EXECUTIVE BOARD MEETING

SM/22/162*
Correction 1

July 21, 2022

To: Members of the Executive Board

From: The Acting Secretary

Subject: **2022 External Sector Report—Chapter 2**

Board Action:	The attached corrections to SM/22/162 (7/1/22) have been provided by the staff:
Evident Ambiguity	**Pages 4 (second bullet), 5, 6 (subsequent footnotes renumbered), 17**
Factual Errors Not Affecting the Presentation of Staff's Analysis or Views	**Pages 4 (Table 2.1) and 23**
Questions:	Mr. Lee, RES (ext. 38753) Mr. Bems, RES (ext. 30693) Ms. Juvenal, RES (ext. 36711)

***Cover replaced on 7/21/22 to correct title of name in questions to be referred to listing.**

- 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 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 towards more labor-intensive sectors.

- Partial implementation of mitigation policies can reverse or magnify external sector effects relative to 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.

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
OPC	Selected Oil Exporters and Other Economies
OEC	Rest of the Advanced OECD
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, ~~Palestine Territory~~ West Bank and Gaza, Qatar, Saudi Arabia, Syria ~~Syrian Arab Republic~~, 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	
2	Gas extraction and utilities	
3	Petroleum refining	Energy sectors other than generation
4	Coal mining	
5	Crude oil extraction	
6	Construction	
7	Other mining	
8	Agriculture and forestry	
9	Durable goods	Goods and services
10	Nondurable goods	
11	Transportation	
12	Services	
13	Coal generation	
14	Natural gas generation	
15	Petroleum generation	
16	Nuclear generation	Electricity generation sectors
17	Wind generation	
18	Solar generation	
19	Hydroelectric generation	
20	Other generation	

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

The Approach: The Model-Based Mitigation Scenario

7. 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.

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

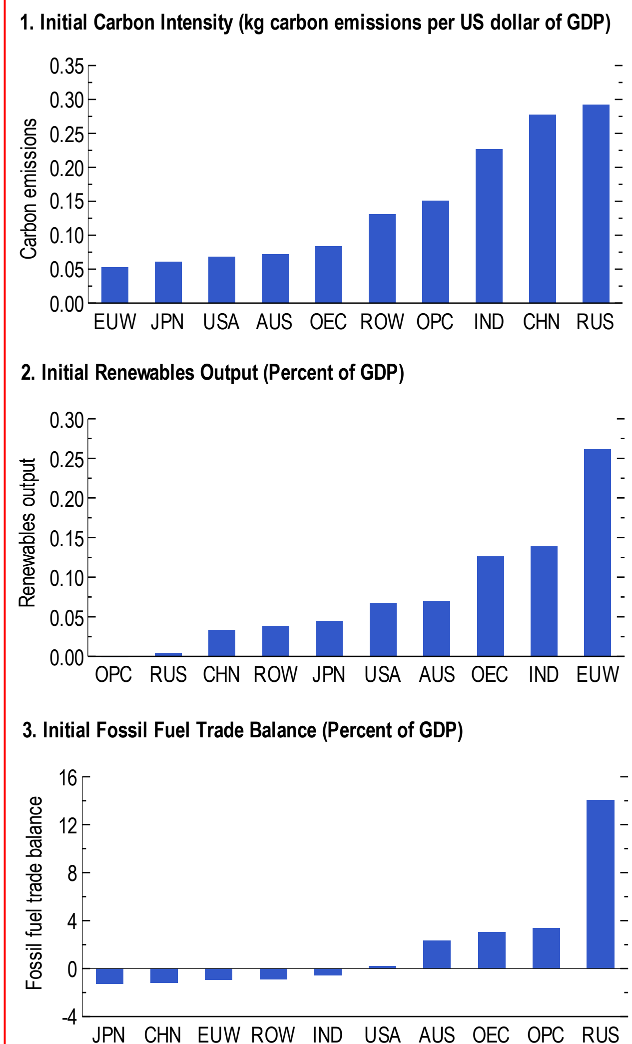
The G-Cubed Model

8. 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).

9. 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 is higher in fast-growing emerging economies such as China and India, as their fossil energy structure relies 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). This sector is dominated by Europe, which accounts for 62 percent of global renewable energy (including solar, wind, and other renewables). The renewables 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 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.

Figure 2.1. Structural Asymmetries

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



Source: IMF staff calculations.

Note: The figure 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 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 = kilogram.

10. 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 the October 2020 WEO Online Annex 3.4, has been applied to study a wide range of macroeconomic policy questions.

11. 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 10 countries and regions.

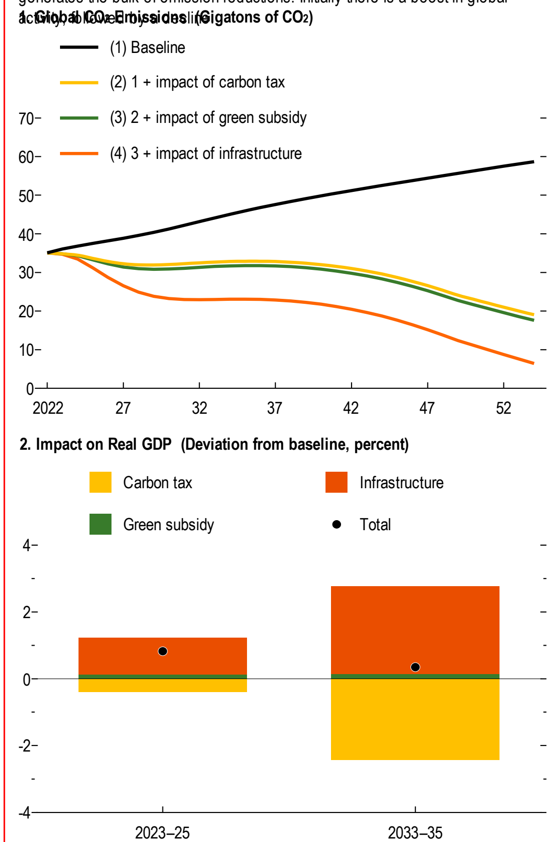
Climate Change Mitigation Scenario

12. 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.[7,~~8~~] The carbon tax consists of an initial tax rate followed by an annual increase of 7 percent. A quarter of the resulting carbon tax revenues are transferred back to households to help protect the purchasing power of the poorest households from the

Figure 2.2. Policy Package
(Deviations from baseline)

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 the October 2020 WEO Online Annex 3.4 for more details on the implementation of the simulation. CO_2 = carbon dioxide.

[5] Note that the precautionary saving motive is absent for 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, where emissions are kept at the initial level because of an outsized negative economic impact from the global decline in demand for fossil fuels.

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Global Implications

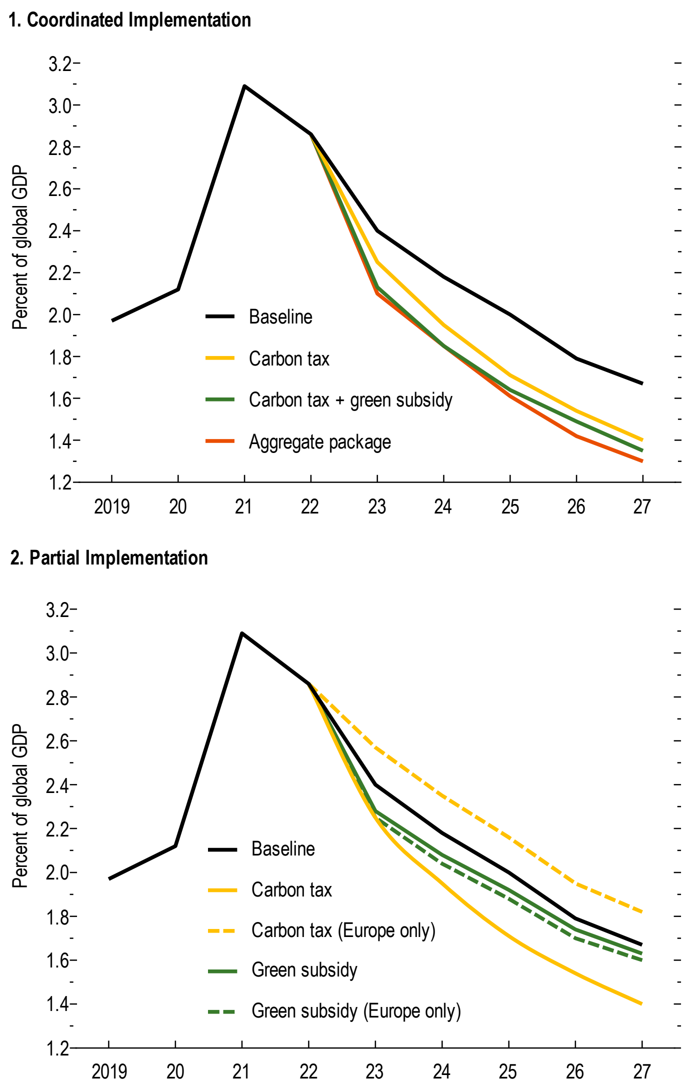
51. Beyond the impact on individual countries and regions, the model simulations reveal several important implications for the global economy.

52. 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/regions, including Japan and Europe, where the carbon tax decreases the current account, are the main individual contributors.

53. 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 decrease by less.

Figure 2.10. Mitigation Policies and Global Balances

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 the October 2020 WEO Online Annex 3.4 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.

54. 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" (ROW) 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.

55. 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

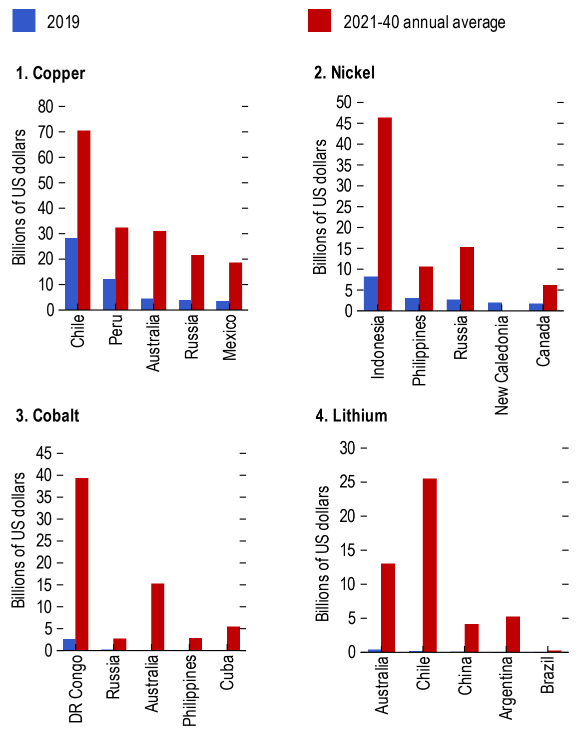
Box 2.3. The Green Energy Transition and Its Impact on Metal Mining

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 by 2050 emissions 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).

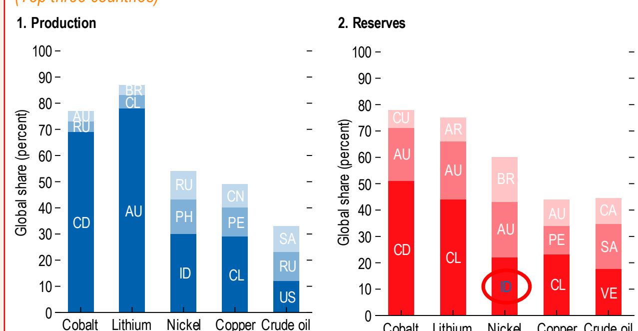
The advent of metals critical for the energy transition could strengthen the impact of global commodity cycles on global balances. Commodity cycles are an important driver of global balances, reflecting both the historical role of cross-border trade in satisfying demand for commodities and the pronounced nature of commodity price cycles. The geographic concentration of production and reserves for the four critical metals is even higher than 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 balances.

Figure 2.3.1. Projected Increase in Revenue for Metal Producers



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. DR Congo = Democratic Republic of the Congo.

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: 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. Cobalt and lithium production data are for 2019. All other data are for 2020.

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