The Coalition of Finance Ministers for Climate Action

MANAGE-WB: a recursive-dynamic CGE model

World Bank

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An overview of MANAGE-WB

MANAGE-WB offers an analytical framework with a comprehensive overview of the macroeconomic impacts of climate change and the effectiveness of various adaptation and mitigation strategies. It is a single-country recursive-dynamic computable general equilibrium (CGE) model utilized in over 50 countries, 20 of which are included in the Country Climate and Development Reports (CCDRs) from the World Bank. Compared with the macrostructural MFMod model, the rich sectoral detail of MANAGE and its robust micro-foundations are areas of strength in the modeling of major structural changes in the economy. In contrast, while MFMod has less sectoral detail, it does a better job at modeling the short-term dynamics of an economy, including the countercyclical influence of fiscal and monetary policies. Monte Carlo experiments of stochastic events can be run with both systems.

MANAGE-WB is particularly adept at capturing sector- and country-specific physical and transition risks associated with climate change. The model provides detailed insights into fiscal outcomes and standard national accounts indicators, as well as distributional effects via welfare metrics for different household groups, sectoral outputs and prices, employment, and wages. Additionally, it offers detailed greenhouse gas inventories, including non-CO_2 process emissions, and evaluates the effects on air pollution and land cover change.

MANAGE-WB allows systematic sensitivity and stochastic assessment of climate change damages for 15 damage vectors. It works in conjunction with energy, transportation, water, agricultural, biophysical, or microsimulation models.

The model is solved using the GAMS numeric solving system and is calibrated to social accounting matrices constructed using the most recent national accounts, fiscal, labor, and household data capturing the current structure of the economy of interest. The structure of the social accounting matrices is consistent with the widely available GTAP social accounting matrices covering over 140 countries.[1] In its latest version, MANAGE-WB generates standard simulation files that are easily adaptable to country- or topic-specific scenarios.

Key strengths

MANAGE-WB offers a rich depiction of climate change mitigation strategies (power mix, substitution between different energy carriers, between energy and capital, land cover changes), which also allows feedback loops to be incorporated within detailed sector models (energy systems, transportation, agricultural, climate change damage models). MANAGE-WB includes a sensitivity and stochastic module for assessing climate damages, including for extreme climate events. A graphical user interface and reporting tools (tables, graphs, maps) allow efficient analysis and comparison across different scenarios. The model is set up in a flexible and modular fashion such that it can be used with differently detailed databases to allow for detail where necessary. Modules such as those for climate change damages, vintage, or sector-specific capital, or forward-looking analysis can be used on demand. While it requires detailed data, integration with the GTAP Data Base provides broad coverage for about 140 countries, encompassing around 80 sectors with specifics on power generation, greenhouse gases, emissions, and land use.

Limitations

MANAGE-WB is neoclassical in nature (i.e., market clearing and flexible prices). Notably, the model clears markets at each time-slice, which reduces its suitability for analyzing shocks that take more than one time period (a year for MANAGE-WB) to resolve. For slow-moving effects such as the gradual rise of temperatures and changes in rainfall patterns this is not a serious shortcoming. Like most macroeconomic models, MANAGE-WB uses relatively smooth functional forms to characterize technology. As a result, the rapid development of new sectors requires external-to-the-model information on the size and speed of growth of the sector in order for these to be properly simulated. MANAGE-WB also does not normally model monetary policy, rational expectations, and nominal

1 https://www.gtap.agecon.purdue.edu/databases/.

rigidities. Finally, the model requires a great deal of information about the adjustment of different sectors to changed economic circumstances (elasticities of substitution). By default, MANAGE-WB relies on the elasticities that have been compiled and estimated by GTAP, which may not be appropriate in a given country. While these elasticities can be reestimated at the country level, and this is often done for the most important elasticities, many others retain their default values.

Relevance to Ministries of Finance

The MANAGE-WB tool is particularly valuable for Ministries of Finance, as it provides an analytical framework of climate policies in an economy-wide context that captures the direct and indirect effects. It incorporates detailed data on Government revenues (tax and non-tax revenue), expenditures (current and capital), fiscal balances, and debt, while also capturing the effects of policies on GDP, sectoral output, employment, and welfare. Importantly, the model is mindful of resource constraints, which limit the range of policies that can be implemented sustainably. The model can be used not only for climate-specific policies, but also for other policy priorities, and to understand the climate implications of policies not directly focused on climate issues. Used carefully, it can compare alternative policies and quantify the most cost-effective interventions as well as the economy's vulnerability to climate risks and resource limitations.

The analysis helps decision-makers prioritize interventions with the highest cost-benefit ratio given the level of exposure of the economy to climate hazards or transition risks and considering the resources available. Alternative growth paths toward a resilient low-carbon development can be tested. The model evaluates different revenue recycling schemes following subsidy reforms, or changes in environmental taxes, such as carbon taxes. It also identifies the optimal level of taxes and/or Government and private investments to meet targeted development and climate objectives.

Key policy/analytical questions addressed

MANAGE-WB provides an analytical framework to consider a country's development trajectory through a climate lens. Key questions it can help answer include the following.

- Given the need to adapt to a changing climate, what are the priority actions to promote a development path resilient to climate change?
- How to identify the most economically effective mitigation policies that maximize both development and long-term climate outcomes, and find areas where short-term climate actions will avoid costly "traps" as well as long-term policy reversals?
- How to finance the development-climate agenda in a sustainable and realistic way?

Use in practice

Relative to some other tools CGE models, MANAGE-WB can be more challenging to set up and run in an MoF context. Running and maintaining the model requires a high-level of skill, and staff turnover in Ministries can complicate matters. In several countries—including relatively poor countries—MoFs have been able to set up and use CGE models. Using outside experts or a local university team as a modelers can help overcome these challenges.

The model set-up, database development, and analysis with the MANAGE-WB modeling system can be undertaken by the World Bank modeling team. In such circumstances, MoF staff can focus on interpreting model results and designing scenarios and interpreting them for policymakers. MoF staff can also be trained on the modeling system and perform their own analyses. Counterfactual scenarios are developed with the client, assessed with models, and subsequently refined.

The World Bank offers different options for the training of MoF staff with the aim of enabling the client to use the model independently. A large number of developing-country MoFs have been trained on the MANAGE-WB system and its predecessors. An open-access version of MANAGE-WB will soon be available to increase transparency and facilitate attracting new users globally.

Lessons and challenges

MANAGE-WB is developed based on continuous integration of improvements from different projects. Its current version considers more than a decade of successful application to macroeconomic assessment. The use of the GTAP Data Base and a carefully tested master version allows a fast-track application to a wider range of policy relevant questions. Analysis is typically refined in an interactive process with the client such that the desired level of detail and robustness of results is attained.

Future work

MANAGE-WB is being linked with the set of INVEST natural capital models to quantify the impact of policy and changes on ecosystem services globally, while in parallel different options to better depict the labor market, including from a gender lens, endogenous technical change, and monetary policy, are explored.

Analysis in action

MANAGE-WB has a long history of applications for different types of analyses. MANAGE-WB has been employed in 14 country-specific climate-focused macroeconomic analyses (World Bank Group, 2022, 2023). These include Benin, China, Colombia, Dominican Republic, Ethiopia, Indonesia, Philippines, Republic of Congo, Rwanda, Türkiye, Uzbekistan, and Vietnam. Eight other climate-focused country studies underway include Armenia, Djibouti, Gabon, India, Poland, Tanzania, Togo, and Yemen. The model and its predecessors have been deployed in partnership with MoFs in a number of countries including Algeria, Italy, the Dominican Republic, Poland, Saudi Arabia, and Türkiye. MANAGE-WB has been used in partnership with MoFs to examine climate change policies such as the economic impact of emissions reduction policies, and the introduction of carbon pricing (see, for example, Orecchia et al., 2023). MANAGE-WB has also been used to assess the economic impact of policies to promote growth and economic resilience. In some cases, a country-specific version of the MANAGE-WB model has been developed together with MoFs to facilitate in-house model-based policy assessments; in other cases, the model analysis is performed by the World Bank based on policy scenarios defined jointly with the MoFs and/or other Government Agencies. The World Bank further supports capacity-building in MoFs by providing training in CGE modeling or the use of CGE models for policy analysis to government officials.

Conclusions

Its flexibility and modularity as well as the option to develop a project-specific database render MANAGE-WB an interesting option for macroeconomic analysis. Its recent advancements in usability (graphical user interface, rigorous documentation, refactoring for modular use, adding sensitivity analysis and options for stochastic damages) ease and speed up model application and improve the robustness of results.

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