The Coalition of Finance Ministers for Climate Action

The ThreeME model

French Economic Observatory (OFCE)—Sciences Po

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Overview

The Multi-sector Macroeconomic Model for the Evaluation of Environmental and Energy policy (ThreeME) is a country-level and open-source model designed to evaluate the short-, medium-, and long-term impacts of environmental and energy policies at the macroeconomic and sectoral levels. It combines features of neo-Keynesian models with elements of bottom-up energy models, allowing for a comprehensive assessment of the macroeconomic impacts of decarbonization scenarios and climate policies. The model provides a wide range of outputs, including standard macroeconomic indicators such as GDP, employment, inflation, public deficit, and debt-to-GDP ratio along with sectoral outputs such as production, employment, and investment by sector.

ThreeME also provides a hybrid dimension with the inclusion of environmental indicators, including greenhouse gas emissions and energy consumption by source and sector, which are essential modeling outputs when assessing energy transition scenarios. Additionally, the model allows the analysis of a rich set of price indicators, such as consumer prices, production prices, and energy prices, as well as trade outcomes including imports, exports, and trade balance. ThreeME's hybrid structure allows it to capture both the economic and environmental impacts of policies, making it particularly well suited to assess the impacts of a broad range of environmental policies, including decarbonization scenarios.

Strengths and limitations

Key strengths

ThreeME's key strengths lie in its sectoral and energy disaggregation, which allows the detailed analysis of activity transfers between sectors and the modeling of a broad range of climate and energy policy interventions across economic agents. Its short-run dynamics are very similar to that of neo-Keynesian models, allowing adjustment processes to be analyzed in short- to medium-run horizons in addition to long-term macroeconomic impacts. The hybrid structure, combining macroeconomic and bottom-up modeling approaches for household energy consumption where calibration data is available, offers a comprehensive view of policy impacts. The open-source nature of the model facilitates transparency and adaptability, allowing users to adapt the model to their custom requirements.

Limitations

However, ThreeME also has limitations. Its detailed structure can make it challenging to interpret the large volume of results produced with each run, requiring careful analysis and proper training of modeling teams. The model has extensive data requirements, needing detailed sectoral and energy data for calibration. This can make it challenging to adapt in developing countries, where sectoral data can be lacking. Further, the results can be sensitive to the calibration of behavioral parameters. The financial sector representation is limited, which curtails the scope of impact assessments on the consequences of the energy transition on capital markets. Additionally, the model lacks an explicit spatial dimension, meaning regional impacts within countries are not modeled.

Key assumptions in ThreeME include frictions on the adjustment of prices and quantities, and a choice of a wage curve or Phillips curve relationship for wage determination. These assumptions are crucial in driving the model's results, particularly in terms of employment and inflation dynamics. Users should be aware of these assumptions when interpreting model outputs and considering their policy implications.

Relevance to Ministries of Finance

ThreeME is highly relevant for Ministries of Finance and other economic decision-makers due to its comprehensive coverage of economic and environmental variables. It was designed specifically to assess the macroeconomic impacts of environmental policies, but its rich sectoral disaggregation and price system makes it well suited to evaluate a much broader range of economic policies. In terms of tax and fiscal policy, the model is well suited to the evaluation of the effects of carbon taxes and green

subsidies. ThreeME can project Government revenues and expenditures under different policy scenarios, making it a valuable tool in budget planning. It also helps analyze the impact of green transitions on public debt trajectories.

ThreeME directly reports the key metrics of interest to MoFs, including GDP, unemployment, inflation, debt-to-GDP ratio, and Government balances. It can be used to assess fiscal risks associated with climate change mitigation and energy transition, as well as to design and evaluate climate-aligned fiscal policies. The model's sectoral disaggregation allows MoFs to identify potential winners and losers from policy changes at the sectoral level, informing decisions on targeted support or compensation mechanisms. Its ability to simulate both short- and long-term effects helps in balancing immediate fiscal concerns with longer-term sustainability goals.

The model is particularly useful for MoFs in stress-testing fiscal projections against various climate policy scenarios. It aids in designing fiscally sustainable pathways for meeting national climate commitments and assessing the potential for green fiscal reforms to support both environmental and economic objectives. Furthermore, ThreeME enables the evaluation of distributional impacts of climate policies across sectors and (in some calibrations) household groups, providing crucial information for crafting equitable transition strategies.

Key policy/analytical questions addressed

The outputs provided by the ThreeME model through simulations include not only the usual macroeconomic outputs, but also sectoral data as well as environmental variables such as greenhouse gas emissions or energy consumption. The model can therefore be used to combine the usual macroeconomic analysis with environmental concerns and provide precise insights from the reduction in emissions to estimated sectoral job losses from a given policy or shocks.

The model can be used to replicate standard macroeconomic shocks (i.e., a general increase in Government spending or productivity shocks) as well as more climate-policy oriented shocks, such as carbon tax increases, or fossil fuel price increases, to study the combined impact on the economy and emissions. Furthermore, the sectoral dimension can provide fine-grained analysis regarding sectoral dynamics as, from a climate action perspective, sectoral analysis is key for a more precise understanding of the economic consequences. Effective environmental policy often implies targeting specific industries to make them more environmentally virtuous while undermining more polluting ones (i.e., coal or petroleum).

The focus on the energy sectors brings an additional lens to investigate more precise questions regarding energy policy. In France, the model is used to evaluate comprehensive green transition scenarios[1] with a set of diverse measures including incentives and subsidies, change in energy mix, and change in agents' behaviors (e.g., increasing remote work). The model can be called upon for questions that are not directly climate oriented. For example, its sectoral framework was particularly relevant to study Covid lockdowns economic consequences (Malliet et al., 2020), as the shocks had sectoral specificities that could easily be modeled within the ThreeME framework, unlike the usual macroeconomic models and tools.[2]

Use in practice

ThreeME is an open-source model; an earlier release version with French data is available through GitHub.[3] The infrastructure of the simulations and the user interface are built in R, a statistical open-source software package, well known by economists. This makes the process of simulating scenarios and analyzing results easy, as users can rely on basic R data analysis skills. Historically, the simulations were run through the statistical software package EViews, which requires a paid license; however, active development is ongoing to procure a fully open-source solution.

1 See the French Energy and Climate Directorate report.
2 Links to publications of ThreeME studies can be found at www.threeme.org
3The repository may be accessed at https://github.com/ThreeME-org/ThreeME_V3-open

Calibrated versions of ThreeME for all 27 EU countries and the UK are available by relying on the free Exiobase database[4] and Eurostat data. As is the case with most recent developments, these versions of ThreeME are not made directly available to the public. On a longer-term basis, the research team has experience working with governmental institutions, most recently in France, Mexico, and Luxemburg. In addition to access to the latest versions, the ThreeME developing team also provides the initial technical training for the economists to access and use the model. From these experiences, a set of manuals and user guides are compiled for future reference. In France, the model has become the primary tool for the French Treasury for environmental policy analysis.

ThreeME is built with a block-like structure. This helps to identify the different components of the model, from the core elements (i.e. consumers, producers, prices) to optional ones (i.e. transportation choices, housing energy efficiency), and brings modularity to the tool, as blocks of equations can be added or removed to a certain extent to model new behaviors and shocks.

Lessons and challenges

To ensure the adoption by the French Treasury, a bespoke version of ThreeME incorporating a few modeling changes was brought on in partnership with the research team. Interactions were key to make ThreeME compatible with their existing macroeconomic model and yield coherent behaviors between the two models. For example, some shorter-term dynamics had to be adapted, as ThreeME usually tends to be used in longer-term analysis, and the Treasury was looking to replicate their shorter-term multipliers. This led to some tailored modification of equations, notably on foreign trade and investment blocks.

On the operational side, two types of training are required, one to familiarize teams with the model behaviors, and another more technical one (specifically in R). This can take varying lengths of time depending on the skills of the staff. There can also be an institutional technical challenge; the software installation requires straying from tools usually used in administration, thus relying on the cooperation of IT and security departments. The model and its infrastructure are not extraordinarily demanding, however, and can be run on entry-level computers, provided the required software is installed.

As ThreeME continues to expand and improve, there are internal improvements on a continuous basis, on both the model and the technical infrastructure, which requires communication with the model developers to ensure it remains up to date and to provide access to technical help in case of unforeseen technical issues.

Future work

ThreeME is already open source and can be freely adapted to any country, with the goal of making it an open modeling platform. Future developments fall into three main categories.

First, improving the user experience is a key priority. This includes enhancing technical performance with fully open software and developing interactive tools to facilitate the analysis of data inputs and results.

Second, ThreeME is a hybrid model that can combine top-down economic modules with bottom-up modules, such as those for energy consumption in the residential building sector, transportation modes, or heterogeneous households by income category. However, interconnections between modules remain challenging, especially in an open-source setting. Therefore, improving these interconnections is a crucial area of future research.

Third, the development of new modules is essential. This includes modules for financial markets, the electricity network and market, and climate damage. Additionally, an important projected development is the creation of a multi-regional version of ThreeME that explicitly accounts for trade linking countries, enabling ThreeME to function as a global integrated assessment model (IAM).

4 https://www.exiobase.eu/index.php/about-exiobase

These developments are supervised by the French Economic Observatory (OFCE) in collaboration with researchers and modelers from other national and international institutions, including ADEME, NEO, the French Ministry of Economic Affairs, HACIENDA, STATEC, and UNEP.

Analysis in action

ThreeME has been utilized in various regional contexts to simulate the economic and environmental impacts of different energy transition scenarios. As a collaborative effort between various Ministries, it is regularly used to assess the economic impact of the French low-carbon strategy (SNBC). Similar exhaustive low-carbon scenarios have been implemented for Tunisia, Mexico, and Indonesia with the support of the United Nations Environment Programme (UNEP) and the French Development Agency (AFD).

Partnerships with local users are crucial for a successful experience. The model may require adaptations to the specific country context to account for the local economy's characteristics. Ideally, two types of local partners should be involved. An institutional partner (e.g., economic or energy ministries, energy or environment agencies) is essential for providing credible economic evaluations of projected national policies, such as low-carbon strategies and Intended Nationally Determined Contributions (INDCs). However, institutional partners often face challenges in maintaining modeling knowledge and capacity over the long term due to high turnover and a lack of permanent technical specialists. Therefore, involving an academic partner is crucial for the long-term appropriation and maintenance of the model in the country.

Reference

Malliet, Paul, Frédéric Reynès, Gissela Landa, Meriem Hamdi-Cherif, and Aurélien Saussay (2020) Assessing Short-Term and Long-Term Economic and Environmental Effects of the COVID-19 Crisis in France. *Environ Resource Econ* 76, 867–883. https://doi.org/10.1007/s10640-020-00488-z.