UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

MEMORANDUM

SUBJECT: Transmittal of Charge to the Science Advisory Board Advisory Panel on Economy-Wide Modeling of the Benefits and Costs of Environmental Regulation

FROM: Al McGartland /*signed*/
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TO: Holly Stallworth
Designated Federal Office, Science Advisory Board Staff Office

DATE: February 26, 2015

Attached is EPA's charge to the Science Advisory Board (SAB) Advisory Panel on Economy-Wide Modeling of the Benefits and Costs of Environmental Regulation. We look forward to the Panel's meetings and discussions of the charge and are eager to receive feedback.

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

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Draft Final Charge on the Role of Economy-Wide Modeling in U.S. EPA Analysis of Air Regulations

In accordance with Executive Orders 12866 and 13563, EPA evaluates the benefits, costs, and economic impacts of major air regulations to inform the policy process and the public of their potential economic effects. While cognizant of limited resources and data, EPA strives to rely on the best available science when estimating these economic effects using both benefit-cost analysis and economic impact analysis.

Air regulations considered by EPA vary widely with respect to the types of pollution addressed, sectoral and geographic scope, regulatory design, stringency, types of benefits and costs, and other dimensions. EPA considers these characteristics when gauging which analytic tools can be applied in a practical and analytically defensible way to estimate costs, benefits, and economic impacts within a particular regulatory context. For nearly all benefit-cost analyses conducted by EPA in support of air regulations, costs are estimated using detailed engineering or partial equilibrium sector models which are compared to benefits - also estimated using partial equilibrium models. EPA has evaluated, and will continue to evaluate, the appropriate role for economy-wide modeling in informing the regulatory process.

Peer reviewers of economy-wide models (e.g., ADAGE and IGEM) noted that, on balance, these models provide useful information to EPA when evaluating climate policies. The Advisory Council on Clean Air Compliance Analysis review of the Second Prospective Study of the Clean Air Act Amendments stated that inclusion of benefits in the economy-wide model specifically adapted for use in that study "represent[ed] a significant step forward in benefit-cost analysis" but recommended that EPA be clear about which effects are, and are not, included in the CGE model. EPA recognizes that serious technical challenges remain when attempting to evaluate the benefits and costs of a specific air regulation using economy-wide models.[1]

Policy makers and the public also have a keen interest in the distribution of costs and benefits across households and sectors (i.e., economic impacts) through mechanisms such as energy prices or labor markets. Some external entities have conducted analyses employing economy-wide models to evaluate the distribution of costs of regulation. The accuracy and defensibility of such analyses is also dependent on the quality of the assumptions and data used to represent regulations in the model, and on inherent strengths and weaknesses of the model employed. Whether economy-wide modeling can provide more complete and better information than partial equilibrium and engineering models alone on the benefits, costs and other economic impacts (e.g., productivity, labor market outcomes) needs to be examined.

We ask the Panel to examine the technical merits and challenges, and potential value added of economy-wide modeling to evaluate social costs, benefits, and/or economic impacts of air regulations as a supplement to partial equilibrium or engineering approaches; advise the Agency of the results of this examination so that future EPA decisions on the use of economy-wide models are more fully informed;

[1] EPA Advisory Council on Clean Air Compliance Analysis (2010). *Review of the Final Integrated Report for the Second Section 812 Prospective Study of the Benefits and Costs of the Clean Air Act*, EPA-COUNCIL-11-001.

and identify potential paths forward for improvements in economy-wide models that could address existing limitations and increase their potential utility as analytic tools to support regulatory decisions.

Technical merits and challenges in the use of economy-wide models to evaluate the social costs of an air regulation

When examining the value of a proposed government policy, the social costs can be compared with the social benefits in a benefit-cost analysis, or compared with the social costs of alternative policies that achieve similar goals in a cost effectiveness analysis. Computable general equilibrium (CGE) models provide one potential tool for estimation of the social costs of a policy.

1. EPA has extensive experience using a wide range of economic models to evaluate air regulations. These models are generally tailored to the scope and timeframe of the regulations, ranging from static partial equilibrium models that estimate costs in a single product market in a single year, to dynamic CGE models that estimate costs for multiple markets over time. Given this context, what are the advantages and drawbacks of a CGE approach (versus an engineering or partial equilibrium approach) for estimating social costs, including the differences in social costs between alternative regulatory options?

2. Model choice and the appropriateness of using an economy-wide approach to evaluate the economic effects of policy are dependent on many factors. For example, a CGE model may be more appropriate for use in the analysis of a regulation that is implemented over several years and that constitutes a large-scale intervention in the economy, requiring relatively large compliance expenditures that impact multiple sectors, either directly or indirectly. How does each factor listed below affect the technical merits of using an economy-wide model for estimating social costs? Please consider the relative importance of these factors separately.

    - Relative magnitude of the abatement costs of the rule.
    - Time horizon for implementation of the rule.
    - Number and types of sector(s) directly and/or indirectly affected by the regulation, and the magnitude of these potential market effects.
    - Level of detail needed to accurately represent the costs of the rule (e.g., Is it credible to assume more aggregate model parameters used in CGE are valid for a subset of the industry? When is it important to include a detailed representation of a particular sector, such as the power sector? When is it important to include transition costs?).
    - Appropriate degree of foresight (e.g., When is it appropriate to use a recursive dynamic model or an intertemporally optimizing model? If only one type is available, to what degree can alternative foresight assumptions be approximated?).
    - How a model is closed, particularly how international trade is represented (e.g. When is a detailed representation of the rest of the world important for estimates of social costs?).
    - Considerations relevant to the availability and cost of an economy-wide model versus alternative modeling approaches (i.e., to inform analytic choices that weigh the value of information obtained against analytic expenditures when resources are constrained).
    - Ability to incorporate and appropriately characterize uncertainty in key parameters and inputs (e.g., engineering costs).

3. Are other factors beyond those listed above relevant to consider when assessing whether and how to model the social costs of a regulatory action in an economy-wide framework?

4. Most EPA regulations do not operate through price; instead they are typically emission-rate and/or technology-based standards. What are the particular challenges to representing regulations that are not directly implemented through price in an economy-wide framework? Under what circumstances is it particularly challenging to accurately represent such regulations in these models relative to representing them in other modeling frameworks?

5. EPA has previously used CGE models to estimate the social costs of regulation by calculating equivalent variation (EV) but has also reported changes in other aggregate measures such as GDP and household consumption. Setting aside benefits for the moment, what are the appropriate metrics to measure social costs? What are the advantages or drawbacks of using an EV measure vs. GDP or household consumption to approximate a change in welfare?

6. EPA recognizes that, in some circumstances, the use of multiple models may be advantageous when characterizing the costs of regulation. For instance, an engineering or partial equilibrium model can provide needed sector detail while a CGE model accounts for pre-existing market distortions and how compliance costs in one sector affect other sectors of the economy. In some cases, modelers strive to integrate these two modeling frameworks by establishing hard linkages (i.e., compliance costs are endogenous to the model) or soft linkages (i.e., compliance costs are exogenously specified though the models may be iteratively linked). What conceptual and technical merits and challenges are important to consider when incorporating and potentially linking of detailed sector cost models or bottom-up engineering estimates of abatement costs with a CGE model?

7. When EPA has estimated the economic effects of regulations on multiple markets it has relied primarily on CGE models, such as the EPA-developed EMPAX and the Jorgenson-developed IGEM models. Are there other economy-wide modeling approaches beside CGE that EPA should consider for estimating the social costs of air regulations (e.g., input-output models, econometric macro models, dynamic stochastic general equilibrium models)? What are the potential strengths and weaknesses of these alternative approaches in the environmental regulatory context compared to using a CGE approach?

Technical merits and challenges of using economy-wide models to consider the benefits of an air regulation

Analyses of the economy-wide effects of environmental regulations have largely been limited to an assessment of market-based activities, while ignoring that the demand for environmental quality also may respond to relative price changes. The Second Prospective Analysis of the Clean Air Act Amendments (also known as the Section 812 study) modeled the macroeconomic impacts of air quality-related health improvements by focusing on three specific effects: (1) the change in household time endowment from pollution-related mortality impacts, (2) the change in household time endowment from pollution-related morbidity, and (3) the change in medical expenditures associated with pollution-related morbidity.[2] This is an incomplete list of potential benefits. Some also have posited that there are potential health consequences of regulation, outside of those directly associated with pollution, that are not adequately captured (e.g., due to changes in an individual's employment status, or energy and food price increases that crowd out other consumption for lower income households). EPA seeks guidance regarding the incorporation of these potential benefits estimates into economy-wide modeling frameworks.

1. Setting aside costs for the moment, what are the main conceptual and technical hurdles to representing the benefits of an air regulation in a general equilibrium framework (e.g. data requirements, developing detailed subsections of the model such as more realistic labor markets, scale and scope)? What would be required to overcome them?

2. Benefits estimates for air regulations are often predicated on individuals' willingness to pay for risk reductions, while economy-wide models yield information on changes in overall welfare (e.g. changes in equivalent variation or household consumption), usually limited to market-based impacts. How do we reconcile these two measures? What type of information does each of these measures convey?

3. What are the conceptual and technical challenges to constructing the relationship between public health and economic activity? How can we best capture and communicate the uncertainty surrounding this relationship?

4. For the Section 812 study, EPA modeled mortality and morbidity impacts (e.g., benefits from reduced premature mortality due to reduced PM2.5 exposure) in a CGE framework as a change in the household time endowment. Is it technically feasible and appropriate, and does the empirical literature credibly support, the modeling of mortality and morbidity impacts as a change in the time endowment? If not, what key pieces of information are needed to be able to incorporate mortality and morbidity impacts into a CGE model? Are there other approaches to incorporating these impacts that warrant consideration?

[2] U.S. EPA (2011). *The Benefits and Costs of the Clean Air Act from 1990 to 2020*. http://www.epa.gov/air/sect812/feb11/fullreport_rev_a.pdf.

5. Approximately 95 percent of monetized benefits of air regulations arise from willingness to pay for reductions in the risk of premature mortality, which is not equivalent to the value of the change in the household time endowment. Is there sufficient empirical research to credibly support incorporating other representations of mortality and morbidity impacts or additional benefit or dis-benefit categories? Is there an empirical literature to support the incorporation of potential health consequences of regulation, outside of those directly associated with pollution? What approaches could be used to incorporate these additional effects? What are the conceptual and technical challenges to incorporating them? Under what circumstances would the expected effects be too small to noticeably affect the quantitative results?

6. The public health economics literature examines how shifts in employment result in changes in health status and crime rates. Can these changes form employment shifts be incorporated into a CGE model, and if so, how? If these positive and negative impacts from employment shifts cannot be incorporated into the CGE model, can they be reflected in the economic impact assessment, and if so, how?

7. When individuals experience changes in medical expenditures, this changes the budget available to the consumer for other goods and services. However, the consumer could also experience changes in their relative preferences for these goods and services (e.g., outdoor activities) as a result of a positive or negative change in their health and/or life expectancy. Is this a change that could be captured in a CGE model? Under what circumstances would the expected effect be too small to be of importance to the quantitative results? If this effect cannot be modeled, how can the approach to incorporating the change in medical expenditures, as employed in the Section 812 study, be improved upon?

8. Some potential benefits, such as productivity gains of the workforce due to cleaner air, are not typically quantified in either a CGE or partial equilibrium framework. Is there a sufficient body of credible empirical research to support development of a technique for incorporating productivity gains and other benefits or dis-benefits that have not been typically quantified into a CGE framework? If so, are there particular approaches that EPA should consider?

9. Impacts on non-market resources are not typically incorporated into CGE frameworks, though research has indicated that these impacts could be important in this context. Is there a sufficient body of empirical research to support the development of techniques for incorporating these impacts into existing CGE models that may be available to EPA? What are the particular challenges to incorporating non-use benefits into a general equilibrium framework (e.g. non-separability)?

10. Relative to other approaches for modeling benefits, what insights does a CGE model provide when benefits or dis-benefits of air regulations cannot be completely modeled? How should the results be interpreted when only some types of benefits can be represented in a CGE modeling framework?

11. For some benefit endpoints, EPA takes into account the spatial distribution of environmental impacts when quantifying their effects on human populations. In these cases, is it important to capture the spatial component of health or other types of benefits in an economy-wide framework? What would be the main advantages or pitfalls of this approach compared to partial equilibrium benefit estimation methods used by EPA?

Technical merits and challenges in the use economy-wide models to inform economic impacts analysis for an air regulation

EPA has available to it a range of methods and tools already in use to evaluate the way in which positive and negative economic impacts associated with an air regulation are distributed (e.g., across sectors, households, and time) in accordance with a variety of Executive Orders (i.e., 12866, 13563, and others). Because CGE models capture interactions between economic sectors they may prove useful for identifying impacts outside of the directly regulated sector.

1. CGE models often assume forward-looking rational agents and instantaneous adjustment of markets to a new, long run equilibrium (for instance, most assume full employment). A 2010 peer review of the ADAGE and IGEM models indicated that this is "probably a reasonable assumption as these models should be viewed as modeling scenarios out forty or more years for which economic fluctuations should be viewed as deviations around a full-employment trend." In this context and relative to other tools EPA has at its disposal (e.g., partial equilibrium approaches), to what extent are CGE models technically appropriate for shedding light on the economic impacts of an air regulation, aside from its welfare or efficiency implications? In particular, please consider the following types of economic impacts:

    - Short and long run implications of energy prices for households and firms.
    - Sectoral impacts (including price and quantity changes, plant openings and closures).
    - Impacts on income distribution.
    - Transition costs in capital or labor markets (e.g. representation of rigidities in the labor and capital markets).
    - Equilibrium impacts on labor productivity, supply or demand (e.g. labor market outcomes).

2. Concerns are sometimes raised that in response to a change in U.S. environmental policy some domestic production may shift to countries that do not yet have comparable policies, negatively affecting the international competitiveness of energy-intensive trade-exposed industries and cause "emissions leakage" that compromises the environmental effectiveness of domestic policy. Could a CGE model shed light on the international competitiveness effects of air regulations? If so, what types of CGE models are needed to evaluate its effects? Does accounting for international competitiveness or emission leakage effects in a CGE model necessitate compromises in other modeling dimensions that may be important when evaluating the economic effects of air regulations? Are there other promising general equilibrium models or methods to assess international competitiveness effects of regulations?

3. Organizations outside the federal government have also used CGE models to assess the economic impact of recent EPA regulations. What criteria should be used to evaluate the scientific defensibility of CGE models to evaluate economic impacts? What additional insights can economy-wide modeling provide of the overall impacts associated with a regulation, and in particular labor market impacts, compared to a partial equilibrium analysis? What are the advantages and challenges or drawbacks

of using a CGE or other economy-wide modeling approach compared to a more detailed partial equilibrium approach to evaluate these types of economic impacts?

4. What types of labor impacts (e.g., wage rate, labor force participation, total labor income, job equivalents) can be credibly identified and assessed by a CGE model in the presence of full employment assumptions? How should these effects be interpreted?

5. Are there ways to credibly loosen the full employment assumption to evaluate policy actions during recessions? Are there ways to credibly relax the instantaneous adjustment assumptions in a CGE model (e.g., add friction, add underutilization of resources) in order to examine transition costs in capital or labor markets such that it provides valuable information compared to partial equilibrium analysis or other modeling approaches?

6. Are there other economy-wide modeling approaches that EPA could consider in conjunction with CGE models to evaluate the short run implications of an air regulation (e.g., macro-economic, disequilibrium, input/output models)? What are the advantages or disadvantages of these approaches?

Considerations for generating directly comparable estimates of social costs, benefits, and economic impacts using economy-wide modeling

The benefit-cost framework as employed in EPA analyses compares the health and welfare benefits of a regulation with the social costs of compliance measures necessary to meet the standard. In light of the detailed discussions you have had – pursuant to the preceding charge questions – on representing social costs, benefits, and economic impacts in an economy-wide framework, please answer the following:

1. Compared to other modeling approaches at EPA's disposal, what are the technical merits and challenges of using economy-wide models to evaluate the social costs, benefits, and/or economic impacts of relevant air regulations? What is the potential value added, relative to partial equilibrium approaches, of using economy-wide models in a regulatory setting? What criteria could be used to choose between different economy-wide models/frameworks? What features are particularly desirable from a technical or scientific standpoint?

    - Are there potential interactions between the cost and benefit sides of the ledger (e.g. because of channels through which benefits operate) that make it difficult to make defensible comparisons between costs and benefits whensocial costs are estimated using a CGE framework but some or all of the benefits are estimated using a partial equilibrium framework.

2. When benefits are included in a CGE model, it is possible that welfare measures for the economy as a whole are positive even when there is a temporary negative impact on GDP (for instance, in the Section 812 study).[3] Relying on net measures can obscure the costs and benefits of the policy that are typically reported separately in a regulatory analysis as well as how costs and benefits are distributed throughout the economy (benefits and costs are often distributed differently). What are the potential drawbacks of using economy-wide models to present the welfare implications of compliance costs when there is not a corresponding capability to incorporate benefits?

    - Given the many assumptions and uncertainties inherent in modeling the impacts of a regulation in a CGE or other type of economy-wide framework, are absolute measures of welfare, social costs, and benefits more scientifically defensible or should the focus be on relative comparisons across proposed regulatory alternatives? (Should we have greater confidence in the estimated welfare change between baseline and policy scenario or in the relative difference in welfare across policy scenarios?)
    - What are the technical merits and limitations to presenting both general equilibrium and partial equilibrium measures when assessing the net benefits of a regulation?

[3] In the Section 812 study, GDP was lower in the initial years of the analysis, but by the end of the reference period both GDP and welfare were higher with the Clean Air Act amendments than without them. See Exhibits 13 and 14 at http://www.epa.gov/oar/sect812/feb11/graphicsstack.pdf.

3. EPA guidance states, "To promote the transparency with which decisions are made, EPA prefers using nonproprietary models when available. However, the Agency acknowledges there will be times when the use of proprietary models provides the most reliable and best-accepted characterization of a system. When a proprietary model is used, its use should be accompanied by comprehensive, publicly available documentation."[4] If the SAB advises that the use of economy-wide models may be technically appropriate in certain circumstances, are there particularly useful ways in which results from a CGE model could be presented to the public and policy makers? What information would be most useful to include when describing a CGE-based analysis of an air regulation to make it transparent to an outside reader in a way that allows for active engagement of the public in the rulemaking process (e.g., regarding model scenarios, criteria used to inform model choice, nature of any linkages between economy-wide models and other modeling frameworks, parameter choices)?

4. The National Academy of Sciences (2013) identifies three type of uncertainty: statistical variability and heterogeneity (or exogenous uncertainty); model and parameter uncertainty, and deep uncertainty.[5] Are certain types of uncertainty more of a concern when evaluating social costs, benefits, or economic impacts in an economy-wide framework?[6] Are challenges or limitations related to these uncertainties more of a concern than for partial equilibrium approaches to estimation?

    - How can these types of uncertainty be addressed in an economy-wide modeling framework? Are there best practices to ensure that can EPA be reasonably confident that it is producing credible welfare or economic impact estimates (e.g., model validation exercises)?
    - Are sensitivity analyses of important model parameters and/or model assumptions a technically appropriate way to assess uncertainties involved in this type of economic modeling? Are there circumstances in which the use of multiple models should be considered?
    - Are CGE models precise enough to accurately represent the general equilibrium welfare effects of a regulation that has relatively small engineering costs or monetized benefits? What about for evaluating economic impacts? If yes, under what circumstances?

[4] "This documentation should describe: The conceptual model and the theoretical basis …for the model; the techniques and procedures used to verify that the proprietary model is free from numerical problems or "bugs" and that it truly represents the conceptual model …; the process used to evaluate the model… and the basis for concluding that the model and its analytical results are of a quality sufficient to serve as the basis for a decision… to the extent practicable." See http://www.epa.gov/crem/cremlib.html for more information.

[5] National Research Council (2013). *Environmental Decisions in the Face of Uncertainty.* Washington, DC: The National Academies Press. Available at http://www.nap.edu/catalog.php?record_id=12568.

[6] For instance, several commenters noted that as air pollution is reduced to lower and lower levels, uncertainty regarding incremental mortality benefitsincreases.

- How can the overall degree of uncertainty be characterized when reporting results from economy-wide models? [7]

5. Bearing in mind current and future resource limitations, what should EPA prioritize as its longer term research goals with respect to improving the capabilities of economy-wide models to evaluate social costs, benefits, and/or economic impacts?

[7] Noting that cost estimation is also subject to great uncertainty, the National Academy of Sciences recommended in 2002 that EPA apply the same standards to assessing uncertainties in benefits. It recommended that EPA do more to identify uncertainties that have the greatest influence in estimates of public health benefits, as well as integrate these uncertainties into the primary analyses of benefits. Available at http://www.nap.edu/download.php?record_id=10511#.