Using the MANAGE-WB model in World Bank analytical and advisory work

- DRAFT: NOT FOR PUBLICATION -

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Abstract.

MANAGE-WB is a single-country recursive dynamic Computable General Equilibrium model with a focus on energy, emissions, and climate change impacts. It serves as a rigorous and theoretically consistent framework in the World Bank's analytical and advisory work to develop baselines and assess alternative scenarios from a macro-economic perspective with sectoral detail, in projects with different topical foci such as on Climate Change mitigation and adaptation, on fiscal reforms or on jobs and growth. Compared to scholarly or more standard consulting work, the application of MANAGE-WB in Word Bank projects is based on interactive processes involving the client government(s) and other teams from the Bank. This provides necessary sectoral and other expertise but requires intensive interaction to properly exchange information between different modelling tools and approaches. The team around MANAGE-WB has responded to this specific application profile by developing ready-to-use shock drivers, a post-model reporting tools which can provide ready-formatted input for follow-up analysis, a flexible and modular model structure, backed up by user interface.

Introduction

The Mitigation, Adaptation and New Technologies Applied General Equilibrium at the World Bank (MANAGE-WB) model is a single-country recursive dynamic Computable General Equilibrium (CGE) model with a focus on energy, emissions, and climate change impacts (van der Mensbrugghe, 2020). It serves as a rigorous and theoretically consistent framework in the Bank's analytical and advisory work to develop baselines and assess alternative scenarios from a macro-economic perspective with sectoral detail, in projects with different topical foci such as on Climate Change mitigation and adaptation, on fiscal reforms or on jobs and growth. MANAGE-WB is applied in projects drawing on input from and based on interaction with a client government, and teams of country and sector

experts from the Bank or other entities. Applications typically consider a larger number of economic sectors, commodities, production factors, and household types. They mostly draw on a SAM developed for the project, see the first paper in the session. As detailed in the second paper of the session, flexible nesting structures allow for introducing capital/labor/energy substitution in production, intra-fuel energy substitution across all demand agents, and multi-output, multi-input production structures, all especially relevant for Climate Change Mitigation related work. In the following, we will first briefly compare the typically application of MANAGE-WB with other types of model use, such as academic writing or analysis for consulting projects, before we detail how baselines and counterfactuals are developed with MANAGE-WB in interactive processes, providing examples of analytical work based on MANAGE-WB by the World Bank.

Types of use of economic simulation models

Most economic equilibrium models are developed to analyze real-world problems. Even non-commissioned scholarly work with such models often critically assesses government actions, such as bio-fuels policies (e.g. Hertel et al. 2010). Academic studies are free to decide on model or database detail or the definition of scenarios. They can explore policy changes which (current) governments would not consider, including drastic ones outside what the political economy renders likely. This can be beneficial to provide a broader view of policy options.

As the agents whose actions are analyzed are not involved in the process, views expressed in such studies are solely those of the academic authors. But this independence does not imply that the results presented are an impartial outcome. By sitting down at a desk of an academic institution, an author does not suddenly turn into a soulless machine without norms and beliefs. In any stage of a study, such as deciding on database detail, on model set-up and parameterization, authors must take choices which ultimately impact quantitative results. They decide which results are presented and how they are commented upon. Moreover, like “p-hacking” in econometric studies (Stefan and Schönbrodt, 2023), authors probably want to find some interesting impacts, which often translates into stronger ones, to increase the chance of publication and later citations. Peer review processes increase the chance that results are based on a sound methodology and likely avoid obviously biased choice of scenarios and presentation of results.

Without a client paying for the model analysis, funds for academic studies must be found elsewhere, for instance within the base funding of the institution itself. Academic studies might miss access to detailed information available at government agencies and seldom comprise interactions with the governments whose actions are analyzed. Such interaction can be beneficial to bring in specific expertise, for instance to avoid scenario definitions which are non-compliant with national or international law.

Other scholarly work with equilibrium models focuses on methodological issues, such as papers published in the GTAP journal, for instance, on different approaches to depict

international trade. Policy experiments presented in methodological papers tend to be stylized and might be specifically designed to disentangle the relation between specific impacts and methodological choice.

The academic study which chooses its own theme and approach contrasts with commissioned work. In such a consulting project comprising work with equilibrium models, interaction between analysts and their clients happens mostly before and at the beginning of the project, when the terms of the analysis are settled, and towards the end, when (draft) reports are presented. Scenarios, often set in detail by the client, tend to be close to the current law book. Analysists might face standardized catalogues of questions to address. Examples of such work are the impact assessments of free trade agreements and other legislation by the European Commission (see, for instance, https://policy.trade.ec.europa.eu/analysis-and-assessment_en) which are tendered in competitive processes. Analysists can typically decide to quite some degree on data use and methodological detail in commissioned studies, areas where clients often have limited knowledge. Tenders therefore often require that model teams prove their expertise, for instance, based on records of publications and past projects. Commissioned projects might give privileged access to client data and often comprise control by the client on publication of results. They also often work under tight deadlines which require that either staff works full-time on one study only, or that a larger team of analysts are available. This can make it hard for academic teams, which have obligations such as teaching, to compete with specialized consulting companies. The combination of the quite specialized services to consult based on equilibrium models and the limited number of studies tendered each year can lead to duopolistic settings, especially if procurement favors national providers. Repeated studies by the same team for a government, especially when combined with stricter dis-closure rules, can undermine the value of such services as the public might suggest that results are generated which please the client to secure the business.

Consulting projects don't finance model development and maintenance directly, and the increasing use of competitive tendering processes reduces the chance to cover development and maintenance costs by commissioned studies, as teams which have already an up-to-date suitable model are likely to win due to lower cost. Similarly, to successfully publish based on model results, reviewers will scrutinize data for sufficient detail and actuality, and expect a state-of-the-art model.

Modelling teams therefore seek larger research projects, e.g. from science foundations to fund (necessary) model development, including larger database updates. As research projects are mostly granted in competitive processes, teams might fail to receive necessary funds for model and database updates altogether or at the right time. Moreover, research projects focus on methodological innovations and not on model maintenance. This implies overfunding of development of new models, often hardly

operational when projects end, and underfunding of model maintenance. Moreover, uncertain funds related to project-financed model work can provoke unsustainable fluctuations in staff which renders it hard to maintain human capital. For a deeper discussion, see for instance Podhora et al. 2013. These observations partly explain why many well-known economic equilibrium models are maintained at international organizations able to provide base-funding for model maintenance and non-fixed term contracts for analysists, such as the ENV-LINKAGE model at the OECD or GLOBIOM at IIASA. Models maintained by the organization is then often used for commissioned work within the organization such as for example the European Commission's science and knowledge service JRC which serves the European Institutions with impact assessments and policy analysis (see e.g., Feyen et al 2020, Benedetti Fasil et al. 2022, Christensen 2022, Christensen et al 2019a and 2019b, Barbero et al 2022).

Global CGE modeling benefits compared to other work with economic models as the GTAP center centralizes database updates, and partly model and database extension to keep track with a changing policy focus such as towards environmental issues. For instance, CO2 and non-CO2 accounting and related data are now part of the standard GTAP database and model. From the perspective of the individual user of the GTAP database, outsourcing of these database and model updates not only implies shared fixed costs. Equally important, it avoids hiring staff to build a global database for CGE modelling, now with many satellite accounts attached, which requires very specific expertise. Finding and keeping this human capital would probably be almost impossible for any of the GTAP database users individually.

The application of MANAGE-WB as an interactive process

Compared to commissioned studies, applications of MANAGE-WB are characterized by a more intensive exchange during the full lifetime of a project as detailed now. Work with MANAGE-WB at the World Bank resembles in many aspects a CGE application in research institutions, but projects benefit from the specific client relation between the World Bank and consulted governments, as well as from the structure of the World Bank itself. Projects with MANAGE-WB often involve a matrix structure, where multiple departments of the World Bank with their specific expertise, databases and tools work jointly, while in parallel teams from headquarters and country desks interact. The country desks link the analytical teams, often situated at headquarters, with government representatives. They also bring in specific knowledge on the country, for instance, on current and planned legislation, its economic and political situation, available data etc. Additionally, the Bank maintains a rich network of external consultants, partly scholars, which gives flexibility to react to fluctuating demand for analytical services and to add to the expertise of the Bank's own staff.

Embedded in such projects, MANAGE-WB is used in a wide range of analytical and advisory work including the assessment of economic impacts of climate change damages,

adaptation and mitigation policies as part of the Country Climate Development Reports (CCDR); the impact on economic growth and poverty of policy reforms as part of the Country Economic Memorandums (CEM), impact of climate change on financial stability as part of the Financial Sector Assessment Program (FSAP); and in spending reviews and technical assistance to clients.

Other teams and clients in MANAGE-WB projects typically are already involved in data work, for instance, to find a recent SAM and national accounts. They can help to bridge language barriers. Once the database is constructed, the following interactive process of baseline development and counterfactuals is successful only with appropriate communication of analysts with clients and colleagues from other World Bank teams. Model mechanism underlying results must be explained often in layman terms, as clients and colleagues from other teams at the Bank might have little or even misguiding ideas of how CGE modeling functions. Limitations of what the model or the project as a process can provide and uncertainties related to data, parameters and model structure need to be addressed without the impression of arbitrariness. As the person responsible for project resource management, the project leader must be kept informed about trade-offs between additional detail or quality which can be achieved by addressing remaining concerns of clients and the required resources and time to do so.

Baseline development

The first step in most analysis with MANAGE-WB consists in building a country specific SAM as discussed in the first paper of the session. The following development of one or multiple ex-ante baselines is often a demanding, but fruitful exercise of stepwise refinement. It integrates various projections (GDP, population, GDP composition, Value-added shares of broader sector aggregates, emissions, fiscal accounts, debt, international prices etc.) provided by or agreed upon with the client. Without a baseline which is accepted by the client and suitable also for non-CGE modelers as part of the project team, counterfactual work is hardly possible. Non-CGE modelers will here focus on specifics aspects of the baseline, such as the development of energy demand and supply by carrier, as discussed below in more detail. Providing up-to-date and necessary detailed data, sourced by what the client considers appropriate, and developing agreed-upon, scrutinized baselines in projects with MANAGE-WB requires often a large share of time spent overall on a project.

If multiple baselines are developed, they can vary, for instance, with respect to the successful implementation of planned government policies or different development in world market prices or international demand for exports. For example, the Colombia CCDR considered two baselines; one with continuing oil exports and one where oil exports were declining over time due to implementation of decarbonization by trading partners, (World Bank 2023a, 2023b). A baseline with MANAGE-WB follows the neo-classical growth framework where GDP dynamics depend mostly on three factors: labor supply,

driven by demographics, capital accumulation from net investments, and productivity. The latter is endogenous and recovers the exogenous GDP growth. In MANAGE-WB, the propensity to save by households depends (mildly) on expected returns to capital and the CPI, and funds for investments compete with borrowing to the governments, under endogenous interest rates on government debt. In most applications, both the exchange rate and the ratio between foreign saving and GDP is fixed. To better reflect income dynamics in demand, the parameters of the CDE demand system can be updated based on regression functions driven by income changes estimated from the parameters in the GTAP V11 database. Where land and natural resources are considered as separate primary factors, their supply is typically mostly integrated in the baseline by additional productivity shifters. Many relevant options in baseline construction can be set on the model's Graphical User Interface.

Baselines often include exogenous elements, such as projections of electricity supply from different power generation options (coal, gas, oil, hydro, solar, wind) from power system modeling, or of fiscal revenue streams provided by the client government. They are integrated with productivity or tax shifters. Implausible outcomes of the baseline might root in an inappropriate model set-up, for instance regarding its nesting structure or parameterization, but can also stem from mutually incompatible exogenous assumptions. Addressing such inconsistencies is a delicate issue and finding agreement can be a lengthy process, especially when requiring iterations between models. Clients are often keen to consider recent short-term fluctuations in macro-indicators, due to global or regional shocks (wars, natural disasters, pandemics etc.) which can challenge the equilibrium perspective inherent in CGE modeling.

Counterfactuals

We take the CCDRs as a typical example for analytical work with MANAGE-WB. CCDR related applications comprise two interlinked types of counterfactuals. The first one models GHG emission reduction scenarios. While carbon taxes are typically endogenously under a falling emission ceiling, changes in the power mix, energy use in transport and other sectors might be exogenously driven by input from sectoral teams which might also provide detailed projections of energy use efficiency. Typically, different options to recycle carbon taxes are explored, often in interaction with the poverty team, for instance to dampen unwanted impacts on the poor from carbon-tax pass through in consumer prices. Recycling of corban tax revenue has also been included as part of tax reform pursuing multiple targets such as reducing poverty, improving public services, and boosting investments. The second type of scenario, which can be combined with mitigation related ones, considers a wider range of Climate Change related damages, such as on labor productivity due to heat or on capital stocks due to natural disasters[1]. This

[1] The different CCDR analyses performed with MANAGE-WB has considered a broad range of climate change damages from different climate change scenarios such as reduced labor

non-adaptation scenario is complemented by adaptation scenarios where options such as hardening infrastructure against Climate Change induced changes in the probability or severity of disasters such as floods or tropical storms are considered. Other adaptation measures considered include installing of air condition to reduce heat-induced reduction in labor productivity or installation of irrigation systems to reduce damages to crop yield from drought. These adaptation measures dampen some or all the damages considered but require so-called adaptive, non-productive investments which do not increase the productive capital stock. Quantification of damages, adaptation measures and related costs stems mostly from sectoral biophysical and detailed economic modelling by Bank teams or external consultants. Analysists working with MANAGE-WB must get some understanding of such work to properly integrate shocks in the model, for instance to avoid double-counting of costs related to damages or adaptation measures.

Results from MANAGE-WB typically feed into additional modelling work, partly iteratively. Power system models, for instance, can be informed about projected electricity demands by the CGE, which impacts the simulated cost minimal power mix in this type of model. The updated power mix might then be used to repeat the baseline or a counterfactual again. Changes in income and commodity prices are often used by the Bank's poverty team in micro-simulation work as illustrated in figure 1 from the Dominican Republic CCDR (World Bank 2023c).

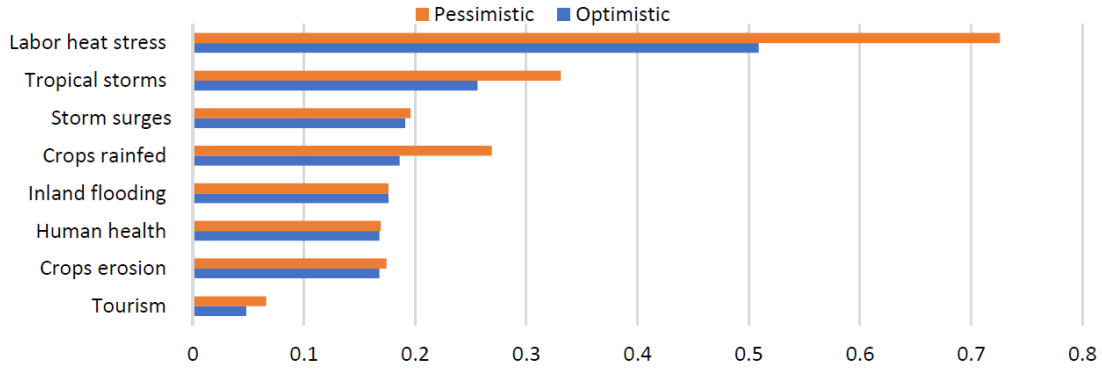

Figure 1. Impact of climate change by channel on the poverty headcount in 2050 projections for Dominican Republic

Source: World Bank calculations based on household survey microdata using macroeconomic projections from MANAGE-WB.

productivity to heat stress, impact on human health, reduced crop yield of irrigated and rainfed crops, soil erosion, impact on livestock production from heat and feed availability, inland and urban flooding, sea level rise, tropical storms, damages to roads and bridges, hydropower production, and loss of tourism.

Summary and concluding remarks

Compared to scholarly or more standard consulting work, the application of MANAGE-WB in Word Bank projects is based on interactive processes involving the client government(s) and other teams from the Bank. This provides necessary sectoral and other expertise but requires intensive interaction to properly exchange information between different modelling tools and approaches. Analysts working on MANAGE-WB needs to ensure that input for other models or sectoral analyses enter well into the CGE model. They also need to ensure that model mechanism underlying results and limitations of the modelling-based analysis is well communicated to team member. MANAGE-WB is used in a wide range of analytical and advisory work. The team around MANAGE-WB has responded to this specific application profile by developing ready-to-use shock drivers, a post-model reporting tools which can provide ready-formatted input for follow-up analysis, a flexible and modular model structure, backed up by user interface.

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