

**Comments from Members of the Chartered SAB on the SAB Draft Report:
SAB Advice on the Use of Economy-Wide Models in the Evaluating the
Social Costs, Benefits, and Economic Impacts of Air Regulations**

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Comments from Lead Reviewers

Comments from Dr. Otto Doering

1. The charge questions were adequately addressed, but there might have been more discussion and assessment of modeling system alternatives to CGE models.
2. I have highlighted below some technical issues that might be addressed further.
3. The report is generally clear and logical; my major concern here is with its accessibility to non-economists, especially the executive summary.
4. The conclusions and recommendation are supported by the body of the report.

The charge questions given to the SAB workgroup were especially challenging, ranging from detailed questions addressing very specific concerns within a modeling framework to broad questions of feasibility and applicability. Among other things, this engendered a certain amount of necessary repetition that increases the density and length of the report. It is not an easy report to read. I am not an expert in CGE modeling. My experience base for air quality regulation analysis is in electric utilities where something like the Wharton econometric models were used for basic economic drivers of supply and demand combined with modeling systems for the utility sector built from the bottom up using production-costing models.

My bias is that one needs to base an exploration of regulatory impacts on detailed sectoral models rather than elasticities. One needs to be able to represent multiple alternative technologies showing potential substitutions. One drawback here is that estimating substitution relationships this way is very hard work and takes resources. I would have liked to see more assessment (maybe a few case study results) of several different approaches to estimating an air quality regulation that highlighted the characteristics, advantages, and disadvantages of each approach and then had these summarized in a table. The report focuses quickly on CGE models as a likely solution to economy wide modeling for regulatory analysis. (The third paragraph in the executive summary does make a case for linked PE and GE models – repeated in 1.1.6)

Executive Summary Comments

The executive summary is long and is forced to be so if it is structured to respond to all the questions. One alternative might have been to have some overarching statements of what the working group thought for each of the three categories of questions near the beginning of the executive summary – then go to the specific questions.

- It might help if near the beginning of the executive summary there were a more complete discussion of ways existing regulatory analysis attempts to incorporate the broader economy and the advantages and disadvantages of different approaches. These advantages and disadvantages could be summarized in tabular form. This comparison and contrast of approaches would reflect a more complete discussion to be created in the beginning of the body of the report.
- Transparency is critically important. While transparency for the modeling community is

important, it is also important to design systems and present results in ways that make the limitations and advantages of the model transparent to policy makers. Section 1.4.3 does some of this.

- In the discussion of all the different things that might be outputs from a CGE model, would it be possible to have a summary table indicating which are easy, difficult, and the possible solution to the difficulty?
- Section 1.3.1 (Appropriate use of CGE models) is critical to this discussion. Section 5.1.1 on page 79 may state this more eloquently. This really is central to all three categories of questions posed by EPA. Something like this might be appropriate nearer the beginning of the executive summary and relate to the comparison and contrasting with other approaches.
- When CGE models are initially being discussed, there needs to be more on the challenge and importance of getting accurate elasticities for the performance of the model and also more on the depth and type of data needed for good performance (for data, some of this is on page 20).

Comments on the Body of the Report

P. 19; The comment that GE is not an alternative to ECA is a critically important point. I would recommend “A Framework for Incremental Cost Analysis of a Rule Change” in the National Research Council’s *Review of the EPA’s economic Analysis of Final Water Quality Standards for Nutrients for Lakes and Flowing Waters in Florida*. If the ECA and the original benefit-cost analysis are flawed, economy wide modeling is unlikely to make it better. The ECA, benefit cost and the GE can be critically important accounting frameworks, but each must be complete and adequately represent the critical drivers.

P.36; Table 1 is very helpful. More tables would help readability.

P. 41; I understand the concern with disaggregation, but either that or close integration with some micro modeling or ECA is going to be necessary to capture the many potential sectoral and other impacts of a rule.

P. 44; The bullet points listing ‘rigidities’ in the real world selection of compliance beyond least cost compliance are very important. They can also be included in the comparing and contrasting of different models. It might also be helpful to discuss more the difficulties of representing performance-based versus technology-based regulation especially if the modeling system cannot easily encompass new potential alternative technologies.

P. 60; If CGE models are likely to be best at informing stakeholders about the benefits and costs of environmental regulations, then demonstrating transparency and effectively communicating these benefits and costs to stakeholders must be a priority effort.

P. 86; Section 5.3.1, ‘Overall Criteria’ for evaluating CGE models has a number of good points that add to section 5.1.1 and could be further emphasized.

Pp. 91-98; Section 5.6 presents some comparisons with other models that might be expanded on near the beginning of the report (Executive Summary) to explain reasons for the concentration on

CGE models in the report. Section 6.1 might be useful here as well.

P. 106; Following up on page 60, the second paragraph on what is necessary to make the model understandable to policy makers and how to present results is a critical challenge for the adoption of CGE (and other models as well). If this discussion could be expanded, with some thoughts and suggestions by those in the working group who have wrestled with this, it would be an important contribution. This goes well beyond public access to models and public databases.

Overall, I would like to see more attention given to comparing and contrasting different approaches to obtaining the economy wide impacts from a regulation and the costs and trade-offs involved in trying to implement such systems before getting into how to implement CGE modeling. This also should provide EPA valuable guidance on which approach is most appropriate for a given problem.

Comments from Dr. Robert Johnston

1) Were the charge questions to the committee adequately addressed?

Yes, the charge questions to the committee were adequately addressed. This SAB report addresses the suitability of economy-wide modeling for evaluating economic outcomes from air quality regulations – including costs, benefits and economic impacts. The report emphasizes CGE models as the best suited of available economy-wide models for such purposes. As noted in the report, the capacity of CGE and other economy-wide models to characterize regulatory outcomes differs for costs, benefits and economic impacts. However, given the current state of economy-wide models, these approaches are not suitable for *stand-alone analysis* of any of these outcomes (benefits, costs or impacts). This is correctly implied by the SAB report, which states that (p. ii): “CGE modeling will be challenging to adopt for analysis of many air regulations...” However, in some cases these models may be useful as a supplement or contrast to current approaches, including partial equilibrium models (PE) or engineering-based cost assessments (ECA).

The SAB report is detailed and comprehensive. Somewhat equivocal responses were provided in response to some charge questions (regarding whether and when CGE modeling is appropriate and how effects should be included). However, this equivocality is warranted in most cases because (a) CGE modeling is better suited to modeling some types of effects than others, (b) the applicability of the assumptions implied by these models varies across contexts, and (c) the field is rapidly advancing. Hence, the SAB is correct to note that CGE could be potentially useful to evaluate certain types of economic outcomes—as a supplement to PE and ECA approaches—when general equilibrium effects are likely to be significant, but that significant advances will be required to reach this potential.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

There are no major technical errors or omissions in the report. It does a good job of characterizing a complex type of modeling. However, a few relevant topics do not appear to be mentioned by the SAB report. A few other topics are mentioned briefly but warrant additional clarification or emphasis. These are detailed below.

Questions Regarding Use of a Non-Forecasting Model for Regulatory Analysis: The SAB report is clear that “a CGE model is emphatically not a forecasting model” and that economy-wide models are analysis tools that show “the consequences of a policy change under very specific circumstances: that all other economic conditions remain at values set in the model’s baseline simulation” (p. 25). However, from a conceptual perspective, regulatory analyses are intended to be *ex ante forecasts*, e.g., of costs, benefits and impacts. It would be useful for the SAB report to address this apparent conceptual discrepancy explicitly—that a non-forecasting tool is being proposed by EPA as a means to conduct a type of forecasting.

The Role of Maintained Assumptions: Another issue that warrants additional emphasis in the SAB report is the extent to which CGE modeling relies on (and is sensitive to) maintained assumptions, such as assumptions regarding the structural form of utility. All economic modeling requires assumptions. However, economy-wide models cannot be validated or empirically verified (i.e., verifying the extent to which they fit actual data) to the same degree as some other types of models (e.g., some econometric PE models). CGE models are not often calibrated to explain actual datasets. Hence, “it cannot be concluded within a typical CGE framework that one model is more accurate than another” (p. 107). Goodness-of-fit tests can be applied, but CGE modeling in general is subject to a wide range of maintained assumptions made by modelers, and these assumptions may not comport with (particularly short run) observed data (e.g., because of assumptions required to maintain model tractability). Issues such as these are mentioned in the body of the report, but should be addressed more explicitly in the letter to the administrator and the executive summary.

One illustrative area in which the sensitivity of economy-wide models to assumptions has been emphasized is climate policy effects. The SAB reports notes (e.g., on page 3) that EPA has a long tradition of using economy-wide models for analysis of climate policy. However, some of these types of models have been subject to criticism, particularly for such issues as the role of maintained assumptions and model specifications. See, for example, Pindyck’s discussion of Integrated Assessment Models and the resulting social cost of carbon estimates (Pindyck 2013). Although the specific issues addressed by Pindyck (2013) are not the same as those addressed by the SAB report—the general themes are similar: to what extent are the results of economy-wide models sensitive to assumptions, specifications and parameter values that cannot be externally validated? The SAB report frequently highlights the advantages of the consistent and comprehensive framework imposed by CGE models (e.g., page 23 and elsewhere). However, while this consistent and comprehensive framework may be useful in many cases (imposing “useful discipline” (p. 58) on the analysis), it may also lead to misguided conclusions if the framework is grounded in incorrect assumptions regarding model structures, functional forms, parameter values, etc.

Using CGE Results to Establish or Infer Welfare Bounds: An additional issue that does not seem to be discussed in the report is the relevance of CGE results for types of welfare measures that are not bounded by income. In multiple locations, the SAB report mentions that WTP measures are bounded by income in CGE models in a way not required by PE models (as they generally should be based on microeconomic theory—you cannot pay more than you have). However, not all welfare measures are bounded in this way. For example, willingness to accept (WTA) measures of welfare change are not bounded by income, and hence CGE models would appear to

have little capacity to provide bounds on these welfare measures. Due to the practical difficulty of estimating WTA measures in many cases, WTP measures are sometimes used instead (even when WTA is conceptually more appropriate for welfare analysis). However, the report seems to imply that CGE models can often be used to bound welfare measures, and does not mention this caveat. The report also gives little attention to cases in which *current* income does not serve as a bound on WTP due to wealth and borrowing. The report addresses temporal considerations to a certain extent—for example the extent to which models accommodate foresight and public sector borrowing. However, some consumers may be able to borrow to pay for current expenditures, thereby trading off current and future consumption and enabling current-period WTP to exceed current-period income, at least in the short run. The capacity of CGE models to account for inter-temporal tradeoffs such as these and implications for welfare estimation does not appear to be discussed. Issues such as these could be mentioned briefly in a footnote, for clarification.

Non-Market Values: Some clarification could help reduce the impression of inconsistency across responses to different charge questions, and particularly responses involving non-market benefits. For example, page 74 (correctly in my view) recommends *against* the inclusion of non-use benefits in CGE models, as these benefits lead to little or no behavioral impacts (e.g., they are almost or entirely separable from market behavior). However, page 102 states that “it may be more straightforward to incorporate separable benefits into CGE frameworks than to design a structural representation of externalities necessary to incorporate non-separable benefits.” The latter statement seems to support the inclusion of separable benefits (which include non-use values) into CGE models. These statements should be clarified—for example by specifying that the statements on page 102 do not imply that CGE modeling be used for non-use value estimation (for which it would be poorly suited in all or nearly all cases).

A second seeming inconsistency is guidance in some parts of the SAB report to estimate some types of benefits using non-GE approaches (PE or ECA) and add these to GE estimates, compared to guidance elsewhere in the report that this should not be done. For example, page 74 states that “if EPA wishes to consider non-use values, it would be appropriate for that to be carried out as a separate PE calculation.” Page 76 then states, “it may not be appropriate to add CGE and non-CGE benefits since they may not have been consistently calculated.” Both these statements are defensible, but the SAB report should clarify how they should be reconciled.

Some areas of the report also seem to be more encouraging regarding the capacity of CGE models to estimate benefits (and particularly non-separable, non-market benefits), while other areas make it clear that current CGE models are not able to provide reliable estimates of these benefits. As stated on page 60, “CGE models are unlikely to be successful at producing precise estimates of policy benefits.” This is largely due to the “discrepancy between the highly granular nature of impacts from air pollution exposure and the highly aggregate structure of GE models” (p. 7). It is also due to the difficulty of specifying functions suitable to capture the structural ways in which GE effects influence demands for the full range of potentially affected market and non-market goods, even when benefits are non-separable. In general, the treatment of non-market benefits could be more consistent across different sections of the report.

Finally, page 66 of the report states that “a subset of research on contingent valuation (CV) asks respondents about their WTP for plans (rather than outcomes) to improve some aspect of environmental quality. This literature may be useful...” There are a few concerns with this statement. First, this literature is not limited to the contingent valuation literature (narrowly

defined), but also includes the broader stated preference literature, including choice experiments. Second, and more important, recent guidance for stated preference valuation explicitly advises caution in the use and interpretation of WTP estimates of this type—drawn from questionnaires that elicit WTP estimates for policies (or plans) without specifying the outcomes of those policies or plans (Johnston et al. 2017a, p. 327). Suggesting the use of contingent valuation estimates is appropriate here. However, I suggest that the SAB report be more circumspect in advising the use WTP estimates associated with plans rather than outcomes, as these estimates may have a considerable likelihood of bias. At a minimum, a footnote should be included to this sentence advising awareness of this concern. See Johnston et al. (2017b) for detailed discussion of this general topic and why caution is advised.

Missing References: There are a number of citations that are either incorrect or missing from the reference list. The report should be proofread to ensure that all references are cited properly. Examples of citations missing from the reference list—at least as cited in the document—include Lucas (1976) and Smith and Zhao (2016). There may be others.

3) Is the draft report clear and logical?

Yes. Aside from the unavoidable equivocality with which the SAB was able to answer some of the charge questions (see #1 above) and the additional need for clarification in a few areas (see #2 above), the draft report is clear and logical. There is some redundancy across sections, but this is largely unavoidable given overlap in the charge questions posed by EPA.

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes, beyond the issues already raised above, the primary conclusions and recommendations are generally supported by the body of the draft report. My only remaining comment relates to the overall tone of the report's conclusions with regard to future prospects for CGE modeling as a tool for regulatory analysis. In some cases, the report seems to be more optimistic about the potential of CGE models to adequately incorporate such elements as non-separable benefits than I think is supported by the current literature—although admittedly this is a matter of perspective on the future potential of these models. However, I do think that a more cautionary tone might be warranted in some sections throughout the report—and particularly in the primary conclusions. For example, adequately accommodating a wide range of separable and/or non-separable benefits within economy-wide models (with sufficient precision for regulatory analysis) faces immense challenges, and the current CGE literature is far from accommodating these challenges.

To address this general concern, I suggest that the conclusions might be edited slightly to better reflect the general limitations of CGE models such as (a) the difficulty externally validating these models, (b) the extent to which they rely on maintained assumptions, (c) seeming incongruities between using a model that is not designed for forecasting to forecast policy outcomes, (d) challenges modeling economy-wide effects over long-time periods, and (e) difficulties

addressing non-market benefits, and particularly those that are largely separable in utility such as nonuse benefits. Most of these and other limitations are clearly discussed in the body of the report, but are not emphasized sufficiently (at least in my opinion) in the letter to the administrator or executive summary. Please note that I am not calling for major changes here, only a few minor edits to the conclusions to reflect the many technical challenges discussed in the body of the report.

References

Johnston, R.J., K.J. Boyle, W. Adamowicz, J. Bennett, R. Brouwer, T.A. Cameron, W.M. Hanemann, N. Hanley, M. Ryan, R. Scarpa, R. Tourangeau and C.A. Vossler. 2017a. Contemporary Guidance for Stated Preference Studies. *Journal of the Association of Environmental and Resource Economists* 4(2): 319-405.

Johnston, R.J., E.T. Schultz, K. Segerson, E.Y. Besedin and M. Ramachandran. 2017b. Biophysical Causality and Environmental Preference Elicitation: Evaluating the Validity of Welfare Analysis over Intermediate Outcomes. *American Journal of Agricultural Economics* 99(1): 163–185.

Pindyck, R.S. 2013. Climate Change Policy: What Do the Models Tell Us? *Journal of Economic Literature* 51(3): 860-872.

Comments from Dr. James Opaluch

1. Were the original charge questions adequately addressed?

In general, the Committee did an excellent job addressing the Charge Questions. There were a large number of Charge Questions, with 29 listed questions, some with multiple sub-parts and multiple questions in each sub-part.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

Improving Data Availability

I strongly agree with the Report that if EPA is to expand its use of CGE models, improving data availability is a top priority. This section of the Report emphasizes the need for times series data, but does not otherwise provide guidance on high priority data collection efforts. It would also be useful for the Report to say something about the “timing” issue regarding acquisition of refined

data. How much time, and what level of effort is needed for EPA to develop a CGE model that provides useful analyses for a significant fraction of EPA's policy needs? The report does indicate that "[b]uilding such datasets is resource-intensive and time-consuming to do well..." and that it could be an "iterative task to be completed over time". But more specific guidance would be helpful. How much of this effort is needed to address what kinds of policy questions. At one extreme, existing CGE models might provide useful insights to some categories of policy questions. At the other extreme, it is unlikely that CGE models can be developed that provide useful information on regulations that focus on very specific production processes in narrow sub-sectors. In between these extremes, how substantial an investment is needed for CGE models to provide substantial insights into a reasonable range of policy questions that are faced by EPA on an ongoing basis.

Other CGE models exist with substantial datasets, including EPA's own EMPAX-CGE model and databases developed by other organizations invest to compile and utilize the necessary data. To what extent can a reliable database build on existing datasets like the EMPAX-CGE, GTAP and Phoenix datasets to reduce cost and time? The discussion that I saw about use of EMPAX-CGE model (page 63) was restricted to quantifying health benefits. But what level of investment is needed, if any, for EPA to use CGE models as part of a hybrid approach that restricts its use of CGE models to estimating market effects, and linked the resultant market impacts while quantifying nonmarket impacts using other approaches.

In my opinion, it is essential that improved data be obtained to support great degree of disaggregation for key sectors to assess policies. This effort should be done strategically to create sectors of special interest for EPA regulations.

It would be useful to get an idea from the report on just how restrictive the aggregation issue is, and how serious this is as a long-term problem inherent in CGE models, versus whether it is a relatively short-term problem, and CGE models can be useful for a range of EPA uses with a reasonable level of effort.

Where is the "long hanging fruit" where a reasonable investment can create less aggregated sectors that would greatly improve the policy questions faced by EPA's purposes? The electric utility and energy sectors more generally are obvious candidates because of their importance for the economy, the high degree of connection across virtually *all* economic sectors, and the fact that energy production is among the largest sources of air pollution. As I understand it, EMPAX-CGE model has only two electricity sectors, fossil fuel and renewable/nuclear (RTI, 2008). The Phoenix model has nine distinct electricity generating technologies (coal, natural gas, oil, biomass, nuclear, hydro, wind, solar, and geothermal), plus they model different efficiencies for carbon capture and storage (Sue Wing et al, 2011).

CGE Models and Technology-based standards.

Charge Question 4 (Section 3.4 in the Report on pages 44-46) asks about the challenges in representing emissions-based or technology-based regulations in an Economy-Wide modeling approach. In response to this question I expected to see more discussion of the opportunities and challenges of using vintage capital models and multiple-technologies, including technologies associated with forward-looking performance-based standards that are not yet feasible, but mandated by technology-forcing regulations. Many EPA regulations are technology-based, indeed technology-forcing, and are intended to induce improvements in air pollution control technology. It is difficult to envision how one might assess technology-forcing regulations without including vintage capital models, or possibly other approaches that include the costs of transitioning from existing technologies to new technologies that might not be completely known at the time of the regulation. CAFE standards and the Renewable Fuel Standards are historic examples of this category of technology-forcing regulations. This can be a big challenge since vintage capital models are almost certainly dynamic, which can cause computational constraints, especially when including forward-looking investment decisions. .

Treatment of Capital

While not an “omission”, I think the Report could have a more extensive discussion of the importance of vintage capital models address the issues that EPA faces, and especially for including transition costs. In particular, most EPA regulations are technology-based and technology-forcing regulations. This means it is important for EPA to understand the consequences of regulations designed to bring about large-scale, sector wide changes in technology, which will typically involve long periods of time with considerable transition costs. A dynamic CGE model with vintage capital, and more generally models with multiple technologies, can provide important insights into the transition costs of regulations, as well as unintended consequences, such as the long term consequences of grandfathering old coal fired powerplants under the Clean Air Act of 1970. This provided incentives for operators to keep old dirty and efficient coal plants operating for many decades—powerplants that were view of low priority to regulate as they were expected to be retired soon, as they were thought to be near the end of their useful life spans. Environmental regulations that that the effect of encouraging continuation of older and less efficient vintages of plants are counterproductive, and models where firms choose among alternative technologies can provide useful insights.

More generally, EPAs technology-based approach to regulation begs for modeling that differentiates by technology and/or is based on a vintage capital model. For example, new supercritical coal plants are much more efficient, therefore have more output per unit coal combustion (and CO₂) than older coal plants. Inclusion of pollution control technologies ranging from smokestack scrubbing to carbon capture and sequestration can potentially take this modeling of changes in technology a giant leap further.

Benefit Analysis

I may be reading it wrong, but the discussion on pages 57 to 58 could be interpreted to indicate that the traditional VSL estimates are likely to be too high because they are not constrained by available budgets. It would be useful for the report to be more clear on this point.

First, the proper welfare measure is the WTA to forego the improvement in air quality. After all, EPA does not compensate firms for losing their right to pollute. This can be interpreted as assigning the public with the property right to a clean environment. The minimum willingness to accept compensation to forego mortality risk reduction (WTA) is the appropriate measure of benefits, and it is not constrained by budgets. Also see the bottom of page 58 through the top of page 59. Top of page 60 continues with the implicit assumption that WTP is the proper measure of value, rather than WTA. If the environment is a publicly owned good, then WTA is the proper measure.

Even in the context where the WTP measure is appropriate (for example, accidental death), recall that VSL is correctly applied to policies that imply small changes in risk to a large population. While it is correct that the VSL numbers are large, many millions of dollars, the resultant WTP per individual is small for a small change in risk. This suggests a very small change in income, and hence a small income effect.

At the same time, imposing new regulations will potentially affect production costs and market prices throughout the economy. As the Report points out, the advantage of the CGE model approach is it accounts for the full implications of these changes throughout the economy, and the subsequent impacts on budget constraints. For example, lost profits to firms implies reduced income to consumers who are firm owners (including pension funds that have stock holdings).

But we need to make sure the accounting details are correct, the proper income adjustment in the CGE model for reduced mortality risks, for example, is not VSL, but the loss in producer surplus, which represents the reduction in income to firm owners, plus there would be an income effect associated with changes in prices.

More generally regarding nonmarket benefits, I agree with the Report's statement that "a GE model can provide plausible and useful insights for evaluating whether the general equilibrium effects of major rules are important enough to warrant modifying PE benefit-cost estimates." I also agree with the Reports conclusion that "EPA should not attempt to include non-use values in GE models". And more generally, I think CGE models are best suited for measuring the MARKET effects, and not the nonmarket benefits.

While, in principle, Social Accounting Matrix can be appended with a suite of non-market activities, I personally believe that CGE models are not the right tools to assess the full suite of non-market benefits associated with air pollution control. At a minimum, it is certainly far beyond the current state-of-the-art for CGE models to properly account for all of the effects associated with mortality, morbidity, aesthetic effects, recreation, non-use values and the full suite of non-market values.

The middle of page 58 indicates logical inconsistencies arising from addressing market and non-market effects as fully separable. I agree with this. But while there market and non-market activities are not fully separable, there remain important separabilities—most obviously for non-use values. In my view, a better way for dealing the non-separable elements is to use a hybrid approach that appends General Equilibrium market impacts (e.g., income and price effects) to a separate analysis of nonmarket values.

The footnote on page 59 describes an approach to incorporating environmental benefits into the utility function, and concludes with “These issues remain to be explored.” I agree that there are interesting approaches that remain to be explored from an academic perspective, but I also believe that the approach is not currently “ready for prime time”, and I personally don’t see CGE models as a promising approach for quantifying the full suite of environmental benefits for the foreseeable future.

I agree with the Report’s conclusion “Perhaps the most important point to be made here is that expecting CGE models to provide more precise estimates of benefits than other approaches is to misunderstand what this set of tools has to offer. In fact, due to the large number of parameters needed in a CGE model, as well as to the high degree of aggregation that may be required, a CGE analysis is likely to produce less precise results than a PE or an engineering study.” CGE models are simply not the right tool for measuring nonmarket benefits.

Modeling Impacts as Changes in Household Time Endowments

Charge question 4 on benefits (Section 4.4 in the report) asks whether it is feasible to model mortality and morbidity impacts as a change in time endowments for households. I think that, in principal, it might be possible to model mortality effects as a change in time endowments, or the “quantity” of life. But I’m not convinced that this is a constructive approach. On the other hand, it does not seem to me to be feasible to model *morbidity* effects as a change in time endowments, as morbidity is a quality of life issue, not a quantity of life issue.

I’m not sure exactly what the Report intends by the discussion on page 59, where it indicates that the wage serves as a shadow price on leisure. In equilibrium, (assuming completely flexible work hours), economic theory suggests that consumers would choose hours worked to equate the marginal value of leisure to the wage rate. But one would not expect that the marginal value of leisure time to be fixed, but rather it would increase as leisure time goes to zero. So clearly one needs to construct a surplus-based measure for the value of reduced leisure time, not simply value leisure time by multiplying wage times hours. Surplus for leisure is not constrained by income, and could be infinite. Indeed, one would expect the marginal value of for leisure to go to infinity as the time spent in leisure goes to zero. Sleep is the most important “leisure” activity, and is well known that we would die without sleep. Indeed studies suggest we can go three times as long without food than without sleep (Everson et al, 1989). This suggests that marginal WTA for reduced leisure could go to infinity as leisure goes to zero. I don’t see how any empirical analysis could possibly calibrate the demand for leisure as leisure time goes to zero. This does not seem like a promising approach to me.

3. Is the Committee’s report clear and logical?

In general, the report is very clear and logical. I make some suggestions above for further clarifications.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Yes

References

Sue Wing, Ian, Kathryn Daenzer, Karen Fisher-Vanden, Katherine Calvin, 2011. "Phoenix Model Documentation", (August). Available online at www.globalchange.umd.edu/data/models/phx_documentation_august_2011.pdf

RTI, 2008. *EMPAX-CGE Model Documentation*, Interim Report Prepared for U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Research Triangle Park, NC 27711

Comments from other SAB Members

Comments from Dr. Sylvie Brouder

Q1) Charge questions adequately addressed?

The answers to the charge questions are consistently highly detailed and thorough if not direct in addressing the specific questions. In many places the text reads a bit like an economic primer attempting to explain everything that might be relevant to consider versus addressing the questions directly. Although this is likely a stylistic choice, I found the completeness of some of the answers to obscure the main or key point of the questions/answer, occasionally to the extent that I wasn't even sure that a direct answer to the question was ever provided. For example, in response to the charge question "When is a detailed representation of the rest of the world important for the estimates of social costs?" (page 33). The following text gives a long explanation of the challenges associated with large/open versus small/closed economies, assumptions regarding demands for imports, representation of foreign agents, trade imbalances, endogenous supplies of labor and capital, etc. but I am not sure I saw that summative (3 to 4 sentence) answer to the actual question. For readability and impact (to make sure the message is delivered), my preference would be to make sure that a strong and succinct answer to the question is provided at the beginning (preferable) or end of the details supplied in response to each question. Some sections give very strong and direct answers to the charge questions (e.g. the summary statement on Appropriate Metrics for Social Costs at the end of the section, p.48). The overall document would be strengthened by making sure explicit answers occur in each section.

The use of EWM in Climate Change and carbon policy is occasionally brought up as an illustrative example and where this is done clarifies points significantly. Is there more opportunity to "build out" this particular example elsewhere in the text?

Q2) Technical errors or omissions / issues not adequately addressed?

The report seems technically complete and offers a lot of useful information relevant to the advice sought by EPA. I am not in a position to judge if all the detail provided enhance or detract from the readability and impact of the document.

On page 36, Table 1 on analytical options – it would seem that a column is missing, one that characterizes the potential costs of applying (or not applying) one alternative modeling approach versus another.

Q3) Draft report clear and logical?

Yes, the overall report is logically constructed in that it follows the charge questions and uses sufficient internal referencing as necessary to identify points made earlier in the document that are relevant to subsequent questions. See Q1, above, on the elliptical nature of some of the answers and suggestions for improvement including making sure that each question has an obvious, direct answer. The Letter to Administrator Pruitt is clear, succinct and straightforward. The Executive Summary could be improved for readability by a more general audience (provided this is desirable). Right now the summary is a long, point-by-point and fairly granular distillation of the main report versus key highlights. It is rich with jargon that, stripped of accompanying examples and context provided in the main report, detract from conveying the most critical, high-level messages. The reader is referred to a glossary (17 times) but, in many cases, the jargon could be replaced by a few simple words that would be more broadly accessible. The Executive Summary is likely to be extracted and making sure that it is understandable as a stand-alone document would further its impact.

Q4) Conclusions drawn / recommendations provided supported by body of draft report?

See Q1 above on making sure that the answers to the specific charge questions or pieces of charge questions are indeed explicit.

Comments from Dr. Joel Burken

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

Yes the request from the National Center for Environmental Economics to evaluate the technical merits, methodological challenges, and potential value of using economy-wide models and also to suggest paths forward that would improve the usefulness of economy-wide models was addressed thoroughly.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

None were noted.

3. Is the Committee's report clear and logical?

I believe so. As a non-expert in this area I was at a loss to follow how some aspects would benefit in broad use of the models, but this is again out of my expertise. The potential to push economy-wide models for assessing the benefits, social costs, and economic impact of could perhaps be better projected to non-experts.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Yes, the committee's report was supported in my opinion.

Comments from Dr. Joel Ducoste

- 1) **Were the charge questions to the committee adequately addressed?**

Yes

- 2) **Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?**

No

- 3) **Is the draft report clear and logical?**

Yes. However, I found the Executive Summary to be very long. While it does try to summarize all aspects of the report, which is large, I do think it could be shortened.

- 4) **Are the conclusions drawn or recommendations provided supported by the body of the draft report?**

Yes

Comments from Dr. Susan Felter

1. **Were the charge questions to the committee adequately addressed?**

Yes, although I note that this is not my area of expertise.

2. **Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?**

Not that I'm aware of, but I note that this is not my area of expertise. As a non-expert, I have one question regarding the recommendation by the SAB to "help establish an open-source project to assemble a freely-available database for use in CGE modeling". It is not clear to me what "help establish" means – this implies that another organization will have a lead role and EPA will just "help". It also raises questions for me about oversight and QC of data and how this would happen. Should these be highlighted as key needs for such a database?

3. **Is the draft report clear and logical?**

Yes

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes.

Comments from Dr. Sue Marty

1. Were the charge questions adequately addressed?

Yes, the charge questions were addressed in a logical order. The factors to consider on whether to develop a new model were particularly useful.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the draft report?

No, in my view, the report is complete. The report would benefit from a careful review as there are some typos. For example, the subject line in the Letter to the Administrator has a typo "...Economy-Wide Models in the Evaluating the Social Costs,..."...the first "the" should be removed. As another example, there is a clarification needed on p. 3 (*Time horizon for implementation of the rule*) in the second sentence. An additional review would be useful.

3. Is the draft report clear and logical?

Yes, the report is well written. It may be possible to streamline the report to minimize some redundancies. For example, the need to link a General Equilibrium (GE) model with a more detailed Partial Equilibrium (PE) model appears multiple times in the document, although this may be by design as the authors try to address different questions. The need for transparency and reproducibility also appears numerous times, but again, these are important points.

4. Are the conclusions drawn or recommendations provided supported by the body of the draft report?

While outside my area of expertise, the conclusions appear to be supported in the body of the report.

5) Does the Letter to the Administrator adequately reflect the findings of the SAB report?

The letter to the EPA Administrator followed the sequence of the report and captured the main points covered in the report summary.

Comments from Dr. Kristina D. Mena

1) Were the charge questions to the committee adequately addressed?

Yes

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the

draft report?

The draft report does a great job of explaining the usefulness and limiting factors associated with using general equilibrium models. Specifically, the discussion on the implications of

international trade is really helpful (especially with the examples provided). At one point, a comment is made in the draft report about conflicting viewpoints on the modeling of trade-related factors. Would it be beneficial to provide more detail about this debate? Would it be helpful when interpreting modeling results? Are relevant literature citations included?

A discussion is presented on pages 38 and 39 regarding model validation. What is meant by model validation as presented in this draft report? What is expected to be achieved in order for a model to be valid? Some philosophically argue that models cannot be validated; otherwise, they are not actually models. Is there adequate detail in the report for EPA to understand the recommendation?

The need for high-quality data is appropriately emphasized. This is mentioned throughout the draft report. In addition, the need for different types of information is also discussed as it relates to various sections. Is the overall recommendation of the development of a database suggesting that a variety of entities with various types of data that can inform computational general equilibrium modeling be part of the same database?

“GE” is listed twice on page xiv

3) Is the draft report clear and logical?

Yes

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes

Comments from Dr. Thomas Parkerton

1) Were the charge questions to the committee adequately addressed?

Yes, each charge question was systematically addressed by the SAB Panel.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

No, based on my limited knowledge of this subject.

3) Is the draft report clear and logical?

The report is generally well written and organized. I identified a few potential opportunities for clarification in the Executive Summary

It may be useful to define what is meant by market clearing in the glossary.

Page 3

It is stated “the larger the regulated sectors share of a particular factor input ...”

Suggest defining/explaining the term “factor” as this term is used here and in a number of places throughout report.

Page 9

It is stated:

“hedonic property value estimates are useful to assess the plausibility of benefit assessments based on the conventional strategy” please clarify what is the conventional strategy (damage function approach?) Also not clear how property estimates help assess plausibility of benefit assessments ... perhaps further explanation or an illustrative example would be helpful.

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

I recommend the authors revisit two conclusions provided in Executive Summary that are highlighted below:

Page 1

It is stated:

“Linked models will usually involve some degree of inconsistency between their components but that will often be acceptable given the increased degree of detail that a linked analysis could provide.”

However, given the limited experience in linking CGE models to PE models that are highlighted in this report, particularly in the specific problem context of evaluating air regulations, I question if it is premature to conclude that such linked models “will often” be acceptable. Perhaps a more objective conclusion is that linked models “may” be acceptable [depending on the various considerations detailed in this report and pending findings of future research that is recommended]

Page 2

It is stated:

“uncertainty arises under all analytical approaches, including PE analysis; however, the scale and complexity of GE models makes the task more difficult, and more important as well.”

This statement seems to understate the importance of uncertainty analysis in PE models which I don’t think is the intent. Suggest revising this sentence such as follows:

“uncertainty arises under all analytical approaches, including PE analysis; however, the scale and complexity of GE models makes the task more challenging yet equally important.”

Comments from Dr. Daniel O. Stram

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

Yes, they appear to have been comprehensively addressed

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee's report?

None that I could detect

3. Is the Committee's report clear and logical?

Yes

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Yes that is my impression.

Comments from Dr. Jeanne VanBriesen

Were the charge questions adequately addressed?

The executive summary includes brief summary answers to ALL the sub-questions for charge questions 1-3, which may be overwhelming to the casual reader, but has the benefit of being comprehensive. The fourth component ('directly comparable estimates') is addressed in section 6 of the report and in section 1.4 of the executive summary. It is not clear to me why 1.4 of the ES is called "additional considerations" rather than "comparable estimates" or something that addresses the issue raised in the charge question regarding the challenge of 'generating directly comparable estimates of social costs, benefits and economic impacts.' The other three charge questions address each of these topics in turn, and question 4 seems to request a response to whether integration of these analyses is possible.

"Cost-effectiveness" is introduced obliquely at the bottom of page 15. It may not be clear to the reader why EWM that improves cost-effectiveness modeling but not benefit-cost analysis is being introduced here. This is part of the response to the request for discussion of challenges associated with 'directly comparable estimates.' If it is not possible for EWM to enable direct comparability and thus it is good enough for cost-effectiveness but not cost-benefit analysis, this should be explicitly stated. This conclusion may be hiding in this section, but it is not clear.

Overall section 1.4 of the ES presents information relevant to some but not all of the sub-questions in charge question 4. This may simply be due to space. I'd encourage a careful re-read to see that the underlying purpose of charge question 4 as described in its title is adequately addressed in the summary of section 6 that appears in section 1.4 of the ES.

For Charge Question 2, the final component of the statement "Please consider the relative importance of these factors separately" was not addressed if that meant "please include a separate section on the relative importance of these factors compared with each other" If it meant, "please consider each factor's importance separately," this was done in the sections under 3.2. In reading the charge, I think it means 'compare the factors and discuss their importance relative to each other' and I was expecting this after 3.2.8. The panel should consider adding a section if they agree with this reading of the charge question. This could also be clarified with EPA to ensure this question is adequately addressed following whatever meaning was desired in the original charge.

The committee is to be commended for the extensive content under charge question 3 (other factors). They have done an exemplary analysis that brings to the EPA important issues left out of the original charge questions. This is a terrific example of the value added of having this type of open-ended component in charge questions.

Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the report?

The panel is to be commended for its clear statement on the use of models for analysis rather than forecasting and for the attention paid to the need for sensitivity analysis, especially related to baseline assumptions. Further, the clear instructions (in multiple places in the ES and report) that model components must all be made available for replication by scientists outside the agency is a welcome and important contribution. Because CGE analysis can incorporate a wide range of considerations and thus model structures and data needs, it is critical that the agency be transparent to enable replication and evaluation of the implications of alternative assumptions, input parameters, and model components.

In the section on ‘time horizon’ in the ES, I think the panel is implying that the analysis has to consider the time frame for the effects even though the model is not a forecast. If that is correct, it might help the reader to provide a bit of additional detail on how the time frame for the effects of the policy is considered within the modeling framework. Further, I am not certain that the term foresight is used here in its colloquial meaning (e.g., p. 28 ‘the use of a model with foresight’); could this be added to the glossary of terms to ensure the technical meaning from economics is adequately understood by the reader?

Is the report clear and logical?

The report is very well written. It was a pleasure to read such a clear presentation of the many issues inherent in the questions posed by EPA. The jargon was a bit heavy in places, but the glossary definitions help. The use of footnotes directing the reader to the glossary for definitions in the text of the executive summary is fine, but non-ideal. Ideally, the executive summary can be understood by a technical non-specialist audience and thus uses less jargon than the overall report. Would it be out of the question to just repeat the definitions in the footnotes on first use within the ES or the body of the report? Or insert hyperlinks to the glossary location of the definition?

The different geographic and temporal limitations of PE and GE models (and facility-level or engineering models) is important, and it is sometimes opaque in the executive summary. A figure / schematic might be helpful (to the extent it is reasonable to create one) with axes of temporal range on the vertical axis and spatial range on the horizontal axis. Each type of model would enable coverage of a range of temporal and spatial conditions.

It is not entirely clear what is meant by “some degree of inconsistency” (ES p. 1) that is introduced when PE and GE models are linked or why the likely degree of inconsistency “will often be acceptable.” This is clear in the report, and thus, a minor edit focused on the inconsistency of variable definitions leading to difficulties in linking is probably sufficient.

P. 49 indicates that soft links between natural systems models and models of changes in environmental quality are “equivalent to assuming separability of all non-market goods.” Given the importance of linking natural system models with changes in environmental quality in order

to ascertain benefits of environmental regulations, it seems this conclusion warrants a more thorough explanation. What are the implications of this assumption of separability for natural system models?

The report seems to imply that regardless of GE vs PE models, the benefits are much more difficult to estimate than the costs. In many sections the challenges of estimating the benefits are mentioned, but the extrapolation of that challenge to the interpretation of models designed to weigh benefits and costs is not always clear as some of this occurs much later in the fourth part of the report. Perhaps this is very well understood in the field, but I was surprised not to see this dichotomy more explicitly stated. [This may be an artifact of the way the charge questions were framed, with challenges for the costs in the first question and challenges for the benefits in the second.] A bit of additional lead into the charge questions and possibly some discussion of why these challenges are reasonably considered separately would be a welcome addition.

Are the conclusions drawn or recommendations provided supported by the body of the report?

Yes. Of particular note, the recommendation that the models be fully transparent, including code, data and parameter choice, is important to ensure adequate reproducibility by all stakeholders.

Each answer to each sub-question is effectively a recommendation, since the charge was to provide detailed recommendations on how to approach CGE modeling. However, this means the report contains hundreds of specific recommendations related to sub-components of the CGE model structure. Following these recommendations is also noted to depend on the policy being evaluated (e.g., which sector or sectors it affects, how connected it is to other sectors). This makes it difficult for the reader to determine what priority the SAB would set to the development of the different modeling components. The final component of the report and the ES is the priorities for future research section, which attempts to integrate and provide a prioritization. This is very important; consider moving it ahead of the more point-by-point analysis throughout the ES. Or, consider renaming it ‘conclusions and recommendations’ to highlight that it is the integrated result of responding to the hundreds of questions in the charge.

Related to this, the report does not explicitly comment on the importance of the various questions or the structure of the charge. It might be helpful to the reader for the report to characterize the nature of the components in the charge. Similar to the end of paragraph 1 on page 18. E.g., the identical wording from page 18 or some variants could be inserted directly above section 1.1 in the ES. “EPA requested the SAB consider the technical merits and challenges in the use of economy-wide models for air quality regulation. The charge was to evaluate (1) measurement of social costs; (2) measurement of benefits; and (3) the economic impact. Further, SAB was asked to comment on how directly comparable estimates of social costs, benefits, and economic impacts could be generated.”

It would improve the usability of the work for EPA if the SAB could provide an up front prioritization of issues *before* the detailed responses to the charge questions. Which of the many issues that EPA raised in the charge questions is the most urgent?

Similarly, the priorities for future research section is relatively brief (esp in the ES). Some additional insights that link these recommendations to the many, many recommendations within the document would help. What parts of the recommended work could be done with existing data and what parts require additional data collection or disaggregation? And, of those requiring

additional data collection, which are the most important data to collect soonest? The report recommends creation of a freely available database to assemble data, which is fine, but are there also data that would need to be collected (not just aggregated in a data structure?).

P. 20. “These difficulties mean that GE modeling will not be suitable for analysis of some regulations” The prior paragraph is excellent and this conclusion is warranted. The SAB was not asked to comment on which regulations would be least suitable for GE models, but it could be helpful to be more explicit if the panel has given this thought. To some extent this is done with the classification “undesirable,” but it is not always clear whether these applications where GE is undesirable is because of the narrow focus of the regulation (as described in the paragraph ending with the sentence quoted here) or because of some structural component (no cross-price effects expected or market distortions unlikely). It seems likely the panel could provide some specific examples. E.g., page 27 provides clear examples where the magnitude effects are insufficient to overcome the uncertainty bounds. Similar examples when GE is **not** suitable would be helpful in other sections. E.g., p. 28 includes the statement “A clear cut case where the features of economy-wide models are particularly important, and where EPA has had a long tradition of using such models, has been the analysis of climate policy.” I would suggest some additional exposition here on why GE models are particularly important for climate policy and/or some references where EPA has used GE models for this application.

Minor typographical or formatting issues requiring attention:

p. 3 line 16 “is a thus” remove ‘a’

p. 22, para 4 line 2 “an ECA a PE approach” something is wrong with this phrase, perhaps missing and “or” before the “a PE”.

p. 38 line 2 under “data” is missing an open parentheses before U.S. (U.S. EPA 2002)

p. 78 last line of first paragraph “different levels of aggregation of would” remove 2nd ‘of’ before ‘would’

In section 6.2.3, the EPA White Papers are mentioned in paragraph 1. A reference should be used.

In section 6.3.1, final paragraph, the Stanford Energy Modeling Forum is mentioned. A reference should be added so the reader can learn more about this. [This is also mentioned on page 112]

Sections 3.2.1 and 3.2.2 have relevant titles but no explicit italicized language from the charge question. All other sections have the language from the charge questions.

Comments from Dr. Charles Werth

1) Were the charge questions to the committee adequately addressed?

Yes, they were adequately addressed.

2) Are there any technical errors or omissions or issues that are not adequately dealt with in the draft report?

I could not identify any technical errors or omissions or issues.

3) Is the draft report clear and logical?

Yes, overall it is a very well organized and clear document. I have one minor observation that may or may not require attention. I think section “1.4.5 Priorities for future research”, in the Executive Summary, is an excellent summary of the highest priority items for the EPA to address. I was surprised that uncertainty was not mentioned in this section, and wonder if this was an oversight.

4) Are the conclusions drawn or recommendations provided supported by the body of the draft report?

Yes, the conclusion drawn and recommendations provided are supported by the body of the draft report.

Comments from Dr. Robyn Wilson

1. Were the original charge questions to SAB Standing or Ad Hoc Committees adequately addressed?

I did feel that the charge questions were adequately addressed, in particular, the level of detail in the report was very helpful for each individual question.

2. Are there any technical errors or omissions in the report or issues that are not adequately dealt with in the Committee’s report?

In general, I thought the report was very well written, but I did have a few questions that may have had to do with terminology (see below). Generally speaking, I am left a bit unclear as to the relative advantage of CGE models versus current approaches when it comes to capturing behavioral heterogeneity and other types of heterogeneity that are relevant to air pollution policy. At times the report seems to imply that CGE models do a fine job on this point, at other it seems to be a critique. Some more clarity on this point would be useful. For example, I received the clear impression that spatial heterogeneity is not captured, but mixed messages on behavioral heterogeneity.

p. 3 – Section on foresight – could you explain this a bit more here? Or perhaps include foresight in your definitions? My interpretation would be that agents rarely have foresight due to a strong present bias/high rates of discounting in decision making, so I am curious if my interpretation is right and if it is every possible to assume forward-looking behavior in these models. This is more clear in the later detailed sections, but could use some additional clarity in the summary.

p. 48 – With EV, how robust are the assessments of value/welfare related to a particular environmental good? If we rely on this measure for social costs there is certainly evidence that

we are underestimating social costs due to judgmental heuristics/biases such as scope insensitivity. WTP measures are mentioned a lot throughout the document, and I am curious as to the limits of such approaches, and how standard methods are getting around potential biases in human judgment.

p. 79 – The charge question under 5.1 states that CGE models assume forward looking rational agents followed by a statement that this is probably a reasonable assumption. As a behavioral scientist this seems like an unreasonable assumption, and I would like to see some discussion of this in the response from SAB as to whether or not this is appropriate. The current response doesn't really address this point, and is it simply because behavioral heterogeneity occurs at a more localized level and that specificity is lost in the aggregate across time? Or is it because the actors in the CGE are more likely to follow rational models of decision making? Assuming there are household level actors, I would imagine this is not true. I would be a bit concerned about a model that assumes forward looking rational agents as this is not behaviorally realistic. It is a bit unclear when the term "behavioral equation" is mentioned, if this implies something other than the forward looking rational actor.

3. Is the Committee's report clear and logical?

Overall, I thought the report was clear and logical. My one critique would be that although the executive summary and introduction read very well, after reading through the full report I was a bit concerned that the amount of detail in the full report may not have been adequately captured in the intro/summary. There are a few sections where it seemed the main points were clearly captured earlier, whereas in some sections this was not always the case (for example, the comparison of models in section 5.6). Perhaps a challenge of clearly capturing the main themes of a rather long and detailed report.

4. Are the conclusions drawn or recommendations provided supported by the body of the Committee's report?

Overall, I thought the report provided very logical conclusions and recommendations. For example, there was a good focus on the importance of capturing/accounting for uncertainty and recognizing the behavioral limits of such models (capturing heterogeneity in response, complex interactions and unexpected responses from a boundedly rational perspective, etc). Also, a good overview of the role of linked models to address issues that are poorly captured in the aggregate (e.g., spatially explicit, localized impacts). My one critique is related to my comments above in Q2 about the lack of clarity around behavioral heterogeneity and the accuracy with which CGE or economy wide models might capture this reality of decision making at a local and/or individual level. I take issue a bit with giving the impression that rational actors with perfect foresight are an accurate way to represent actors in the economy wide model.