The Coalition of Finance Ministers for Climate Action

FSMAT: incorporating climate finance into a stock-flow-consistent disequilibrium framework

Coalition for Capacity on Climate Action (C3A)

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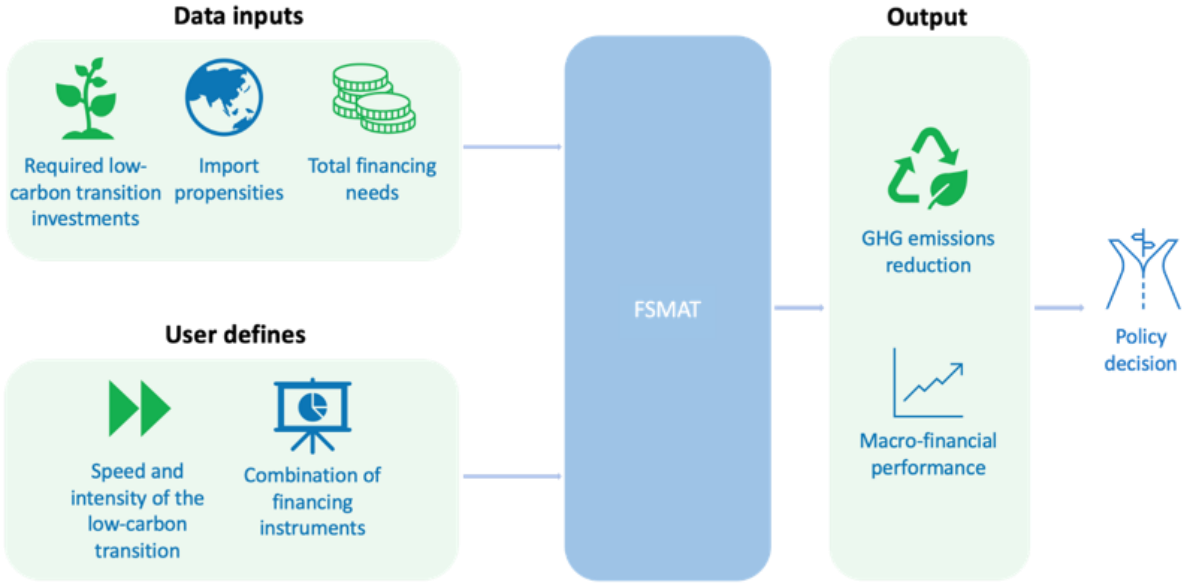
Overview

The goal of FSMAT (the Financial Sector Mitigation and Adaptation Tool) is to represent the macro-financial and environmental implications of different green financial sector interventions (financing strategies, regulations, and tools) for climate-related investments, in a readily available model that can be calibrated to any country.

In the context of NDC 3.0—the third round of Nationally Determined Contributions under the Paris Agreement—and the new Long-Term Strategies being prepared by the Parties to UN Framework Convention on Climate Change (UNFCCC), the question of feasible financing strategies to contribute to countries' emission reduction or adaptation goals has taken a prominent place in the global climate debate. As the Baku to Belem roadmap investigates options to raise US$1.3 trillion of additional funding for emerging markets and developing economies (EMDEs) by 2035 to fill the global financing gap in middle- and low-income countries, and as explicitly advocated by the Expert Review on Debt, Nature and Climate (2025), the need for such a tool is critical. And it is reinforced by the current fragile macroeconomic environment facing many middle- and low-income countries, where high public debt risks, volatile exchange rates and a high cost of access to capital are impeding or worsening their low-carbon development prospects.

In this context, FSMAT would enable users to explicitly explore the investible space for low-carbon and resilient financing options at the country level. It is an empirical stock-flow-consistent (SFC) disequilibrium model developed to explore alternative financing strategies and broader green financial sector interventions for the low-carbon and resilient transition. Developed and maintained jointly by the World Bank and AFD [the French Development Agency], it builds on the GEMMES model (Godin and Yilmaz, 2020) but extends it in two ways. First, it incorporates a built-in database that systematically constructs social accounting matrices and sectoral balance sheets for over 100 countries. Second, it enhances the representation of low-carbon transition investments and the multiple financing strategies, instruments, and policies that can support the funding of these investments.

Figure 1. How FSMAT works



Source: Authors

FSMAT captures the interdependencies between five economic agents, namely government, firms, households, financial institutions, and the rest of the world. It ensures that all financial and real-economy flows between these agents are accounted for in a coherent manner, and that their balance sheets (both their stocks of assets and liabilities) evolve accordingly. This stock-flow-consistent approach is crucial when analyzing climate and financial or fiscal policies as it properly accounts for public or private debt accumulation dynamics, investment financing conditions, and other forms of sectoral imbalances.

FSMAT provides a robust framework for understanding how climate-related shocks propagate through the economy and how different policies can mitigate physical or transition risks. This feature makes FSMAT particularly useful for exploring the impact of different green financial sector interventions on climate aspects (e.g., emission reductions or increased resilience to climate impacts) through related investments, as well as broader macroeconomic variables such as debt sustainability, income distribution, and economic resilience.

The dynamic behaviour in FSMAT is driven by agents' continuous adjustment of their decision variables—such as wages, prices, consumption, investment, portfolio allocation, and financing sources—toward endogenously moving target values. These target values refer to variables such as wages, prices, consumption or investment levels, and evolve based on theoretical foundations but are fundamentally validated through empirical data. Rather than assuming static equilibrium conditions, FSMAT captures the gradual adaptation of economic agents to changing conditions, allowing for the emergence of path-dependent dynamics, structural shifts, and potential instabilities in response to climate policies, financial conditions, and macroeconomic shocks. The stock-flow consistency of the models ensures that these behavioural features are embedded in an accounting structure where all budget constraints are fulfilled.

Variables and policy questions addressed

FSMAT is designed to assess macro-financial dynamics under different climate investment financing scenarios, defined either exogenously by the modelers and the users, or endogenously, constrained within a series of identifiable risks. Based on those inputs, it can project trajectories for key macroeconomic variables, including real GDP growth, inflation and interest rates, exchange rate dynamics, government budget balance and public debt, current account balance, and sectoral debt accumulation. FSMAT can also represent associated emission reductions and climate impacts related to a range of extreme events. (See Figure 2 below.)

FSMAT examines how different climate-related financing instruments, policies, and strategies affect macro-financial variables, and the environmental effect they may have. For instance, relying solely on domestic public debt to finance the transition may increase bond market instability and lead to rising interest rates, reducing demand and output. Similarly, excessive external private sector borrowing for green projects could also lead to instability, as the interest payments would put pressure on the current account, which can trigger a currency depreciation that increases the inflation rate. Ultimately, FSMAT can investigate different ways to fill the climate financing gap and their respective effects on financial stability and growth. This assessment is critical to policymakers in general and Ministries of Finance, in particular in the run-up to COP30 in Belem.

Figure 2. Typical FSMAT outputs (for selected variables in Brazil)

Notes: The line plots compare the dynamic impact of three alternative financing instruments (green bonds in foreign exchange [FX], green bonds in local currency [LCU] and concessional lending by multilateral development banks), and the combined effects, for some selected variables in Brazil. The radar chart compares the impact of the three individual policies in a specific year for some specific variables. The axes measure ratio to the best-case scenario.

Source: Authors, based on FSMAT outputs

Strengths and key assumptions

A key strength of FSMAT is its ability to highlight a very granular range of financing strategies and their effects on the real economy. For example, it is able to explicitly represent the detailed EcoInvest policies of the Brazilian Ecological Transformation Plan, including blended finance and currency hedging mechanisms. It focuses on potential financial fragilities, debt accumulation, and sectoral imbalances, making the tool well-suited for detecting the risk of a financial or currency crisis occurring. Given its flexibility and detailed description of the financial sector, FSMAT can be used to analyze the effects of a wide range of policies at the macro level, such as climate, fiscal, income, monetary, and credit policies, focusing on their impact on sectoral balances and long-term stability. Furthermore, their continuous time specification enables a description of disequilibrium dynamics.

As an SFC model, FSMAT ensures the fulfillment of agents' budget constraints over time (Godley and Lavoie, 2007). SFC models ensure that all stocks (e.g., capital, wealth, debt) and flows (e.g., income, consumption, investment) are consistent with accounting principles, maintaining a comprehensive link between stocks and flows over time. The models are "watertight", ensuring that every income payment and financial flow out of one sector corresponds to an inflow into another, preventing inconsistencies in sectoral accounts.

Limitations and challenges

A limitation of FSMAT is that it is an aggregated macroeconomic model, making it less suitable for detailed sectoral or bottom-up analyses. To overcome this limitation, it can either rely on exogenous assumptions or be directly integrated with other sectoral modeling frameworks, such as input–output models or techno–economic models of the energy system.

Another limitation is simply related to the lack of detailed financial sector data available in some countries, which makes the calibration of the tool more difficult or uncertain in some cases, or may require moving beyond international data for calibration, which increases the development time. This modeling approach requires institutional sector accounts, which many countries do not systematically compile. Incorporating additional assets and liabilities—both the standard and the more recent and innovative—while maintaining stock-flow consistency necessitates continuous data collection and harmonization. The basic data structure based on international data sources already enables the potential calibration of around 100 countries.

Other challenges lie in the uncertainties surrounding green technology performance, future climate conditions, and the novelty of green financing tools, so that defining realistic scenarios requires careful consideration.

Use cases and applications

The global transition to a low-carbon economy requires an unprecedented increase in green investment to mitigate climate change and achieve sustainability goals, as stated in the Independent High-Level Expert Group's most recent report on climate finance (Bhattacharya et al., 2024). It also requires a structural transformation process whereby countries reduce their dependency on the production, consumption, and exports of fossil fuels. Policymakers seek financing strategies that mobilise resources and reduce the climate financing gap while minimizing macroeconomic costs, ensuring financial stability, and sustaining economic growth.

In this context, FSMAT is particularly valuable for exploring how different financing strategies impact the macro-financial stability of economies undergoing a low-carbon transition. The model can be used to evaluate scenarios such as the macroeconomic effects of increasing green bond issuance to finance renewable energy investments, the implications of different concessional lending schemes for debt sustainability and the external balance, the risks associated with foreign direct investment in low-carbon infrastructure projects, and the role of central banks in supporting green finance while maintaining financial stability.

As an example, to evaluate the impact of the Ecological Transformation Plan (ETP) on the Brazilian economy, FSMAT was tailored to the Brazilian economy, generating simulations for the period through to 2030 (see Figure 2 above). The model was calibrated using Brazilian data, using an adjusted set of equations to take into account the importance of the minimum wage in the wage-setting process (and its automatic indexation to GDP and inflation in 2023), fiscal dynamics, the monetary policy rule, the high weight of natural resources on the export basket, supply-side constraints and endogenous productivity mechanisms. The tool was then used to understand the impacts of the blended finance instrument of the ETP, the green bond initiative and the Tropical Forest Fund Facility (TFFF). This example shows how the tool can be customized to the specific structural and policy context of Ministries of Finance. Similar country adaptations of FSMAT are possible as far as the data allows; ideally, the Ministry of Finance (along with other stakeholders such as research institutes) would be actively involved in the process.

References

Bhattacharya A, Songwe V, Soubeyran E and Stern N (2024) *Raising Ambition and Accelerating Delivery of Climate Finance.* London: Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science. https://www.lse.ac.uk/granthaminstitute/publication/raising-ambition-and-accelerating-delivery-of-climate-finance/

Espagne E, Oman W, Mercure J-F, Svartzman R, Volz U, Pollitt H, Semieniuk G and Campiglio E (2023) *Cross-border risks of a global economy in mid-transition*. Vol. 184. International Monetary Fund.

Expert Review on Debt, Nature and Climate (2025) *Healthy Debt on a Healthy Planet: Towards a Virtuous Circle of Sovereign Debt, Nature and Climate Resilience. Final Report.* https://debtnatureclimate.org/reports/healthy-debt-on-a-healthy-planet-towards-avirtuous-circle-of-sovereign-debt-nature-and-climate-resilience/

Godin A and Yilmaz SD (2020) *Modelling small open developing economies in a financialized world: A stock-flow consistent prototype growth model.* AFD research papers No. 125.

Godley W and Lavoie M (2006) *Monetary economics: an integrated approach to credit, money, income, production and wealth*. Springer.