ES. EXECUTIVE SUMMARY: SCENARIOS OF GREENHOUSE GAS EMISSIONS AND ATMOSPHERIC CONCENTRATIONS: CCSP PRODUCT 2.1 A

ES.1. Background

The *Strategic Plan for the U.S. Climate Change Science Program* (CCSP 2003) noted that “sound, comprehensive emissions scenarios are essential for comparative analysis of how climate might change in the future, as well as for analyses of mitigation and adaptation options.” The *Plan* included Product 2.1, which consists of two parts: *Scenarios of Greenhouse Gas Emissions and Atmospheric Concentrations* and *Review of Integrated Scenario Development and Application*. This report presents the results from the scenario development component; the review of scenario methods is the subject of a separate report. Guidelines for producing these scenarios were set forth in a Prospectus, which specified that the new scenarios focus on alternative levels of atmospheric stabilization of the radiative forcing from the combined effects of a suite of the main anthropogenic greenhouse gases (GHGs). The Prospectus also set forth criteria for the analytical facilities to be used in the analysis, and the results from three models that meet these conditions are reported here.

Scenarios such as those developed here serve as one of many inputs to public and private discussions regarding the threat of climate change, and the goal of this report is to contribute to the ongoing and iterative process of improvement. The intended audience includes analysts, decision-makers, and members of the public who may be concerned with the energy system and economic effects of policies leading to stabilization of human influence on the atmosphere. For example, these scenarios may provide a point of departure for further studies of mitigation and adaptation options, or enhance the capability for studies by the U.S. Climate Change Technology Program (CCTP) of alternative patterns of technology development.

Each of the three participating analytical models was used to develop a “no stabilization policy” or reference scenario to serve as baseline for comparing the cases with emissions control, and then each was applied to an exploration of paths that led to alternative levels of radiative forcing. Results of these calculations were selected to provide insight into questions, such as the following:

- *Emissions trajectories*. What emissions trajectories over time are consistent with meeting the four alternative stabilization levels? What are the key factors that shape the emissions trajectories that lead toward stabilization?

- *Energy systems*. What energy system characteristics are consistent with each of the four alternative stabilization levels? How might these characteristics differ among stabilization levels?

- *Economic implications*. What are the possible economic implications of meeting the four alternative stabilization levels?

Although each of the models simulates the world as a set of interconnected nations and multi-nation regions, the results in this report focus primarily on the U.S. and world totals.

With the exception of the stabilization targets themselves and a common hypothesis about international burden-sharing, there was no direct coordination among the modeling groups either in the assumptions underlying the no-policy reference or the precise path to stabilization. Although the scenarios were not designed to span the full range of possible futures and no explicit uncertainty analysis was called for, the variation in results among the three models nevertheless give an impression of the unavoidable uncertainty that attends projections many decades into the future.

ES.2. Models Used in the Scenario Exercise

The Prospectus set out the criteria for participating models: they must (1) be global in scale, (2) be capable of producing global emissions totals for designated GHGs, (3) represent multiple regions, (4) be capable of simulating the radiative forcing from these GHGs and substances, (5) have technological resolution capable of distinguishing among major sources of primary energy (e.g., renewable energy, nuclear energy, biomass, oil, coal, and natural gas) as well as between fossil fuel technologies with and without carbon capture and storage systems, (6) be economics-based and capable of simulating macroeconomic cost implications of stabilization, and (7) look forward to the end of the twenty-first century or beyond. In addition, modeling teams were required to have a track record of publications in professional, refereed journals, specifically in the use of their models for the analysis of long-term GHG emission scenarios.

Application of these criteria led to the selection of three models:

- the Integrated Global Systems Model (IGSM) of the Massachusetts Institute of Technology's Joint Program on the Science and Policy of Global Change
- the MiniCAM Model of the Joint Global Change Research Institute, which is a partnership between the Pacific Northwest National Laboratory and the University of Maryland
- the Model for Evaluating the Regional and Global Effects (MERGE) of GHG reduction policies developed jointly at Stanford University and the Electric Power Research Institute.

Each of these models has been used extensively for climate change analysis. The roots of each extend back more than a decade, during which time features and details have been added. Results of each have appeared widely in peer-reviewed publications.

ES.3. Approach

As directed by the Prospectus, a total of 15 separate scenarios were developed, 5 from each of the three modeling teams. First, reference scenarios were developed on the assumption that no climate policy would be implemented beyond the set of policies currently in place (e.g., the Kyoto Protocol and the U.S. carbon intensity target, each terminating in 2012 because targets beyond that date have not been identified). Reference scenarios were developed independently, with the Prospectus requiring only that each modeling team apply assumptions that they believed were "meaningful" and "plausible." Thus, each of the three reference scenarios provided a different view of how the future might unfold without additional climate policies.

Each team then produced four stabilization scenarios by constraining the models to achieve the radiative forcing targets. Stabilization was defined in terms of the total long-term radiative impact of a suite of GHGs including carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).[1] The four stabilization scenarios were developed so that the increased radiative forcing from these gases was constrained at no more than 3.4 W/m^2 for Level 1, 4.7 W/m^2 for Level 2, 5.8 W/m^2 for Level 3, and 6.7 W/m^2 for Level 4. These levels were defined as increases above the preindustrial level, so they include the roughly 2.2 W/m^2 increase that had already occurred as of the year 2000. To facilitate comparison with previous work focused primarily on CO_2 stabilization, these levels were chosen so that the associated CO_2 concentrations, accounting for radiative forcing from the non-CO_2 GHGs, would be roughly 450 ppmv, 550 ppmv, 650 ppmv, and 750 ppmv. Assessment of the consequences for climate and ecosystems of these levels of human influence on the Earth's radiation balance lay beyond the mandate of this scenario study.

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[1] These are the gases enumerated in the Kyoto Protocol and in the U.S. goal to reduce the intensity of GHG emissions relative to GDP. Other substances with radiative impact, such carbon monoxide (CO), ozone (O_3), and aerosols were not included in the scenario design.

A scenario exercise such as this continues climate research and analysis that has gone on for over 20 years. Also, this work will necessarily be continued and refined as the field advances, new information becomes available, and decision-makers raise new questions and issues. Similar work is being conducted by modeling teams in Europe and Asia, and scenarios developed here add to this larger body of work.

ES.4. Findings

Findings are summarized first for the “no stabilization policy” or reference scenario, and then for the four stabilization cases.

ES.4.1. Reference Scenarios

The difficulty in achieving any specified level of atmospheric stabilization depends heavily on the emissions that would occur otherwise: i.e., the “no-climate-policy” reference strongly influences the stabilization cases. If a no-policy world has cheap fossil fuels and high economic growth, then dramatic changes to the energy sector and other parts of the economy may be required to stabilize the atmosphere. On the other hand, if the reference case shows lower growth and emissions, and perhaps increased exploitation of non-fossil sources even in the absence of climate policy, then the effort will not be as great.

Energy production, transformation, and consumption are central features in all of these scenarios, although non-CO_2 gases and changes in land use also make a significant contribution to net emissions. Demand for energy over the coming century will be driven by economic growth but will also be strongly influenced by the way that energy systems respond to depletion of resources, changes in prices, and technology advance. The projected demand for energy in developed countries remains strong in all scenarios but is even stronger in developing countries, where millions of people seek greater access to commercial energy. These developments determine the emissions of GHGs, their disposition, and the resulting change in radiative forcing under reference conditions.

The three reference scenarios show the implications of this increasing demand and the improved access to energy, with the ranges reflecting the variation in results from the different models:

- *Global primary energy production rises substantially in all three reference scenarios, from about 400 EJ/y in 2000 to between 1300 and 1550 EJ/y in 2100. U.S. primary energy production also grows substantially, about 1½ to 2½ times present levels by 2100. This growth occurs despite continued improvements in the efficiency of energy use and production. For example, the U.S. energy intensity declines 50 to 70% between 2000 and 2100.*

- *All three reference scenarios include a gradual reduction in the dependence on conventional oil resources. However, in all three reference scenarios, a range of alternative fossil-based resources, such as synthetic fuels from coal and* *unconventional oil resources (e.g., tar sands, oil shales) are available and become economically viable. Fossil fuels provided almost 90% of global energy supply in the year 2000, and they remain the dominant energy source in the three reference scenarios throughout the twenty-first century, supplying between 60 and 80% of total primary energy in 2100.*

- *Non-fossil fuel energy use grows over the century in all three reference scenarios. The range of contributions in 2100 is from 250 EJ to 600 EJ—between roughly half to a level equivalent to total global energy consumption today. Even with this growth, however, these sources never supplant fossil fuels although they provide an increasing share of the total, particularly in the second half of the century.*

- *Consistent with the characteristics of primary energy, global and U.S. electricity production shows continued reliance on coal although this contribution varies among the reference scenarios. The contribution of renewables and nuclear energy varies considerably in the different reference cases, depending on resource availability, technology, and non-climate policy considerations. For example, global nuclear generation in the reference scenarios ranges from an increase over current levels of around 50%, if political considerations constrain its growth, to an expansion by more than an order of magnitude, assuming economically driven growth.*

- *Oil and natural gas prices are projected to rise through the century relative to year 2000 levels, whereas coal and electricity prices remain relatively stable. The models used in the exercise were not designed to project short-term fuel price spikes, such as those that occurred in the 1970s and early 1980s, and more recently in 2005. Thus, the projected price trends should be interpreted as long-term average price trends.*

- *As a combined result of all these influences, emissions of* CO_2 *from fossil fuel combustion and industrial processes increase from approximately 7 GtC/y in 2000 to between 22 and 24 GtC/y in 2100; that is, anywhere from three to three and one-half times current levels.*

The non-CO_2 greenhouse gases—CH_4, N_2O SF_6, PFCs, and HFCs—are emitted from various sources including agriculture, waste management, biomass burning, fossil fuel production and consumption, and a number of industrial activities:

- *Projected future global anthropogenic emissions of* CH_4 *and* N_2O *vary widely among the reference scenarios, ranging from flat or declining emissions to an increase of 2 to 2½ times present levels. These differences reflect alternative views of technological opportunities and different assumptions about whether current emissions rates will be reduced significantly for other reasons, such as air pollution control and/or higher natural gas prices that would further stimulate the capture of* CH_4 *emissions for its fuel value.*

Projected increases in emissions from the global energy system and other human activities lead to higher atmospheric concentrations and radiative forcing. This increase is moderated by natural biogeochemical removal processes:

- *The ocean is a major sink for* CO_2 *that generally increases as concentrations rise early in the century. However, processes in the ocean can slow this rate of increase at high concentrations late in the century. The scenarios have ocean uptake in the range of 2-3 GtC/y in 2000, rising to about 5-8 GtC/y by 2100.*

- *Two of the three models include a sub-model of the exchange of* CO_2 *with the terrestrial biosphere, including the net uptake by plants and soils and the emissions from deforestation, which is modeled as a small annual net sink (less than 1 Gt of carbon) in 2000, increasing to an annual net sink of 2 to 3 GtC/y by the end of the century. The third model assumes a zero net exchange. In part, modeled changes reflect human activity (including a decline in deforestation), and, in part, it is the result of increased uptake by vegetation largely due to the positive effect of* CO_2 *on plant growth. The range of estimates is an indication of the substantial uncertainty about this carbon fertilization effect and land-use change and their evolution under a changing climate.*

- *GHG concentrations rise substantially over the century in the reference scenarios. By 2100,* CO_2 *concentrations range from about 700 to 900 ppmv, up from 370 ppm in 2000. Projected* CH_4 *concentrations range from 2000 to 4000 ppbv, up from 1750 ppb in 2000; projected* N_2O *concentrations range from about 375 to 500 ppbv, up from 317 ppbv in 2000.*

- *The resultant increase in radiative forcing ranges from 6.5 to 8.5* W/m^2 *relative to preindustrial levels (zero by definition) and compares to approximately 2* W/m^2 *in the year 2000, with non-*CO_2 *GHGs accounting for about 20 to 30% of this at the end of the century.*

ES.4.2. Stabilization Scenarios

Important assumptions underlying the stabilization cases involve the flexibility that exists in a policy design, and as represented in the model simulation, to seek out least cost abatement options regardless of where they occur, what substances are abated, or when they occur. It is a set of conditions referred to as “where”, “what”, and “when” flexibility. Equal marginal costs of abatement among regions, across time (taking into account discount rates and the lifetimes of substances), and among substances (taking into account their relative warming potential and different lifetimes) will under special circumstances lead to least cost abatement. Each model applied an economic instrument that priced GHGs in a manner consistent with their interpretation of “where,” “what” and “when” flexibility. The economic results thus assume a policy designed with the intent of achieving the required reductions in GHG emissions in a “least-cost” way. Key implications of these assumptions are that: (1) all nations proceed together in restricting

GHG emissions from 2012 and continue together throughout the century, and that the same marginal cost is applied across sectors, (2) the marginal cost of abatement rises over time reflecting different interpretations and approaches among the modeling teams of "when" flexibility, and (3) the radiative forcing targets were achieved by combining control of all greenhouse gases – with differences, again, in how modeling teams compared them and assessed the implications of "what" flexibility.

Although these assumptions are convenient for analytical purposes, to gain an impression of the implications of stabilization, they are idealized versions of possible outcomes. For these results to be a realistic estimate of costs would require, among other things, the assumption that a negotiated international agreement include these features. Failure in that regard would have a substantial effect on the difficulty of achieving any of the targets studied. For example, a delay of many years in the participation of some large countries would require a much greater effort by the others, and policies that impose differential burdens on different sectors can result in a many-fold increase in the cost of any environmental gain. Therefore, it is important to view these result as scenarios under specified conditions, not as forecasts of the most likely outcome within the national and international political system. Further, none of the scenarios considered the extent to which variation from these "least cost" rules, might be improved on given interactions with existing taxes, technology spillovers, or other non-market externalities.

If the developments projected in these reference scenarios were to occur, concerted efforts to reduce GHG emissions would be required to meet the stabilization targets analyzed here. Such limits would shape technology deployment throughout the century and have important economic consequences. The stabilization scenarios demonstrate that there is no single technology pathway consistent with a given level of radiative forcing; furthermore, there are other possible pathways than are modeled in this exercise. Nevertheless, some general conclusions are possible.

- *Stabilization efforts are made more challenging by the fact that in two of the modeling teams' formulations, both terrestrial and ocean* CO_2 *uptake decline as the stringency of emissions mitigation increases.*

- *Stabilization of radiative forcing at the levels examined in this study will require a substantially different energy system globally, and in the U.S., than what emerges in the reference scenarios in the absence of climate change considerations. The degree and timing of change in the global energy system depends on the level at which radiative forcing is stabilized.*

- *Across the stabilization scenarios, the energy system relies more heavily on non-fossil energy sources, such as nuclear, solar, wind, biomass, and other renewable energy forms. Importantly, end-use energy consumption is lower. Carbon dioxide capture and storage is widely deployed because each model assumes that the technology can be successfully developed and that concerns about storing large amounts of carbon do not impede its deployment. Removal of this assumption would make the stabilization levels much more difficult to achieve* *and, if not restrained for reasons of safety and proliferation concerns, a much greater demand for nuclear power.*

- *Significant fossil fuel use continues across the stabilization scenarios, both because stabilization allows for some level of carbon emissions in 2100 depending on the stabilization level and because of the presence in all the stabilization scenarios of carbon dioxide capture and storage technology.*

- *Emissions of non-*CO_2 *GHGs, such as* CH_4, N_2O, *HFCs, PFCs, and* SF_6, *are all substantially reduced in the stabilization scenarios.*

- *Increased use is made of biomass energy crops whose contribution is ultimately limited by competition with agriculture and forestry. One model examined the importance of valuing terrestrial carbon similarly to the way fossil fuel carbon is valued in stabilization scenarios. It found that in stabilization scenarios important interactions between large-scale deployment of commercial bioenergy crops and land use occurred to the detriment of unmanaged ecosystems when no economic value was placed terrestrial carbon.*

- *The lower the radiative forcing limit, the larger the scale of change in the global energy system, relative to the reference scenario, required over the coming century and the sooner those changes would need to occur.*

- *Across the stabilization scenarios, the scale of the emissions reductions required relative to the reference scenario increases over time. The bulk of emissions reductions take place in the second half of the century in all the stabilization scenarios. But near-term emissions reductions occurred in all models in all stabilization scenarios.*

- *The 2100 time horizon of the study limited examination of the ultimate requirements of stabilization. However, it is the case that atmospheric stabilization at any of the levels studied requires human emissions of* CO_2 *in the very long run to be essentially halted altogether because, as the ocean and terrestrial biosphere approach equilibrium with the target concentration level, their rate of uptake falls toward zero. Only capture and storage of* CO_2 *could allow continued burning of fossil fuels. Higher radiative forcing limits can delay this requirement beyond the year 2100 horizon, but further reductions after 2100 would be required in any of the cases studied here.*

Fuel sources and electricity generation technologies change substantially, both globally and in the U.S., under stabilization scenarios compared to the reference scenarios. There are a variety of technological options in the electricity sector that reduce carbon emissions in these scenarios:

- *Nuclear, renewable energy forms, and carbon dioxide capture and storage all play important roles in stabilization scenarios. The contribution of each can* *vary, depending on assumptions about technological improvements, the ability to overcome obstacles such as intermittency, and the policy environment surrounding them, for example, the acceptability of nuclear power.*

- *By the end of the century, electricity produced by conventional fossil technology, where CO_2 from the combustion process is emitted freely, is reduced from the reference scenarios in the stabilization scenarios. The level of production from these sources varies substantially with the stabilization level; in the lowest stabilization level, production from these sources is reduced toward zero.*

The economic effects of stabilization could be substantial although much of this cost is borne later in the century if the mitigation paths assumed in these scenarios are followed. As noted earlier, each of the modeling teams assumed that a global policy was implemented beginning after 2012, with universal participation by the world's nations, and that the time path of reductions approximated a "cost-effective" solution. These assumptions of "where" and "when" flexibility lower the economic consequences of stabilization relative to what they might be with other implementation approaches:

- *Across the stabilization scenarios, the carbon price follows a pattern that, in most cases, gradually rises over time, providing an opportunity for the energy system to change gradually. Two of the models show prices $10 or below per ton of carbon at the outset for the less stringent cases, with their prices rising to $100 per ton in 2020 for the 450 ppmv case. IGSM shows higher initial carbon prices in 2020, ranging from around $20 for 750 ppmv to over $250 for the 450 ppmv target.*

- *While the general shape of the carbon value trajectory is similar across the models, the specific carbon prices required vary substantially for reasons that reflect the underlying uncertainty about the effort that would be required. Differences among the reference cases has the main effect to mid-century while differences among models in assumptions about the cost and performance of future technologies have the greatest effect in subsequent decades. Other differences modeling approach also contribute to the inter-model variation.*

- *Non-CO_2 gases play an important role in shaping the degree of change in the energy system. Scenarios that assume relatively better performance of non-CO_2 emissions mitigating technologies require less stringent changes in the energy system to meet the same radiative forcing goal.*

- *These differences in carbon prices and other model features lead to a wide range of the cost of the various stabilization targets. For example, for the 450-ppmv scenario estimates of the reduction in Gross World Product (aggregating country figures using market exchange rates) in mid-century from around 1% in two of the models to approximately 5% in the third, and in 2100 from less than 2% in two of the models to over 16% in the third. This difference among models is a product of the variation in model structure and reference case assumptions noted* *earlier. At mid-century the difference in projected cost is mainly attributable to variation in the reference scenario, whereas late in the century the model estimates depart primarily because of differences in assumptions about technology change. As noted earlier, the overall cost levels are strongly influenced by the burden-sharing conditions that all models imposed, the assumption of "where" flexibility, and an efficient pattern of increasing stringency over time. Any variation in assumptions regarding these conditions would lead to higher cost. Also, the use of exchange rates based on purchasing power parity could lead to different global results. Thus, these scenarios should not be interpreted as applying beyond the particular conditions assumed.*

- *Such carbon constraints would also affect fuel prices. Generally, the producer price for fossil fuels falls as demand for them is depressed by the stabilization measures. Users of fossil fuels pay for the fuel plus a carbon price if the* CO_2 *emissions were freely released to the atmosphere, so consumer costs of energy rise with more stringent stabilization targets.*

Achieving stabilization of atmospheric GHGs poses a substantial technological and policy challenge for the world. It would require important transformations of the global energy system. Assessments of the cost and feasibility of such a goal depends importantly on judgments about how technology will evolve to overcome existing limits and barriers to adoption and on the efficiency and effectiveness of the policy instruments for achieving stabilization. These scenarios provide a means to gain insights into the challenge of stabilization and the implications of technology.

ES.5. The Scenarios as a Basis for Further Analysis

The review process for this scenario product is the start of a dialogue among scenario-developers and the user community. That dialogue has already suggested the need for better-quantified estimates of uncertainty and further sensitivities to help understand differences among the models and the affects of different factors on outcomes. Each of these requests stems from a particular interest of a user and each is very reasonable, but it is not possible to provide insights into all these questions with a limited number of scenarios.

These scenarios can be used as the basis of further analysis. For example, they could be applied as the basis for assessing the climate implications of alternative stabilization levels. Such studies might begin with radiative forcing levels from the scenarios, with the individual gas concentrations or with the emissions, augmenting the results provided here with assumptions about the reflecting and absorbing aerosols.. Applications of this type could be made directly in climate models that do not incorporate a three-dimensional atmosphere and detailed biosphere model. For the more complete models some approximation would need to be imposed to allocate the short-lived gases by latitude or grid cell.

The scenarios could also provide a basis for partial equilibrium analysis of technology penetration with the prices of fossil fuels under the various scenarios used to study the target cost performance of new technologies. Differences in results among the three models provide a range of conditions for assessing the range of conditions in which a new technology would have to compete, or the subsidy needed to gain early introduction. Such studies might include the non-climate environmental implications of implementing potential new energy sources at a large scale.

Finally, these scenarios can serve as an input to a more complete analysis of the welfare effects of the different stabilization targets. For example, the results contain information that can be used to calculate indicators of consumer impact in the U.S.

ES.6. Moving Forward

This effort is but one step in a long process of research and assessment, and the scenarios and their underlying models will benefit from further work. Here we summarize some of the limitations of the effort to date and avenues they suggest for future research and model development.

ES.6.1. Technology Sensitivity Analysis

Much useful work could be done in sensitivity analysis of various technology assumptions – a task beyond the scope of this scenario study. For example, what are the implications of various levels of political constraint on the expansion of nuclear power, or of carbon capture and storage? What would be the effect of different cost assumptions for nuclear, wind, and biomass energy?

ES.6.2. Consideration of Less Optimistic Policy Regimes

Much can be learned by assessment of scenarios that explore alternative versions of domestic and international policy regimes. The cost to the U.S. and to other countries depends critically on how the economic burden of emissions reduction is shared. If, in contrast to the assumptions in this study, some large nations delay for several decades before participating in an international regime then the overall burden of stabilization could be radically increased. And even with universal participation there are a wide range of solutions as to who pays for the reductions.

Equally important, studies are needed of scenarios with institutional assumptions other than the highly stylized ones studied here, where international flexibility yields equal marginal costs across nations, applied in a cost-efficient pattern over time. Some sectors are inevitably exempted, others enter through a cumbersome crediting system, and the policy mix inevitably includes a substantial number of regulatory measures. Considering that costs are so dependent on the allocation of burden among regions and the details of domestic measures, the simple policy architecture assumed here can lead to cost estimates that, taken on face value, are likely to be misleading.

ES.6.3. Expansion/Improvement of the Land Use Components of the Models

Given their relative importance, forest and agricultural sinks and sources need more attention. Additional research and model development is needed to provide a better integration of potential biomass programs, economic models of human land use, and models of the biogeochemistry of terrestrial ecosystems. Also, even more than for energy the idea of a broad cap-and-trade system applied to agriculture and forest sinks is problematic. Instead, incentives for agriculture and forest sinks have been proposed through crediting systems or more traditional agriculture and forestry programs, and analysis methods need to be improved to better represent these complexities.

ES.6.4. Inclusion of other Radiatively-Important Substances

In this study, the focus has been on the relatively long-lived GHGs. Tropospheric ozone and aerosols also have strong climatic effects and future efforts need to be expanded to include them.

ES.6.5. Decision-Making under Uncertainty

Formulation of a response to the climate threat is ultimately a problem of decision-making under uncertainty – suggesting the need for assessment of the risks and how alternative policies might reduce the odds of bad outcomes. The Prospectus for this effort focused on scenarios with only one reference case, with its underlying parameters, to be developed by each modeling group. The variation in results across these models provides the barest glimpse of the uncertainty in human-climate system or of the effects of alternative policies. Studies of these phenomena require analysis of the uncertainty in (preferably several different) individual models. It is a big task, far beyond the scope of this study, but nonetheless is an important future step in work of type carried out here.