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Economic Growth and Greenhouse Gas Mitigation in California

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EXECUTIVE SUMMARY

The California economy has an enviable record of technological progress, and the challenge presented by climate change is a new opportunity for the state to demonstrate its talent for combining advances in public policy and private sector innovation to enhance environmental quality and economic growth.

This research note offers preliminary results on the link between greenhouse gas (GHG) abatement strategies and economic growth from on-going research with a forecasting model of the California economy. The Berkeley Energy and Resources (BEAR) Model is a detailed empirical simulation tool that can evaluate the complex linkages between climate policy and economic activity. In the analysis presented here, eight targeted GHG emission policies are combined with an overall cap to meet the state's targets for 2020. No specific implementation of the cap is assumed; these results can be interpreted as the result of an efficient combination of policies. Examining alternative scenarios for state climate policy over the next fifteen years, a few salient conclusions emerge:

1. California's GHG targets are attainable, but too ambitious to be met by voluntary initiative. Policy action to meet the targets should be relatively inclusive, with mandatory participation by all sectors representing a significant share of emissions.

2. An Emissions Cap, supported by regulatory and market-based implementation programs, can return California's GHG emissions to 1990 levels by 2020 and stimulate the state economy.

3. Climate policies that create direct incentives for industries to invest in new technologies can provide additional stimulus for new employment and growth.

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Table ES-1: Macroeconomic Impacts of 8 CAT policies plus a 2020 GHG Cap*
*****(1990 GHG Emissions Levels by 2020)

Annual Impact	8 CAT policies + Cap	8 CAT policies + Cap w/Innovation Incentives
Gross State Product (2006 dollars) *% change from 2020 baseline*	**+$60 Billion** *(+2.4%)*	**+$74 Billion** *(+3.1%)*
Employment (thousands) *% change from 2020 baseline*	**+17** *(+.08%)*	**+89** *(+0.44%)*

The findings reported here indicate that California can establish global leadership in growth-oriented climate policy and energy innovation. Well-designed and implemented strategies can bring forth the state's enormous innovation potential and apply it to one of the most compelling challenges of our era.

Notes on the policy scenarios and results:

The policy scenarios included here are designed to represent important elements of California's climate action policies that are under development, including AB32 ("The California Global Warming Solutions Act") as well as several Climate Action Team (CAT) measures. One of the key findings of this report is that regulatory and market-based strategies are complementary; each excels at achieving different forms of mitigation. We show how all significant stationary source emitters could contribute to meeting the state's reduction goals, either through inclusion in a cap, an offset mechanism, or through regulatory programs.

The analysis presented here is an update to a study released in January that concluded achieving half the 2020 targets would promote economic growth in California (Roland-Holst, 2006). This study extends the earlier work to meet all of the 2020 targets, and confirms the earlier conclusion about economic benefits.

The positive economic results are derived from two primary sources: savings from improvements in energy efficiency and reduced energy bills that offset the cost of achieving emission reductions and, in related policy scenarios, the benefits of investing in technologies for innovation. California has a long history of leadership in both of these areas, and continuing along these lines will yield positive economic and environmental benefits for the state.

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While our results are encouraging, they may be overly conservative for several reasons. First, we do not consider spontaneous technological innovation in this version of the BEAR model, and only a few GHG mitigation technologies are represented explicitly, although these features will be added to later versions of the model. Second, only 8 of 34 Climate Action Team policies are modeled here, and several with significant mitigation potential are not considered. Including these would reduce the estimated mitigation burden and attendant costs for industries covered in this analysis. Third, the results consider only limited potential for technical and fuel substitution (e.g., the substitution of renewable energy sources for fossil fuel power plants). Finally, we do not allow for lower-cost reductions from offsets or links to other carbon regimes to replace reductions from the sources considered here.

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CONTENTS

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1. INTRODUCTION

Climate change will have serious impacts on the state of California and is now widely recognized as an important global challenge. As the largest state economy in the world's largest economy, and as an economy built upon innovation, California is in a special position to lead climate change policy by example and by insight. The state government has already contributed to this effort, and the results reported here join a body of previous research into how climate policies can be formulated to encourage economic growth. In this paper, a state-of-the-art economic model is used to assess potential state policies for managing greenhouse gas (GHG) emissions, meeting the 2020 GHG target while promoting economic growth. These results elucidate detailed linkages between policy and behavior, efficiency and growth. Generally speaking, it is apparent from this analysis that growth and environmental objectives are not only compatible, but can be mutually reinforcing in the right policy environment.

The complexities of today's global economy make it very difficult for intuition or rules-of-thumb to reliably support policy-making, and using inadequate analytical tools or weak comparison cases would be at best sub-optimal and at worst misleading. Market interactions are so pervasive in determining economic outcomes that more sophisticated empirical research tools are needed to improve visibility for both public and private sector decision makers. The preferred tool for detailed empirical analysis of economic policy is now the Calibrated General Equilibrium (CGE) model. It is well suited to GHG research because it can detail structural adjustments within economies and elucidate their interactions in external markets. The CGE research tool used for this assessment, the Berkeley Energy and Resources (BEAR) model, was developed to evaluate the economic impacts of energy and climate polices in California and contains a level of detail and overall structure specifically suited to this task. However, innovation processes are not captured in this version of the BEAR model and only a few GHG mitigation technologies are represented explicitly. Further work is underway to add these features, but their absence here means that the results may be overly conservative, i.e. the costs of mitigation could be lower than estimated here. A general overview of the BEAR model is provided in Section 2 to facilitate

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interpretation of the results that follow. Section 3 presents the policy scenarios evaluated in this report, with results in Section 4 and conclusions in Section 5.

2. OVERVIEW OF THE BEAR MODEL

The Berkeley Energy and Resources (BEAR) model is in reality a constellation of research tools designed to elucidate economy-environment linkages in California. The schematics in Figures 2.1 and 2.2 describe the four generic components of the modeling facility and their interactions. This section provides a brief summary of the formal structure of the BEAR model.[1] For the purposes of this report, the 2003 California Social Accounting Matrix (SAM), was aggregated along certain dimensions. The current version of the model includes 50 sectors aggregated from the original California SAM. The equations of the model are completely documented elsewhere, and for the present we only discuss its salient structural components.

2.1. Structure of the CGE Model

Technically, a CGE model is a system of simultaneous equations that simulate price-directed interactions between firms and households in commodity and factor markets. The role of government, capital markets, and other trading partners are also specified, with varying degrees of detail and passivity, to close the model and account for economywide resource allocation, production, and income determination.

The role of markets is to mediate exchange, usually with a flexible system of prices, the most important endogenous variables in a typical CGE model. As in a real market economy, commodity and factor price changes induce changes in the level and composition of supply and demand, production and income, and the remaining endogenous variables in the system. In CGE models, an equation system is solved for prices that correspond to equilibrium in markets and satisfy the accounting identities

[1] See Roland-Holst (2005) for a complete model description.

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governing economic behavior. If such a system is precisely specified, equilibrium always exists and such a consistent model can be calibrated to a base period data set. The resulting calibrated general equilibrium model is then used to simulate the economywide (and regional) effects of alternative policies or external events.

The distinguishing feature of a general equilibrium model, applied or theoretical, is its closed-form specification of all activities in the economic system under study. This can be contrasted with more traditional partial equilibrium analysis, where linkages to other domestic markets and agents are deliberately excluded from consideration. A large and growing body of evidence suggests that indirect effects (e.g., upstream and downstream production linkages) arising from policy changes are not only substantial, but may in some cases even outweigh direct effects. Only a model that consistently specifies economywide interactions can fully assess the implications of economic policies or business strategies. In a multi-country model like the one used in this study, indirect effects include the trade linkages between countries and regions which themselves can have policy implications.

The model we use for this work has been constructed according to generally accepted specification standards, implemented in the GAMS programming language, and calibrated to the new California SAM estimated for the year 2003.[2] The result is a single economy model calibrated over the fifteen-year time path from 2005 to 2020.[3] Using the very detailed accounts of the California SAM, we include the following in the present model:

[2] See e.g. Meeraus et al (1992) for GAMS Berck et al (2004) for the California SAM.

[3] The present specification is one of the most advanced examples of this empirical method, already applied to over 50 individual countries or combinations thereof (see e.g. Francois and Roland-Holst, 2000; Lee and Roland-Holst, 1995, 2000, 1998ab; Lee et al., 1999).

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Figure 2.1: Component Structure of the Modeling Facility

Development of the California modeling capacity is proceeding in four distinct component areas.

1. core CGE model
2. emissions module
3. energy generation module
4. a separate component for developing extensions.

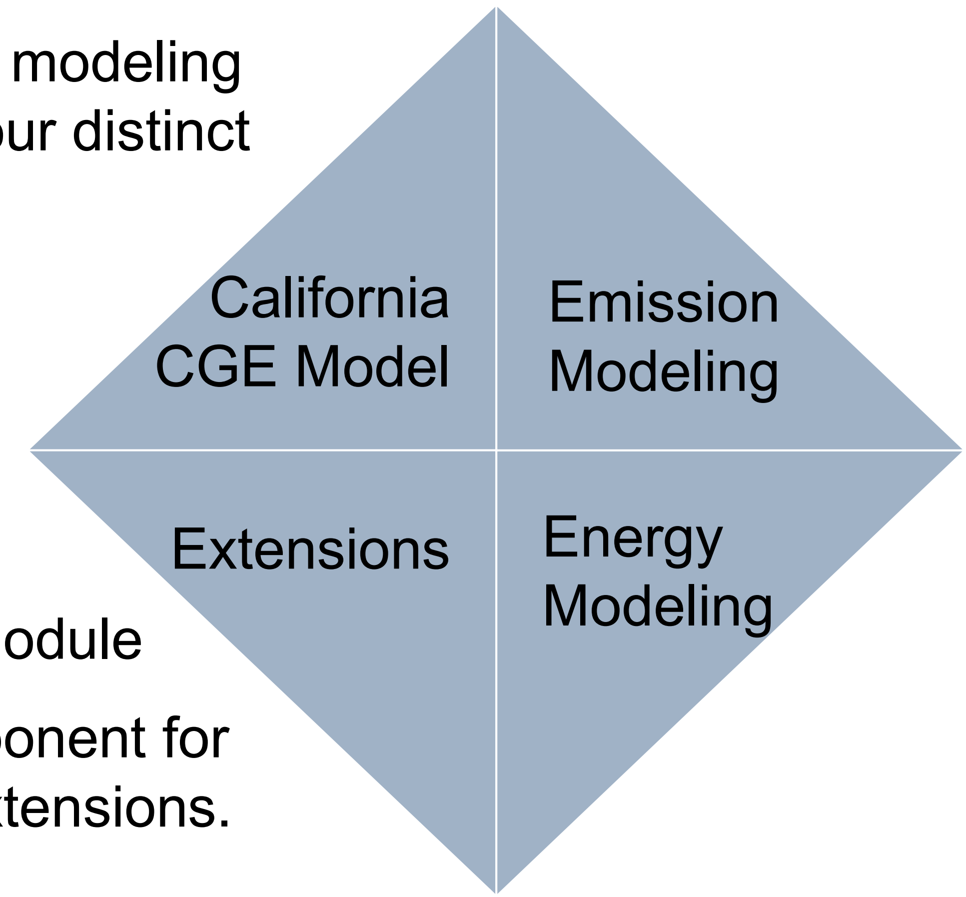

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Figure 2.2: Schematic Linkage between Model Components