remains broadly unchanged generate a Dutch-disease-type effect, with export activity shrinking as a share of GDP.

Finally, individual country responses to the mitigation policy package and its components exhibit a sizable country-specific component. Despite strong correlations, current account and RER responses cannot be fully explained by the investment behavior. This is to be expected, given the significant variation in the size of policy shocks across countries, as well as in country characteristics. For example, countries vary in their degree of openness (that is, the shares of their output that are exported and the shares of their final demand that are imported), their bilateral exposures, the sectoral structure of their economic activity, and their labor force trends.

Alternative Scenarios

Role of Policy Synchronization

A partial or asynchronous implementation of mitigation policies adds a policy asymmetry that can alter external sector outcomes. The analysis thus far has examined globally coordinated implementation of mitigation policies, with all countries reaching the emission reduction targets. However, the progress and medium-term commitments toward climate change mitigation vary considerably across countries.[20] To explore the implications of the uneven progress, this section examines an alternative partial implementation scenario, focusing on a case in which only one region—Europe—implements the carbon tax and the green subsidy.[21]

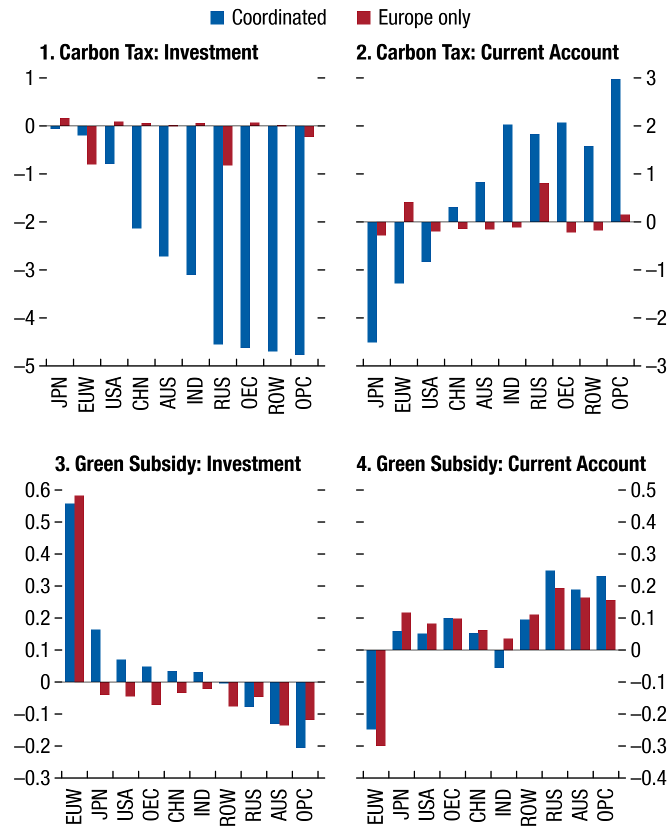
For the global economy, the implementation of the carbon tax in Europe leads to the familiar intertemporal adjustment in the investment-saving balance: a fall in investment and saving, accompanied by a reduction in the global interest rate. With only Europe implementing the tax, the size of the adjustment is significantly smaller than under coordinated implementation, with a mere 0.2 percent of GDP drop in investment (and saving) globally and a 0.02 percentage point decrease in the interest rate over the first decade.

The muted global impact hides large differences in investment and current account responses across countries (Figure 2.8, panels 1 and 2). As the carbon tax reduces the anticipated return on investment in Europe, investment and saving fall in that region (Figure 2.8, panel 1). For fossil fuel exporters there is a sizable negative economic impact. Spillovers from reduced demand

Figure 2.8. Impact of Partially Implemented Mitigation Policies on the External Sector

(Deviations from baseline; 2023–33 average; percent of GDP)

If only Europe implements the carbon tax, the fall in investment in Europe is magnified, relative to what takes place under a coordinated implementation of the tax. Upstream energy supplies are similarly impacted. As a result, the current account response in Europe is reversed from a decline to an increase.



Source: IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. See Table 2.1 for a list of region codes.

[20]See the IMF Climate Change Dashboard at https://climatedata.imf.org/.

[21]While Europe, as the green transition front-runner, is an instructive scenario specification, broadly similar findings were obtained with other partial-implementation scenarios (for example, the case of mitigation policies implemented only by advanced economies).

for fossil fuels in Europe depress investment upstream in Europe's fossil-fuel-supplying countries—Russia and to a lesser extent other fossil-fuel-exporting developing economies (such as those in the OPC group). For the other regions, in the absence of a carbon tax, investment increases marginally, while saving declines, as in Europe. Reflecting the investment responses, capital flows out of Europe and its fossil fuel suppliers and into the regions and countries that do not impose the carbon tax, as revealed by current account surpluses in Europe and fossil-fuel-producing countries and regions and deficits in other countries and regions (Figure 2.8, panel 2). Box 2.2 presents a stylized two-country graphic illustration of these economic forces, excluding the spillovers to fossil fuel suppliers.

Relative to coordinated implementation, a unilateral carbon tax in Europe reveals a sizable negative competitiveness impact for that region. The fall in investment in Europe is magnified because the carbon tax (and the anticipated decline in the return on investment) is accommodated by a smaller decline in the global interest rate than would occur with coordinated implementation (Figure 2.8, panel 1). Furthermore, the current account response is reversed, as the outsized fall in investment increases the current account in Europe (Figure 2.8, panel 2). Instead of drawing capital inflows, the imposed permanent carbon tax turns Europe into a source of capital outflows as investment shifts toward regions with a higher return on investment.[22]

By contrast, the green subsidy, when implemented in Europe only, further boosts economic activity in the region. Not surprisingly, given Europe's outsized role in the global green subsidy, results for this scenario resemble those of the coordinated implementation scenario (Figure 2.8, panels 3 and 4). The key difference between the results in the two scenarios is that a subsidy only in Europe raises the global interest rate by less. As a result, investment in Europe is boosted, further decreasing the region's current account.[23] For other countries and regions, external sector outcomes reflect a trade-off between the green subsidy and a more muted increase in the global interest rate. Where the subsidy under coordinated implementation is small (OPC, Russia), the interest rate effect dominates, increasing investment and reducing the current account balance. Where the subsidy is more sizable (Japan, United States), the absence of the subsidy dominates, reducing investment and increasing the current account (Figure 2.8, panel 4).

Overall, partial implementation of mitigation policies can have sizable and varied impacts on the external sector, either putting countries at a competitive disadvantage or magnifying the economic boost from a mitigation policy. However, a critical shortcoming of partial implementation is the failure to deliver the necessary global carbon emission reductions. To succeed in averting climate change, it is essential that both advanced economies and developing countries cooperate in achieving the climate mitigation targets, including through burden-sharing arrangements such as income-differentiated carbon price floors or sectoral carbon pricing (Parry, Black, and Roaf 2021; Chateau, Jaumotte, and Schwerhoff 2022b).

Differentiated Mitigation Efforts

One concern with the net-zero emissions by 2050 scenario is the disproportionate economic cost imposed on developing economies. The globally growth-neutral design of the mitigation policy package hides considerable differences across countries, with the more carbon-intensive developing economies incurring disproportionate declines in investment, output, and employment in response to the carbon tax (see the October 2020 WEO; see also Jaumotte, Liu, and McKibbin 2021). Although in the longer term there is little room for differentiation of mitigation efforts across countries, over the next decade advanced economies have pledged to lead the effort (IEA 2021; Parry, Black, and Roaf 2021). How would mitigation efforts centered on advanced economies impact this chapter's external sector findings?

To address this question, an alternative scenario increases the carbon tax for the five advanced regions and countries to double emission reductions from an average of 20 percent to 40 percent by 2030, relative to the baseline. The more stringent targets are broadly consistent with the 2030 mitigation pledges by advanced economies (Parry, Black, and Roaf 2021). For developing regions, 2030 emission targets are reduced from an average of 32 percent to 20 percent,

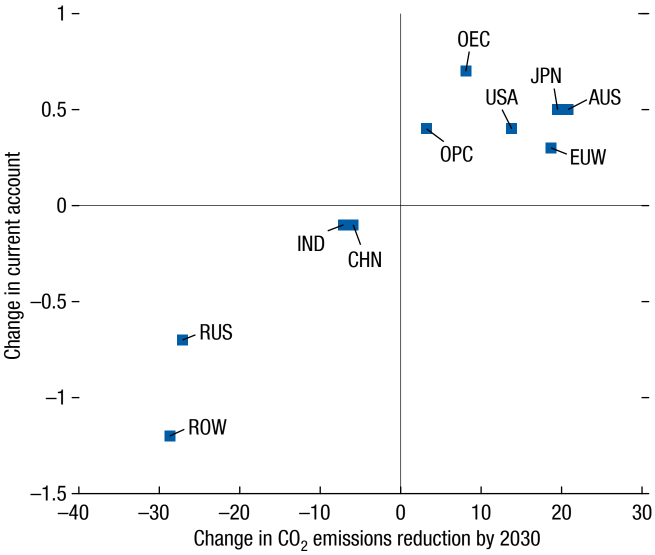
[22]Recent literature explores border carbon adjustments as a policy tool to reduce the negative competitiveness effect from a unilateral carbon tax. While not examined in this chapter, such an adjustment would be implemented by countries with stricter climate policies on the imported carbon content from regions with more limited climate change mitigation efforts. The bulk of the impact of border carbon adjustments can be achieved by focusing on energy-intensive and trade-exposed sectors (Chateau, Jaumotte, and Schwerhoff 2022b).

[23]In the stylized two-country graphic illustration of the model's forces shown in Box 2.2, the Europe-only green subsidy would be captured by an outward shift in the investment curve in the green region only, that is, a reverse of the case covered in Figure 2.2.2.

Figure 2.9. Impact of Larger Emission Reductions in Advanced Economies

(Percentage points relative to baseline mitigation scenario)

Increased burden sharing in climate change mitigation efforts between advanced and developing countries would moderate the external sector impact of the carbon tax. Relative to the baseline scenario, current accounts in advanced economies would increase and those of developing countries would decrease, reducing the shift in global capital flows toward the greener advanced economies.



Source: IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. See Table 2.1 for a list of region codes.

again reflecting available country-specific pledges. Thus, broadly in line with the internationally coordinated carbon price floor proposal in the October 2022 *Fiscal Monitor*, by 2030 advanced economies reduce emissions by approximately twice as much as developing economies.[24]

[24]Full consistency cannot be ensured, because the October 2022 *Fiscal Monitor* limits the proposal to selected economies and does not specify post-2030 paths for carbon emissions. Analysis of the differentiated mitigation efforts builds on the examination of the carbon tax as the sole mitigation policy in Jaumotte, Liu, and McKibbin (2021). Reported results assume that (1) following increased medium-term (2030) burden sharing, country-specific emission reduction targets of 80 percent are met by 2050, except for the OPC region; and (2) all carbon tax revenues are applied toward public debt repayment. The main findings remain broadly unchanged if instead all carbon tax revenues are transferred to households. Qualitative findings are also not altered if 2050 emission targets are not imposed and instead the 2030 differentiated mitigation efforts are maintained during the subsequent decades.

Increased burden sharing of emission reductions tempers the external sector response to the carbon tax. Higher 2030 emission cuts in advanced economies increase their current accounts relative to the baseline net-zero emissions by 2050 scenario (Figure 2.9). Conversely, the more gradual emission reductions in developing economies by 2030 reduce their current accounts relative to the same benchmark. The size of the shift in capital flows toward the five higher-income regions and countries is reduced by a third. These changes are driven by the higher (lower) carbon taxes in advanced (developing) economies.

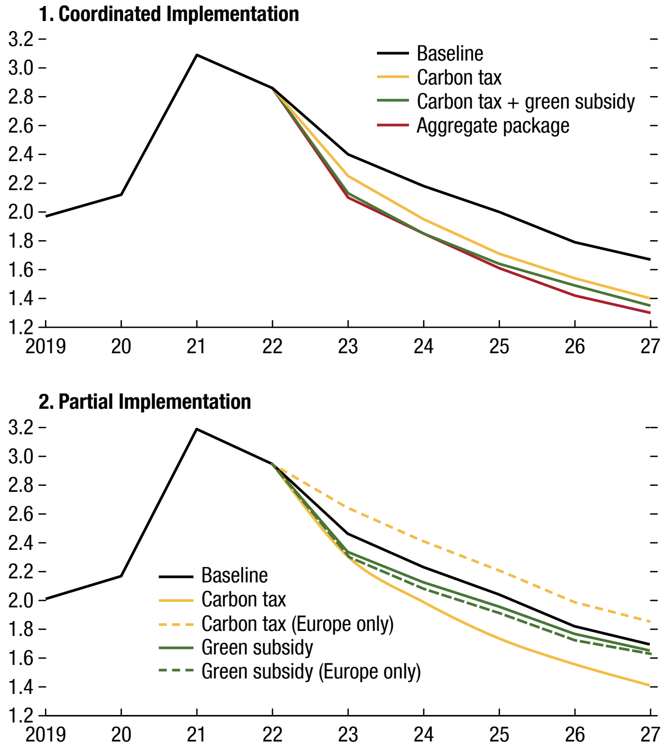
Fiscal Revenue Recycling Assumptions

The baseline carbon tax policy transfers a quarter of the tax revenues back to households to help protect their purchasing power from the increase in energy prices. The remaining three-quarters is recycled to reduce government debt. Since the external sector impact of the climate mitigation package is dominated by the carbon tax, it is important to understand whether the results are sensitive to this recycling assumption.

An expanded scenario analysis reveals a limited impact from the fiscal recycling assumption for the external sector outcomes. The analysis examines two opposing scenarios, with the tax revenues either used to reduce public debt or fully transferred to households. Quantitatively, current account responses are larger when the revenue is recycled to reduce government debt. However, the average difference in the absolute current account response across the 10 countries and regions (when the two extreme revenue-recycling assumptions are compared) is smaller than 0.25 percent of GDP, suggesting that the chapter's findings are not driven by the specific revenue-recycling assumption. The limited impact can be explained by the relatively small size of carbon tax revenue during the first decade, at 0.6 percent of GDP for the average country. The small size of carbon tax revenue would also limit the external sector impact of alternative tax specifications, including revenue-neutral approaches. Such alternative specifications can impact aggregate investment behavior but will have a more limited effect on the heterogeneity of the investment response, which determines the external sector adjustment.

Figure 2.10. Mitigation Policies and Global Balances
(Percent of global GDP)

Coordinated mitigation policies would reduce global balances, with the carbon tax providing the largest contribution by 2027. However, partial implementation could strengthen or reverse this effect.



Sources: IMF, *World Economic Outlook*; and IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. Global balances are defined as the sum of absolute current account balances. "Baseline" refers to April 2022 WEO projections for output and current account.

Global Implications

Beyond the impact on individual countries and regions, the model simulations reveal several important implications for the global economy.

The globally coordinated climate change mitigation policy package reduces global balances. To assess the impact, model-based current account and output deviations from the baseline are added to the April 2022 WEO medium-term current account and output projections. Results show a 0.3 percent of global GDP reduction in global current account balances by 2027, with contributions from each of the three individual mitigation policies (Figure 2.10, panel 1). The carbon tax accounts for more than two-thirds of the decline. Current account surplus countries and regions, including Europe and Japan, where the carbon tax decreases the current account, are the main individual contributors.

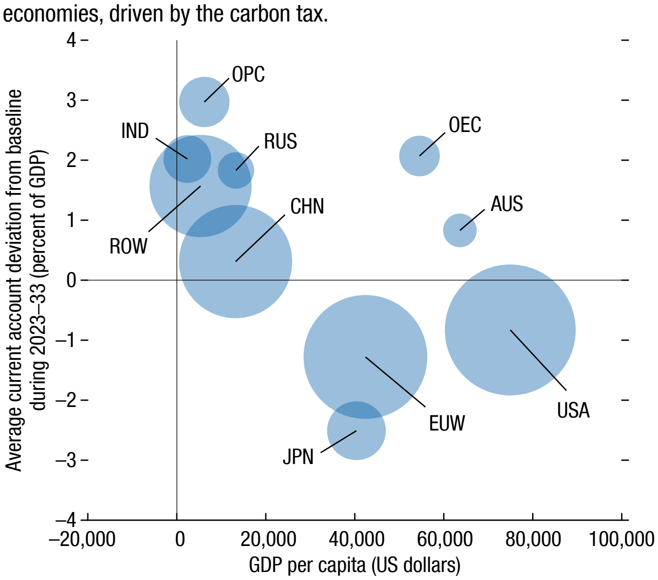
However, the reduction in global balances can depend on coordinated implementation of mitigation policies. In a Europe-only partial implementation scenario, the carbon tax increases global balances (Figure 2.10, panel 2) as the current account in Europe increases. At the same time, partial implementation of the green subsidy in Europe reduces global balances by more than coordinated implementation. The difference is again driven by the current account response in Europe, with the decrease magnified under partial implementation (Figure 2.8, panel 4). Separately, results show that the burden sharing effort would moderate the decline in global balances by 15 percent by 2027, as current accounts in advanced economies would decrease by less.

The globally coordinated mitigation policy package shifts global capital flows toward advanced economies. Inflows into Europe, Japan, and the United States are met with outflows from lower-income oil-exporting developing economies, India, and other countries included in the model's "rest of the world" region (Figure 2.11). As already indicated in panel 3 of Figure 2.7, cross-border capital flows are driven by the carbon tax policy, which decreases the current account in greener economies and increases it in the more carbon-intensive regions.

Prospects for the global interest rate are closely linked to the dynamics of aggregate investment. Carbon taxes reduce investment, gradually decreasing the interest rate over the three decades of globally coordinated climate change mitigation efforts (Figure 2.12). In contrast, the front-loaded green infrastructure policy raises the global interest rate in the short term, but its impact is transitory, dissipating as the infrastructure boom moderates after the first decade. Given its limited size, the green subsidy has a muted impact on the global interest rate. Overall, following an initial infrastructure-investment-induced rise, the mitigation policy package leads to a gradual decline in the global interest rate.

Figure 2.11. Mitigation Policies and Cross-Border Capital Flows

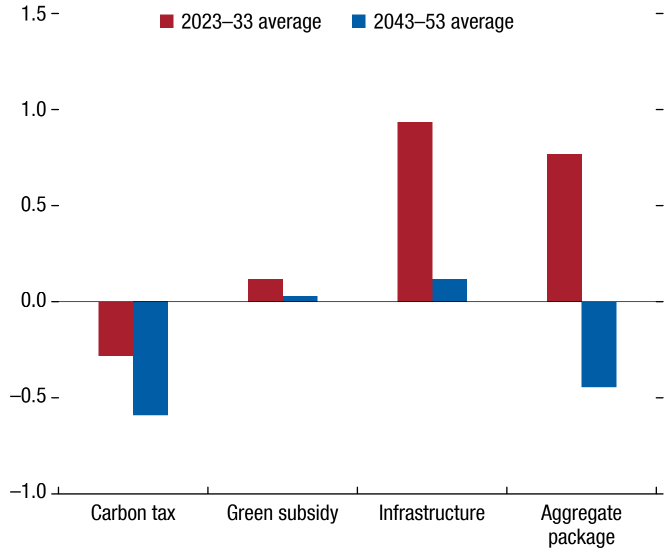
Capital flows toward higher-income and less carbon-intensive economies, driven by the carbon tax.



Sources: IMF, *World Economic Outlook*; and IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]). See Online Annex 3.4 of the October 2020 WEO for further details. See Table 2.1 for a list of region codes.

Figure 2.12. Mitigation Policies and Global Interest Rates
(Percentage point deviation from baseline)

Responding to changes in investment, global interest rates fall with the carbon tax and increase with the boost to green infrastructure. The mitigation policy package results in an initial rise in the global interest rate—given the front-loaded nature of the green infrastructure component—followed by a sustained decline as the carbon tax increases.



Source: IMF staff calculations.
Note: The simulations are based on a net-zero emissions by 2050 scenario run using the G-Cubed global macroeconomic model (October 2020 *World Economic Outlook* [WEO]).

Conclusion

While ensuring that paramount climate targets are met, a range of climate mitigation policies could imply substantially different external sector adjustments. A globally coordinated carbon tax disproportionately reduces investment in more carbon-intensive economies as the return on investment in carbon-intensive activities falls permanently. The heterogeneous investment responses, in turn, sizably decrease current accounts in the greener advanced economies and increase current accounts in the more carbon-intensive and fossil-fuel-dependent countries. Ultimately, country characteristics such as initial carbon intensity and net fossil fuel exporter status, as well as projected labor force and productivity growth rates, drive the current account response in the model. In contrast to the carbon tax, supply-side policies—green subsidies and infrastructure investment—have a more limited impact on the external sector, either because of their constrained size or because of their symmetric nature, which induces comparable investment and saving responses, leaving the current account broadly unchanged.

The external sector impact of climate change mitigation policies depends crucially on the degree of policy synchronization across regions. When the carbon tax is implemented in Europe alone, the current account there increases (instead of a decline under coordinated implementation) because the tax hike reduces domestic investment and shifts capital abroad. By contrast, a partial implementation of the green subsidy, when implemented in Europe alone, magnifies the external sector impact: the more muted interest rate response stimulates investment, further decreasing the current account. Partial implementation scenarios also highlight the importance of bilateral linkages and spillovers (for example, Europe's historical dependence on Russia's fossil fuel exports) in determining region-specific external sector outcomes following a policy shock. A crucial shortcoming of partial implementation is its failure to address climate change.

Targeted modifications to the coordinated mitigation policy package can moderate its external sector impact.

Increased burden sharing, whereby advanced economies undertake a heavier load of emission reductions by 2030, can reduce the external sector adjustment by muting the differences in investment responses across countries. Similarly, policies that expand the renewables sector in countries where the sector is the smallest can accelerate investment where it is constrained the most, again moderating the external sector responses across countries.

A coordinated net-zero emissions by 2050 mitigation policy package would reduce global balances one-quarter by 2027. Carbon taxes would account for three-fourths of this reduction. This finding, however, could be reversed if mitigation policy implementation is not coordinated across regions. Results also reveal a shift in cross-border capital flows toward the greener economies, which can be moderated by increased burden sharing in carbon emission reductions. Finally, the mitigation policy package affects global interest rates. Following an initial rise reflecting the front-loaded infrastructure investment policy, the global interest rate falls over time as carbon tax levels increase.

Box 2.1. Oil Discoveries and the External Sector

Energy transitions following significant oil discoveries can have large external sector effects. This box analyzes the examples of one advanced economy (Norway), one low-income economy (Equatorial Guinea), and one emerging economy (Mexico) (Figure 2.1.1). In these three cases there is a clear pattern in the response of investment and the current account following the discovery. First, investment booms at the time of the oil discovery and during the subsequent years in order to build up extraction and production facilities; second, this investment boom results in a current account decline.

The case of Norway and the North Sea oil discoveries is documented in earlier literature (Arezki, Ramey, and Sheng 2017; Obstfeld and Rogoff 1995). In the four years following the oil discovery (between 1974 and 1978), investment increased on average by 17 percent, while the current account deficit more than doubled. Investment and current account deficits peaked three years after the oil discovery. Afterward, growth in oil exports increased the current account, while investment returned to preboom levels.

In Equatorial Guinea the Zafiro oil field discovery in 1995 resulted in an investment surge of 74 percent on average between 1995 and 1998, while the current account reached a deficit of 90 percent of GDP in 1998.

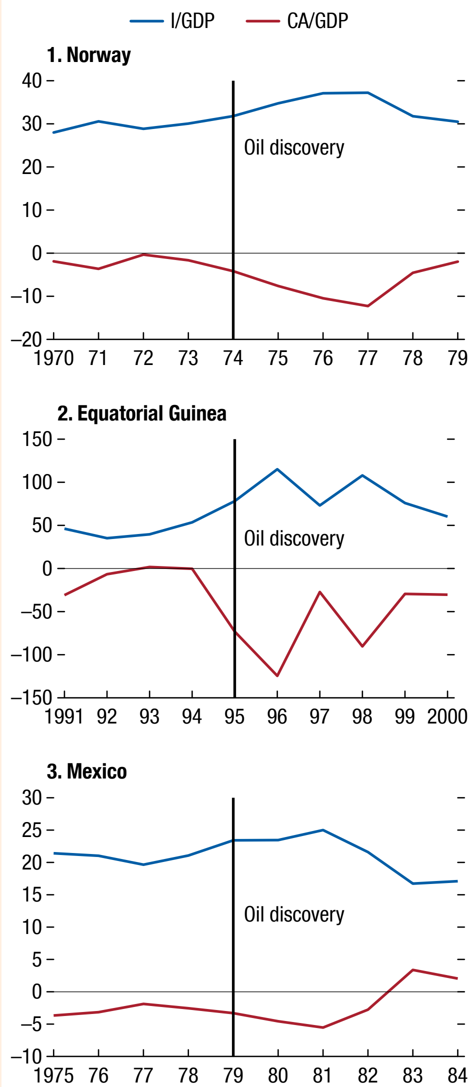
In Mexico, the discovery of the Ku-Maloob-Zaap field in 1979 resulted in an average investment increase of 11 percent between 1979 and 1982, while the current account as a share of GDP peaked with a deficit of 5.5 percent in 1981.

The transmission mechanism for the cases of oil discovery fits well with the narrative analyzed in this chapter. The economic forces are present in the G-Cubed model simulations analyzed, with the sign flipped, as the mitigation policies analyzed lead to an overall reduction in investment instead of an increase.

The author of this box is Luciana Juvenal.

Figure 2.1.1. Evolution of the Current Account and Investment Following an Oil Discovery

(Percent of GDP)



Sources: External Wealth of Nations database; IMF, International Financial Statistics database; IMF, *World Economic Outlook*; and World Bank, World Development Indicators database.

Note: CA/GDP = current account as a share of GDP; I/GDP = investment as a share of GDP.

Box 2.2. Understanding the Carbon Tax Effects in the G-Cubed Model

This box uses a simple Meltzer diagram to provide intuition for the current account results of the G-Cubed model.

Setup

The current account of a given country equals the difference between saving and investment, $CA = S - I$. In turn, saving depends positively on interest rates, while investment depends negatively on them. The saving-investment relationship can therefore be illustrated in a so-called Meltzer diagram.

The Impact of a Carbon Tax

The diagram in Figure 2.2.1 considers a two-region world economy differentiated by each region's respective carbon intensity—a country characteristic that determines external sector outcomes. In the initial steady state, captured with blue lines, saving equals investment, and the current account is zero in both economies. The introduction of a carbon tax, represented by the red curves, shifts the investment curve left in both regions, capturing the reduced return on investment. The shift is larger in the more carbon-intensive region (Region 2), because a given carbon tax reduces the return on investment by more when carbon intensity is higher.

The author of this box is Rudolfs Bems.

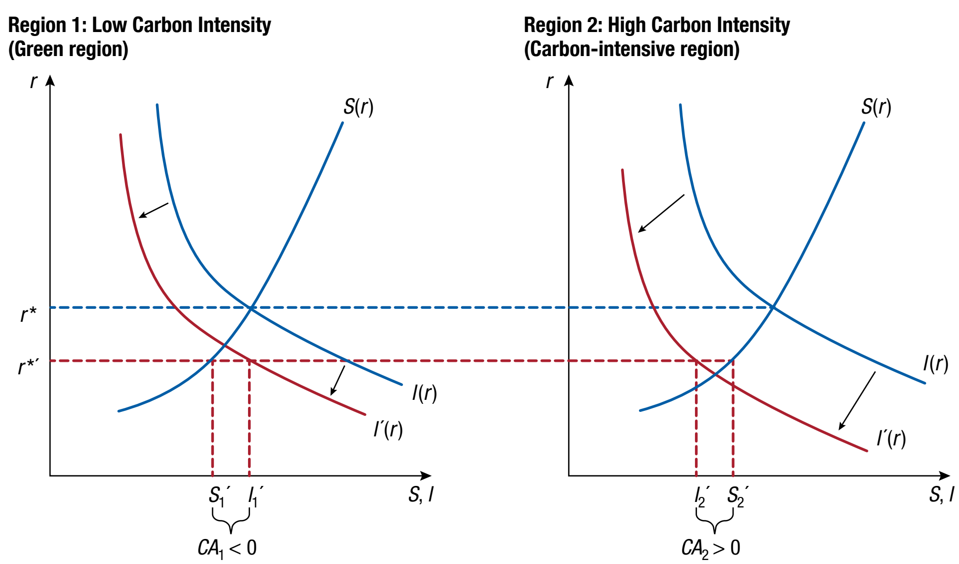
Takeaways

As a result of the carbon tax:

- The global interest rate falls ($r^* \rightarrow r^{*\prime}$) until the global current account adding-up constraint holds ($CA_1 + CA_2 = 0$).
- In the new equilibrium, saving falls in both regions by an equal amount, as there is movement along the identical $S(r)$ curve.
- Investment also falls in both regions, but by less in the greener region (Region 1).
- The current account falls in the greener economy, with an offsetting increase in the more carbon-intensive economy. The current account response is driven by the heterogeneity in the investment response.

Two additional points are worth mentioning. First, if carbon intensities are identical in the two regions, then the declines in investment and saving coincide, and the current account would stay at zero ($CA_1 = CA_2 = 0$). Second, in a richer setting, such as in the G-Cubed model, the saving curve can differ across countries (for example, owing to differences in labor force projections), generating some variation in

Figure 2.2.1. The Carbon Tax Impact—Case of Coordinated Implementation



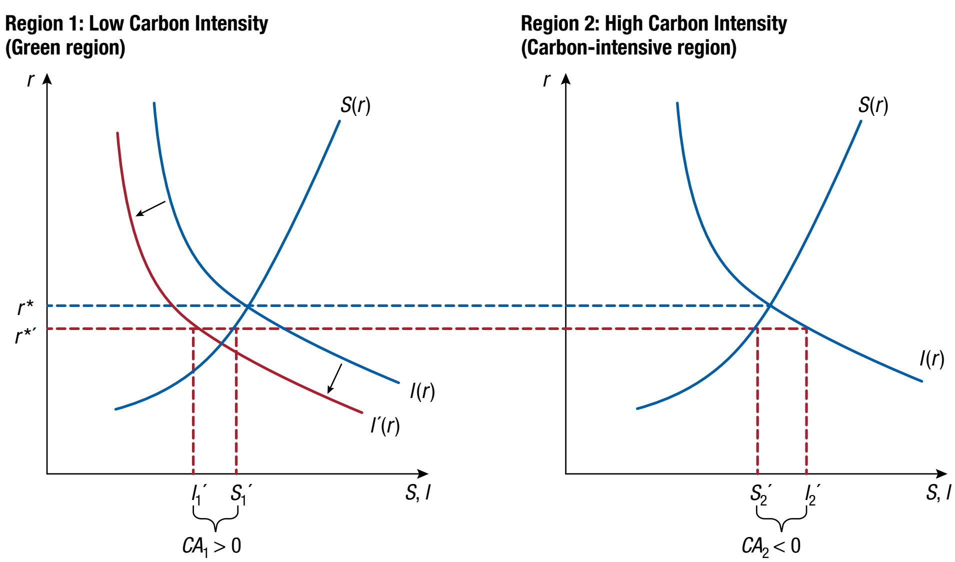
Box 2.2 *(continued)*

the saving response between the regions. The saving curve could also shift to varying degrees across countries in response to the tax, for example, reflecting intertemporal smoothing. Nevertheless, the carbon-tax-induced shift in the investment curve remains the main driver of the current account response.

By contrast, if the greener region (Region 1) acts alone in implementing the same carbon tax, the external sector impact is reversed relative to what was observed in Figure 2.2.1. In this case, as under coordinated implementation, the interest rate falls, and saving is reduced by the same amount in both regions, although partial implementation reduces the magnitude of the required adjustment for both variables (Figure 2.2.2).[1] However, investment now falls by more in Region 1, while increasing in Region 2, which in the absence of a tax takes advantage of the reduced interest rate. As a result, the current account impact is reversed under partial implementation: it decreases in Region 1 and increases in Region 2.

[1]In a richer modeling environment, the magnitude of the adjustment for the interest rate and saving will depend on the relative size of the region that implements the carbon tax. If Region 1 is small enough not to affect the global interest rate, then only investment in Region 1 would decrease in response to the tax shock.

Figure 2.2.2. The Carbon Tax Impact—Case of Partial Implementation



Box 2.3. The Green Energy Transition and Its Impact on Metal Mining

This box looks at the impact of the green energy transition on producers of four critical metals: copper, nickel, cobalt, and lithium.

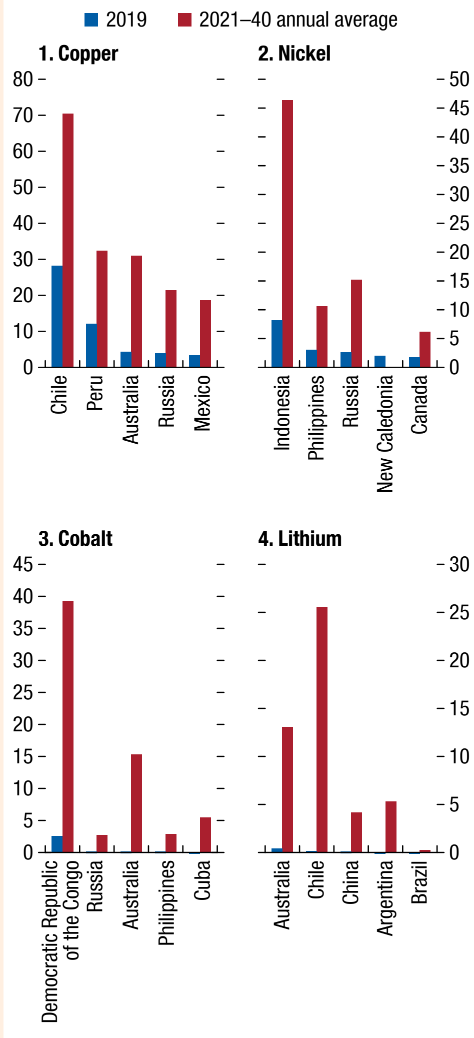
Not all commodity exporters will face a demand contraction as a result of the green transition. While demand for fossil fuels will decline, the International Energy Agency's net-zero emissions by 2050 scenario projects a significant rise in demand for metals critical for green energy transitions. For example, the value of annual copper production could more than double in main exporting countries over the next two decades under such a scenario. Projected increases for the other metals are even more dramatic (Figure 2.3.1).

The advent of metals critical for the energy transition could strengthen the impact of global commodity cycles on global current account balances. Commodity cycles are an important driver of global current account balances, reflecting both the historical role of cross-border trade in satisfying demand for commodities and the pronounced nature of commodity price cycles. The geographic concentration of production and reserves for the four critical metals is even higher than that for fossil fuels (Figure 2.3.2). Hence, as metals replace fossil fuels, the role of cross-border trade in satisfying global demand for commodities could increase, strengthening the impact on global current account balances.

The authors of this box are Rudolfs Bems and Martin Stuermer.

Figure 2.3.1. Projected Increase in Revenue for Metal Producers

(Billion of US dollars)

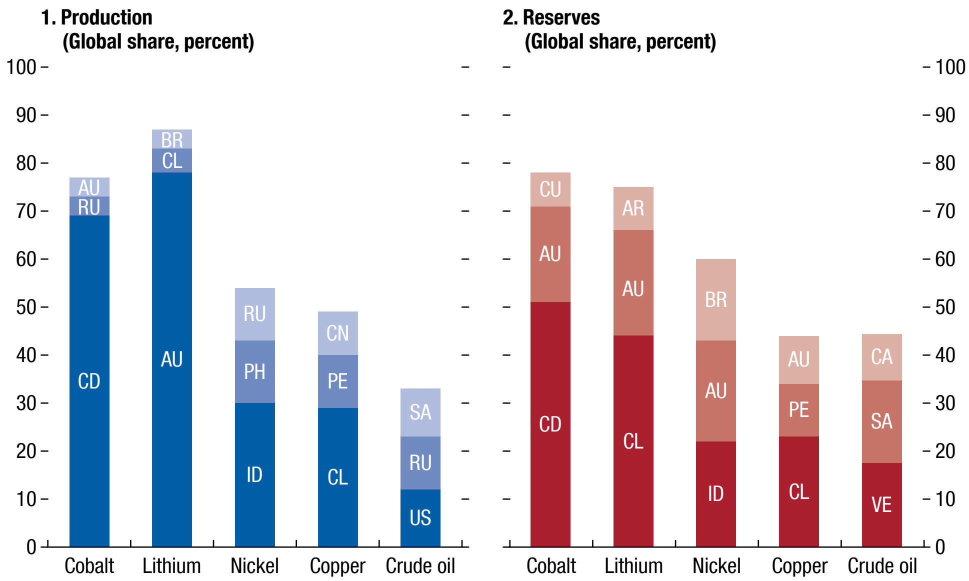


Sources: Boer, Pescatori, and Stuermer (2021); International Energy Agency (IEA); US Geological Survey; and IMF staff calculations.
Note: The scenario value of production is based on reserves data and the IEA net-zero emissions scenario.

Box 2.3 *(continued)*

Figure 2.3.2. Comparison of the Geographic Concentration of Production and Reserves for "Green" Metals versus Crude Oil

(Top three countries)



Sources: US Geological Survey; and IMF staff calculations.

Note: Cobalt and lithium production data are for 2019. All other data are for 2020. AR = Argentinia; AU = Australia; BR = Brazil; CA = Canada; CD = Democratic Republic of Congo; CL = Chile; CN = China; CU = Cuba; ID = Indonesia; PE = Peru; PH = Philippines; RU = Russia; SA = Saudi Arabia; US = United States; VE = Venezuela.

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