The Coalition of Finance Ministers for Climate Action

IMF-ENV: integrating climate, energy, and trade policies in a general equilibrium framework

International Monetary Fund (IMF) Research Department

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Overview

The IMF-ENV model is a global dynamic computable general equilibrium (CGE) model based on input-output tables for 160 countries and 76 commodities. It is a model of the real economy that offers detailed sectoral and country granularity as well as a comprehensive representation of trade flows. It is well suited to study the medium- to long-term effects of policies that cause significant structural changes in the economy, such as climate, energy, and trade policies. It shows how the policies impact the allocation of factors of production (e.g., employment, investment) across sectors, trade flows, and international competitiveness, as well as standard real macroeconomic variables, and emissions. Policies that can be simulated include different carbon pricing schemes (e.g., carbon taxes on different activities/sources/gases, national and regional ETS, CBAM), energy policies (e.g., subsidies, feebates, direct and indirect regulations), sectoral regulations (e.g., overall and sector-specific energy efficiency standards, requirements to install household heat pumps, regulatory policies on land, fisheries, and forestry sectors), and new green technologies (e.g., carbon capture, utilization, and storage (CCUS), electric vehicles (EVs)).

IMF-ENV can provide impacts of climate mitigation policies on energy and emissions (i.e., CO_2, CH_4 and N_2O emissions, composition of electricity generation, energy security indices), real macroeconomic variables (e.g., GDP impacts, consumer prices, real wages), sectoral economic activity (e.g., gross-valued added, gross investments, employment), fiscal effects (e.g., changes in composition of Government income flows and expenditures), and international trade patterns (e.g., international commodity prices, market shares by sectors, exports and imports by sectors). The comprehensive technical documentation of IMF-ENV can be found in Chateau et al. (2025).

Strengths and limitations

The IMF-ENV model is especially well-suited to analyzing sectoral effects stemming from structural shifts and the impact of energy and climate policies. One of its primary advantages is that the model considers interlinkages among various sectors, agents, markets, and international transactions, thereby showing the broader domestic and global economic impacts of policies and uncovering indirect (general equilibrium) effects. The model includes detailed sectoral and country-specific information, with the default aggregation covering 25 world regions, including individual G20 economies and 36 sectors. Different policy instruments can be incorporated flexibly, allowing the analysis of general equilibrium and cross-border effects through detailed trade flow representation.

CGE models such as IMF-ENV are limited in analyzing short-term macroeconomic fluctuations. They are real-economy models, and therefore unable to examine monetary policy effects due to the absence of considerations for nominal interest rates, nominal exchange rates, and inflation. Additionally, CGE models are complex, relying on extensive datasets and numerous parameters, including elasticities and technological adjustments, requiring specialized training to effectively develop and operate these models.

Relevance to Ministries of Finance

IMF-ENV can provide impacts of climate mitigation policies on emissions, real macroeconomic variables, sectoral economic activity, and international trade patterns.

Aspects of particular interest to MoFs include the following:

1) *Economic strategy and policy:* IMF-ENV can be used to simulate alternative fiscal policy packages to reach NDCs and assess their fiscal and economic implications.
2) *Fiscal policy and budget*: the high level of sectoral granularity and the incorporation of general equilibrium effects allow better estimates of revenue and spending implications of different climate policies.

3) *Financial policy and oversight:* the NGFS scenarios have been modeled within IMF-ENV to produce various detailed outcomes, such as sectoral value-added, capital and labor demand, and overall GDP impacts for all G20 economies.

These results have been integrated into the Financial Sector Assessment Programs (FSAPs) to examine transition risks and enhance the understanding of their potential effects on financial stability.

Key policy/analytical questions addressed

The IMF-ENV model has been widely used in various areas, including international policy coordination, competitiveness, carbon leakage, energy security, green transition growth opportunities, and climate finance. It also supports climate policy analysis within individual countries through IMF Article IV consultations and Financial Sector Assessment Programs (FSAPs). Policies that can be simulated include:

(1) *Carbon pricing* (carbon taxes on activities/sources/gases, national and regional ETS, CBAM)
(2) *Energy policies* (subsidies, feebates, direct and indirect regulations)
(3) *Sectoral regulations* (energy efficiency standards, household heat pump requirements, land, fisheries, and forestry sector policies)
(4) *New green technologies* (CCUS and EVs).
(5) *Results on* emissions, real macroeconomic variables, fiscal variables, sectoral activity, and international trade.

Use in practice

Global CGE models such as IMF-ENV typically use subscription-based datasets like the GTAP Data Base[2] along with a wide range of parameters from the literature. Given the complexity in the IMF-ENV model, the development and application of IMF-ENV require specialized, trained staff. The technical documentation for the IMF-ENV model (Chateau et al., 2025), provides insights on integrating climate and energy-specific modules, and these details could be useful for extending existing MoF models.

Lessons and challenges

Developing CGE models from scratch is a resource-intensive task and requires specialized expertise. A pragmatic strategy for Ministries may include enhancing their current analytical tools to establish a link between economic and environmental outcomes, facilitated through capacity-building initiatives. For instance, MoFs can augment single-country CGE models, which are typically employed for non-climate analysis, by incorporating economic outcomes along with emissions and environmental data. This approach enables the model to analyze climate mitigation and transition issues. This would allow Ministries to improve their analytical capabilities for domestic climate policy without developing new models. Additionally, institutions such as the IMF can utilize global models such as IMF-ENV to address multilateral action, international policy spillovers, and regional policy interests.

Future work

IMF-ENV is in continuous development. Recently, two model versions focusing on Sub-Saharan Africa and the Middle East and Central Asia regions have been developed. Current development efforts are aimed at creating an R&D and technology diffusion module and updating the characterization of international capital flows in the model.

Moreover, several model extensions are possible conditional on data availability and relevance for a country. IMF-ENV can be linked to sector-specific models such as energy, agriculture, or land-use, based on data availability. It can also account for climate change damages at both a sectoral level (e.g., agricultural labor, transportation, energy supply) and an aggregate level (e.g., real GDP, overall labor productivity). This applies to both long-term climate shifts and variations in extreme weather

2 See https://www.gtap.agecon.purdue.edu/databases/default.asp

events. The model can use household survey data or link to microsimulation models to analyze poverty and inequality effects through household incomes and expenditures for all simulated macro policies.

Analysis in action

The IMF-ENV model has been widely used in a variety of contexts, including multi-country studies on international climate policy cooperation (see Chateau et al., 2022a; Schwerhoff et al. 2022), cross-border effects of asymmetric climate policies (see Fournier et al., 2024), energy security (see Dolphin et al., 2024; Rojas-Romagosa, 2024), climate financing (Schwerhoff et al., 2022; Cai et al., 2024), and supporting climate policy analysis within individual countries. It has been applied for the analysis of climate mitigation and decarbonization policies in many IMF AIV consultations (see, for example, applications for Canada,[3] India,[4] Indonesia,[5] Italy,[6] Mexico,[7] Poland (International Monetary Fund. 2023), Saudi Arabia (International Monetary Fund. 2023b), South Africa (Qu et al., 2023), U.S. (International Monetary Fund, 2023c)) and several FSAPs (see applications for Germany (International Monetary Fund,. 2022a), Kazakhstan (International Monetary Fund,. 2024a), Mexico (International Monetary Fund, 2022b), and Japan (International Monetary Fund, 2024b)). In the context of G20 countries, it has been used to assess the macroeconomic impacts of domestic mitigation policies, to explore a range of policy instruments, and to conduct research on competitiveness and carbon leakage, emphasizing the importance of simultaneous climate policy implementation across countries (see Chateau at al., 2022b, 2023).

Conclusions

The IMF-ENV model is developed within the Research Department of the IMF, to specifically address questions regarding the transition to low-carbon economies and mitigation efforts. Several applications of the model to a variety of topics already exist. The model is continuously updated to refine its core features, enabling it to effectively analyze upcoming climate, energy, and trade policy announcements from various countries. Upcoming developments include the addition of a technology diffusion module and updating the characterization of international capital flows.

3 https://www.imf.org/en/Publications/CR/Issues/2023/07/27/Canada-2023-Article-IV-Consultation-Press-Release-and-Staff-Report-537072
4 https://www.imf.org/en/Publications/CR/Issues/2022/12/21/India-2022-Article-IV-Consultation-Press-Release-Staff-Report-and-Statement-by-the-527283
5 https://www.imf.org/en/Publications/CR/Issues/2023/06/22/Indonesia-2023-Article-IV-Consultation-Press-Release-Staff-Report-and-Statement-by-the-535060
6 https://www.imf.org/en/Publications/CR/Issues/2022/07/28/Italy-Selected-Issues-521489
7 https://www.imf.org/en/Publications/CR/Issues/2023/10/31/Mexico-2023-Article-IV-Consultation-Press-Release-and-Staff-Report-541023

References

Cai, Kailhao, Thibault Lemaire, Andrea Medici, Mr Giovanni Melina, Gregor Schwerhoff and Sneha D. Thube (2024) Harnessing Renewables in Sub-Saharan Africa – Barriers, Reforms, and Economic Prospects. *International Monetary Fund Staff Climate Notes* 2024/005, A001. https://doi.org/10.5089/9798400290107.066

Chateau, Jean, Florence Jaumotte, and Gregor Schwerhof (2022a) *Economic and Environmental Benefits from International Cooperation on Climate Policies*. IMF Departmental Paper 2022/007. https://www.imf.org/en/Publications/Departmental-Papers-Policy-Papers/Issues/2022/03/16/Economic-and-Environmental-Benefits-from-International-Cooperation-on-Climate-Policies-511562

Chateau, Jean, Florence Jaumotte, and Gregor Schwerhoff (2022b) *Climate Policy Options: A Comparison of Economic Performance*. Washington, D.C.: International Monetary Fund. https://doi.org/10.5089/9798400225239.001

Chateau, Jean, Geetika Dang, Margaux MacDonald, John Spray, and Sneha Thube (2023) *A Framework for Climate Change Mitigation in India*. Washington, D.C: International Monetary Fund. https://doi.org/10.5089/9798400247002.001

Chateau, Jean, Hugo Rojas-Romagosa, Sneha D Thube, and Dominique van der Mensbrugghe (2025) IMF-ENV: Integrating Climate, Energy, and Trade Policies in a General Equilibrium Framework. *IMF Working Paper Series* 2025(077). https://doi.org/10.5089/9798229005029.001

Dolphin, Geoffroy, Romain Duval, Hugo Rojas-Romagosa, and Galen Sher (2024) *The Energy Security Gains from Strengthening Europe's Climate Action*. Washington, D.C: International Monetary Fund. https://doi.org/10.5089/9798400265655.087

Fournier, Jean-Marc, Tannous Kass-Hanna, Liam Masterson, Anne-Charlotte Paret, and Sneha Thube (2024) *Cross-Border Impacts of Climate Policy Packages in North America*. Washington, D.C: International Monetary Fund. https://doi.org/10.5089/9798400268960.001

International Monetary Fund (2023b) *Saudi Arabia: 2023 Article IV Consultation-Press Release; Staff Report; and Informational Annex*, IMF Middle East and Central Asia Dept. *IMF Staff Country Reports* 2023(323). https://doi.org/10.5089/9798400252099.002

International Monetary Fund (2022a) *Germany: Financial System Stability Assessment*. Washington, D.C.: International Monetary Fund. https://doi.org/10.5089/9798400216886.002

International Monetary Fund (2022b) *Mexico: Financial Sector Assessment Program-Financial System Stability Assessment*. Washington, D.C.: International Monetary Fund. https://doi.org/10.5089/9798400223686.002

International Monetary Fund (2023a) *Republic of Poland: Selected Issues*. Washington, D.C.: International Monetary Fund. https://doi.org/10.5089/9798400244612.002

International Monetary Fund (2023c) *United States: 2023 Article IV Consultation-Press Release; Staff Report; and Statement by the Executive Director for the United States*. Washington, D.C.: International Monetary Fund. https://doi.org/10.5089/9798400245176.002

International Monetary Fund (2024a) *Republic of Kazakhstan Financial Sector Assessment Program-Technical Note on Climate-Related Risks and Financial Stability*. Washington, D.C: International Monetary Fund. https://doi.org/10.5089/9798400273629.002

International Monetary Fund (2024b) *Japan Financial Sector Assessment Program-Financial System Stability Assessment*. Washington, D.C: International Monetary Fund. https://doi.org/10.5089/9798400273384.002

Qu, Haonan, Suphachol Suphachalasai, Sneha Thube, and Sébastien Walker (2023) *South Africa Carbon Pricing and Climate Mitigation Policy*. Washington, D.C.: International Monetary Fund. https://doi.org/10.5089/9798400247620.018

Rojas-Romagosa, Hugo (2024). *Medium-Term Macroeconomic Effects of Russia's War in Ukraine and How It Affects Energy Security and Global Emission Targets*. Washington, D.C: International Monetary Fund. https://doi.org/10.5089/9798400264269.001

Schwerhoff, Gregor, Simon Black, Karlygash Zhunussova, Jean Chateau, Sneha Thube, Ian Parry, and Florence Jaumotte (2022). Getting on Track to Net Zero. *Staff Climate Notes* 2022/010. https://www.imf.org/en/Publications/staff-climate-notes/Issues/2022/10/31/Getting-on-Track-to-Net-Zero-Accelerating-a-Global-Just-Transition-in-This-Decade-525242