



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

MEMORANDUM

SUBJECT: Transmittal of Charge to the Science Advisory Board for the Computable General Equilibrium (CGE) Model Review Panel

FROM: Al McGartland /signed/
Director, National Center for Environmental Economics, Office of Policy

TO: Holly Stallworth
Designated Federal Office, Science Advisory Board Staff Office

DATE: August 5, 2019

Attached is EPA's charge to the Science Advisory Board (SAB) for the Computable General Equilibrium (CGE) Model Review Panel. We look forward to the Panel's meetings and discussions of the charge and are eager to receive feedback.

If you have any questions or need further information, please contact Ann Wolverton from OP's National Center for Environmental Economics (NCEE) at 202-566-2278.

cc: Brittany Bolen
Lindsey Jones
Thomas Brennan
David Dunlap

Technical Review of EPA's Computable General Equilibrium Model, SAGE
Background and Charge

In September 2017, the Science Advisory Board (SAB) issued its final report on the use of general equilibrium approaches to prospectively evaluate the costs, benefits, and economic impacts of environmental regulation.¹ The SAB affirmed the importance of using a computable general equilibrium (CGE) model to capture important interactions between markets when there are both significant cross-price effects and distortions in those markets.² Given the typical level of aggregation in CGE models and their focus on long run equilibria, the SAB observed that CGE modeling results are complements to, rather than substitutes for, the other types of detailed analysis that the EPA conducts for its rulemakings. The report also noted that CGE frameworks offer valuable insights into the social costs of regulation even when benefits are not incorporated into the models, though it highlighted explicit treatment of benefits as a long-term research priority. In addition, the SAB observed that CGE models may also offer insights into the ways costs are distributed across regions, sectors, or households.³

To ensure that CGE models are appropriately leveraged in future regulatory analyses, the National Center for Environmental Economics (NCEE) was tasked with leading the EPA's efforts to develop economy-wide modeling capabilities.⁴ Since the EPA's use of CGE models for regulatory development has historically been quite limited, NCEE has focused on capacity-building, beginning with the development of a new CGE model called SAGE.⁵ The new model is a dynamic intertemporal applied general equilibrium model of the U.S. economy with subnational resolution across both regions and households and is the focus of the CGE Model Review Panel's current review.

The 2017 SAB report advised the EPA not to rely on a single CGE model to meet all its analytical needs. The EPA seeks to balance this advice, that a model is fit for purpose, with the sometimes-substantial time and resource constraints of the regulatory process and the challenges of representing specific regulations in a CGE framework. As the SAB noted, the extent to which CGE models add value to regulatory analysis depends on data availability. Data limitations can be a significant obstacle to

¹ The EPA conducts benefit-cost analysis (BCA) for all economically significant or particularly novel rulemakings. Economically significant rules are defined by Executive Order 12866 as those with costs and/or benefits of at least \$100 million (nominal) in a single year. The purpose of the BCA is to inform the policy process by quantifying the expected social benefits and costs of alternative regulatory options relative to a baseline representation of what is expected to occur in the absence of the regulation. In addition, the EPA often evaluates who is expected to gain or lose due to regulation, referred to as an economic impact analysis.

² While the report declined to identify when CGE analysis is warranted based on the magnitude of expected abatement costs, it noted that a partial equilibrium (PE) approach is likely sufficient when a regulation is expected to have limited impacts outside regulated industry.

³ For the full report, including additional recommendations and advice, see:

[https://yosemite.epa.gov/sab/SABPRODUCT.NSF/0/4B3BAF6C9EA6F503852581AA0057D565/\\$File/EPA-SAB-17-012.pdf](https://yosemite.epa.gov/sab/SABPRODUCT.NSF/0/4B3BAF6C9EA6F503852581AA0057D565/$File/EPA-SAB-17-012.pdf).

⁴ The response letter to the SAB is available at:

[https://yosemite.epa.gov/sab/SABPRODUCT.NSF/0/4B3BAF6C9EA6F503852581AA0057D565/\\$File/SAB-17-001-3488+Peter+S.+Thorne,+Ph.D.pdf](https://yosemite.epa.gov/sab/SABPRODUCT.NSF/0/4B3BAF6C9EA6F503852581AA0057D565/$File/SAB-17-001-3488+Peter+S.+Thorne,+Ph.D.pdf).

⁵ The new CGE model is called SAGE, as in SAGE is an Applied General Equilibrium model.

achieving the granularity needed to adequately represent a regulation when estimating its effects. U.S. regulations vary widely - they may be a performance-based emissions rate standard or specify the use of pollution control equipment and/or the alteration of a productive process. Often standards are differentiated by vintage, such that new and existing facilities or products are treated differently. Standards may be further differentiated by fuel type, industrial process, product, or other factors. They also may apply to individual production units or to facilities. A regulation may span many sectors (e.g., toxic emission standards for boilers) or be limited to a single sector (e.g., cement, automotive coatings, or coal ash retention ponds). There may be less information available on certain aspects of compliance costs of the affected universe, and the extent to which this information maps cleanly to the industry sectors represented in a CGE model varies.⁶

Given these challenges, NCEE has attempted to develop a reasonably flexible CGE modeling framework that can be modified for use within a specific regulatory context. In the model version shared with the SAB panel for review, there are several alternative variants of the basic SAGE framework nested within the existing structure; it can be run as a static or dynamic model, at a national or subnational level, with different assumptions regarding capital mobility, and using different baseline specifications. In addition, care has been taken to develop a build stream that is transparent and flexible to allow for modification. For example, the default model represents 23 aggregated sectors and nine subnational regions to allow analysts to further disaggregate the model as needed (data allowing). Further disaggregation may be desirable, for example, when a regulation only applies to a subset of an industry or when regional differences are important.

There also may be instances in which SAGE is not the most appropriate CGE modeling tool. For instance, a small open economy CGE model of the U.S. economy may not be the best fit for evaluating the effects of a policy with significant trade or competitiveness implications. The SAB also noted that in some instances the insights gained from a CGE analysis may be limited without additional technological detail, which could potentially be achieved by linking an aggregate CGE and detailed sector models. Efforts to explore explicit linking of SAGE with sector models are in the early stages and outside the scope of this review.

We are cognizant of the SAB 2017 advice that the EPA rely on open source models and data for its regulatory analyses to the extent possible. The EPA is making the source code and model documentation publicly available and is committed to the public availability of future versions. Currently, SAGE's social accounting matrix (SAM) is based on IMPLAN data, and due to the proprietary nature of that data the model's SAM is not currently publicly available.⁷ However, EPA is an active supporter of open source data alternatives such as the Wisconsin National Data Consortium (WINDC) that could facilitate an open source SAM in the future.⁸

⁶ Analysts may have to grapple with substantial uncertainty when identifying affected entities, methods of compliance, expenditures associated with possible control strategies, and whether costs borne by firms in one sector will result in notable price changes that could affect sectors not subject to the regulation.

⁷ The model's package includes source code for the build stream and detailed instructions for adding the IMPLAN data if a licensed copy is available.

⁸ See <https://windc.wisc.edu/> for more information.

For review purposes, we will provide the CGE Model Review Panel with the following materials:

To aid in assessing the technical accuracy and defensibility of the SAGE model, we provide **model documentation, model source code, build stream, and source data**. The documentation describes each major model component, identifies each key parameter value and source, and explains how to run the model. In addition, the documentation describes in detail two general approaches to representing an environmental regulation in the SAGE model. Peer reviewers are encouraged to run the model and explore how it performs under different conditions when responding to the charge. The documentation also provides model results based on highly stylized regulatory scenarios to facilitate this exploration, along with a description of model diagnostics to facilitate a more in-depth evaluation.

We also provide a short memo summarizing **priorities and broad approaches for accomplishing near-term model improvements and evaluations**. Models are always being updated and improved, and we expect SAGE to be no different. We have identified several potential model updates and design evaluations that may be accomplished over the next two to three years. These include: improving sales and excise tax data; improving the representation of the consumer demand system; and evaluating the sensitivity of model results to large vs. small open economy assumptions.

To answer the questions on model versioning, we provide **a memo describing the proposed versioning system for SAGE and the way we anticipate it would be applied**. Updating the model raises questions of how to consistently identify and track model versions over time. It is important to transparently differentiate between major model updates, smaller bug fixes, data updates, and one-off branches when the model is modified for a single regulatory application. Versioning also relates to peer review of the model: incorporation of smaller changes or data updates likely do not need to undergo additional peer review for those components alone; however, more substantial model changes may warrant peer review. While all regulatory analyses using SAGE will be available for review and comment by the public, certain modifications of SAGE for a specific regulatory application may also warrant peer review.

In addition, we provide the panel with **other materials for general reference**. These include the previous SAB panel's report on the role economy-wide modeling might play at the agency in its regulatory analyses, the social cost white paper the EPA provided to the previous panel, and a paper recently accepted to the *Journal of the Association of Environmental and Resource Economists* that evaluates the difference between social and engineering costs of regulation using the SAGE model.

Charge for CGE Model Review Panel

The EPA requests that the CGE Model Review Panel provide written explanations to support its responses to each question. When changes are recommended, the EPA requests that the Panel also provide documentation.

Technical accuracy and defensibility of the SAGE computable general equilibrium (CGE) model:

1. Is the model documentation clear, accurate, and transparent? Do you have any specific suggestions for how to improve it?
2. Are the model structure and assumptions reasonable and consistent with economic theory?
3. Are the inputs used in the model (e.g., elasticities, social accounting matrix) reasonable and reflective of the peer-reviewed literature?
4. Does the model produce intuitive and expected results?
5. Each model run is subjected to a series of tests to verify that the solution represents an equilibrium. Additional tests are performed to verify that implicit parameters (e.g., labor supply elasticity) match their calibration targets. Are there other verification tests that should be incorporated into the model?
6. While the most appropriate approach for modeling a policy will be regulation specific, is the general framework for capturing compliance requirements in the model reasonable? Are there other approaches that should be incorporated into the model?

Approach to model versioning and peer review of future model updates:

7. Is the outlined versioning framework transparent and reasonable? Do you have any specific suggestions for how to improve it?
8. Are the criteria in EPA's memo for the types of model changes that warrant subsequent peer review reasonable?

Priorities for near-term improvements to SAGE modeling framework:

9. Are the anticipated updates outlined in EPA's memo sensible next step improvements to the model and its parameterization?
10. Does the SAB recommend additional near-term updates to the SAGE modeling framework or parameterization?