Compilation of Comments received for 12-9-05 Teleconference of the Second Generation Model Advisory Panel

DISCLAIMER: The following are comments from various members of the Second Generation Model Advisory Panel on recent papers describing the Second Generation Model (see "revised documentation" posted at http://www.epa.gov/air/sgm-sab.html). These comments are submitted for discussion purposes only. The Dec. 9, 2005 teleconference of the SGM Advisory Panel will discuss these and other comments on the revised documentation on SGM posted at the link above.

These comments do not represent final or consensus views of the Second Generation ModelAdvisory Panel or the EPA Science Advisory Board. These comments have not been reviewed for approval by the chartered Science Advisory Board. Neither do these comments represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use.

The SGM Advisory Panel is part of the activities of the EPA Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency.

Part I: Recommended Improvements to Model Documentation

A. Model-Structure Documentation (Goulder, Paltsev and Sue Wing)

B. Parameter and Data Documentation (Rose and Dahl)

Part II: Recommended Initial Work for Improved Data (Harrison and Paltsev) – see attached

Part III: Recommended Improvement to Model Structure and Output

A. Update the data set (Harrison and Paltsev)

B. Model simulations and backcasting exercises (Hanemann, Burtraw, Harrison & Opaluch)

C. International Trade (Sue Wing and Harrison) – see attached

D. Household Utility and Welfare (Opaluch, Hanemann and Pizer) – see attached

E. Production Functions (Pizer, Opaluch and Shortle) – see attached

F. Other greenhouse gases (Paltsev, Goulder and Rose) – see attached

G. Sector specific policies (Shortle and Burtraw) -- see attached

Appendix A: List of ETE Clarifications (Dahl and Pizer) -- see attached
Appendix B: Details on Existing Documentation

Part II
Submitted 12-4-05 by Harrison and Paltsev

Notes on Responses from SGM on Data Issues

Three new documents were provided by the SGM team and reviewed: *The SGM: Comparison of SGM and GTAP Approaches to Data Development* (Paper 1), *The SGM: Data, Parameters, and Implementation* (Paper 2), and *The SGM: Model Description in Theory* (Paper 3). These are each a good first step towards documentation and discussion of choices with respect to data, but they are not enough in terms of data improvement.

We have six concerns.

First, the SGM approach described in Paper1 missed a crucial part of the data balancing issue: consistency across regions. They can do a nice job of fitting IO table and energy balances simply because they have allowed themselves more degrees of freedom than they should: they do not care about actual energy (and commodity) prices and international trade. This is a fundamental problem, since SGM has no coherent theory of international trade that is connected to the core models of each region.

Second, in Paper 1 we would like to see a comparison with other regions where IO data is not as questionable as in China. For example, a comparison with regions such as the US or Europe.

Third, there does not appear to be any comparison with GTAP energy data. In Paper 1, there is a discussion of GTAP volume data (price times quantity), the IO table of China (price times quantity), and IEA energy data (quantity). But GTAP also provides energy data they derive from IEA statistics.

Fourth, we still need to see a comparison between SGM data and GTAP data at an aggregate level for all 13 SGM regions, to see how they balance globally. Again, this international and global perspective is fundamental to the modeling of the effects of major energy policies, and cannot be ignored.

Fifth, in Paper 2 (page 4, Table 2.1) there is a list of SGM data. Most of the tables are twenty years old. I'm not sure one can use the model in 2005 to make projections with these data. To some extent this is always a concern with the data needed for CGE models, but the GTAP database has a much more recent vintage than this.

Finally, we do not see any source provided for data on greenhouse emissions. Nor do we see any reporting of aggregate numbers in some form. In Paper 2 (page 12) there is a mention of the kind of data needed for non-CO2 gases tracked in the model. However, we do not see any references to the database used. We believe that the same is true for CO2 emissions.

In sum, the new material from SGM does not cause us to revise our core recommendations with respect to data. Nor does it provide much confidence that the SGM team can efficiently address the data concerns, since there are some fundamental conceptual gaps (e.g., global consistency, and consistency with international trade flows).

Part III, Item C
Submitted 11-29-05 by Sue Wing and Harrison

Comments on PNNL-15437 – Future Directions for SGM's Development: International Trade

While we applaud the efforts of the modeling team to incorporate international trade into the SGM model, we nonetheless wish to raise some concerns about their proposed approach, namely, the use of calibrated logistic share equations to simulate the partitioning of the aggregate uses of each commodity into imported and domestic varieties.

Recall that in our original recommendations we encouraged the modeling team to employ the Armington specification of international trade, in which the economy's total use of each commodity is represented as a constant elasticity of substitution (CES) aggregate of domestically produced and imported quantities of the good. This specification is the standard for multi-regional simulations for very good reasons, because it offers the key benefits of:

- Flexible demand functions for domestic output and imports
- An abundance of econometric estimates of the elasticity of substitution in different industries—e.g., for North America, Stern, Francis, and Schumacher (1976), Shiells, Stern, and Deardorff (1986), Reinert and Roland-Holst (1992), Shiells and Reinert (1993), and Gallaway, McDaniel and Rivera (2003).
- Global regularity, in the sense of Perroni and Rutherford (1995)

The alternative approach proposed by the model the modeling team would not only fail to capitalize on these advantages, it would also introduce significant additional work on their part, which can be avoided. To see this, assume that the aggregate use of good i, A_i, is produced from imported and domestic varieties D_i and M_i, respsectively, according to an aggregation technology, f_i:

$$A_i = f_i(D_i, M_i)$$

The aggregate price of i, p_i, is determined by the dual cost function c_i, denominated over the prices of imported and domestic varieties, p_i^D and p_i^M:

$$p_i = c_i(p_i^D, p_i^M)$$

Presumably the share equation to be employed will be similar to the following:

(1)

$$S_i^M = \frac{p_i^M \left(\frac{\partial c_i}{\partial p_i^M} \right)}{p_i^D \left(\frac{\partial c_i}{\partial p_i^D} \right) + p_i^M \left(\frac{\partial c_i}{\partial p_i^M} \right)} = \frac{\exp\{\alpha_i^M + \beta_i^{DM} \ln p_i^D + \beta_i^{MM} \ln p_i^M + \gamma_i^M \ln A_i\}}{\left(\begin{array}{c} \exp\{\alpha_i^D + \beta_i^{DD} \ln p_i^D + \beta_i^{DM} \ln p_i^M + \gamma_i^D \ln A_i\} \\ + \exp\{\alpha_i^M + \beta_i^{DM} \ln p_i^D + \beta_i^{MM} \ln p_i^M + \gamma_i^M \ln A_i\} \end{array} \right)},$$

where S^M is the import share of the value of aggregate use of commodity i, p^D and p^M the prices of domestic and imported varieties of i, A represents the (Armington) aggregate demand for i, and α^D, α^M, β^{DD}, β^{MM}, β^{DM} and γ^D, γ^M, are estimated parameters.

In the general, n-input case the logit share equation does not contain an analogue of the elasticity of substitution. This threatens to complicate analysis of the sensitivity of traded industries to climate change mitigation measures, as there is seemingly no way to evaluate the responsiveness of these sectors' activity levels to different degrees of fungibility between domestic and imported varieties. However, Considine (1989: 934-938) shows that in the 2-input case, eq. (1) is very similar to the CES function in its properties and behavior. This result both highlights the utility of our recommended approach and implies that the modeling team can avoid reinventing the wheel by simply following our original guidance.

Finally, we emphasize that the justification advanced by the modeling team for using the logistic approach, namely, that it will preserve energy *quantities* in the aggregation process, appears to be fraught with dubious premises. In the case of *quantity* rather than *cost* shares, i.e.,

$$\tilde{S}_i^M = \frac{\partial c_i / \partial p_i^M}{\partial c_i / \partial p_i^D + \partial c_i / \partial p_i^M},$$

the degree to which the logistic model retains its global properties is questionable. What is certain is that the analogue of the elasticity of substitution vanishes, with the result that sensitivity analysis becomes a complicated task.

In our judgment it is far better to improve the model using economically meaningful approaches rather than sacrifice the economics for the sake of getting energy quantities right. We feel strongly on this point, particularly given that other models (e.g., GTAPinGAMS, MIT EPPA) are able to employ the Armington specification without it having much of an adverse impact on the calculation of energy trade volumes.

References

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2. Gallaway, Michael P., Christine A. McDaniel and Sandra A. Rivera (2003). "Short-Run and Long-Run Industry-Level Estimates of U.S. Armington Elasticities," North American Journal of Economics and Finance 14(1): 49-68.
3. Perroni, Carlo and Thomas F. Rutherford (1995). "Regular Flexibility of Nested CES Functions", European Economic Review 39, 335-343.

4. Reinert, Kenneth A. and David W. Roland-Holst, 1992. "Armington Elasticities for United States Manufacturing Sectors," Journal of Policy Modeling, v14, n5, pp. 631-39.
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6. Shiells, Clinton R. and Kenneth A. Reinert, 1993. "Armington Models and Terms-of-Trade Effects: Some Econometric Evidence for North America," Canadian Journal of Economics, v26, n2, pp. 299-316.
7. Stern, Robert M., Jonathan Francis, and Bruce Schumacher, 1976. Price Elasticities in International Trade: An Annotated Bibliography. London: Macmillan.

Submitted 12-5-05 by Opaluch
Part III, Item D

Recommendation: Derive household behavior from utility maximization; consider changes in welfare in policy assessments.

The Panel recommends that believes that a utility theoretic basis should be provided for consumer behavior in the SGM model. The discussion below focuses only on the general representation of consumer demand functions, and on the use of demand functions to construct welfare measures. This section does not include a discussion of specific issues relevant to inter-temporal decision making, such as the allocation of income among current versus future consumption through savings/borrowing, nor on labor/leisure choices by consumers. These are significant topics involving specialized issues that are deserving of separate consideration, but are not covered below.

The simplest approach for creating a utility theoretic basis for an aggregate model is based on the notion of the "representative consumer". Here, aggregate (or average) demand is treated as if it were generated from a single utility maximizing individual (see, for example, the discussion in Deaton and Muellbauer, 1980, p 149-158). As detailed below, the representative consumer approach has been widely criticized by economists. Nevertheless, we believe that the general approach can be a pragmatic tool for assessing welfare effects. In particular, we recommend that the SGM be modified to provide a utility theoretic basis by employing multiple representative consumers, one representative consumer for each of several socio-demographic groups. The discussion below focuses primarily on income, but the same logic holds when prices vary over consumers.

The challenge faced in extend the model to multiple representative consumers is to identify data adequate to specify a demand function for separate representative consumers (e.g., a representative low income vs. middle income individual). The Computable General Equilibrium literature has several examples of models based on multiple representative consumers, involving anywhere from small to very large numbers of separate representative consumers (e.g., Piggott and Whalley, 1985; Cockburn, 2001; Cogneau and Robillard, 2000; Harrison, Rutherford, Tarr and Gurgel, 2005).

The panel recommends that the SGM model be revised to reflect this state-of-the-art treatment of a utility theoretic basis of CGE models, with multiple representative consumers. The model should also calculate welfare measures and include these measure in the output.

Discussion

This section provides a discussion of the utility theoretic basis of aggregation across consumers, and expressing aggregate demand as a function of prices and aggregate income. The primary focus of the discussion below is on linear aggregation. We conclude with a brief discussion of nonlinear aggregation.

As indicated above, the representative consumer model has been widely criticized by economists (see for example, Kirman, 1992; Stoker, 1993; Slesnick, 1998). There are only special conditions under which a "representative consumer" exists that can rationalize aggregate, market behavior. That is, microeconomic theory implies that we cannot expect an aggregate demand functions to have the same properties as a disaggregate demand function resulting from utility maximization, except under very special circumstances. As emphasized by Stoker, "[t]aken at face value, representative agent models have the same value as traditional, *ad hoc* macroeconomic equations; namely they provide only statistical descriptions of aggregate behavior patterns, albeit descriptions that are straightjacketed by the capricious enforcement of restrictions of optimizing behavior of a single individual."

Secondly, even when the aggregate demand function behaves as if it were generated by a "representative consumer", preferences of the "representative consumer" need not be representative of the preferences of individual consumers. For example, Kerman shows that you can design cases where all individual consumers in society rank commodity bundle A above bundle B, but the "representative consumer" ranks commodity bundle B above bundle A. So even when a representative consumer exists, the preferences of the "representative consumer" need not be consistent with the preferences of the individual consumers.

More specifically, it is widely known one cannot recover "average" preferences (or welfare measures such as compensating or equivalent variation) from an aggregate demand function, except under very specialized conditions, termed exact linear aggregation. The most general form of disaggregate demand that allows for exact linear aggregation is the Gorman form (e.g., Deaton and Muelbauer, 1980; Varian, 1992), which has demand functions of the form:

$$x_i(\mathbf{p},m_i) = a_i(\mathbf{p}) + b(\mathbf{p})\, m_i$$

where $x_i()$ is demand for consumer i, $\mathbf{p}$ is a vector of market prices, $a_i(.)$ is a function of prices that can vary over consumers, b(.) is a coefficient that is a function of prices but is

the same for all consumers, and m_i is income for consumer i.[1] With a single representative consumer, the Gorman form implies linear Engle curves, with a slope that is constant across all consumers, so that a marginal dollar of income is allocated across goods in an identical manner, independent of the recipient of the income. In particular, rich people and poor people spend a marginal dollar in the same proportion across commodities. This violates basic intuition, and also severely limits the ability of the model to calculate the distributional implications of policies. For example, the Gorman form implies that there are no luxury goods or necessities.

In order to overcome this strong assumption, we recommend adoption of an approach with multiple representative consumers, separated by income group, so that we have demand for each product category by a representative consumer within each income group. This implies that overall aggregate demand would be comprised of several sub-aggregates, one for each income class. The advantage of having separate representative consumers for each income group is that the income slope, b(P), can vary across income groups. So an individual within the low income group would spend a larger fraction of a marginal change in income on necessities, and an individual within the highest income group would spend a larger fraction of a marginal change in income on luxuries. In effect, the Engle curves become piecewise linear, where the slope varies across income groups.

This would greatly strengthen the ability of the model to calculate the distributional implications of policies across income groups. Note that strictly speaking a model based on multiple representative consumers has problems similar those for a single representative consumer. Yet such a model may still be useful as a pragmatic tool to measure welfare effects, and in particular to examine distribution implications of policies across income groups.

With multiple representative consumers, the Gorman form becomes:

$$x_i^j(\mathbf{p}, m_i^j) = a_i^j(\mathbf{p}) + b^j(\mathbf{p}) m_i^j$$

where j represents income group. Aggregate demand within each income group is:

$$\mathrm{X}^j(\mathbf{p}, \mathrm{M}) = \mathrm{A}^j(\mathbf{p}) + \mathrm{b}^j(\mathbf{p})\, \mathrm{M}^j$$

where the caps indicate the sum over all consumers in income category j, and representative (average) demand for category j becomes:

[1] Note that the Gorman form implies a "representative consumer" with an indirect utility function of the form $u_i(\mathbf{p},m) = v_i(\mathbf{p})+w(\mathbf{p})m$ and an expenditure function of the form $e_i(\mathbf{p},u) = c_i(\mathbf{p})+ d(\mathbf{p})u$, which are highly restrictive. For example, the Gorman form allows marginal utility of income to depend upon prices, but not on income, and is equal for *all* consumers. The generality of the functional forms for the representative consumer needs to be restricted further if one accounts for the fact that all consumers do not face a single, common price for each commodity.

$$x^{j}(\mathbf{p}, m^{j}) = a^{j}(\mathbf{p}) + b^{j}(\mathbf{p})\, m^{j}$$

where x^j is average demand in income class j, $a^j(\mathbf{p})$ is the average of the a_i^j's for income class j and m^j is average income within income class j. There are many special cases of the Gorman form that have been applied to demand systems, including the Stone-Geary form (e.g., Deaton and Muelbauer, 1980).

Other empirical specifications for representative consumers are based on nonlinear aggregation, where representative income is not average (or aggregate) income, but might also include higher order moments of the income distribution. These approaches, sometimes termed "Generalized Linearity" (GL), are generally based on estimating budget share equations, rather than demand functions. Nonlinear aggregation includes specifications such as Price Independent Generalized Linearity (PIGL), the logarithmic form of PIGL (PIGLOG), the Almost Ideal Demand System (AIDS), etc. (see, for example, Deaton and Muellbauer, 1980).

GL represents an improvement over linear aggregation in that generalized linearity allows for nonlinear Engle curves, and it allows one to consider the impacts on consumption of changes in the distribution of income. However, to my knowledge it is not straightforward to recover welfare measures, such as aggregate compensating or equivalent variation from the budget share equations of the "representative" consumer resulting from nonlinear aggregation. Hence, while nonlinear aggregation is a definite improvement over linear aggregation for estimating aggregate consumption (in the form budget share equations), it is not useful for providing welfare measures.

In sum, nonlinear aggregation is a preferred approach for specifying aggregate consumption in a form that is consistent with utility theory. In this case, the representative consumer can have nonlinear Engle curves, and hence consumption patterns can depend upon the entire distribution of income, not just average (or aggregate) income. However, to our knowledge it is not straightforward to construct aggregate welfare measures, since the resultant budget share equations are not those for the "average" (or aggregate) consumer.

Linear aggregation has the advantage that the welfare measure for the representative consumer can be used to calculate aggregate compensating or equivalent variation. However, linear aggregation places very strong constraints on the utility functions, and in particular, the assumptions underlying exact linear aggregation preclude one from identifying distributional effects of policies across socio-demographic groups (e.g., income groups). This is presumably an important motivating factor for extending the SGM to include a utility theoretic basis for consumption.

Using exact linear aggregation, but specifying multiple representative consumers, one for each of various socio-demographic groups, allows one to calculate aggregate welfare measures, as well as welfare measures disaggregated across groups, so that distributional effects can be identified. While linear aggregation with multiple representative

consumers faces the same qualitative conceptual difficulties, it may be a useful pragmatic tool for welfare measurement. For these reasons we recommend adoption of a utility theoretic model with multiple representative consumers.

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Stoker, Thomas M., 1993. "Empirical Approaches to the Problem of Aggregation over Individuals" *Journal of Economic Literature* Vol. 31 No.4, pp 1827-1874..
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Part III, Item E
Submitted by Pizer, Opaluch, Shortle on 12-2-05

Add the following line:

Employ a nested CES production structure more in line with existing CGE models and parameterized based on empirical data. Specifically, we believe the model should

include a value-added/energy subnest with materials, with further energy and capital-labor sub-sub-nests (similar to virtually all the referenced models)

Part III, Item F
Submitted by Paltsev and Rose on 12-5-05

Add the following paragraph:

The SGM documentation should provide references to CO2 and other GHG databases used in the model. It also should provide aggregate numbers for all GHG gases for the baseyear for all 13 SGM regions."

Part III, Item G Submitted by Shortle and Burtraw on 12-2-05
Agriculture/Forestry

Agricultural and forest sectors are essential components of the SGM as important sources and sinks of CO2. Agriculture is also a significant source of non-CO2 GHGs. Agricultural and forest sectors of both developed and developing nations are subject to extensive policy interventions that influence the amount of land crops, pasture, and forests, the types of commodities produced, and production practices that affect carbon fluxes and non-CO2 GHG emissions. An example receiving much attention is the Conservation Reserve Program (CRP) in the U.S. The CRP pays farmers to take crop land of production. The lands are left unplowed and planted to cover crop. GHGs from the use of farm machinery are eliminated, carbon releases that occur with tillage are eliminated, and carbon is sequestered in soils is increased. In addition to affecting carbon fluxes and non-CO2 emissions, agricultural and forest policies influence the marginal costs of sequestration in agricultural and forest lands, and thus the potential participation of and gains from agriculture and forest in carbon trading or other carbon policies.

The SGM model is without agricultural and forest policies. More importantly, the highly simplistic specification of the agriculture/forest sector in the model does not facilitate the effects of agricultural and forest policies, or policies directly addressing GHSs, on key variables influencing carbon fluxes in these sectors or non-carbon GHSs. The overall utility of the model for GHG policy analysis is correspondingly limited.

Recommendations elsewhere in this report call for revisions of the production structure of the model to use nested CES production functions. The revisions of the production structure would offer an opportunity as well for revisiting the specification of the combined agriculture and forestry sector to increase the capacity of the model to reflect the influences of agricultural and forest policies and GHGs and the marginal costs of sequestration in agricultural and forests. Dissaggregation of the combined agriculture

and forest sector into separate sectors, and possible further dissagregation of the agricultural and forest sectors into subtypes useful for policy analysis (e.g., crops, livestock) would increase the capacity of the model. Further, because of the importance of land and land policies to both sectors, and the importance of land cover to GHGs, inclusion of land as an input in the production of these products would increase the utility of the model for agricultural and forest policy analysis.

Received from Dahl on 12-6-05

Comments on ETE and other comments on The Second Generation Model: Model Description and Theory

This theory documentation is now much clearer. ETE has not been separated out as a separate sector until the end and the equations have been made more generic. This has made it much easier to follow. A numeraire has been used to deflate price and income to ensure homogeneity on page 5 but ETE has not been specifically mentioned. A numeraire is mentioned again on page 32 in the trade module but not assigned to a sector. It is mentioned again on page 35 and assigned to ETE sector. I think I would not assign it to a sector here either and leave all the discussion of what sector is the numeraire to the input documentation. The assignment of a number of emissions to ETE on page 38 is a little unclear. I found the generic discussion of the model easier to follow. You might leave the specific assignment of the pollutants in Table 10.1 to the input section with a bit more discussion of the assignments to ETE there For CO_2 emissions could you have one generic equation but note what the xrefoil, xdgas, are for coal oil and gas in a footnote.

Other comments and edits.

Page 4. The definition of sets was very helpful, could you add a definition of elements in the sets. A6 lists of indexes was also quite helpful. It might be helpful to include the indexes of the sets here as well.

The right square bracket did not print out correctly for me in equations 4,5,6, in footnote 19, 30, in footnote 36, 44, 63, 64,66, 74, 79, 83, 84

Page 10 you might want to call $\pi_{j,yr}$ expect $\pi_{j,yr}$

Page 13, footnote 19, could you move definition of fac_{NJ} into the footnote so reader does not have to go hunt it up.

Footnote 20, what happened with zero profit condition? I take it things penetrated too quickly from earlier discussion. Could a cost of adjustment be added instead with zero profits/

Top of 13, when an investment decision is made is the same interest rate assumed to hold for all future periods

Eq. 20. I don't understand the intuition in this equation.

Page 18 "found simply" to "found by simply"

Page 21- can the introduction of new technology only be done in subsectors?

Page 22 You lost me on the discussion of of αnew αold etc. in footnote 36. How do they relate to the $\alpha_{i,j,t}$ in eq. 43.

Could you add a reference on how to get eq. 55-57.

Page 28 "can found" to "can be found"

Page 40 footnote 46, I'd add because emissions are measured per dollar.

Page 40 "form dollars" to "from dollars.