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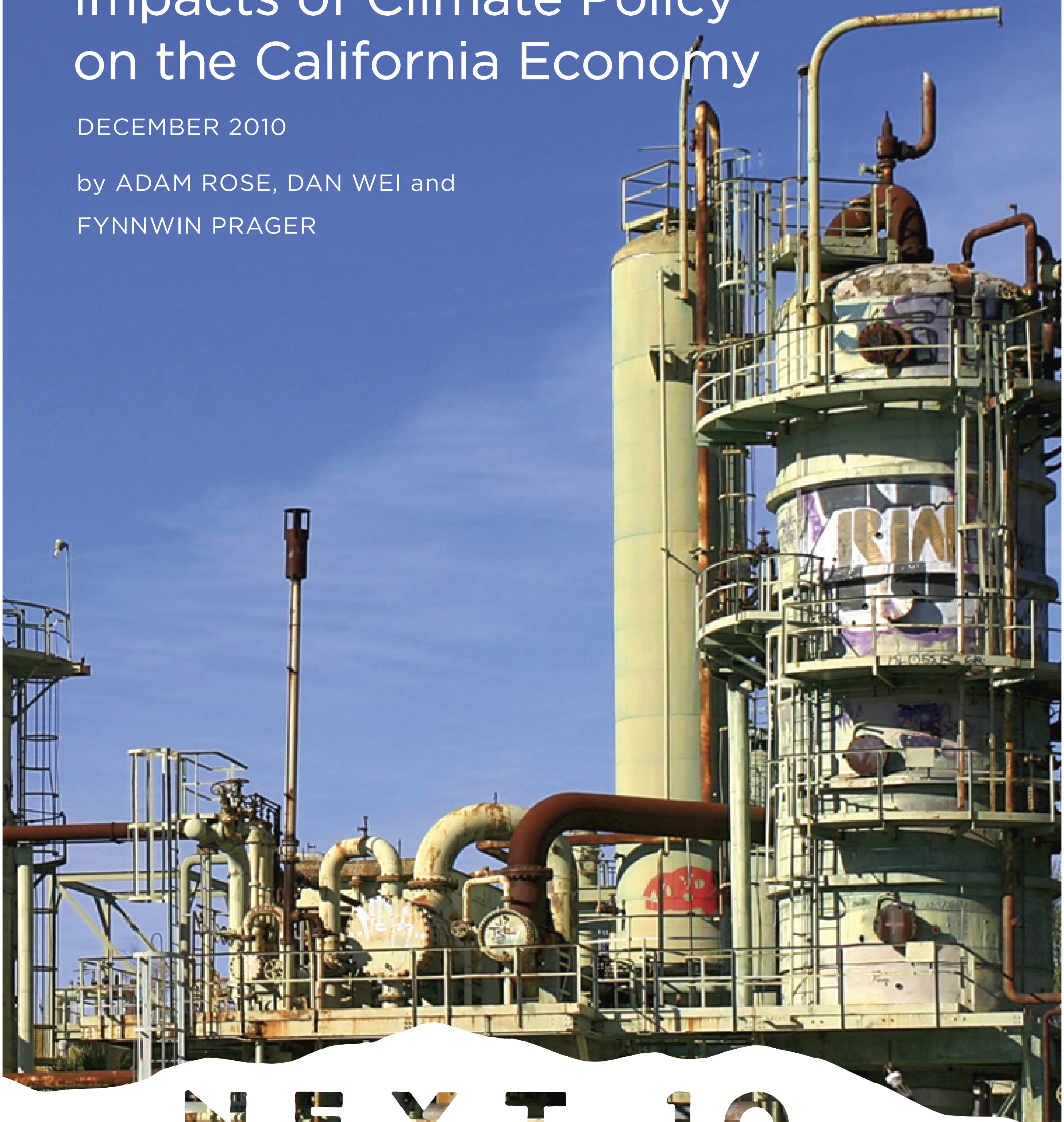
EDUCATING, ENGAGING AND EMPOWERING CALIFORNIANS TO IMPROVE OUR STATE'S FUTURE

Impacts of Climate Policy on the California Economy

DECEMBER 2010

by ADAM ROSE, DAN WEI and

FYNNWIN PRAGER



NEXT 10

AGGREGATE AND DISTRIBUTIONAL IMPACTS OF AB32 ON THE CALIFORNIA ECONOMY: ALTERNATIVE ALLOCATION STRATEGIES FOR CAP AND TRADE

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AGGREGATE AND DISTRIBUTIONAL IMPACTS OF AB32 ON THE CALIFORNIA ECONOMY

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Executive Summary

The purpose of this report is to estimate the economic impacts of the allocation of tradable emission allowances and the recycling of revenues they generate when auctioned under California Assembly Bill 32, The Global Warming Solutions Act of 2006. The analysis covers both the aggregate impacts on the State's economy and the distribution of impacts across sectors and income groups. Hence, we address both efficiency and equity, as well as potential tradeoffs between these objectives.

The Regional Economic Models, Inc., Policy Insight Plus (REMI PI$^+$) Model is used to undertake the analysis in conjunction with a Multi-Sector Income Distribution Matrix (MSIDM) developed by the authors. The REMI Model was chosen for a combination of reasons pertaining to accuracy, cost, and manageability. The MSIDM supplements it with a more detailed income distribution analysis capability.

The study is based on data obtained from California Air Resources Board (CARB) simulations of direct economic impacts of alternative policy designs, or scenarios. We applied a 169-sector CA REMI PI$^+$ Model to estimate various types of indirect, or macroeconomic, impacts. The CA REMI PI$^+$ Model was first recalibrated with California economic data and ENERGY 2020 Model energy and environmental data to be consistent with the application in this report.

We examined three variants of the main policy case--Reference Case 1-- recently analyzed by CARB (2010). This case represents the combination of the proposed Cap and Trade (C&T) program and six "Complementary Policies" specified in the latest CARB Scoping Plan (2009) to promote greenhouse gas (GHG) emission reduction measures unresponsive to price signals. This policy case assumes full implementation of these Complementary Policies and also allows for the purchase of offsets from sectors not covered by the cap.

CARB is considering two major approaches to the allocation of GHG emission allowances: output-based free allocation to capped sectors and auctioning them to the highest bidder. The auction approach raises the interesting issue of what to do with the revenue. Several options exist but the focus of this report is on "recycling" the revenues to California households. The motivations include compensating energy consumers for potentially higher energy prices and more generally favoring transfers to lower income groups to help promote equity. Following the recommendation of the CARB Economic and Allocation Advisory Committee (EAAC, 2010), we examine two distinct recycling approaches where: a) households below 150% of the poverty line are compensated for their increased expenditures on energy by lump sum transfers (equal per capita dividends) and the remainder of the revenue is used for personal income tax relief for all income brackets, and b) all households are given equal per capita dividends In the end, our findings indicate that energy prices on net will decrease and hence the special compensation requirement for low income groups on this basis is not required. Accordingly, we adjusted the scenarios analyzed to those in Table ES-1, simply either a personal income tax reduction or an equal per capita dividend.

Table ES-1. Scenarios Analyzed

S1. CARB Case 1 with 100% Auction of GHG emission allowances in each year a. 100% proportional personal income tax reduction ($7.9 billion in total in 2020) b. 100% per capita dividend ($194/person in 2020) S2. CARB Case 1 with 50% Auction and 50% Free Allocation of allowances in each year a. 100% proportional personal income tax reduction ($3.9 billion in total in 2020) b. 100% per capita dividend ($97/person in 2020) S3. CARB Case 1 with 100% Free Allocation of allowances in each year

Table ES-2 summarizes the projected impacts of policy scenarios on major macroeconomic indicators, such as gross state product (GSP), income, and employment in Year 2020. They stem from a number of factors. First, overall, CARB policies are expected to generate billions of dollars of cost savings through energy efficiency improvements and other measures. These lower the cost of production in businesses and increase the spending power of households, thereby stimulating the economy. At the same time, out-of-pocket expenditures to mitigate GHGs or to purchase allowances will increase businesses' cost of production, and they will attempt to pass on these cost increases in the form of higher prices to their customers. This, in turn increases production costs in other businesses, and continues through successive rounds of ripples of cost-push inflation. Moreover, this decreases the purchasing power of household income, thereby having a dampening effect. Returning the allowance auction revenues back to the households to relieve increased direct or indirect burdens from increased energy costs or from negative macroeconomic impacts would improve the aggregate impacts on the state economy, as well as achieving distributional objectives.

Table ES-2. Aggregate Impacts of AB 32 in Year 2020—CARB Reference Case 1 Combined with Alternative Revenue Recycling Scenarios

Macroeconomic Indicator	Level in 2020					Percentage Change from Baseline in 2020				
	1a	1b	2a	2b	3	1a	1b	2a	2b	3
GSP (billion 2007$)	2,477	2,478	2,480	2,480	2,482	0.3%	0.3%	0.4%	0.4%	0.5%
Labor earnings (billion 2007$)	1,317	1,318	1,318	1,319	1,319	0.5%	0.5%	0.5%	0.5%	0.6%
Employment (thousands)	22,016	22,019	22,030	22,031	22,042	0.5%	0.5%	0.6%	0.6%	0.6%
HH Income (billion 2007$)	1,432	1,432	1,434	1,434	1,436	0.4%	0.4%	0.5%	0.5%	0.7%
Consumption (billion 2007$)	2,242	2,242	2,245	2,245	2,249	0.7%	0.7%	0.8%	0.8%	1.0%
CPI (2000=100)	160	160	160	160	160	0.1%	0.1%	0.1%	0.1%	0.1%

The results indicate that the three policy scenarios examined would have very small positive aggregate impacts on the State's economy by Year 2020. Interestingly, the recycling of auction revenues is crucial at the aggregate level, because without this feature the aggregate impacts would be slightly negative in terms of GSP for Scenarios 1 and 2. When we incorporate the effects of auction revenue recycling in the form of income tax relief or per capita dividends to all households, the stimulus effects more than offset the slightly negative impacts stemming from the polices and measures alone. At the same time, there is little variation in the aggregate impacts across scenarios, with only a $5 billion spread in GSP and a $4 billion spread in Household Income between highest and lowest impact scenarios. For the revenue recycling scenarios this is not surprising given the fact that recycled revenues are relatively small (never exceeding 0.5% of Total Household Income) and vary so little between the alternatives.

The following is a brief summary of the aggregate impacts of each policy scenario analyzed. (The allowance price is $21/tCO2e in each scenario, reflecting the policy assumptions associated with CARB's "Case 1"):

Scenario 1a (100% Auction of Allowances with Proportional Income Tax Reduction): The total government revenues collected from allowance auction are $7.9 billion under the 100% Auction assumption. Recycling these revenues as an equal proportional California personal income tax reduction across all income brackets results in an overall GSP gain of $6.3 billion (or a 0.3% increase from baseline) and an employment increase of 110 thousand jobs in terms of person-year equivalents (or 0.5% above baseline). The Consumer Price Index is projected to increase by 0.1%.

Scenario 1b (100% Auction of Allowances with Equal Per Capita Dividend): The total government revenues collected from allowance auction are again $7.9 billion as in Scenario 1a. Recycling these revenues as lump sum transfer payments on an equal per household basis (7.0 billion or $194 per capita after taxes) results in an overall GSP gain of $7.3 billion (or a 0.3% increase from baseline) and an employment increase of 113 thousand jobs in terms of person-year equivalents (or 0.5% above baseline). The Consumer Price Index is projected to increase by 0.1%.

Scenario 2a (50% Auction and 50% Free Allocation of allowances with Proportional Income Tax Reduction): The results of this scenario are approximately half way between the results for Scenarios 1a and 3, indicating an absence of any significant non-linearities and synergies in the underlying application of the mitigation options and in the model. Since only 50% of the allowances are auctioned, the total government revenues collected are $3.9 billion. Recycling these revenues as an equal proportional California personal income tax reduction across all income brackets results in an overall GSP gain of $9.2 billion (or a 0.4% increase from baseline) and an employment increase of 124 thousand jobs in terms of person-year equivalents (or 0.6% above baseline). The Consumer Price Index is projected to increase by 0.1%..

Scenario 2b (50% Auction and 50% Free Allocation of allowances with Equal Per Capita Dividend): Like Scenario 2a, the total government revenues collected from allowance auction are $3.9 billion under the 50% Auction assumption. Recycling these revenues as equal per capita dividends across all income brackets results in an outcome imperceptibly different from Scenario 2a, because the amount of revenue to be recycled is relatively small and the distributions across income brackets do not differ much from that scenario.

Scenario 3 (100% Free Allocation of allowances to various categories of emitters of GHGs): In this scenario, no government revenues are collected. Instead, emitters receive the allowance value of $7.9 billion. This scenario puts less pressure on the price of fossil energy and other inputs and activities that generate emissions. It results in an overall GSP gain of $11.5 billion (or a 0.5% increase from baseline) and an employment increase of 137 thousand jobs in terms of person-year equivalents (or 0.6% above baseline). The Consumer Price Index is also projected to increase by 0.1%.

Table ES-3 presents the impacts of the policy cases on residential and non-residential electricity prices in Year 2020 under the assumption of 100% auction of allowances. Electricity prices are projected to decrease in all the cases, primarily due to the total generation cost decrease associated with the increased utilization of CHP and to the negative shift in demand stemming from energy efficiency. The production cost increases of the power sector due to the purchase of allowances has a considerable offsetting effect on these influences; however, this is not big enough to reverse the sign of the impact.

Table ES-3. Electricity Price Impacts of California Policy Cases, Year 2020 (100% Auction of Allowances)

Policy Case	Residential (% change)	Non-Residential (% change)
Case 1 Scenario 1b	-3.29%	-4.85%
Case 2 Scenario 1b	-5.56%	-6.86%
Case 5 Scenario 1b	-2.39%	-2.95%

CARB has defined five policy cases for implementing AB32. In our study, we analyzed three of them. Policy Cases 1 and 2 both assume full implementation of the six complementary policies, though Case 1 allows the usage of offsets for compliance, while Case 2 does not. Cases 3 to 5 are sensitivity cases relating to the effectiveness of the complementary policies (all allowing the use of offsets). Case 5 assumes the lowest level of effectiveness of the complementary policies. The three policy cases analyzed in this study are Cases 1, 2, and 5.

The electricity price results are consistent with the ENERGY 2020 data inputs, which project that fuel cost decreases are greater than capital cost and O&M cost increases in the electricity sector. The one apparent anomaly—that prices decrease more under Case 2 than Case 1—can be readily explained. It stems from the fact that the ENERGY 2020 model predicted substantially more electricity generation reductions from fossil fuel generation facilities in Case 2 due to the lack of offsets, and hence a larger overall fuel cost reduction in overall electricity generation cost. The high allowance price of Case 2 greatly increases the production cost of the power sector due to the allowance purchases. However, this effect is not large enough to offset the effect of the reduced fuel cost. Electricity prices are also projected to fall, but only very slightly less for the 50-50 Scenario and Free Allocation Scenario in 2020, respectively, than for the Auction Scenario of Case 1. This is, in part, due to the fact that electricity generators will have less additional costs to pass through to customers in the free allocation case.

The impacts of the five scenarios of Case 1 on the size distribution of personal income are not dramatically different (see Table ES-4). Scenarios 1 and 2 result in a negative impact on the lowest income bracket despite the revenue recycling and despite the fact that the overall income distribution is improved (overall, incomes become less divergent). This is due in part to an increase in the price of goods that have become more expensive, while being a higher proportion of the expenditures of the very poor than of other income groups. The outcome is also due to sectoral shifts, including employment opportunities that have disproportional effects across the socioeconomic spectrum. This means that the equal per capita dividends are inadequate in compensating the lowest income bracket, though the next two income brackets (which are also below 150% of the poverty line threshold) have income gains higher than does the average household.

Table ES-4. Per Household Impacts of AB32-- CARB Reference Case 1 Combined with Alternative Revenue Recycling Scenarios, Year 2020 (2007$)

Income Bracket	Baseline	Level in 2020					Percent Change from Baseline in 2020				
		1a	1b	2a	2b	3	1a	1b	2a	2b	3
<12.5k	6,875	6,852	6,853	6,871	6,871	6,889	-0.33	-0.33	-0.06	-0.06	0.20
12.5-22.5k	19,250	19,378	19,377	19,387	19,387	19,396	0.66	0.66	0.71	0.71	0.76
22.5-30k	28,875	29,042	29,045	29,066	29,067	29,089	0.58	0.59	0.66	0.67	0.74
30-40k	38,500	38,671	38,678	38,706	38,709	38,738	0.45	0.46	0.53	0.54	0.62
40-52.5k	50,875	51,073	51,083	51,116	51,122	51,158	0.39	0.41	0.47	0.48	0.56
52.5-62.5k	60,900	61,111	61,127	61,156	61,164	61,197	0.35	0.37	0.42	0.43	0.49
62.5-80k	78,375	78,556	78,577	78,621	78,631	78,680	0.23	0.26	0.31	0.33	0.39
80-100k	99,000	99,318	99,346	99,387	99,400	99,449	0.32	0.35	0.39	0.40	0.45
100-150k	137,500	138,132	138,168	138,240	138,257	138,340	0.46	0.49	0.54	0.55	0.61
150k+	649,474	651,687	651,830	652,872	652,943	654,044	0.34	0.36	0.52	0.53	0.70
Total	114,058	114,471	114,497	114,625	114,637	114,774	0.36	0.38	0.50	0.51	0.63

For Scenario 3, under conditions of a 100% Free-Allocation of allowances, the outcome for the lowest income brackets is positive, though the impact on the overall income distribution is worse. This is because the outcome is significantly skewed away from the lowest income group and more favorable to the highest income group than any of the scenarios we have simulated.

Note that the recycling of revenues has a limited potential to affect the overall income distribution. For example, the nearly $7 billion in allowance revenues (after tax) translate into about $556 per household or $194 per person in the state in the Equal Per Capital Dividend Scenario. Table ES-5 presents the direct income transfer of the allowance revenues for Scenarios 1a and 1b, and the value of the allowances themselves for Scenario 3 of CARB Policy Case 1. The percentages of the distributed revenues (or values) with respect to pre-policy, per household income are also presented. Still the availability of allowance auction revenues or their free allocation does raise some important equity issues. For example, $556 represents nearly 10 percent of the income of those households in the lowest income bracket. The worst case scenario 1a with respect to the lowest income group yields a loss of income for the entire bracket of $25 million, which translates to a loss of $23 per household in that bracket, despite $556 per household being transferred as a dividend. In contrast the greatest gain of any scenario goes to the highest income bracket under Free Allocation. This $5.1 billion gain translates into more than $4,500 per household in that bracket; at the same time, it represents only slightly less than 1.0 percent of the average household income in this bracket. Other impacts on a per household basis are presented for all the Scenarios of CARB Policy Case 1 in Table ES-6. Results for Scenarios 2a and 2b fall mid-way between those of Scenario 1 and Scenario 3.

Note that the results do indicate an efficiency-equity tradeoff. Scenario 3, Free Allocation, is projected to yield the largest increase in GSP and Personal Income, but it worsens the overall income distribution. Still, it is the only scenario that yields gains to the lowest income groups and reaps reward for the highest income group, more than twice as high as Scenarios 1a and 1b. The gains in aggregate economic activity are fairly minor, amounting to no more than 0.5 percent in GSP for the most effective scenario from an efficiency standpoint. The difference between the highest impact scenario (3) and the lowest (1a) in terms of GSP is only $5.3 billion and 33,000 jobs. Some might consider these to be relatively small gains to give up to achieve the nearly the greatest improvement in the income distribution (Scenario 1a fares

Table ES-5. Distribution of Allowance Revenues and Values, Per Household, Year 2020

Income Bracket	Pre-policy Household Income ($)	Average Pre-Policy Tax per Household ($)	Scenario 1a Tax Relief Transfers		Scenario 1b Per Capita Dividend Transfers		Scenario 3 Allowance Value	
			($)	(%)	($)	(%)	($)	(%)
<12.5k	6,875	34	4	0.05%	556	8.09%	284	4.13%
12.5-22.5k	19,250	58	22	0.11%	556	2.89%	305	1.58%
22.5-30k	28,875	173	19	0.07%	556	1.93%	318	1.10%
30-40k	38,500	385	75	0.20%	556	1.44%	314	0.82%
40-52.5k	50,875	814	200	0.39%	556	1.09%	323	0.63%
52.5-62.5k	60,900	1,218	130	0.21%	556	0.91%	345	0.57%
62.5-80k	78,375	1,881	217	0.28%	556	0.71%	372	0.48%
80-100k	99,000	2,871	434	0.44%	556	0.56%	462	0.47%
100-150k	137,500	5,363	629	0.46%	556	0.40%	657	0.48%
150k+	649,474	48,711	4,910	0.76%	556	0.09%	3,072	0.47%
Total	114,058	5,247	631	0.55%	556	0.49%	631	0.55%

Table ES-6. Per Household Impacts of AB32 – CARB Reference Case 1 Combined with Alternative Revenue Recycling Scenarios, Year 2020 (2007$)

	Change in 2020				
Income Bracket	1a	1b	2a	2b	3
<12.5k	-23	-22	-4	-4	14
12.5-22.5k	128	127	137	137	146
22.5-30k	167	170	191	192	214
30-40k	171	178	206	209	238
40-52.5k	198	208	241	247	283
52.5-62.5k	211	227	256	264	297
62.5-80k	181	202	246	256	305
80-100k	318	346	387	400	449
100-150k	632	668	740	757	840
150k+	2,214	2,357	3,399	3,469	4,571
Total	413	438	566	579	716

almost as well as 1b). At the same time, if the main equity focus is on the lowest income group, then the situation improves in Scenario 3—the lowest bracket fares better than in all other scenarios, while the economy expands the most. However, the equity-efficiency tradeoff still persists and is worst for Scenario 3 because it is estimated to yield the largest spread between the lowest and highest income brackets.

The aggregate results presented here are similar to those in the analysis of climate action plans of Florida, Pennsylvania, and Michigan (see, Rose and Wei, 2009, 2010; Miller et al., 2010). The differences between this analysis and the others is that the latter use input data that are more optimistic regarding energy efficiency, renewable energy, and several other mitigation options are used in the state action plans analysis. The results presented here regarding aggregate impacts are also similar to those estimated by Roland-Holst (2008, 2010a) in previous studies about the impacts of AB32, as well as in his companion study, which is based on very similar data to ours. The results are similar to those recently estimated by CARB (2010), but differ in sign from the recent study by Charles Rivers Associates (CRA, 2010). Allowance revenue recycling effects are not examined in these other studies, except for Roland-Holst (2010b), who found some similar results in some cases.

Our results on the distributional impacts of climate change policy are similar to those found by others as well (see, e.g., Hasset et al., 2007; Burtraw et al., 2008; Goulder et al., 2009), including the companion study by Roland-Holst (2010). They find the Free Allocation approach to be generally more regressive than the auction approach. When considering revenue recycling, these studies also find a more equitable outcome associated with per capita dividends in comparison to personal income tax reduction; we found them to be essentially the same. The difference between the present study and these others is in the variation between policy designs. The major explanation is the strong workings of macroeconomic linkages that cause major changes in the sectoral mix that favor higher income brackets. Another difference between our study and the others is the variation in outcomes is more muted than in the other studies, which were performed at the national or large region level, in part because of the relatively smaller amount of recycled revenues considered here, even after adjusting for the size of the economies modeled.

Summary Points

- Aggregate impacts of AB32 are estimated to be very slightly positive, generally in the range of 0.3 to 0.5% of Gross State Product (GSP) in the Year 2020.

- Employment increases are estimated to be 0.5 to 0.7% in 2020, indicating that AB32 is slightly more labor-intensive than the average operation of the California Economy.

- Consumer prices are estimated to increase by only 0.1%.

- Consumers benefit from improved energy efficiency in their own homes and in businesses providing them with goods and services.

- Auctioning greenhouse gas emission allowances provides opportunities for recycling revenues:

  - Auction revenues are estimated to be at most $7 billion in 2020, and, while this is a very small portion of the California economy, it is a significant portion of state government revenue to be returned to businesses and households.

  - Revenue recycling to households through proportional personal income tax relief or equal per capita dividends improves aggregate economic gains and slightly narrows the disparity in the overall distribution of income.

- Allowances can also be granted for free to GHG emitters:

- Free allocation can result in an almost imperceptible decrease in GSP if the opportunity cost of allowances is passed on to customers and a very small gain in GSP if opportunity costs are not passed on.

- Free Allocation results in a widening of the disparity in the overall income distribution.

- The exit of industries form the state as a result of AB32, “leakage”, is estimated to be minimal.

- Macroeconomic linkages in the California economy are complex and have a strong influence on the impacts of AB32.

- AB32 is a win-win-win policy. It has the potential to improve the State’s economy, reduce income disparities, and reduce greenhouse gas emissions.

I. Introduction and Overview

The California's Global Warming Solutions Act of 2006 (AB 32) was passed in September 2006, establishing a state greenhouse gas (GHG) emissions cap for Year 2020 and other target years. The goal for 2020 is to reduce the state GHG emissions to 1990 levels. AB 32 directed the California Air Resources Board (CARB) to develop a Scoping Plan to identify technically feasible and cost-effective GHG reduction measures. The Plan includes both a number of complementary policy measures and a GHG cap-and-trade program in order to achieve the reduction goal in a cost-effective manner. According to the Plan, the mandatory caps will start from Year 2012 for emission sources under the Narrow Scope: electric power generation, energy-intensive industries, other industry fuel-combustion processes, and electric power imported into California. Starting from Year 2015, the beginning of the second compliance period, a Broad Scope of sectors will be included under the cap. These are passenger and freight transportation and all remaining fossil-fuel combustion sources that are not included in the Narrow Scope.

These GHG mitigation polices will have a major effect at the site of the implementation of individual mitigation and sequestration options. Some of these options can result in cost-savings directly to businesses, for example, that implement them, and they can also provide gains to their customers if the savings are passed on in the form of lower prices. It is also likely that some other options will incur additional costs to businesses, households, non-profit institutions, and government operations, thereby affecting their competitiveness or purchasing power. In these cases, many entities will try to recoup these cost increases by raising their prices.

Complicating the situation are various types of indirect effects stemming from economic interdependence. Increases in demand ripple through the economy generating a set of successive rounds of positive multiplier effects on suppliers. Cost savings are passed along to several rounds of customers to add further to the stimulus. Decreases in demand will have their own ripple effects on different sets of suppliers and customers in an analogous negative way. The interactive sum of all of these price and quantity effects for the entire economy of the state are referred to as macroeconomic effects.

The purpose of this report is to estimate the economy-wide and distributional impacts on California of AB32. In this study, we used the Regional Economic Models, Inc. (REMI) Policy Insight Plus (PI^+) Model (REMI, 2010), the most widely used state-level economic modeling software package in the U.S. A California version of the REMI Model was applied to the estimation of the macroeconomic impacts of a Cap and Trade (C&T) program and "Complementary Policies" on output, income, employment, and prices in the state for year 2020.

Our results indicate that the net macroeconomic impacts of AB 32 Policy Cases examined on the California economy will be slightly positive in the Year 2020. While many mitigation activities incur costs, as when there is a need to purchase new equipment, these activities are more than offset by lower production costs and consumer spending of energy savings, by the stimulus to businesses in the state that produce the necessary equipment, and by the stimulus effects of auction revenues recycling.

Income distribution impacts are examined in relation to revenue recycling variants of the California Air Resources Board (CARB) main policy case and are relatively mixed in the Year 2020. For example, a scenario involving Equal Lump Sum Transfers (Per Capita Dividends) of allowance revenues from a 100% auction results in a negative impact on the lowest income bracket despite the revenue recycling and despite the fact that the overall income distribution is improved (overall, incomes become less divergent). This means that the per capita dividends are inadequate in compensating the lowest income bracket. A scenario involving 100% Free Allocation of allowances puts less pressure on the price of fossil energy and other inputs and activities that generate emissions. Although there is no revenue to recycle there are significant distributional implications of providing a free asset to various groups within the state. In this case, the income of the lowest bracket increases, but to a lesser absolute and proportional extent than for the other brackets. Moreover, the overall income distribution becomes more divergent, not surprisingly because of the larger than average gains to and larger weight in the income distribution of the upper two brackets.

This report is divided into 6 sections. Section II summarizes the REMI PI^+ Model we use to estimate the macroeconomic impacts, as well as an overview of the ENERGY 2020 data and how they are further refined and linked to key structural and policy variables in the REMI Model. Section III presents a summary of the Multi-Sector Income Distribution Matrix methodology. Section IV presents and interprets the aggregate and sectoral simulation results. Section V presents and interprets the impacts on the size distribution of personal income. Section VI provides a summary.

II. REMI Model Analysis

Several modeling approaches can be used to estimate the total regional economic impacts of environmental policies, including both direct (on-site) effects and various types of indirect (off-site) effects. These include: input-output (I-O), computable generated equilibrium (CGE), mathematical programming (MP), and macroeconometric (ME) models. Each has its own strengths and weaknesses (see, e.g., Rose and Miernyk, 1989; Partridge and Rickman, 1998).

The choice of which model to use depends on the purpose of the analysis and various considerations that can be considered as performance criteria, such as accuracy, transparency, manageability, and costs. After careful consideration of these criteria, we chose to use the Regional Economic Models, Inc. (REMI) Policy Insight Plus (PI^+) Model. The REMI PI^+ Model is superior to the others reviewed in terms of its forecasting ability and is comparable to CGE models in terms of analytical power and accuracy. With careful explanation of the model, its application, and its results, it can be made as transparent as any of the others.[1] Moreover, the research team has used the model successfully in similar analyses in the states of Florida, Pennsylvania, Michigan and New Mexico (Rose and Wei, 2009; Rose and Wei, 2010a; Miller et al., 2010; Rose et al., 2010).

A. Model Description

The REMI Model has evolved over the course of 30 years of refinement (see, e.g., Treyz, 1993). It is a (packaged) program, but is built with a combination of national and region-specific data. Government agencies in practically every state in the U.S. have used a REMI Model for a variety of purposes, including evaluating the impacts of the change in tax rates, the exit or entry of major businesses in particular or economic programs in general, and, more recently, the impacts of energy and/or environmental policy actions.

A detailed discussion of the major features of the REMI Model is presented in Appendix A. We simply provide a summary for general readers here. A macroeconometric forecasting model covers the entire economy, typically in a “top-down” manner, based on macroeconomic aggregate relationships such as consumption and investment. REMI differs somewhat in that it includes some key relationships, such as exports, in a bottom-up approach. In fact, it makes use of the finely-grained sectoring detail of an I-O model, i.e., it divides the economy into 169 sectors, thereby allowing important differentials between them. This is especially important in a context of analyzing the impacts of GHG mitigation actions, where various options were fine-tuned to a given sector or where they directly affect several sectors somewhat differently.

The macroeconomic character of the model is able to analyze the interactions between sectors (ordinary multiplier effects) but with some refinement for price changes not found in I-O models. In other words, the REMI model incorporates the responses of the producers and consumers to price signals in the simulation. In contrast, in a basic input-output model, the change in prices is not readily taken into account. More specifically, a basic input-output model separates the determinants of quantity and prices, i.e., price changes will not generate any substitution effects in an I-O analysis, while the REMI model is capable to capture this and other price-quantity interactions.[2] The REMI Model also brings into play features of labor and capital markets, as well as trade with other states or countries, including changes in competitiveness.

The econometric feature of the model refers to two considerations. The first is that the model is based on inferential statistical estimation of key parameters based on pooled time series and regional (panel) data across all states of the U.S. (the other candidate models use "calibration," based on a single year's data). This gives the REMI PI^+ model an additional capability of being better able to extrapolate the future course of the economy, a capability the other models lack. The major limitation of the REMI PI^+ model versus the others is that it is pre-packaged and not readily adjustable to any unique features of the case in point. The other models, because they are based on less data and a less formal estimation procedure, can more readily accommodate changes in technology that might be inferred, for example from engineering data. However, data were lacking to make these adjustments in this study.

The use of the REMI PI^+ Model involves the generation of a baseline forecast of the economy through 2020, consistent with the California ENERGY 2020 and CARB baseline (see Appendix B for a summary of how we reconcile the REMI model forecast with the economic and energy consumption forecast used in the ENERGY 2020 model). Then simulations are run of the changes brought about through the implementation of the various GHG mitigation policy options. This includes the direct effects in the sectors in which the options are implemented, and then the combination of multiplier (purely quantitative interactions), general equilibrium (price-quantity interactions), and macroeconomic (aggregate interactions) impacts. The differences between the baseline and the "counter-factual" simulation represent the total state economic impacts of these policy options.

B. Input Data

The quantification analysis of the costs/savings of policy options in the CARB (2010) analysis is limited to the direct effects of their implementation. For example, the direct costs of an energy efficiency option include the energy customers' expenditure on energy efficiency equipment and devices. The direct benefits of this option include the savings on energy bills of the customers.

Before undertaking any economic simulations, the costs and savings for the policy options are translated to model inputs that can be utilized in the Model. This step involves the selection of appropriate policy levers in the REMI PI^+ Model to simulate the policy's changes. The input data include sectoral spending and savings over the full time horizon (2010-2020) of the analysis.

Major ENERGY 2020 outputs include the following:

- GHG emission reductions by sector
- Electricity generation capacity and generation output by fuel type
- Electricity sales by sector
- Utility generating cost
- Fuel prices by sector

- Fuel expenditures by sector
- Device investment by sector
- Self generation investment by sector
- Process investment by sector
- Distance travelled
- Vehicle efficiency

The basic data represent two sets of GHG mitigation policy options: complementary policies (Pavley II Vehicle Standards, Low Carbon Fuel Standard, VMT-Reduction Measure, 33% RPS, Energy Efficiency, Combined Heat and Power) implemented via regulation and the policy options implemented under the Cap and Trade program (primarily through individual emitter choice in response to price signals). Appendix C presents detailed descriptions of the complementary policies.

The following ENERGY 2020 data, in real dollar values where applicable, are utilized as input data in REMI:

1. Annualized Device Investment
2. Annualized Self Generation Investment
3. Annualized Process Investment
4. O&M Expenditures
5. Annual Fuel Expenditures
6. Utility Generating Costs (by generation type)[3]
7. Post-policy Emissions of covered sectors; Offset Usage; Bank Allowances Used
8. Equilibrium Allowance Price

The original data we obtained from the ENERGY 2020 Model (E2020) are the simulation outputs of the Reference Case run and the Policy Case runs. Since the REMI model simulations are driven by the *value changes* of the policy–related variables (or "policy levers") with respect to the baseline levels, we first compute the difference in values of the above key variables between the E2020 Reference Case run and the Policy Case/Scenario run. Appendix Tables D1 and D2 show the major Year 2020 ENERGY 2020 Model output data we used in the REMI analysis. Appendix Table E1 presents the mapping of E2020 Model outputs into REMI inputs for an example policy.

C. Simulation Set-up in REMI

Figure 1 shows how a policy simulation process is undertaken in the REMI PI$^+$ model. First, a policy question is formulated (such as what would be the economic impacts of implementing the Energy Efficiency Programs). Second, external policy variables that would embody the effects of the policy are identified (take Energy Efficiency as an example, relevant policy variables would include incremental costs and investment in energy efficient appliances; final demand increase in the sectors that produce the equipment and appliances; and the avoided consumption of electricity, natural gas, etc.). Third, baseline values for all the policy variables are used to generate the control (baseline) forecast. In REMI PI$^+$, this forecast uses the most recent data available (i.e., 2007 data) for the study region, and the external policy variables are set equal to their baseline values. Fourth, an alternative forecast is generated by changing the values of the external policy variables. Usually, these changes represent the direct effects of the simulated policy scenario. Fifth, the effects of the policy scenario are measured by comparing the baseline forecast and the alternative forecast. Sensitivity analysis can be undertaken by running a series of alternative forecasts with different assumptions on the values of the policy variables.

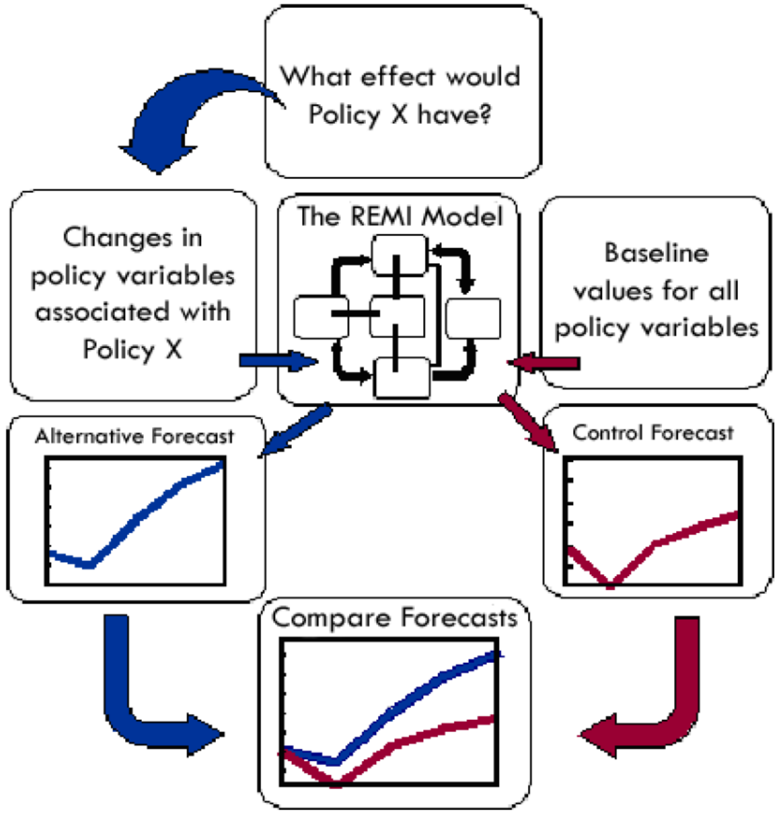

Figure 1. Policy Simulation in REMI

D. Main Policy Cases

CARB has defined 5 policy cases for implementing AB32 (see Table 1). Each of the cases represents the combination of the C&T program and the six "Complementary Policies." The policy cases vary according to effectiveness of complementary policies and assumptions on offsets. Policy Cases 1 and 2 both assume that 100% of the reduction goals of the six complementary options can be achieved. The difference between these two cases is that Case 1 allows the usage of offsets for compliance, while Case 2 does not. Cases 3 to 5 are sensitivity cases of the effectiveness of the complementary policies (all allowing the use of offsets). Case 3 evaluates the impacts of the transportation policies' effectiveness on the allowance price and compliance cost. This Case assumes that LCFS and Pavley II can achieve only half of the potential emission reduction goals by 2020. The Vehicle Miles Travelled (VMT) reduction policy is excluded from the analysis in this Case. Case 4 evaluates the impacts of the Electricity and Natural Gas policies' effectiveness on the allowance price and compliance cost. This Case assumes that Energy Efficiency and Combined Heat and Power (CHP, or co-generation) can achieve only half of the emission reduction goals by 2020. The 33% RPS policy is excluded in the analysis in this Case. Case 5 is a combination of Cases 3 and 4 in terms of the assumptions on the effectiveness of the complementary policies. Both VMT reduction and RPS are excluded in this Case, while the remaining four complementary policies are assumed to be half effective. In this study, we only analyze Cases 1, 2 and 5.

Table 1. CARB Policy Cases

Case No.	Case Descriptions	Complementary Policies					
		LCFS	Pavley II	VMT Reduction	Energy Efficiency	33% RPS	CHP
1	Cap-and-Trade with Offsets	Full	Full	Full	Full	Full	Full
2	Cap-and-Trade without Offsets	Full	Full	Full	Full	Full	Full
3	Transportation Policy Sensitivity with Offsets	Half	Half	Excluded	Full	Full	Full
4	Electricity and Natural Gas Policy Sensitivity with Offsets	Full	Full	Full	Half	Excluded	Half
5	Combined Sensitivity with Offsets	Half	Half	Excluded	Half	Excluded	Half

"Full" means that the complementary policy fully achieves its emissions-reduction target by 2020.
"Half" means that the complementary policy achieves only one-half of its emissions-reduction target by 2020.
"Excluded" means that the complementary policy is absent from the analysis, thereby achieving none of its targeted emissions reduction by 2020.
Source: CARB (2010).

E. Basic Assumptions

Table 2 summarizes the major assumptions used in our simulations. We analyze the attainment of the ARB goal of reducing emissions of 6 major categories of greenhouse gases by 15% below 2005 levels by the Year 2020. This calls for a phase-in of sectors covered by the cap, such that all sectors other than Agriculture, Forestry, and Solid Waste are covered by the target year. Our analysis allows for the use of offsets and banking in the main Policy Case. Autonomous energy efficiency improvement (AEEI) is assumed to average 1.5% per year for the economy as a whole. Revenue recycling design will vary according to the scenarios discussed below.

Table 2. Policy Simulation Assumptions

	Component	Assumption
1	GHG Pollutants	CO2, CH4, N2O, SF6, PFC, and HFC
2	2020 Emissions Goal	15% below 2005 emissions
3	Covered Sectors	Electricity & large industrial, transportation/ commercial/residential fuels & small industrial
4	Banking	Allowed
6	Offsets	Offsets estimated to 49% of C&T reduction
7	Energy Efficiency	Sustain historical 1.5% improvement per year
8	Revenue Recycling	Varies by scenario

III. Income Distribution Methodology

A. Background

Distributional impacts of climate policy have received increased attention in recent years (Parry et al., 2008; Burtraw et al., 2008; Hassett et al., 2009; Metcalf, 2009; Rausch et al., 2010). These impacts clearly have normative implications in terms of equity of the size distribution of personal income overall or in terms of the lowest income groups more specifically. The differentiated allocation of allowances across sectors has equity implications as well. However, some of the concern is also attributable to currying favor with special interest groups (and their elected representatives). This falls more in the realm of "positive" economics of predicting or steering the outcome of the policy-making process in general (see, e.g., Olson, 1965) and with respect natural resource and environmental policy in particular (see, e.g., Rose et al., 1988).

The issue of income distribution arises prominently in the context of emission allowance trading. The Coase Theorem states that how property rights are allocated will not undercut efficiency objectives, as long as transaction costs are low and there are no significant income effects. This provides policy-makers with considerable leeway in deciding how to allocate allowances in the first place, whether by free allocation or by auction to the highest bidder. However, real world complications, especially surrounding the distribution of proceeds of the auctioning approach, reveal the potential for efficiency-equity tradeoffs.

Households can be impacted by climate policies through numerous avenues. They are affected by the level and composition of changes in economic activity in individual sectors, such as changes in wages, profits, and job opportunities. Households are also impacted if the prices of greenhouse gas-intensive products increase in response to the policy. The degree to which such production cost increases are passed onto consumers depends upon the competitiveness of the market and the extent level of government regulation. Moreover, all these changes vary across sectors, socioeconomic groups, and geographic areas (Oladosu and Rose, 2007; Fullerton et al., 2008; Burtraw et al., 2008).

Of special concern is the impact on low income households because they tend to be more vulnerable to any losses in general and because they are likely to be affected disproportionately. Lower income groups spend a higher proportion of their income on necessities, such as electricity and gasoline. These goods are among the most likely to have their prices affected by climate policy, with most studies projecting an increase.

To counter such regressive impacts, a number of proposals have been offered relating to compensation of those most vulnerable. One approach is to provide a greater proportion of free emission allowances to targeted groups. An approach that lends itself more to fine-tuning, however, is the use of revenues from a carbon tax or allowance auction. The distribution, or “recycling”, of this revenue can take on many forms.

The analytical method employed within this literature tends to reflect the focus of analysis. Those studies emphasizing consumption impacts across households largely develop models adept at capturing price changes and relative household expenditures (Burtraw et al., 2009; Hassett et al., 2009; Metcalf, 2008, 2009; Parry et al, 2009). In contrast, those studies with a broader definition of income distribution impacts often use computable general equilibrium or macroeconometric models, which incorporate both consumption and income impacts (Fullerton and Heutal, 2007; Oladosu and Rose, 2007; Rausch et al., 2010; Rose et al, 2010). This research has been modeled as both static and dynamic (Rausch et al, 2010), the difference being whether relevant exogenous and endogenous factors are adjusted to key changing conditions or updated over time.

Burtraw et al. (2009) examine a range of possible revenue recycling alternatives for compensation, including reductions in payroll tax and income tax, lump sum payments, and expansions in the Earned Income Tax Credit program, of which the latter two are found to be the least regressive (see also, Oladosu and Rose, 2007; Burtraw and Palmer, 2008; Metcalf et al., 2008). Other options for revenue recycling, such as investment in research and development for alternative energy technology have been found to be relatively less regressive, especially in the short term. At the same time, some have found that corporate tax reductions are likely to be regressive, though others have suggested this option might have different outcomes in the long run, because it could stoke productivity and research and development investments in alternative energy technology, thereby providing potentially greater environmental improvements at lower cost in the future.

In this report, we will examine the following Scenarios relating to the distributional impacts of CARB Case 1 emission allowance allocation.

Income Distribution Scenarios

S1. CARB Case 1 with 100% Auction of GHG emission allowances in each year
   a. 100% proportional personal income tax reduction ($7.9 billion in total in 2020)
   b. 100% per capita dividend ($194/person in 2020)

S2. CARB Case 1 with 50% Auction and 50% Free Allocation of allowances in each year
   a. 100% proportional personal income tax reduction ($3.9 billion in total in 2020)
   b. 100% per capita dividend ($97/person in 2020)

S3. CARB Case 1 with 100% Free Allocation of allowances in each year

B. Basic Modeling Considerations

Here we summarize the method used to estimate the income distribution impacts of AB32. The REMI Model is disaggregated for only a coarse grouping of 5 income brackets, and its income distribution data have not been updated to match the rest of the model. We supplement the REMI Model with a Multi-Sector Income Distribution Matrix (MSIDM) that provides a more up-to-date accounting of income distribution across 10 income brackets. The MSIDM consists of the distribution of income payments by sector for each of the 10 income brackets. Following the method of Rose et al. (1988), it is constructed using data from the U.S. Bureau of Labor Statistics Occupational Employment Statistics Division and the U.S. Census (see Prager, 2010 for a detailed explanation of model construction).

The 2007 California Multi-Sector Income Distribution Matrix (MSIDM) was developed using a combination of state and federal tax agency and IMPLAN data. The overall approach detailed below was based on the methodology developed by Rose et al. (1988) and Li et al. (1999), with modifications made when recommended data were not available.

Income brackets were indentified for California households indirectly. Ideally, income brackets would contain an evenly distributed number of households, e.g., 10 percent of households in each bracket. Structuring income brackets this way enables easier interpretation of distributional impacts. However, there are no exact data at the California level to identify household income brackets. As such, the U.S. level household income distribution brackets (U.S. Census, 2010) were used for two reasons. First, individual income distribution patterns are very similar for the U.S. and California, as shown in Table 3, with California's household income brackets marginally higher, at about a ratio of 10 to 1 for most brackets. Second, California median income of $55,450 (U.S. Census, 2010) is similar to, though again marginally higher than, the U.S. median income of $50,233 (U.S. Census, 2010).

Table 3. U.S. and California Individual Income Distributions

Percentile	U.S.				California			
	Income bracket	Total income (billion 2007$)	No. of returns (million)	% of returns	Income bracket	Total income (billion 2007$)	No. of returns (million)	% of returns
10	<5k	-79.0	13.8	9.72	<7k	-7.1	1.4	9.93
20	5-12.5k	165.1	18.1	12.69	7-13k	13.5	1.3	9.37
30	12.5-17.5k	171.1	11.5	8.07	13-20k	26.6	1.6	11.21
40	17.5-25k	320.3	11.2	7.86	20-27k	33.4	1.4	9.90
50	25-32.5k	503.7	16.4	11.50	27-35k	43.2	1.4	9.71
60	32.5-42.5k	509.6	13.8	9.72	35-45k	53.9	1.3	9.16
70	42.5-55k	613.8	12.3	8.61	45-60k	78.1	1.5	10.72
80	55-77.5k	1,058.1	16.7	11.76	60-80k	92.2	1.5	9.25
90	77.5-130k	1,451.1	14.6	10.26	80-125k	146.4	1.4	10.02
100	>130k	4,102.3	14.0	9.80	>125k	510.6	1.5	10.73
Totals		8,815.9	142.4	100.00		990.7	14.4	100.00

Sources: U.S. Internal Revenue Service (2010); California Franchise Tax Board (2010).

The labor income side of the matrix was produced by combining 2007 California employment numbers (California Employment Development Division, 2010a)[4] with occupations per sector data (California Employment Development Division, 2010b) and wage estimates by occupation (U.S. Bureau of Labor Statistics, 2010). In contrast to the Rose et al. (1988) approach, for which the best available income by occupation data was the average (mean) wages by occupation and sector, the U.S. Bureau of Labor Statistics wage estimates by occupation data are now reported in percentiles (10, 25, 50, 75, 90) along with the mean (see Appendix F for further details).

For the capital income matrix we used a similar method as reported in Li et al. (1999). Here, we first scaled up the dividend income matrix from Rose et al. (1982; p. 65), which is the only such matrix available based on primary data, using dividend to total income ratios from California Department of Finance, Economic Research Unit (2010). Hence it is assumed that the California dividend income has the same distribution across income brackets as dividend income at the national level. The California Department of Finance data are used primarily to ensure that the overall dividend to income ratio is up-to-date. This is important to note as 1982 was a recession year, and hence capital earnings were depressed for that year. In 1982, U.S. wage and salary accounted for 81.7 percent of adjusted gross income (Rose et al., 1988:40), compared with 67.2 percent for 2007 (IRS, 2010). For California in 2007, wage and salary accounted for 63.6 percent of adjusted gross income (CA Department of Finance, 2010). Again, see Appendix F for details and Appendix G for key data.

In our calculations, we also make the distinction between variable and constant income. We define variable income as income that changes with the level of economic activity, and we include most labor and capital income in this category. Examples of constant (exogenous) income types, such as most pensions and annuities and transfers (e.g., unemployment and alimony), are stable over time and are largely insulated from macroeconomic changes. Our simulations only allow for variable income to be impacted by policy changes, while constant income remains unaffected.

The MSIDM is balanced using the RAS biproportional matrix weighting procedure. The RAS procedure forces the sum of row and column elements of a matrix (in this case the pre-tax and pre-transfer income distribution matrix by sector and income bracket) to conform to control totals included in the algorithm code. These control totals act as anchors, so that the adjusted matrix is consistent with the macroeconomic data. As such, the control totals must be external to the original matrix estimation process. In other words, the control totals cannot be used to estimate the original matrix and then also to anchor the row and column sums.

Finally, we summed the labor and capital income matrices to produce a total income MSIDM. It is translated into a coefficient matrix for policy simulations that affect the size and composition of income payments by dividing each sector-bracket income value by the total income for that sector.

C. Dynamic MSIDM

There are four considerations in a macro model that have the greatest effect on the income distribution impacts:

1. Relative price changes
2. Factor substitution
3. Occupational substitution
4. Changes in relative factor prices

The REMI Model calculates relative price changes for commodities, as well as changes in relative factor price. It also allows for factor substitution (between capital, labor, and energy). Unfortunately, REMI does not readily produce occupation changes. The effect of relative factor price changes on the distribution of income is calculated via our MSIDM as follows:

a. Utilize the REMI Model to obtain the impacts of a policy simulation with respect to wage/salary return changes by sector, along with the economy-wide capital return change. Although REMI only provides a single aggregate rate of return for capital, this is reasonable because of capital mobility of the single capital aggregation in the model.

b. Apply these changes to convert the static MSIDM into a dynamic one. This involves changing the shares of the wage and capital components in each sector of the matrix. We need not feed in any changes in income returns by income bracket into corresponding consumption changes because REMI does this automatically in response to income changes.

c. Multiply the changes in sectoral gross output by the revised (dynamic) MSIDM to obtain the revised change in income distribution.

Thus, we are able to trace a circular flow of income generation, income receipt, and consumption stimuli in our model. The method also has the potential to factor in technological change over time. This is a solid conceptual and empirical base for a dynamic income distribution analysis.

IV. Aggregate Results

Preliminary results of the application of the REMI PI^+ Model to the analysis of the impacts of the AB 32 Policy Cases on the California economy are presented in this section. We confine our attention to examining three of the five policy cases analyzed by CARB (recall Table 1). Each of the cases represents the combination of the C&T program and a number of "Complementary Policies" (all six in Cases 1 and 2; four with half effectiveness in Case 5).

A. 100% Allowance Auction Scenarios

Table 4 summarizes the projected impacts of three policy cases on macroeconomic indicators of gross state product (GSP), income, and employment in Year 2020 under the assumption of Equal Lump Sum recycling of revenues (Scenario 1b). The results indicate that each of the three policy cases examined would have a very slight positive impact on the State's economy by Year 2020. Note that it may seem counter-intuitive that Case 2, which is more restrictive than Case 1, has a larger positive impact. The reason is that the ENERGY 2020 analysis projected a significantly greater implementation of cost saving mitigation options in this case because there is a greater incentive to do so. Also, the stimulus effects stemming from auction revenue recycling are highest in this case due to it having the highest allowance price under the "no offsets" assumption.

Table 4. Aggregate Economic Impacts of AB32 Policy Cases for Year 2020
(100% Auction of Allowances)
(GSP and Income figures in billion 2007$)

Policy Case	Gross State Product Impacts		Income Impacts		Employment Impacts	
	Level	Percent	Level	Percent	Level	Percent
Case 1 Scenario 1b	$7.3	0.3%	$6.1	0.5%	113,094	0.5%
Case 2 Scenario 1b	$36.2	1.5%	$32.0	2.4%	411,092	1.9%
Case 5 Scenario 1b	$16.9	0.7%	$14.8	1.1%	234,816	1.1%

Interestingly, the recycling of auction revenues is crucial at the aggregate level, because without this feature the aggregate impacts would each be negative (see the decomposition of the results in Table 5). Since the analysis above assumes that allowances are fully auctioned, the out of pocket expenditures to purchase allowances will increase the emitters' cost of production, and they will attempt to pass on these cost increases in the form of higher prices to their customers.[5] This, in turn increases the cost of production in other businesses, and continues through successive rounds of ripples of cost-push inflation. Moreover, it decreases the purchasing power of household income. The decomposition shows that without the recycling of these auction revenues, the total impacts to the economy would be negative. Returning the revenues back to the households as lump sum payment transfers to relieve the possible negative impacts on consumers would greatly improve the overall impacts on the state economy and could achieve distributional objectives as well. Moreover, revenue recycling can be fine-tuned to achieve various distributional goals.

It may strike the reader that the recycling is simply a transfer and should not affect the results. First, we note that the pre-transfer case is just an artificial analytical construct that "holds" the auction revenues from purpose of comparison. Also, even when the transfer is made its effect is not just a "wash" but involves a net gain to the economy. All recycled revenues go to residents of California. However, some of the costs are imposed on those outside the state in the form of reductions of profits (a major proportion of ownership of capital is outside the state) and the cost pass-through to purchasers of California exports.

Table 5. GSP Impacts of AB32 Policy Cases Before and After Auction Revenue Recycling, Year 2020 (100% Auction of Allowances)
(GSP figures in billion 2007$)

Policy Case	Before Auction Revenue Recycling		After Auction Revenue Recycling	
	Level	Percent	Level	Percent
Case 1 Scenario 1b	-$0.1	-0.0%	$7.3	0.3%
Case 2 Scenario 1b	-$0.9	-0.0%	$36.2	1.5%
Case 5 Scenario 1b	-$18.6	-0.8%	$16.9	0.7%

Following is a brief summary of the aggregate impacts of each Policy Case analyzed (see Table 5 for a decomposition of the aggregate results):

Case 1: In the absence of the recycling of the auction revenues, this policy case yields the lowest overall negative impacts to the economy compared with other cases. In the 100% auction allowance allocation scheme, the total government revenues from auction are determined by the total amount of unabated emissions from the entities covered by the emissions cap (excluding any offset credits held by the entities) and the allowance price. In Case 1, the allowance price is $21/tCO_2e$[6] and the total government revenues collected from allowance auction are $7.9 billion. Recycling these revenues as lump sum transfer payments on an equal per household basis results in an overall GSP gain of $7.3 billion, or a 0.3% increase from baseline and an employment increase of 113,094 jobs in terms of person-year equivalents, or 0.5% above baseline.

Case 2: This case is the same as Case 1 but with no use of offsets. The economic impacts in Year 2020 without the revenue recycling effects are more negative than Case 1. With no offsets being allowed, the equilibrium allowance price in this case rises to $106/t, which is the highest one among the 3 cases examined. The high allowance price leads to substantial government revenues collected from auction -- nearly $40 billion. The GSP increase is $36.2 billion, or a 1.5% increase in this Case. The employment increase is 411,092 jobs, or a 1.9% increase from baseline.

Case 5: This is the combined sensitivity case to evaluate how the effectiveness of the Complementary Policies would affect the allowance price and the compliance costs. This case yields by far the most negative impacts to the economy in the absence of the government revenue recycling because many of the mitigation options are relatively more expensive than in the other two cases. The allowance price is $102/t, which leads to total allowance auction revenues of $38 billion. The GSP increase is $16.9 billion, or 0.7%. Employment gains in the Year 2020 are 234,816 jobs, or a 1.1% increase over baseline.

Table 6 presents the impacts of the policy cases on residential and non-residential electricity prices in Year 2020 under the 100% auction of allowances. Electricity prices are projected to decrease in all the cases. These results are due primarily to the total electricity generation cost (a combination of capital cost, O&M cost, and fuel cost) decrease associated with the increased utilization of CHP[7] and to the negative shift in demand stemming from energy efficiency. The production cost increases of the power sector due to the purchase of allowances has considerable offsetting effect on these influences (especially in Case 2 and Case 5, where the allowance price is high, and thus the allowance purchase cost of the power sector is high); however, it is not large enough to reverse the sign of the impact.

Table 6. Electricity Price Impacts of California Policy Cases, Year 2020 (100% Auction of Allowances)

Policy Case	Residential (% change)	Non-Residential (% change)
Case 1 Scenario 1b	-3.29%	-4.85%
Case 2 Scenario 1b	-5.56%	-6.86%
Case 5 Scenario 1b	-2.39%	-2.95%

The results are consistent with the ENERGY 2020 data inputs noted below, which project that fuel cost decreases are greater than capital cost and O&M cost increases in the electricity sector. The one apparent anomaly—that prices decrease more under Case 2 than Case 1—can be readily explained. It stems from the fact that the ENERGY 2020 model predicted substantially more electricity generation reductions from fossil fuel generation facilities (mainly NG-fired generation) in Case 2 due to the lack of offsets, and hence a larger overall fuel cost savings. The high allowance price of Case 2 greatly increases the production cost of the power sector due to the allowance purchases. However, this effect is not large enough to offset the effect of the reduced fuel cost. Electricity prices are also projected to fall for the Free Allocation case in 2020—a decline of 3.29% for residential customers and 4.07% for non-residential customers.

Below are the input data for the generation cost changes and allowance costs (where applicable) for the electricity sector we used in the REMI analysis:

<u>Case 1</u>:

Capital Cost Change: $1.87 B (simulated as Capital Cost Increase in REMI)
O&M Cost Change: $0.63 B (simulated as Production Cost Increase in REMI)
Fuel Cost Change: -$5.5 B (simulated as Production Cost Decrease in REMI)
Allowance Cost: $1.31 B (simulated as Production Cost Increase in REMI) for Scenario 1b

<u>Case 2</u>:

Capital Cost Change: $1.87 B (simulated as Capital Cost increase)
O&M Cost Change: $0.60 B (simulated as Production Cost increase)
Fuel Cost Change: -$11.24 B (simulated as Production Cost decrease)
Allowance Cost: $5.92 B (simulated as Production Cost increase)

<u>Case 5</u>:

Capital Cost Change: $0 B (simulated as Capital Cost increase)
O&M Cost Change: $0.03 B (simulated as Production Cost increase)
Fuel Cost Change: -$7.4 B (simulated as Production Cost decrease)
Allowance Cost: $6.20 B (simulated as Production Cost increase)

Appendix H and Appendix I present the impacts of CARB Policy Case 1 combined with alternative allowance allocation and revenue recycling scenarios on a sectoral basis. The results are generally as expected, with the largest absolute and percentage decreases in sectors such as Electric Power Generation, Oil and Gas Extraction and Petroleum Refining, as well as sectors that are relatively energy-intensive, such as Aluminum and Chemical Manufacturing. The largest increases are found in sectors that relate to household spending, such as Real Estate, Retail Trade and Personal Services and in sectors supporting the implementation of renewable energy, such as Engines, Turbines, and Power Transmission Equipment Manufacturing.

B. 100% Free Allowance Allocation Scenario

In this section, we analyze the macro impacts of the C&T program with an alternative allowance allocation scenario — 100% Free Allocation of allowances. Under this policy scenario the total amount of allowances that equal the emissions cap will be allocated among the cap covered sectors. In the previous (100% Auction) case, the covered sectors need to purchase allowances for all unabated emissions, and the ENERGY 2020 model assumes that all of these allowance costs will be automatically passed on to energy consumers through energy price increase. In the 100% Free Allocation case, the cap covered sectors have no additional cost pressures upon their compliances with the reduction target.[8]

However, ICF did not simulate 100% Free Allocation of allowances for any of the policy cases with the ENERGY 2020 Model. We were thus forced to use an indirect approach to perform the REMI simulation. This involves first computing the total allowance payment for each covered sector in the 100% auction case using the following formula:

Sectoral Allowance Payment = (Sectoral Emission - Offset Credits + Bank Flow) × Allowance Price

The ENERGY 2020 post-policy GHG emissions for each sector are obtained from CARB (2010). Since there is no information on offset use and allowances withdrawn from banking for each sector, we distribute total offsets used and total bank flow in Year 2020 among the ENERGY 2020 cap covered sectors using the sectoral share of GHG reductions as weights.

Next, we simulate “rebates” to the sectors that equal the total allowance payment the sectors spend in the 100% auction scenario. This approach uses the additional variable “rebates” to counter-balance the additional allowance cost the sectors bear in the auction scenario, and by doing so the 100% auction simulations are adjusted to reflect the impacts that one would expect from a 100% free-allocation scenario. After the computation of the total value of allowances for each major ENERYG 2020 sector, we distribute the total values among relevant REMI sectors using the baseline fuel consumptions of each sector as weights. In the REMI model, we simulate the allowance payment rebate for each sector as “Industry Sales / Exogenous Production” (Total Revenue) increase. For the residential sector, we use the “Transfer Payment” variable in REMI.[9]

Table 7 presents the aggregate economic impacts of alternative recycling scenarios for Policy Case 1. The impacts rise as the auction requirement decreases and hence the upward pressure on the price of such goods as electricity decreases as well. However, we note below that Scenario 3 is the least attractive from an overall equity standpoint.

Table 7. Aggregate Economic Impacts of Policy Case 1 for Various Allocation/Recycling Policy Design Scenarios, Year 2020

(GSP and income figures in billion 2007$)

Scenario	Gross State Product Impacts		Income Impacts		Employment Impacts	
	Level	Percent	Level	Percent	Level	Percent
Scenario 1a	$6.9	0.3%	$5.1	0.4%	110,855	0.5%
Scenario 1b	$7.3	0.3%	$5.4	0.4%	113,094	0.5%
Scenario 2a	$9.2	0.4%	$7.1	0.5%	124,191	0.6%
Scenario 2b	$9.4	0.4%	$7.2	0.5%	125,305	0.6%
Scenario 3	$11.5	0.5%	$9.4	0.7%	136,805	0.6%

Our approach to simulating the Free Allocation scenario effectively represents an upper bound on the GSP impacts because it stifles all price increases stemming from opportunity costs (though not mitigation cost), where such price increases would mute economic growth. To estimate the lower-bound impacts, where the total allowance opportunity costs are passed through to consumers, we need simply exclude the artificial allowance rebates in our simulation, while at the same time excluding any revenue recycling. This is because the allowance costs in the auction case are equal to the total opportunity costs of the free-allocated allowances to the emission sources in the Free-Granting case. The impacts of this case are reported in Table 5 as "Case 1 Before Auction Revenue Recycling", which yields a -$0.08 billion decrease in GSP in Year 2020, or a -0.003% decrease from the BAU level. This simulation, which we label Scenario 3', is the worst scenario in terms of GSP impacts. Even if half of the opportunity costs are passed through, this would be the worst case scenario simulated in this study.

C. Leakage

A major concern relating to climate change mitigation policy is "leakage," which refers to the prospect that increased costs of production in some economic sectors in a state implementing the policy will lead firms in these sectors to flee to safe havens where such policies are not in effect. This is not only bad for the state's economy but also undercuts climate change policy if the same emissions are simply generated elsewhere. According to our results, the issue of leakage is less likely to occur in relation to AB32 than suggested by other studies, primarily because we find the impacts of the various policy scenarios to be positive overall. Of course, there are sectoral variations, including projected negative impacts on several sectors.

The REMI Model is capable of analyzing leakage by calculating the impact of AB32 on the rest of the U.S. The results for Scenario 1b, for example, in terms of aggregate impacts indicate that while California GSP goes up by $6.7 billion (0.2%), rest of U.S. GDP goes down by $4.9B (-0.02%). The reason is that overall AB32 is projected to improve the competitiveness of the state's economy, rather than hindering it, thereby causing just the opposite of leakage in the aggregate. With respect to leakage for individual sectors, we examined the prospects for Scenarios 1a, 1b, and 3 (see Appendix J). We estimate that leakage could take place for those sectors whose output decreases in California and whose output is projected to increase in the rest of the U.S. For Scenarios 1a and 1b, this is the case for only 8 of 169 sectors, only one of which (Glass and Glass Product Manufacturing) is projected to have an output decline exceeding 1% in the Year 2020. For scenario 3, leakage might take place for 15 sectors, 3 of which overlap with the 8 in Scenarios 1a and 1b. Petroleum Refining and Miscellaneous Mining are the two major sectors to be affected by leakage in this case, though the projected amount of production in these sectors leaving California is very low, i.e., the reductions in output in these sectors are relatively absolute and only very small proportion actually shifts to other locations.

V. Income Distribution Impacts

A. Government Revenues from Allowance Auctions

Table 8 presents mitigation compliance data estimated by the ENERGY 2020 Model for the target year for the three of the five CARB policy cases analyzed in this study (CARB, 2010). The first numerical row shows the equilibrium allowance price to achieve the state emission reduction target. The second row shows the ENERGY 2020 post-policy emissions from the cap covered sectors. Row three presents the usage of offsets. Row four indicates the amount of banking, (negative numbers connote withdrawals).

The amount of allowances the cap covered sectors need to purchase from the auction market is computed using the following formula:

Total Allowances Purchased from Auction = Covered Emissions – Offsets + Bank Flow

The total amount of allowances purchased from auction computed from the above equation is essentially the same for all the cases--376 MMTCO2e. Auction revenues are computed as the product of the auction allowance quantity and the allowance price. Since the allowance price in Year 2020 varies substantially across policy cases, the total government revenues collected from allowances auction also vary significantly, as indicated in the last row of Table 8.

Table 8. ENERGY 2020 Compliance Summary Table for Year 2020

	Case 1	Case 2	Case 5
Allowance Price in 2020 ($/ton)	$21	$106	$102
Covered Emissions (MMT)	405.5	389.6	419.7
Offsets (MMT)	11.6	0	15.0
Bank Flow (MMT)	-17.2	-13.4	-28.0
Allowances Purchased from Auction (MMT)	376.7	376.2	376.7
Auction Revenues (billion $)	$7.91	$39.88	$38.42

B. Allocation and Revenue Recycling Scenarios

1. Allowance Auction Revenue Recycling

a. Government Revenue Recycling as Personal Income Tax Relief

In these scenarios we assume that the auction revenues will be distributed as equal proportional California Personal Income Tax Relief for all income brackets. Column 2 in Table 9a shows the total number of households in each of the ten income brackets. Column 3 computes the percentage of households within each bracket. The next column in Table 9a shows how the total auction revenues for Recycling Scenario "a" are distributed among the ten income brackets based on the percentage of households within each bracket. Table 9b presents the distribution of allowance revenues on a per household basis. The percentages of the distributed revenues with respect to the pre-policy per household income are also presented.

b. Government Revenue Recycling as an Equal per Capita Dividend to Households

In these scenarios, we assume that the auction revenues will be distributed as equal Per Capita Dividends (lump sum payments) for all income brackets. The second to last column in Table 9a shows how the total auction revenues are distributed among the ten income brackets. Note that we assume that these dividends are taxable; hence their total is lower than in the column for income tax relief. Table 9b shows that the per household dividend is equal across all the income brackets at the amount of $556.

The transfer payments are translated to a vector of final demand changes in the REMI Model by distributing them among the169 sectors based on the consumption coefficient column of each income bracket. The total "Exogenous Final Demand" change to each REMI sector is the sum of consumption changes of all the income groups. The state income tax on these lump-sum payments is simulated as an increase in state "Government Spending".

Table 9a. Distribution of Allowance Revenues and Values, Year 2020

Income Brackets	Estimated CA Households per Bracket (millions)	Households (%)	Scenario 1a Personal Income Tax Reduction[a] (billion 2007$)	Scenario 1b Per Capita Dividend after tax[b] (billion 2007$)	Scenario 3 Allowance Values[c] (billion 2007$)
<12.5k	1.08	8.63	0.004	0.601	0.307
12.5-22.5k	0.83	6.63	0.018	0.462	0.253
22.5-30k	2.04	16.31	0.039	1.135	0.649
30-40k	1.25	9.99	0.094	0.695	0.393
40-52.5k	0.92	7.35	0.184	0.512	0.297
52.5-62.5k	1.31	10.47	0.170	0.729	0.452
62.5-80k	1.56	12.47	0.338	0.868	0.581
80-100k	0.92	7.35	0.399	0.512	0.425
100-150k	1.43	11.43	0.900	0.795	0.940
150k+	1.17	9.35	5.745	0.651	3.594
Total	12.51	100.00	7.892	6.958	7.892

[a] Personal income tax reduction of each income bracket in Case 1 Scenario 2a is half that of Case 1 Scenario 1a.
[b] Per capita dividend of each income bracket in Case 1 Scenario 2b is half that of Case 1 Scenario 1b.
[c] Allowance value of each income bracket in Case 1 Scenarios 2a and 2b is half that of Case 1 Scenario 3.

Table 9b. Distribution of Allowance Revenues and Values, Per Household, Year 2020

Income Bracket	Pre-policy Household Income ($)	Average Pre-Policy Tax per Household ($)	Scenario 1a Tax Relief Transfers		Scenario 1b Per Capita Dividend Transfers		Scenario 3 Allowance Value	
			($)	(%)	($)	(%)	($)	(%)
<12.5k	6,875	34	4	0.05%	556	8.09%	284	4.13%
12.5-22.5k	19,250	58	22	0.11%	556	2.89%	305	1.58%
22.5-30k	28,875	173	19	0.07%	556	1.93%	318	1.10%
30-40k	38,500	385	75	0.20%	556	1.44%	314	0.82%
40-52.5k	50,875	814	200	0.39%	556	1.09%	323	0.63%
52.5-62.5k	60,900	1,218	130	0.21%	556	0.91%	345	0.57%
62.5-80k	78,375	1,881	217	0.28%	556	0.71%	372	0.48%
80-100k	99,000	2,871	434	0.44%	556	0.56%	462	0.47%
100-150k	137,500	5,363	629	0.46%	556	0.40%	657	0.48%
150k+	649,474	48,711	4,910	0.76%	556	0.09%	3,072	0.47%
Total	114,058	5,247	631	0.55%	556	0.49%	631	0.55%

2. 50% Auction of Allowances and 50% Free Allocation

This is a hybrid of scenarios 1 and 3. The basic transfer payments are half of those presented in Tables 9a and 9b for Scenarios 1a and 1b. The Free Allocation of Allowances is half their potential value as well.

3. 100% Free Allocation of Allowances

Some additional calculations were required to simulate the aggregate and distributional impacts of the 100% Free Allocation scenario because ENERGY 2020 simulations of direct effects of this case were not available. This required that we apply the device of "rebates" to reflect their values for expenditures on allowances in the ENERGY 2020 auction simulations by all emitters. The last columns of Tables 9a and 9b show the value of the allowances from Free Allocation for each of the entire income brackets or on a per household basis for each bracket, respectively.

C. Distributional Impacts

Tables 10a & 10b to 12a & 12b present distributional impacts of Scenarios 1a, 1b, and 3.[10] The decomposition of the results for Scenarios 2a and 2b are not presented because the impacts are basically mid-way between Scenarios 1 and 3. The overall results for all scenarios, however, are presented in Table 15. Note that the results are presented both in the aggregate for each bracket and on a per household basis.

Scenario 1a results in a negative impact on the lowest income bracket, amounting to $25 million (see tables 10a and 10b), despite the revenue recycling and despite the fact that, overall, incomes become less divergent, as will be shown more explicitly below. This is due in part to an increase in the price of goods that have become more expensive, while being a higher proportion of the expenditures of the very poor than of other income groups. The outcome is also due to sectoral shifts, including employment opportunities that have disproportional effects across the socioeconomic spectrum. This means that the lump sum transfers are inadequate in compensating the lowest income bracket, though the next two income brackets (which are also below 150% of the poverty line threshold) have income gains higher than the average for this scenario.

Scenario 1b results are very similar to those of Scenario 1a (Tables 11a and 11b). The impacts are almost identical for the lowest two income groups, but better for the remaining ones. This is possible because the overall impact on Personal Income is slightly higher for Scenario 1b than 1a.

Table 12a presents the basic input data and results for Scenario 3. Note that it differs in format from Table 11a in that the third column of numbers represents these allowance values, rather than the lump-sum transfers in the pure auction case. The results of Scenario 3 are more favorable to the lowest income group than in Scenario 1b, for example, in absolute terms (they are positive in this case), but not in relative terms. This is not surprising in that free allowances go to owners of firms, who typically have higher incomes than the general population. In fact the percentage increase in the incomes of the $150K plus income bracket is twice as high in Scenario 3 as in Scenario 1b (see also Table 12b).[11]

The income distribution impacts of Scenario 3', the Free Allocation Scenario with opportunity costs passed through, are presented in Table 13. This scenario shows mixed results. The lowest income bracket is greatly adversely affected—six times more than any other bracket (see the last two columns of Table 13). However, the overall income distribution results represent a slight improvement over the base case (Pre-Policy). This is primarily because Scenario 3' is projected to have adverse impacts on four of the five highest income brackets as well. Additional macroeconomic considerations of these results will be discussed at greater length below.

Table 10a. C&T with Offsets Policy, Revenue Recycled to Reduce Income Tax (Scenario 1a), Year 2020 (100% Auction of Allowances) (2007$)

Income Brackets	Pre-Policy Income Distribution (billion $)	Post-Policy Income Distribution (billion $)	Tax Relief Transfers (billion $)	Total Change	
				(billion $)	%
<12.5k	7.4	7.4	0.004	-0.025	-0.331
12.5-22.5k	16.0	16.1	0.018	0.106	0.662
22.5-30k	58.9	59.2	0.039	0.340	0.577
30-40k	48.1	48.3	0.094	0.214	0.445
40-52.5k	46.8	47.0	0.184	0.182	0.389
52.5-62.5k	79.8	80.1	0.170	0.277	0.347
62.5-80k	122.3	122.5	0.338	0.283	0.231
80-100k	91.1	91.4	0.399	0.293	0.321
100-150k	196.6	197.5	0.900	0.903	0.459
150k+	759.9	762.5	5.745	2.590	0.341
Total	1,426.9	1,432.0	7.892	5.163	0.362

Table 10b. C&T with Offsets Policy, Revenue Recycled to Reduce Income Tax (Scenario 1a), Per Household, Year 2020 (100% Auction of Allowances) (2007$)

Income Brackets	Pre-Policy Income Distribution ($)	Post-Policy Income Distribution ($)	Tax Relief Transfers ($)	Total Change	
				($)	%
<12.5k	6,875	6,852	4	-23	-0.331
12.5-22.5k	19,250	19,378	22	128	0.662
22.5-30k	28,875	29,042	19	167	0.577
30-40k	38,500	38,671	75	171	0.445
40-52.5k	50,875	51,073	200	198	0.389
52.5-62.5k	60,900	61,111	130	211	0.347
62.5-80k	78,375	78,556	217	181	0.231
80-100k	99,000	99,318	434	318	0.321
100-150k	137,500	138,132	629	632	0.459
150k+	649,474	651,687	4,910	2,214	0.341
All Households	114,058	114,471	631	413	0.362

Table 11a. C&T with Offsets Policy, Revenue Recycled as Taxable Per Capita Dividend (Scenario 1b), Year 2020 (100% Auction of Allowances) (2007$)

Income Brackets	Pre-Policy Income Distribution (billion $)	Post-Policy Income Distribution (billion $)	Per Capita Dividend Transfers (billion $)	Total Change	
				(billion $)	%
<12.5k	7.4	7.4	0.601	-0.024	-0.326
12.5-22.5k	16.0	16.1	0.462	0.106	0.660
22.5-30k	58.9	59.3	1.135	0.346	0.587
30-40k	48.1	48.3	0.695	0.222	0.462
40-52.5k	46.8	47.0	0.512	0.191	0.408
52.5-62.5k	79.8	80.1	0.729	0.298	0.373
62.5-80k	122.3	122.6	0.868	0.315	0.258
80-100k	91.1	91.4	0.512	0.317	0.348
100-150k	196.6	197.6	0.795	0.954	0.485
150k+	759.9	762.6	0.651	2.751	0.362
Total	1,426.9	1,432.3	6.958	5.475	0.384

Table 11b. C&T with Offsets Policy, Revenue Recycled as Taxable Per Capita Dividend (Scenario 1b), Per Household, Year 2020 (100% Auction of Allowances) (2007$)

Income Brackets	Pre-Policy Income Distribution ($)	Post-Policy Income Distribution ($)	Per Capita Dividend Transfers ($)	Total Change	
				($)	%
<12.5k	6,875	6,853	556	-22	-0.326
12.5-22.5k	19,250	19,377	556	127	0.660
22.5-30k	28,875	29,045	556	170	0.587
30-40k	38,500	38,678	556	178	0.462
40-52.5k	50,875	51,083	556	208	0.408
52.5-62.5k	60,900	61,127	556	227	0.373
62.5-80k	78,375	78,577	556	202	0.258
80-100k	99,000	99,346	556	346	0.348
100-150k	137,500	138,168	556	668	0.485
150k+	649,474	651,830	556	2,357	0.362
All Households	114,058	114,497	556	438	0.384

Table 12a. C&T with Offsets Policy (Scenario 3), Year 2020
(100% Free Allocation of Allowances) (2007$)

Income Brackets	Pre-Policy Income Distribution (billion $)	Post-Policy Income Distribution (billion $)	Allowance Values (billion $)	Total Change	
				(billion $)	%
<12.5k	7.4	7.4	0.307	0.015	0.198
12.5-22.5k	16.0	16.1	0.253	0.121	0.757
22.5-30k	58.9	59.3	0.649	0.437	0.742
30-40k	48.1	48.4	0.393	0.297	0.618
40-52.5k	46.8	47.1	0.297	0.260	0.556
52.5-62.5k	79.8	80.2	0.452	0.389	0.488
62.5-80k	122.3	122.7	0.581	0.476	0.389
80-100k	91.1	91.5	0.425	0.413	0.453
100-150k	196.6	197.8	0.940	1.201	0.611
150k+	759.9	765.2	3.594	5.348	0.704
Total	1,426.9	1,435.8	7.892	8.957	0.628

Table 12b. C&T with Offsets Policy (Scenario 3), Per Household, Year 2020
(100% Free Allocation of Allowances) (2007$)

Income Brackets	Pre-Policy Income Distribution ($)	Post-Policy Income Distribution ($)	Allowance Values ($)	Total Change	
				($)	%
<12.5k	6,875	6,889	284	14	0.198
12.5-22.5k	19,250	19,396	305	146	0.757
22.5-30k	28,875	29,089	318	214	0.742
30-40k	38,500	38,738	314	238	0.618
40-52.5k	50,875	51,158	323	283	0.556
52.5-62.5k	60,900	61,197	345	297	0.488
62.5-80k	78,375	78,680	372	305	0.389
80-100k	99,000	99,449	462	449	0.453
100-150k	137,500	138,340	657	840	0.611
150k+	649,474	654,044	3,072	4,571	0.704
All Households	114,058	114,774	631	716	0.628

Table 13. C&T with Offsets Policy, Without Revenue Recycling (Scenario 3'--100% Free Allocation of Allowances with Opportunity Costs Passed Through), Year 2020 (2007$)

Income Brackets	Pre-Policy Income Distribution (billion $)	Post-Policy Income Distribution (billion $)	Total Change	
			(billion $)	%
<12.5k	7.4	7.4	-0.056	-0.760
12.5-22.5k	16.0	16.0	0.037	0.232
22.5-30k	58.9	59.0	0.103	0.174
30-40k	48.1	48.2	0.029	0.060
40-52.5k	46.8	46.8	0.012	0.026
52.5-62.5k	79.8	79.8	-0.014	-0.018
62.5-80k	122.3	122.1	-0.147	-0.120
80-100k	91.1	91.1	-0.026	-0.029
100-150k	196.6	196.8	0.154	0.078
150k+	759.9	759.2	-0.718	-0.094
Total	1,426.9	1,426.2	-0.594	-0.042

The changes in the overall income distribution can be measured in a more precise way by calculating the Gini coefficient for the distribution of transfers/allowance values alone and for the final outcome. This coefficient is a one-parameter estimate of the skewness of the distribution, i.e., a measure of inequality. On a scale between 0 and 1, smaller Gini coefficients reflect a more equal distribution, while larger values represent a more unequal distribution.

Table 14 presents Gini coefficient results. As described above, Scenarios 1a, 1b, 2a, and 2b are distinguished only by the amount of transfers to each income bracket, while Scenario 3 differs from them only in the free allocation of allowances, and hence the Row 2 listing the "Change in Income Distribution Before Transfers or Allocations" is the same for each scenario. The final two rows of Table 14 highlight how these different transfers impact the Gini coefficient for each Scenario. As shown in the first row of Table 14, the Gini coefficients for all scenarios after the implementation of Case 1 C&T and Complementary policies before auction revenue recycling show a slight decrease from the Pre-Policy, or baseline, level of 0.5924.[12] This indicates that the income distribution improves from the general effect of Case 1.

For Scenarios 1a, 1b, 2a, 2b, and 3 the Gini coefficient results suggest that macroeconomic impacts of income transfers are less equitable than the pre-revenue recycling results, as shown in Table 14. Revenue recycling here acts as a net stimulus to the economy and in fact no sectors are worse off as a result. These benefits are passed on to the highest income brackets at a disproportionate rate for many sectors. The majority of sectors that benefit most from the revenue recycling also have a higher than average proportion of income for the highest bracket. For example, for Scenario 1a, the highest bracket income proportion of Real Estate (81.1%), Construction (57.5%), and Telecommunications (76.7%) are all above the economy-wide average of 53.3% (Appendix Table K1 presents more details of income distribution impacts of the ten sectors that benefit most from revenue recycling in Scenario 1a). Hence for any revenue recycling option, when households spend their transfers, higher income households benefit overall in comparison to the pre-recycling results. The impacts on the overall income distribution thus

Table 14. Gini Coefficient Impacts, Year 2020

	Pre-Policy	Scenario 1a	Scenario 1b	Scenario 2a	Scenario 2b	Scenario 3
Total Income Distribution Before Transfers or Allocations	0.592411	0.592227	0.592227	0.592227	0.592227	0.592227[a]
Change in Income Distribution Before Transfers	n.a.	-0.000184	-0.000184	-0.000184	-0.000184	-0.000184
Direct Transfers	n.a.	0.765602	0.000000	0.765602	0.000000	0.430757
Total Income Distribution After Transfers	0.592411	0.592312	0.592322	0.592465	0.592470	0.592622
Change in Income Distribution After Transfers	n.a.	-0.000099	-0.000089	0.000054	0.000059	0.000211

[a] This is also the Gini coefficient of Scenario 3' (Free Allocation with opportunity cost passed through).
n.a. is "not applicable".

Table 15. Per Household Impacts of AB32 -- CARB Reference Case 1 Combined with Alternative Revenue Recycling Scenarios, Year 2020 (2007$)

Income Bracket	Baseline	Level in 2020					Percent Change from Baseline in 2020				
		1a	1b	2a	2b	3	1a	1b	2a	2b	3
<12.5k	6,875	6,852	6,853	6,871	6,871	6,889	-0.33	-0.33	-0.06	-0.06	0.20
12.5-22.5k	19,250	19,378	19,377	19,387	19,387	19,396	0.66	0.66	0.71	0.71	0.76
22.5-30k	28,875	29,042	29,045	29,066	29,067	29,089	0.58	0.59	0.66	0.67	0.74
30-40k	38,500	38,671	38,678	38,706	38,709	38,738	0.45	0.46	0.53	0.54	0.62
40-52.5k	50,875	51,073	51,083	51,116	51,122	51,158	0.39	0.41	0.47	0.48	0.56
52.5-62.5k	60,900	61,111	61,127	61,156	61,164	61,197	0.35	0.37	0.42	0.43	0.49
62.5-80k	78,375	78,556	78,577	78,621	78,631	78,680	0.23	0.26	0.31	0.33	0.39
80-100k	99,000	99,318	99,346	99,387	99,400	99,449	0.32	0.35	0.39	0.40	0.45
100-150k	137,500	138,132	138,168	138,240	138,257	138,340	0.46	0.49	0.54	0.55	0.61
150k+	649,474	651,687	651,830	652,872	652,943	654,044	0.34	0.36	0.52	0.53	0.70
Total	114,058	114,471	114,497	114,625	114,637	114,774	0.36	0.38	0.50	0.51	0.63

stem from a combination of the direct effect of the transfers, non-linearities in the model, but mostly the interactions of the sectoral mix and macro effects associated with different levels of transfers and policy case designs. Note that this explanation also pertains to why the income distribution results of the Scenario 3' (Free Allocation scenario with opportunity cost of allowances passed through) have an overall more even income distribution than the scenarios that involve revenue recycling.

Since the personal income tax reductions of Scenario 1a are skewed toward higher income brackets, it is not surprising that this Scenario results in a worsening of the overall income distribution when compared to the pre-recycling results, as exhibited by an increase in the Gini coefficient between rows 2 and 5 of Table 14. Because the transfers for Scenario 1b are lump sum, they have a Gini coefficient of 0.0, or perfectly egalitarian (see row 3 of Table 14), which puts downward pressure on the Gini coefficient.

However, the Gini coefficient is not reduced but actually increases slightly from 0.592227 to 0.592322 (about 0.02 percent). Again, the impacts on the overall income distribution stem primarily from the changes in the sectoral mix that favor higher income groups.

As shown in Table 14, the free granted allocation values for Scenario 3 are much more unevenly distributed than in Scenario 1b (compare the Gini coefficient of 0.431 in row 3 with the other entries in that row). The overall results of Scenario 3 indicate it yields the least egalitarian outcome of the scenarios simulated (a 0.000211 increase in the Gini). This is a bit surprising because the direct distribution of free allowances, although highly uneven (Gini of 0.431), is still more even than the baseline income distribution (Gini of 0.592). This implies the outcome is dominated by the indirect (macroeconomic) effects. The outcome is significantly skewed against the lowest income group, and more favorable to the highest income group than any of the scenarios we have simulated. Overall, the various factors influencing the distributional outcomes include relatively larger increases in the output of sectors that have more evenly distributed income payouts. This appears to offset the inherent regressivity of higher energy prices.

Additional anomalies in the income distribution results are primarily due to the macroeconomic impacts of income transfers favoring higher income brackets. Scenarios 1a and 1b both result in income distributions that are fairer than the status quo. The relative values of the Gini coefficient results for Scenarios 1a and 1b are counter-intuitive at first glance. Lump sum transfers alone (Scenario 1b) should be more equitable than proportional income tax relief (Scenario 1a). Yet these results show that Scenario 1a results in a very slightly fairer income distribution than Scenario 1b, though it is important to note that Scenario 1a and 1b results are very similar to one another, the difference in Gini coefficients being only 0.00001. We compared the dynamic MSIDM results for Scenarios 1a and 1b in terms of those sectors that differ the most between Scenarios 1a and 1b in terms of gross output impacts. We found that 8 of the 10 most contrasting sectors (those for which Scenario 1b yields higher gross output impacts than Scenario 1a) distribute 57.7% to 82.94% of their income to the highest income bracket; in contrast, on an economy-wide average basis, only 50.2% of total income is distributed to the highest income bracket. Moreover, in general, the highest bracket is also influential mathematically because the Gini coefficient calculation is anchored to the highest and lowest values of the distribution; thus a change to the highest bracket only would change the Gini coefficient more than an equivalent change to a middle bracket alone. Finally, sensitivity tests on our model reveal that if we were to decrease pre-policy, economy-wide income for the highest bracket by 7 percent, while holding the gross output results constant, this would cause the Gini coefficient results for Scenarios 1a and 1b to switch and match theoretical expectations--Scenario 1b would become fairer than Scenario 1a. This suggests that these counter-intuitive results are largely driven by the highest income bracket of the MSIDM (see details in Appendix Table K2).

Note that the recycling of revenues has a limited potential to affect the overall income distribution. The nearly $7 billion in allowance revenues (after tax) translate into about $550 per household or less than $200 per person in the state. Still the availability of allowance auction revenues or their free allocation does raise some important equity issues. For example, $550 represents nearly 10 percent of the income of those households in the lowest income bracket. The worst case with respect to the lowest income group, Scenario 1a, yields a loss of income for the entire bracket of $25 million, which translates to a loss of $23 per household in that bracket, though this is after $556 per household has been transferred as a dividend. In contrast, the greatest gain of any scenario goes to the highest income bracket under Free Allocation. This $5.1 billion gain translates into more than $4,500 per household in that bracket! At the same time, it represents only slightly less than 1.0 percent of the average household income in this bracket. Other impacts on a per household basis are presented for all Scenarios of Case 1 in Table 16. Again, results for Scenarios 2a and 2b fall mid-way between those of Scenario 1 and Scenario 3.

Table 16. Per Household Impacts of AB32 – CARB Reference Case 1 Combined with Alternative Revenue Recycling Scenarios, Year 2020 (2007$)

	Change in 2020				
Income Bracket	1a	1b	2a	2b	3
<12.5k	-23	-22	-4	-4	14
12.5-22.5k	128	127	137	137	146
22.5-30k	167	170	191	192	214
30-40k	171	178	206	209	238
40-52.5k	198	208	241	247	283
52.5-62.5k	211	227	256	264	297
62.5-80k	181	202	246	256	305
80-100k	318	346	387	400	449
100-150k	632	668	740	757	840
150k+	2,214	2,357	3,399	3,469	4,571
Total	413	438	566	579	716

Note that the results do indicate an efficiency-equity tradeoff. Scenario 3, Free Allocation, is projected to yield the largest increase in GSP and Personal Income, but it worsens the overall income distribution. Still, it is the only scenario that yields gains to the lowest income groups, and it reaps rewards for the highest income group more than twice as high as Scenarios 1a and 1b. The gains in aggregate economic activity are fairly minor, amounting to no more than 0.5 percent in GSP for the most effective scenario from an efficiency standpoint. The difference between the highest impact scenario (3) and the lowest (1a) in terms of GSP is only $5.3 billion and 33,000 jobs. Some might consider these to be relatively small gains to give up to achieve the greatest improvement in the income distribution (Scenario 1a fares almost as well as 1b). At the same time, if the main equity focus is on the lowest income group, then there is no equity-efficiency tradeoff in Scenario 3—the lowest bracket fares better than in all other scenarios, while the economy expands the most.

Some caveats are in order. First, when opportunity costs of freely allocated allowances are fully passed through to customers of firms receiving the allowances (Scenario 3'), this scenario yields negative economic impacts, and, even if only half the costs are passed through, this scenario would yield lower economic impacts, in terms of both GSP and income, than all the other scenarios. In addition, it is projected to result in adverse impacts on the lowest income bracket.

The macroeconomic interactions in the California economy have a strong bearing on the aggregate and distributional results. For example, they change the distributional outcomes considerably in most of the scenarios. Because macroeconomic impacts are difficult to model, an additional buffer is recommended in designing policy. For example, if the concern is with the outcome of the lowest income brackets, additional transfers should be considered for income groups of special concern.

VI. Conclusion

This study summarizes the analysis of the aggregate and distributional impacts of the AB32 policies on the California economy. We used a state of the art macroeconometric model known as REMI PI^+ Model to perform this analysis. The analysis is based on data on policy cases provided by the California Air Resources Board and ICF International, Inc., on simulations of direct economic impacts of these policies. The methodology was supplemented by a Multi-Sector Income Distribution Matrix and by data on CA household income from various tax authorities.

Each of the three AB32 Policy Cases we evaluated in this study is projected to yield a small positive impact on the State's economy by Year 2020. For the California Personal Income Tax Reduction Scenario (1a) of the 100% Auction Scenario (S1), the allowance price is $21/tCO2e, and the total government revenues collected from allowance auction are $7.9 billion. This policy case yields an overall GSP gain of $6.9 billion and an employment increase of 110,855 jobs after auction revenues are recycled as tax reductions. For the Equal Per Capita Dividend Scenario (1b) of the 100% Auction Scenario (S1), the allowance price and total government revenues are same with Scenario 1a. This policy case yields an overall GSP gain of $7.3 billion and an employment increase of 113,094 jobs after auction revenues are recycled as an equal Per Capita Dividend to each household.

The 100% Free Allocation Scenario (S3) yields an overall GSP gain of $11.5 billion (0.5% above the baseline level) and an employment increase of 136,805 jobs (0.6% above the baseline level). Compared with the 100% Auction Scenarios, the aggregate economic gains of the Free Allocation Scenario are more positive when the opportunity costs of GHG allowances are not passed through. The major reason is that the latter does not raise the price of energy as much as do the auction scenarios. When these opportunity costs are fully, or even partially passed through, the ranking is just the opposite—Scenario 3 fares worst of all in terms of output and employment impacts. The mixed cases of Free Allocation and of Auction with Tax Relief and Per Capita Dividend (Scenarios 2a and 2b, respectively) yield results mid-way between the pure cases.

The economic gains of AB 32 stem primarily from the ability of mitigation options to lower the cost of production. This emanates primarily from their ability to improve energy efficiency and thus lower production costs and increase consumer purchasing power. The results also stem from the stimulus of increased investment in energy-saving equipment and the expansionary impacts from auction revenue recycling.

These economic improvements are projected to be distributed relatively evenly in terms of income brackets and labor and capital income shares for the Free Allocation Scenario when opportunity cost increases are not translated into price increases. There is no income bracket that gains substantially at the expense of others, with the exception of the relatively small gains for the lowest income group. However, the impacts for this scenario are projected to be quite unevenly distributed, with negative impacts on both the lowest and four highest brackets when the opportunity costs are fully or partially passed through to customers of firms receiving allowances. The Auction Scenarios combined with either California Personal Income Tax Relief or a Per Capita Dividend are projected to incur small losses to the lowest income group, because of the strong influence of structural shifts in the economy that affect employment opportunities for this group. The same basic outcome is projected for the mixed Scenarios, which are a 50-50 split of Auction and Free Allocation. This suggests that even larger transfers may be needed for the lowest group under these Scenarios to avoid an inequitable outcome. Moreover, these transfers can be made with only a minimal sacrifice in economic efficiency.

The aggregate results presented here are similar to those in the analysis of climate action plans in Florida, Pennsylvania and Michigan (see, Rose and Wei, 2009, 2010a; Miller et al., 2010). The differences between this analysis and the others is that the latter use input data that are more optimistic regarding energy efficiency, renewable energy, and several other mitigation options are used in the state action plans analysis. The results presented here are more positive in percentage terms than those found by the authors in another WCI state--New Mexico (see Rose et al., 2010). The results are also similar to those estimated by Roland-Holst (2008, 2010a) in previous studies about the impacts of AB32 and in a current companion report to ours. The results are similar to those recently estimated by CARB (2010), but differ in sign from the recent study by Charles Rivers Associates (CRA, 2010). Allowance revenue recycling effects are not examined in these other studies, except for Roland-Holst (2010b), who found some similar aggregate results in some cases.

Our distributional impact results differ somewhat from those of a companion study by Roland-Holst (2010) for several reasons, even though the two studies address the same policy scenarios and are based on many of the same assumptions and use some common data. The most obvious reason is the difference in modeling approaches—the BEAR Model being a computable general equilibrium and the REMI Model being macroeconometric. Otherwise, the major differences are in assumptions, such as the one regarding the extent to which opportunity costs of free granted allowances are passed through to customers of firms receiving the allowances. Another major reason is a difference in the data on the distribution of transfers. For Scenario 2b, for example, these transfers (and equal share of per capita dividends and free allowance values) lean slightly more toward middle-income bracket groups in the Roland-Holst study than in ours, while the distribution of transfers leans slightly more toward the highest income bracket in our study than in Roland-Holst's.

Our distributional impact results are similar to those found by others as well (see, e.g., Hasset et al., 2007; Burtraw et al., 2008; Goulder et al., 2009). They find the Free Allocation approach to be generally more regressive than the auction approach. When considering revenue recycling, these studies also find a more equitable outcome associated with per capita dividends than personal income tax reduction; we found them to be essentially the same. The major explanation is the strong workings of macroeconomic linkages that cause major changes in the sectoral mix that favor higher income brackets (e.g., Real Estate, Construction, and Telecommunication). Another difference between the present study and these others is in the extent of variation between policy designs. The variation in outcomes is more muted than in the other studies, which were performed at the national or large region level, in part because of the relatively smaller amount of recycled revenues considered here, even after adjusting for the size of the economies modeled. The results are also similar to those in Roland-Holst's companion study to this one, which is based on very similar input data to ours.

Note that the estimates of economic benefits reported in this study represent a lower bound from a broader perspective. They do not include the avoidance of damage from the climate change that continued baseline GHG emissions would bring forth, the reduction in damage from the associated decrease in ordinary pollutants, the reduction in the use of natural resources, the reduction in traffic congestion, etc.

Overall, the findings from this study suggest that implementing the proposed California climate change policy in AB32 would generate small net positive economic impacts to the State's economy. Moreover, the impacts on all but the lowest income group are positive and in line with gains to other income groups. Revenue recycling is a flexible policy instrument and can be refined to alleviate such inequities to any specific income groups.

Endnotes

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[1] There is a debate about the size of the multipliers used in different regional policy analysis models. Rickman and Schwer (1995) compared the default multipliers in three of these models: IMPLAN, REMI and RIMS II. The comparison shows that the default multipliers have significant differences. Comparatively speaking, IMPLAN estimates the largest multipliers, while REMI estimates the smallest multipliers. The differences stem from three major causes. However, the REMI model has its special features that are important to our policy analysis. First, both IMPLAN and RIMS II are static input-output models, while the REMI model is dynamic. Thus, the REMI model has the capability to analyze the time path of impacts of the simulated policy change and is superior to the other two models in terms of its forecasting ability. In fact, the implicit multipliers of REMI vary from year to year. Second, the REMI model is non-linear. Therefore, in contrast to the other two models, the REMI simulation results are not dependent on fixed multipliers or linear relationship with the input data. In the REMI analysis, changes in the magnitude of the inputs will lead to an appropriate variation in the model's multipliers. Moreover, since the REMI multipliers are generally smaller than the multipliers of the other two models, this means that our impacts lean to the more conservative side, i.e., positive economic impacts are more likely to be understated than overstated.

[2] The production cost change of each sector in REMI will first affect the price of the goods produced by this sector. Then the price change will generate successive impacts to the down-stream customer sectors that use the product of sector *i* as an intermediate input. The only exception is that REMI does not fully pass the production cost change of the energy supply sector (especially the electric generation sector) to the down-stream commercial and industrial customer sectors automatically. This must be done by manual insertions of changes in the model.

[3] The ENERGY2020 model did not account for the costs of new transmission facilities that might be needed for the 33% RPS complementary policy (CARB, 2010).

[4] Where employment per industry figures were presented for a higher-level sector only – for example for the mining industry as a whole, and not disaggregated for Coal mining, Metal Ore mining, and Nonmetallic mineral mining – U.S. Census Employment per Industry data were used to disaggregate the Employment Development Division data proportionally. For Farming industries, IMPLAN 2007 employment compensation data were used to achieve a similar disaggregation.

[5] ENERGY 2020 assumes that the cost of purchasing allowances at auction is passed onto consumers through increased fuel prices. The ability to pass costs through to customers depends on the responsiveness of demand to a change in price. The less responsive the demand is to a price change, the greater the industry's ability to pass cost changes forward. For example, the literature indicates that energy commodities (like electricity and gasoline) are price inelastic. Therefore, it is reasonable to assume that most of the allowance costs initially paid by the energy supply sectors will eventually be passed onto the consumers as an increase in fuel prices.

[6] There is likely to be a feedback effect on allowance prices from recycling but our model is not able to evaluate this feedback effect, Roland-Holst (2010) finds to be significant for Scenario 3.

[7] CHP also involves capital investment and O&M cost increases, as well as fuel cost decreases for the industrial and commercial sectors that install the CHP systems. These values are entered into the REMI model as capital cost, production cost, and fuel cost changes of the corresponding industrial and commercial sectors. In terms of the

utility sector, the increased supply of electricity from CHP reduces the demand from the utility sector, which leads to decreased O&M and fuel costs of this sector.

[8] The literature on emission allowance trading has traditionally postulated that there is no difference in outcomes with respect to economic efficiency between a system of free-granted allowances and a system of auctioned allowances. The former requires out-of-pocket expenditures, while *opportunity costs* of use of free-granted allowances are cited as a justification for an increase in cost to firms receiving them. That is, each time a firm uses an allowance, it foregoes the opportunity to reap revenues from its sale. While the conceptual grounding for this proposition is solid, real world policy-making is not likely to uphold it. Most analysts have recently concluded that public utilities commissions are unlikely to grant rate increases to electric utilities on the basis of free-granted permits (see, e.g., Burtraw et al., 2008). In fact, the recent Economic and Allocation Advisory Committee (EAAC) to the California Air Resources Board on the implementation of its climate action plan (Assembly Bill 32), recommended against any such rate increase on this basis. Even some non-regulated firms in today's business environment are not likely to raise their prices because of the increase in opportunity costs so as to avoid adverse public reactions. Therefore, in this report, we assume direct and indirect cost impacts of free-granted versus auctioned allowances differ. For the former case we factor in the cost of actual mitigation or any purchase of allowances, but do not include the opportunity costs of allowances allocated for free.

[9] These suppress the higher price effects due to increased cost from paying for allowances. Therefore, any price changes in this Scenario are due solely to the mitigation response, and do not include passing along any of the opportunity cost of allowances. The direct mitigation response, in terms of fuel expenditure changes and changes in the composition of energy use, is already incorporated into the ENERGY 2020 analysis. In addition, the REMI model calculates the indirect (macro) effects of these ENERGY 2020 changes.

[10] We use income as a welfare measure in this analysis. For an excellent discussion of the limitations of this measure and the advantages of alternatives such as consumption and consumers surplus, the reader is referred to Burtraw et al (2008).

[11] We simulated Scenario 3 in two ways: a) offsetting auction allowance purchases by increasing firm revenue and b) decreasing the cost of production. The former resulted in more reasonable results overall, but did result in one bias that is likely to increase the estimate of income going to the lowest income bracket. This stems from the fact that the gains from increased revenues go to all income recipients of the firm in the REMI Model, rather than just to shareholders in the form of increased profits. Further, however, while in the short run, any rebates granted to a private company could well be transferred directly to shareholders purely in the form of profits, in the long run, it is likely that some surplus profits would instead be channeled towards investment in labor and capital, otherwise companies might lose their competitive edge in the market. This would result in rebates benefiting households via both capital and labor incomes in the long run.

[12] The distributional impact results differ little between our static and dynamic modeling approaches. As described above, one element of our dynamic modeling approach is to estimate changes in the labor and capital income in each sector that result from a policy change. However, these changes do not alter the distributional results significantly. For example, the $62.5 to $80k income bracket experiences the greatest change from the adjustment of $4 million, or 0.001% of total income for that bracket. Moreover, the Gini coefficient only changes by a maximum of 2 units at the sixth decimal place. The small impact of the adjustment is largely due to the fact that labor and capital income ratios for each sector change by only a small amount. Moreover, when such changes are more dramatic (e.g., the Natural Gas Distribution sector has a pre-adjustment labor income ratio of 0.426 and a post-adjustment ratio of 0.418 for Case 5), – these changes are offset by other changes in the opposite direction as they work through both REMI and the MSIDM.

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APPENDIX A. Description of the REMI PI$^+$ Model

REMI PI$^+$ is a structural economic forecasting and policy analysis model. It integrates input-output, computable general equilibrium, econometric and economic geography methodologies. The model is dynamic, with forecasts and simulations generated on an annual basis and behavioral responses to wage, price, and other economic factors.

The REMI model consists of thousands of simultaneous equations with a structure that is relatively straightforward. The exact number of equations used varies depending on the extent of industry, demographic, demand, and other detail in the model. The overall structure of the model can be summarized in five major blocks: (1) Output and Demand, (2) Labor and Capital Demand, (3) Population and Labor Supply, (4) Compensation, Prices, and Costs, and (5) Market Shares. The blocks and their key interactions are shown in Figures A1 and A2.

The Output and Demand block includes output, demand, consumption, investment, government spending, import, product access, and export concepts. Output for each industry is determined by industry demand in a given region and its trade with the US market, and international imports and exports. For each industry, demand is determined by the amount of output, consumption, investment, and capital demand on that industry. Consumption depends on real disposable income per capita, relative prices, differential income elasticities and population. Input productivity depends on access to inputs because the larger the choice set of inputs, the more likely that the input with the specific characteristics required for the job will be formed. In the capital stock adjustment process, investment occurs to fill the difference between optimal and actual capital stock for residential, non-residential, and equipment investment. Government spending changes are determined by changes in the population.

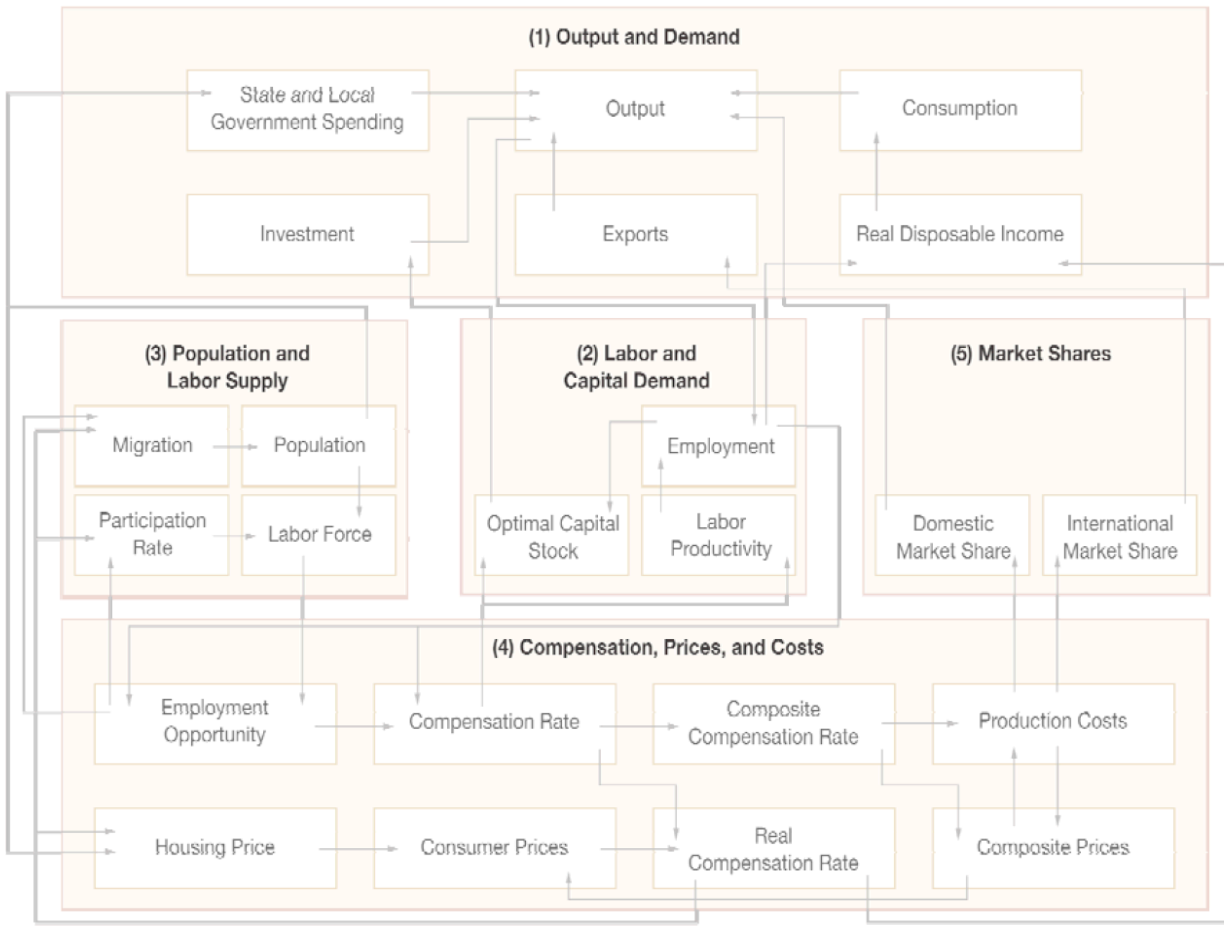
The Labor and Capital Demand block includes the determination of labor productivity, labor intensity and the optimal capital stocks. Industry-specific labor productivity depends on the availability of workers with differentiated skills for the occupations used in each industry. The occupational labor supply and commuting costs determine firms' access to a specialized labor force.

Labor intensity is determined by the cost of labor relative to the other factor inputs, capital and fuel. Demand for capital is driven by the optimal capital stock equation for both non-residential capital and equipment. Optimal capital stock for each industry depends on the relative cost of labor and capital, and the employment weighted by capital use for each industry. Employment in private industries is determined by the value added and employment per unit of value added in each industry.

The Population and Labor Supply block includes detailed demographic information about the region. Population data is given for age and gender, with birth and survival rates for each group. The size and labor force participation rate of each group determines the labor supply. These participation rates respond to changes in employment relative to the potential labor force and to changes in the real after tax compensation rate. Migration includes retirement, military, international and economic migration. Economic migration is determined by the relative real after tax compensation rate, relative employment opportunity and consumer access to variety.

The Compensation, Prices, and Costs block includes delivered prices, production costs, equipment cost, the consumption deflator, consumer prices, the price of housing, and the wage equation. Economic geography concepts account for the productivity and price effects of access to specialized labor, goods and services.

Figure A1. REMI Model Linkages (Excluding Economic Geography Linkages)

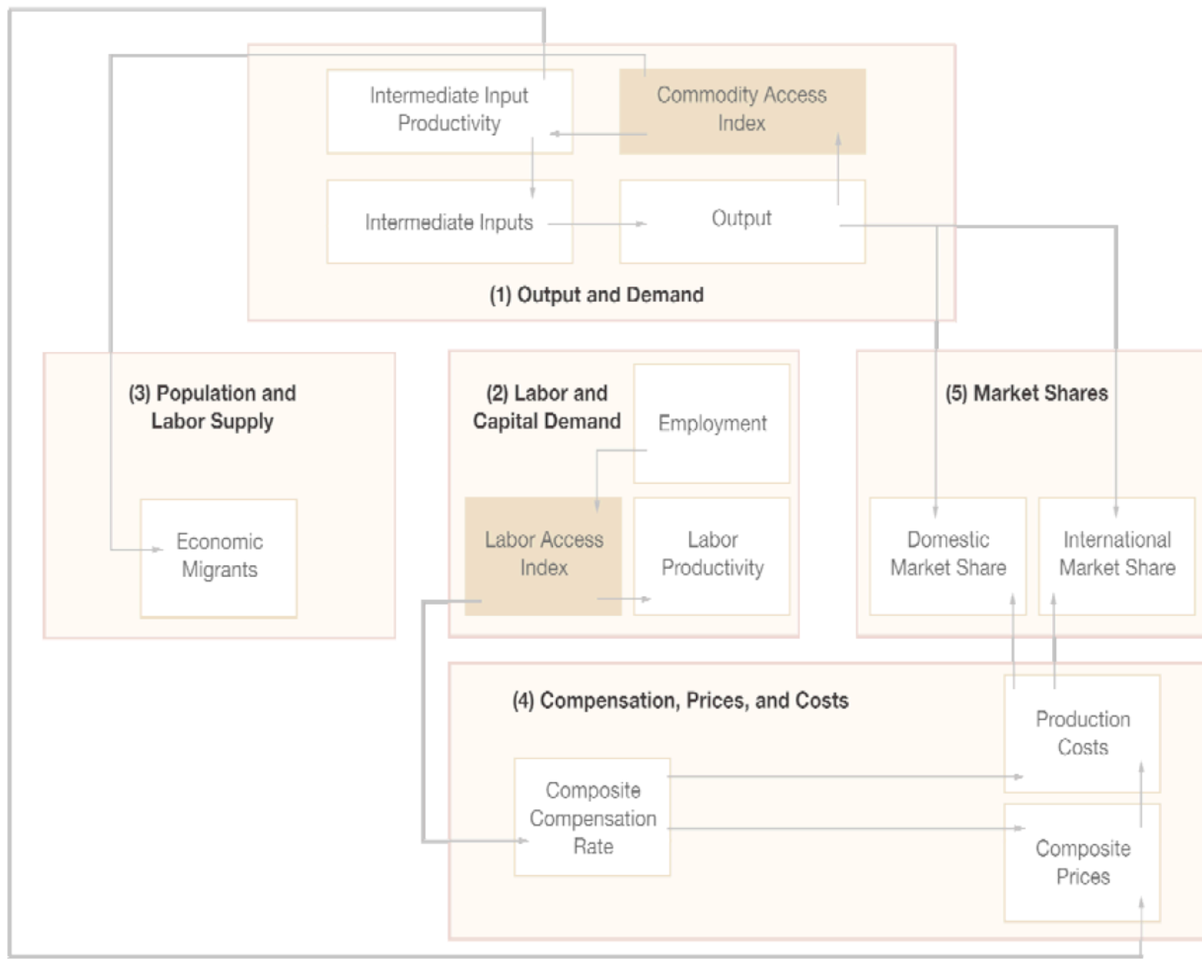


These prices measure the value of the industry output, taking into account the access to production locations. This access is important due to the specialization of production that takes place within each industry, and because transportation and transaction costs associated with distance are significant. Composite prices for each industry are then calculated based on the production costs of supplying regions, the effective distance to these regions, and the index of access to the variety of output in the industry relative to the access by other uses of the product.

The cost of production for each industry is determined by cost of labor, capital, fuel and intermediate inputs. Labor costs reflect a productivity adjustment to account for access to specialized labor, as well as underlying compensation rates. Capital costs include costs of non-residential structures and equipment, while fuel costs incorporate electricity, natural gas and residual fuels.

The consumption deflator converts industry prices to prices for consumption commodities. For potential migrants, the consumer price is additionally calculated to include housing prices. Housing price changes from their initial level depend on changes in income and population density. Regional employee compensation changes are due to changes in labor demand and supply conditions, and changes in the national compensation rate. Changes in employment opportunities relative to the labor force and occupational demand change determine compensation rates by industry.

Figure A2. Economic Geography Linkages



The Market Shares equations measure the proportion of local and export markets that are captured by each industry. These depend on relative production costs, the estimated price elasticity of demand, and effective distance between the home region and each of the other regions. The change in share of a specific area in any region depends on changes in its delivered price and the quantity it produces compared with the same factors for competitors in that market. The share of local and external markets then drives the exports from and imports to the home economy.

As shown in Figure A2, the Labor and Capital Demand block includes labor intensity and productivity, as well as demand for labor and capital. Labor force participation rate and migration equations are in the Population and Labor Supply block. The Compensation, Prices, and Costs block includes composite prices, determinants of production costs, the consumption price deflator, housing prices, and the wage equations. The proportion of local, interregional and international markets captured by each region is included in the Market Shares block.

Appendix B. REMI Model Reconciliation

This section describes the approaches used to reconcile the ENERGY 2020 and REMI PI^+ models for California, such that both models are generating equitable baseline projections. It is important that both models form similar baseline projections, as impacts are generated from comparisons to baselines on the assumptions of policy changes. Because the two models share many common measures, the REMI PI^+ model can be reconciled to reflect baseline projections of the ENERGY 2020 model. However, since modeling philosophies and foci differ between the two models, some limitations to the detail that can be reconciled exist. The reconciliation task concludes with both models generating similar sectoral growth in output, of gross regional product, personal income, population and proximally equal energy use over common forecast horizons. To reconcile the two models, the REMI PI^+ model baseline projections through 2020 were modified to match projected growth of key sectors of the ENERGY 2020 model.

Table B1 shows the pre-reconciliation and post-reconciliation REMI PI^+ model projected growth rates for comparison with those of ENERGY 2020. The results shown in Table B1 suggest that the reconciled REMI PI^+ model is effectively tracking the ENERGY 2020 projections. The following discussion begins by comparing the ENERGY 2020 and REMI PI^+ models for California. It then discusses the process of reconciling the REMI PI^+ model to fit the ENERGY 2020 model forecasts.

Table B1. Baseline Growth Rates 2010-2020

	Pre-Reconciliation REMI PI+	Reconciled REMI PI+	ENERGY 2020
GRP (Real $)	2.5%	2.7%	2.6%
Industry (Real $)	1.8%	1.1%	1.1%
Commercial (Real $)	2.7%	3.1%	3.0%
Population	0.9%	1.0%	1.2%
Personal Income (Real $)	1.7%	2.3%	2.8%

The ENERGY 2020 model is a detailed fuel supply and demand model for modeling energy policy impacts on energy markets and economic activity. Baseline projections of key economic variables drive fuel demands over the long-term forecast horizon used in the impact analysis. That is, population and economic activity projections drive simulated demands for various fuels and energy stocks. The model is built on three integrated modules including an emissions, an energy demand and an energy supply module. The fuel supply and demand modules interact to determine fuel prices, investment in energy resources necessary to keep pace with demand, and emissions. Policies that impact fuel markets, in turn, influence the macroeconomy. However, the ENERGY 2020 model simulations only anticipate direct impacts on key macroeconomic variables and do not take into account secondary impacts that arise through indirect and induced effects. Calculating economic impacts requires the use of a sophisticated model that captures the major structural features of an economy, the workings of its markets, and all of the interactions between them. Because the REMI PI^+ model provides a richer set of economic linkages, ENERGY 2020 simulations are imposed on to the REMI PI^+ model for simulating macroeconomic effects of energy sector changes. The ENERGY 2020 policy simulations therefore drive the REMI PI^+ macroeconomic impact simulations. The differences in the macroeconomic impact simulation values from baseline values indicate the size of the impacts on employment and gross regional product. Setting both models to start from similar economic baseline projections assures that uneven baselines do not bias the estimated macroeconomic outcomes of energy policy changes.

Baseline REMI PI^+ projections of personal income and population are first modified to fit baseline projections of ENERGY 2020. According to Table B1 the REMI PI^+ projections of real personal income and population are lower than those for ENERGY 2020. The policy variable Compensation Rate, All Industry (share) under the Compensation, Prices and Costs block of the REMI model are progressively increased from 0 to 2.5 percent annual growth between 2010 and 2020 to nudge REMI personal income to ENERGY 2020 projections. Additionally, the Economic Migration, Total (share) policy variable under the Population and Labor Supply block is progressively increased from 0 to 1.5 percent annual growth between 2010 to 2020. The baseline projections are recalculated. However, feedback effects negated most of the direct effects on personal income and net migration. Hence, national wage rates were increased by the same extent of California to alleviate relative wage differentials to the rest of the U.S. This failed to increase personal income as labor force expansion suppressed wages. To further reconcile, total Factor Productivity, All industries (share) policy variable under the Compensation, Prices and Costs block was increased from 0 to 5 percent from 2010 to 2020 and immigration was suppressed from 0 to -4 percent over the same period. This resulted in comparable estimates of population and personal income growth. However, this process was reiterated after reconciling the industry production component of the REMI PI^+ model, described below.

ENERGY 2020 provides projected sector contributions to gross state product for 37 different business sectors. The sectors are grouped into industrial and commercial sectors, where industrial sectors comprise mostly of goods producing sectors. The ENERGY 2020 model anticipates lower industrial growth and higher commercial growth relative to the REMI model. Hence, the policy variables Industry Sales/Exogenous Production (amount) from the Output and Demand Block for all 96 REMI industrial sectors were decreased year-by-year by an equal value of 0.7% decline per year from 2010 to 2020. The same policy variables for the 68 commercial sectors were increased year-by-year by an equal value of 0.3 percent growth per year. Then each of the 169 sectors of the REMI model was aggregated to the 37 ENERGY 2020 sectors. The growth rates of each of the 37 aggregate sectors were then modified up or down according to the relative growth rates. Hence, two sets of sectoral growth projections are combined for each sector, as described in the two-part process above. The REMI baseline projections are recalculated and the process was repeated three times to approximate convergence to the ENERGY 2020 model. Unfortunately, this adjustment causes population and personal income to change, so a final iteration is required.

A final iteration of personal income and population reconciliations are performed to accommodate changes brought about by reconciling the 37 output sectors. This last set of reconciliations follows the personal income and population reconciliation described above. However, parameter bounds limited the ability to fully reconcile these two variables. In conclusion, the final average annual population growth rate of the REMI PI^+ projections was 0.2% below ENERGY 2020, and personal income was 0.5% below ENERGY 2020. We conclude that personal income and population cannot be increased further without imposing solution problems on the REMI PI^+ model.

Because the ENERGY 2020 model is an energy demand and production simulation model, whereas the REMI PI^+ model is an economic and policy impact simulation model, the treatment of energy sectors in both models differ substantially. The ENERGY 2020 model has detailed treatment of fuel consumption, supply, and prices. In this the interaction of the quantity of fuel supplied and demanded, interact with capacity and policy constraints to establish fuel prices. Increases in fuel prices spark investment in efficiency and energy production. Alternatively, the REMI PI^+ model treats energy as a factor of production whose relative cost to other regions reflects on the model region’s competitiveness in the global economy. Rather than breaking energy consumption out into detailed fuel components, REMI aggregates energy into a single relative energy cost for its 169 commercial and industrial sectors. Hence, the REMI PI^+ model lacks the underlying structure of energy markets, but accounts for energy consumption as a factor of economic activity.

REMI PI^+ does not explicitly model the demand for fuel (Treyz, Rickman and Shao, 1992). Instead a single composite factor fuel is modeled as a substitute for labor and capital within a Cobb-Douglas production function. REMI PI$^+$ simulates changes in fuel's share of total factor inputs as the change of relative cost of fuel. That is, value added output for sector *i* is modeled as,

$$VA_i = A_i(E_i)^{\alpha_i}(K_i)^{\beta_i}(F_i)^{\gamma_i},$$

where *VA* is sector *i*'s contribution to gross regional product, *A* is total factor productivity, *E* is labor, *K* is capital and *F* is fuel. The fixed coefficients, α, β and γ sum to unity. Optimizing and solving for cost minimizing labor provides,

$$E_i = (1/A_i)(w_i/\alpha_i)^{\alpha_i - 1}(c_i/\beta_i)^{\beta_i}(f/\gamma_i)^{\gamma_i}VA_i$$

Doing the same for national VA and dividing provides,

$$E_i = (1/RFPROD_i)(RLC_i)^{\alpha_i - 1}(RCC_i)^{\beta_i}(RFC_i)^{\gamma_i}(E_i^U/VA_i^U)VA_i$$

Where *RFPROD* is the ratio of state to national total factor productivities, *RLC* is the relative labor cost, *RCC* is the relative cost of capital and RFC is the relative fuel cost. A similar expression can be expressed for capital (*K*). However, *F* is not explicitly modeled. The *RFC* is simply set to a constant over the forecast horizon. It is greater than one if state fuel costs are higher than the national and less than one if lower. For California, the ratio is 1.204, suggesting that residents and businesses generally spend about 20.4 percent more per unit of energy than the national average. Policy levers that increase the cost of fuel will increase the demand for labor and capital relative to fuel, such that businesses and household become more efficient in the use of fuel. Relative fuel prices are not endogenous in the REMI PI$^+$ model. In fact, the REMI PI$^+$ model does not track the absolute price of fuel – leading many user of the REMI PI$^+$ model to rely on energy models to provide inputs to the REMI PI$^+$ model. Because relative production costs are used to drive regional competitiveness, the model traces cost changes relative to the national average when modeling regional product demand; where national costs are set to unity.

REMI's treatment of energy consumption precludes isolating absolute prices and consumption of energy by sector. The ENERGY 2020 projects fuel consumption by sector and tracks changes to fuel consumption and prices. These changes are applied to the REMI PI+ model for modeling how such changes impact households and industries. Unfortunately, REMI PI+ does not track energy consumption in absolute values like the ENERGY 2020. Rather it assumes a relative cost to national costs by industry. This hinders the ability to match energy use projections between the ENERGY 2020 and the baseline REMI PI$^+$ models. The inability to match energy expenditures one-to-one between the models may cause concern about the validity of outcomes, but we content the risks to the model simulation are minor.

REMI PI+ treats energy expenditures as a cost of production. Firms respond to increases in fuel costs by passing the costs to the customer, shifting to less-fuel intensive production or reducing production levels. The opposite is true for reductions in fuel prices. The ENERGY 2020 model provides the cost of energy changes that are then used to drive the macroeconomic responses in the REMI PI+ model. The REMI PI+ model bases sector responses on national data that reflects sector expenditures on energy consumption. However, if these specifications are not reflective of the California sectors, they may lead to over- or under estimates of the true policy costs. To test the sensitivity of the sector cost to misspecifications, several tests were conducted. Experiments with the model indicate that a 1 percent misspecification of fuel's share of total sector costs would result in only one-tenth of one percent of misallocation of costs, and even less of an impact on GSP. This is partially the result of profit maximizing assumptions of the model that establishes that firms will seek to shift inputs to minimize production costs. It also reflects the relatively small role that energy contributes to total operating costs of most sectors.

Table B2. California Sector Aggregates

Ag #	ENERGY 2020	REMI PI+
1	Agriculture	Forestry; Fishing, hunting, trapping Support activities for agriculture and forestry
2	Forestry	Logging
3	OilGasMining	Oil and gas extraction
4	Mining	Coal mining Metal ore mining Nonmetallic mineral mining and quarrying Support activities for mining
5	Construction	Construction
6	Utilities	Electric power generation, transmission, and distribution Natural gas distribution Water, sewage, and other systems
7	Lumber	Sawmills and wood preservation Veneer, plywood, and engineered wood product manufacturing Other wood product manufacturing
8	PrimaryMetals	Iron and steel mills and ferroalloy manufacturing Steel product manufacturing from purchased steel Alumina and aluminum production and processing Nonferrous metal (except aluminum) production and processing Foundries
9	FabMetals	Forging and stamping Cutlery and handtool manufacturing Architectural and structural metals manufacturing Boiler, tank, and shipping container manufacturing Hardware manufacturing Spring and wire product manufacturing Machine shops; turned product; and screw, nut, and bolt manufacturing Coating, engraving, heat treating, and allied activities Other fabricated metal product manufacturing
10	Machines	Agriculture, construction, and mining machinery manufacturing Industrial machinery manufacturing Commercial and service industry machinery manufacturing Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing Metalworking machinery manufacturing Engine, turbine, power transmission equipment manufacturing Other general purpose machinery manufacturing
11	Nonmetallic	Clay product and refractory manufacturing Glass and glass product manufacturing Cement and concrete product manufacturing Lime, gypsum product manufacturing; Other nonmetallic mineral product manufacturing
12	TransEquip	Motor vehicle manufacturing Motor vehicle body and trailer manufacturing Motor vehicle parts manufacturing Aerospace product and parts manufacturing Railroad rolling stock manufacturing Ship and boat building Other transportation equipment manufacturing
13	Computers	Computer and peripheral equipment manufacturing Communications equipment manufacturing Audio and video equipment manufacturing Semiconductor and other electronic component manufacturing

Ag #	ENERGY 2020	REMI PI^{+}
14	ElectricEquip	Navigational, measuring, electromedical, and control instruments manufacturing Manufacturing and reproducing magnetic and optical media Electric lighting equipment manufacturing Household appliance manufacturing Electrical equipment manufacturing Other electrical equipment and component manufacturing
15	Furniture	Household and institutional furniture and kitchen cabinet manufacturing Office furniture (including fixtures) manufacturing Other furniture related product manufacturing Medical equipment and supplies manufacturing Other miscellaneous manufacturing
16	Food	Animal food manufacturing Grain and oilseed milling Sugar and confectionery product manufacturing Fruit and vegetable preserving and specialty food manufacturing Dairy product manufacturing Animal slaughtering and processing Seafood product preparation and packaging Bakeries and tortilla manufacturing Other food manufacturing Beverage manufacturing Tobacco manufacturing
17	Textiles	Fiber, yarn, and thread mills Fabric mills Textile and fabric finishing and fabric coating mills Textile furnishings mills Other textile product mills
18	Apparel	Apparel knitting mills Cut and sew apparel manufacturing Apparel accessories and other apparel manufacturing Footwear manufacturing
19	Leather	Leather, hide tanning, finishing; Other leather, allied product manufacturing
20	Paper	Pulp, paper, and paperboard mills Converted paper product manufacturing
21	Printing	Printing and related support activities
22	Chemicals	Basic chemical manufacturing Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing Pesticide, fertilizer, and other agricultural chemical manufacturing Pharmaceutical and medicine manufacturing Paint, coating, and adhesive manufacturing Soap, cleaning compound, and toilet preparation manufacturing Other chemical product and preparation manufacturing Plastics product manufacturing
23	Petroleum	Petroleum and coal products manufacturing
24	OtherMfg	
25	Rubber	Rubber product manufacturing
26	Retail	Retail trade
27	Wholesale	Wholesale trade
28	Freight	Truck transportation Rail transportation Couriers and messengers
29	TransServices	Warehousing and storage
30	Passenger	Transit and ground passenger transportation
31	Pipeline	Pipeline transportation Water transportation

Ag #	ENERGY 2020	REMI PI[+]
32	Communication	Newspaper, periodical, book, and directory publishers Software publishers Motion picture and sound recording industries Internet and other information services Broadcasting (except internet) Telecommunications
33	FIRE	Monetary authorities, credit intermediation Funds, trusts, and other financial vehicles Securities, commodity contracts, and other financial investments and related activities Insurance carriers Agencies, brokerages, and other insurance related activities Real estate Automotive equipment rental and leasing Consumer goods rental and general rental centers Commercial and industrial machinery and equipment rental and leasing Lessors of nonfinancial intangible assets
34	Office	Legal services Accounting, tax preparation, bookkeeping, and payroll services Architectural, engineering, and related services Specialized design services Computer systems design and related services Management, scientific, and technical consulting services Scientific research and development services; Other professional, scientific, and technical services Advertising and related services Management of companies and enterprises Office administrative services; Facilities support services Employment services Business support services; Investigation and security services; Other support services Travel arrangement and reservation services Services to buildings and dwellings Waste collection; Waste treatment and disposal and waste management services
35	Education	Elementary and secondary schools; Junior colleges, colleges, universities, and professional schools; Other educational services
36	Health	Offices of health practitioners Outpatient, laboratory, and other ambulatory care services Home health care services Hospitals Nursing care facilities Residential care facilities Individual, family, community, and vocational rehabilitation services Child day care services
37	Recreation	Performing arts companies; Promoters of events, and agents and managers Spectator sports Independent artists, writers, and performers Museums, historical sites, and similar institutions Amusement, gambling, and recreation industries Accommodation Food services and drinking places

Appendix C. Complementary Policies Description

Complementary policies are those that may be pursued whether a cap-and-trade program is implemented or not. They include:

Pavley II Vehicle Standards. The marginal vehicle efficiency for passenger cars and light trucks is incrementally increased, beginning in 2017, to reach a new vehicle fleet of 42.5 mpg by 2020. Policy impacts include increases in expenditure for vehicles of greater efficiency and decreases in fuel expenditures.

Low-Carbon Fuel Standard (LCFS). The ethanol share of passenger ground transportation fuels is increased to approximately 18% for light vehicles and the biodiesel share of freight ground transportation is increased to approximately 15% to represent a 10% reduction in the carbon intensity of fuels by 2020. For exposition purposes biofuels from the Federal RFS are included as part of the LCFS policy. Biofuels have historically been priced above gasoline, although with federal tax credits, a maturing biofuels industry, and projected higher crude prices, the cost of producing biofuels relative to petroleum-based fuels is expected to decline within the next several years. Nevertheless, for this analysis, staff assumes that biofuels will continue to be priced above gasoline. Furthermore, it is assumed that a sufficient amount of the type of biofuels needed to comply with the standard will be available.

VMT-Reduction Measure. Vehicle miles traveled per year in California are assumed to be reduced by 4 percent by 2020. This measure is representative of changes that could occur through the implementation of SB 375—a 2008 state law to reduce GHG emissions from vehicles by redesigning communities. No assumptions are made with regard to exactly how this reduction would be achieved or the cost of achieving it.

33-Percent Renewable Portfolio Standard. The sales share of renewable electricity (not required to be in-state) is increased to 33 percent by 2020. The type of renewable generation built to meet this mandate was based on resource mix projections by the California Public Utilities commission. The costs for any new transmission needed to comply with a 33-Percent Renewable Portfolio Standard are not accounted for in the ENERGY 2020 model.

Residential and Commercial Energy Efficiency. Building and device efficiency standards and programs are assumed to reduce electricity sales by 24,200 GWh and natural gas sales by 800 million therms by 2020. The efficiency is represented in the model as an increase in device and building efficiency standards. The increased costs of actual equipment upgrades associated with these efficiency gains are captured in the model; however, utility program and administration costs are not estimated.

The availability of low-cost energy-efficiency potential is based on market failures that have prevented the penetration of energy-efficient devices among some customers. In this analysis, we assume that this efficiency potential exists without being specific as to what market failures are being corrected by the policy intervention.

Combined Heat and Power (CHP). This measure sets a target of an additional 4,000 MW of installed CHP capacity by 2020, enough to displace approximately 30,000 GWh of demand from other power-generation sources. It is assumed that the heat output of these facilities is used to serve existing or new heating loads. Increasing the deployment of efficient CHP will require addressing these barriers and instituting incentives or mandates where appropriate.

Heavy-Duty Vehicle and Marine Efficiency. This measure increases freight endues efficiency in trucks to reflect the SmartWay program of the U.S. Environmental Protection Agency (EPA), and it increases the use of on-shore electricity for ships in port.

Source: CARB. 2010. *Updated Economic Analysis of California's Climate Change Scoping Plan*. Available at: http://www.arb.ca.gov/cc/scopingplan/economics-sp/updated-analysis/updated_sp_analysis.pdf.

Appendix D. Year 2020 ENERGY 2020 Data

Table D1. Year 2020 ENERGY 2020 Investments and Expenditures Data Used in REMI Analysis (2007 M$/Yr)

	Difference from Reference Case				% Change from Reference Case		
	Case 1	Case 2	Case 5		Case 1	Case 2	Case 5
Device Investments							
Residential	686	870	954		4%	5%	6%
Commercial	1,006	1,192	2,196		13%	15%	28%
Energy Intensive	173	178	165		9%	9%	8%
Other Industry	22	21	0		4%	3%	0%
Passenger Transportation	-5,695	-6,065	-220		-4%	-4%	0%
Freight Transportation	198	204	206		7%	8%	8%
Agriculture	0	-5	-18		0%	-3%	-9%
Total	-3,609	-3,606	3,283		-2%	-2%	2%
Self Generation (CHP) Investments							
Residential	0	0	0		0%	0%	0%
Commercial	789	861	547		1480%	1613%	1026%
Energy Intensive	753	664	502		980%	865%	654%
Other Industry	641	528	376		7226%	5956%	4242%
Passenger Transportation	0	0	0		0%	0%	0%
Freight Transportation	0	0	0		0%	0%	0%
Agriculture	46	35	22		405%	311%	191%
Total	2,229	2,087	1,447		1483%	1389%	963%
Process Investments							
Residential	94	219	183		0%	0%	0%
Commercial	5	11	-60		0%	0%	0%
Energy Intensive	16	69	70		1%	4%	4%
Other Industry	4	16	19		0%	0%	0%
Passenger Transportation	0	0	0		0%	0%	0%
Freight Transportation	0	0	0		0%	0%	0%
Agriculture	-1	3	4		0%	1%	1%
Total	118	319	217		0%	0%	0%
Device O&M Expenses							
Residential	1,361	1,870	1,941		23%	32%	33%
Commercial	531	791	1,352		39%	58%	100%
Energy Intensive	533	574	591		23%	25%	26%
Other Industry	105	138	134		18%	24%	23%
Passenger Transportation	-293	-3,184	-176		0%	-4%	0%
Freight Transportation	79	933	1,002		2%	28%	30%
Agriculture	2	-9	-33		0%	-2%	-8%
Total	2,316	1,112	4,812		-2%	-2%	1%

Fuel Expenditures							
Residential	-2,301	-2,042	102		-10%	-9%	0%
Commercial	-2,373	-2,002	1,251		-13%	-11%	7%
Energy Intensive	-1,100	-1,310	-1,613		-7%	-8%	-10%
Other Industry	-609	-474	-439		-8%	-7%	-6%
Passenger Transportation	-3,953	-4,306	-1,691		-6%	-7%	-3%
Freight Transportation	-635	-1,154	-1,324		-3%	-6%	-6%
Agriculture	-134	-111	-159		-4%	-3%	-4%
Total	-11,105	-11,400	-3,874		-7%	-7%	-3%

Table D2. Year 2020 ENERGY 2020 Decomposed Utility Generating Costs Data Used in REMI Analysis (2007 M$/Yr)

	Difference from Reference Case				% Change from Reference Case		
	Case 1	Case 2	Case 5		Case 1	Case 2	Case 5
Capital Cost							
Coal	0	0	0		0%	0%	0%
NG/Oil	0	0	0		0%	0%	0%
Biomass	42	42	0		105%	105%	0%
Biogas	35	35	0		897%	897%	0%
Geothermal	67	67	0		41%	41%	0%
Hydro	1	1	0		42%	42%	0%
Wind	404	404	0		131%	131%	0%
Solar	1,322	1,322	0		565%	565%	0%
Landfill Gas	0	0	0		0%	0%	0%
Trash	0	0	0		0%	0%	0%
Nuclear	0	0	0		0%	0%	0%
Unknown	0	0	0		0%	0%	0%
Total	1,872	1,872	0		248%	248%	0%
O&M Cost							
Coal	0	-3	-3		-1%	-15%	-13%
NG/Oil	-26	-53	-32		-3%	-7%	-4%
Biomass	13	13	0		23%	23%	0%
Biogas	24	24	0		142%	142%	0%
Geothermal	86	86	0		21%	21%	0%
Hydro	0	0	0		0%	0%	0%
Wind	144	144	0		102%	102%	0%
Solar	389	389	0		591%	591%	0%
Landfill Gas	0	0	0		0%	0%	0%
Trash	0	0	0		0%	0%	0%
Nuclear	0	0	0		0%	0%	0%
Unknown	0	0	0		0%	0%	0%
Total	629	599	-35		31%	30%	-2%

Fuel Cost							
Coal	-17	-186	-167		-8%	-92%	-83%
NG/Oil	-5,623	-11,160	-7,258		-37%	-74%	-48%
Biomass	56	56	0		7%	7%	0%
Biogas	53	53	0		109%	109%	0%
Geothermal	0	0	0		0%	0%	0%
Hydro	0	0	0		0%	0%	0%
Wind	0	0	0		0%	0%	0%
Solar	0	0	0		0%	0%	0%
Landfill Gas	0	0	0		0%	0%	0%
Trash	0	0	0		0%	0%	0%
Nuclear	0	0	0		0%	0%	0%
Unknown	0	0	0		0%	0%	0%
Total	-5,530	-11,237	-7,425		-33%	-68%	-45%

Appendix E. Mapping of ENERGY 2020 Direct Economic Impacts and REMI Policy Variables

The mapping in Table C1is divided into six main sections, each of which illustrates the bridge of one of the E2020 data categories to REMI policy lever inputs. The first column shows the E2020 output data categories as well as the E2020 sectors. The second column shows the selection of policy levers in the REMI model. The third column includes notes on additional assumptions adopted in the calculation of the REMI input data.

The first set of inputs is the change in annualized device investment, which represents the capital investment in energy efficiency equipment and devices by the residential, commercial, and industrial sectors. For the non-transportation commercial and industrial sectors, the impacts of capital investment are simulated in REMI by increasing the value of the "Capital Cost" variable of individual commercial sectors and individual industrial sectors. We assume that 50% of the capital investment will come from financing and the interest payment accounts for around 30% of the total financed capital investment. The investment impacts on equipment supply sectors are simulated by increasing the value of the "Investment Spending on Producers Durable Equipment" variable in REMI. For the capital investment change in freight transportation, we change the value of the "Capital Cost" variable of the Truck Transportation sector and Rail Transportation sector. The corresponding investment impacts are the "Exogenous Final Demand" changes to the Motor Vehicle Manufacturing, Motor Vehicle Parts Manufacturing, and Railroad Rolling Stock Manufacturing sectors. Since the REMI model has a much more disaggregated sectoring scheme than the E2020 Model, we distribute the total capital cost among the relevant REMI commercial and industrial sector, and between Truck Transportation and Rail Transportation sectors using sectoral energy consumption as weights. For example, the E2020 only provides the data for the aggregated commercial sector. The total capital investment cost is distributed among the 61 non-transportation commercial REMI sectors based on the sectoral fuel consumptions. The interest payment of financed capital investment is simulated as "Exogenous Final Demand" change to the Monetary Authorities, Credit Intermediation sector. For the residential sector, the capital investment change to energy efficiency appliances and devices and the investment change to passenger cars are simulated separately. For the former, the investment expenditure changes are simulated as "Consumer Spending" change in Kitchen & Other Household Appliances and Video & Audio Goods. For the latter, we change the "Consumer Spending" in New Autos, Net Purchases of Used Autos, Other Motor Vehicles, and Motor Vehicle Parts. The baseline Personal Consumption Expenditure (PCE) weights are used to divide the spending among the various relevant consumption categories. The interest payment of financing is simulated as a change in the "Consumer Spending" in Bank services. Personal consumption on all the other goods and services is changed correspondingly. For example, if households increase their spending in efficiency appliances, we assume that the households will decrease their spending proportionally on all the other goods and services. In the REMI Model, the investment impacts on the appliances and equipment supply sectors and the vehicle and vehicle parts manufacturing sectors are forthcoming through internal linkages of the "Consumer Spending" variable and the "Exogenous Final Demand" variable of the affected manufacturing sectors. The "Capital Cost" variable is in the "Compensation, Prices, and Costs Block" of the REMI model, while the "Exogenous Final Demand", "Investment Spending on Producers Durable Equipment", "Consumer Spending (amount)" and "Consumption Reallocation (amount)" variables can be found in the "Output and Demand Block" in the REMI Model (see the five REMI major structural blocks and their key interactions in the two Figures shown in Appendix A).

The second set of inputs is the change in annualized self generation investment. This investment refers to the capital cost spent in installing Combined Heat and Power system on-site of large commercial and industrial facilities. The increased capital investment is simulated by increasing the value of the "Capital Cost" variable of individual commercial sectors and individual industrial sectors. Again, we assume that 50% of the capital investment comes from financing and the interest payment accounts for around 30% of the total financed capital investment. The corresponding stimulus effects are the "Exogenous Final Demand" of the Construction sector and Engine, Turbine & Power Transmission Equipment sector.

The third set of inputs is the change in annualized process investment. In the E2020 model, process investment represents the investment to improve building efficiency by the residential, commercial, and industrial sectors. For the commercial and industrial sectors, this is again simulated as "Capital Cost" increase of individual commercial sectors and individual industrial sectors, using the sectoral energy consumption as weight for the cost distribution. The corresponding stimulus investment impacts are simulated by increasing the "Exogenous Final Demand" of the Construction sector and the following building materials manufacturing sectors: Glass and Glass Product Manufacturing sector, Plastics Product Manufacturing sector, Other Non-Metallic Mineral Product Manufacturing sector, Veneer, Plywood, and Engineered Wood Product Manufacturing sector, Clay Product and Refractory Manufacturing sector. For the commercial sectors, we assume the split percentages among these sectors are 40%, 20%, 10%, 10%, 10%, and 10%, respectively. For industrial sectors, the assumed split percentages among these sectors are 50%, 20%, 10%, 10%, 0%, and 10%, respectively. For the residential sector, the investment expenditure on building materials are simulated as increased "Consumer Spending" in Other Durable House Furnishings (and decreasing all the other consumptions correspondingly). As for the interest payment of financing, we again change the "Exogenous Final Demand" of the Monetary Authorities, Credit Intermediation sector for the commercial and industrial sectors and change the "Consumer Spending" in Bank services for the residential sector.

The fourth set of input data is the change in O&M expenditures. For commercial and industrial sectors, this is simulated by increasing the value of the "Production Cost" variable of individual commercial sectors and individual industrial sectors. The corresponding stimulus or dampening impacts (for the increased or decreased O&M expenditures) are simulated by increasing the value of "Industry Sales" for each relevant sector (assuming the O&M activities are performed by the same sector that increases the O&M expenditure). When the production cost of the industrial and commercial sectors are increased due to the increased O&M expenditures, REMI does not automatically increase the value of industry sales to reflect the increased value of O&M. Therefore, when it is assumed that the O&M activities are preformed by the same sector that makes the O&M payments, the value of the "Production Cost" variable and the value of the "Industry Sales" variable of the same sector need to be increased in two separate steps in REMI. The "Production Cost" variable is in the "Compensation, Prices, and Costs Block" of the REMI model, while the "Industry Sales" variable can be found in the "Output and Demand Block". For the residential sector, the O&M expenditures on energy efficiency appliances and devices and on passenger vehicles are simulated by changing the "Consumer Spending" in Other Household Operation and in Motor Vehicle Repair, respectively. The consumer expenditures on all the other commodity categories are adjusted accordingly.

The five set of inputs is the change in fuel expenditures. For the non-transportation commercial, industrial, and residential sectors, the decreased fuel expenditures are simulated by decreasing the "Electricity and Natural Gas Fuel Cost" variables. The "Exogenous Final Demand" of the Electric Power Generation, Oil and Gas Extraction, Coal Mining, and Petroleum and Coal Products Manufacturing sectors is decreased to reflect the fact of reduced fossil fuel consumptions. For the transportation sector, due to the policies of Clean Car Standards and VMT reductions, the transportation fuel consumption is estimated to decline. This is simulated by decreasing the value of the "Residual Fuel Cost" variable of the Truck Transportation sector. The "Exogenous Final Demand" of the Petroleum and Coal Products Mfg sector is decreased at the same time. For the residential sector, as the consumptions in fuel commodities change, the consumption expenditures on all the other commodity categories are adjusted accordingly. As with the "Capital Cost" and "Production Cost" variables, the "Fuel Cost" variables are found in the "Compensation, Prices, and Costs Block" of the REMI model.

The last set of input data is for the Electric Power Generation sector. The changes in utility generating costs for each generation type are divided into three components: annualized capital investment, fuel expenditures, and O&M expenditures. With the replacement of fossil fuel electricity generation by renewable electricity generation, capital investment in power sector is projected to increase. The increased capital investment is simulated as a "Capital Cost" increase in the Electric Power Generation sector, while the increase in O&M expenditures and decrease in fuel expenditures are simulated by increasing or reducing the value of the "Production Cost" of the Power Generation sector. The corresponding stimulus effects are the "Exogenous Final Demand" increase of the Construction sector and Engine, Turbine & Power Transmission Equipment sector due to the increased capital investment in the power sector. The "Exogenous Final Demand" of the Coal Mining sector and Oil and Gas Extraction sector decreases due to the reduced electricity generation from fossil fuels. The "Industry Sales" of the Ag and Forestry sector increase due to the increased demand of biomass feedstock in power generation.

In REMI simulation, we also need to address issues of potential double-counting. Since the ENERGY 2020 model assumes 100 percent auction of the allowances, the data on fuel expenditure changes (in dollar terms) for the residential, commercial, and industrial sectors include the effect of allowances cost. In other words, when we use the ENERGY 2020 output data as input to REMI, the fuel expenditure data already incorporate the higher utility cost stemming from the purchases of emission allowances from auction. To avoid potential double-counting, for the Electric Power Generation sector, we only simulate in REMI the impacts of changes in capital cost, O&M cost, and fuel cost of electricity generation. The production cost increase due to the purchases of allowances is not simulated in REMI for the Electric Power Generation sector. This is because the ENERGY 2020 model runs have already assumed that all the effects of the allowance cost will pass through onto the customer sectors through electricity price increase and fuel expenditure increase of these sectors. If we simulate production cost increase for the Power Sector to reflect the allowance purchases at the same time, there will be an issue of double-counting.

In addition, changes in utility investment and utility fuel expenditures are also reflected in the price of electricity. Therefore, both the capital cost and fuel cost changes of the utility sector stemming from power generation mix and capacity changes are all reflected in the other sectors' use of electricity. Thus, including both utility investment and fuel expenditure changes along with the fuel expenditure changes of all other economic sectors simultaneously in the REMI simulation would result in some double-counting. To avoid the double-counting, we need to block the utility cost change passing onto the customer sectors through electricity price changes. Our previous experiences of REMI analysis indicate that the model automatically passes through the utility cost change onto electricity price change for the residential sector, but not to the producing sectors (commercial and industrial sectors). This is because the model treats all the fuel-producing industries differently than other producing sectors in a way that the capital and production cost changes in these sectors will not automatically pass through to the fuel buying sectors. Fuel is treated as a component of value-added in REMI, and thus it must be changed exogenously by the user. Therefore, in our case, we only need to block the utility cost pass through onto the residential sector. This is done by first running the value changes of utility generating costs in REMI. Then in the REMI output, we extract the results of residential electricity price changes in percentage terms. Next, in the second round simulation, we include all the policy variables again as in the first round simulation. However, we include one additional policy variable of residential electricity price change, with the value equal to residential electricity price change we get from the first round simulation but with a sign change, i.e., if the utility generating cost change yields a residential electricity price increase of 3% in the first round simulation, we reduce the residential electricity price by 3% in the second round simulation.

Appendix Table E1. Mapping Table of ENERGY 2020 Direct Economic Impacts and REMI Policy Variables for an Example Policy Case

ENERGY 2020 Direct Economic Impact	REMI Policy-Related Variable	Notes and Additional Assumptions
1. Change in Annualized Device Investment of the following sectors: Residential Commercial Paper Chemicals Petroleum Nonmetallic Minerals Primary Metals Mining Except Oil and Gas Oil and Gas Extraction Other Industry Passenger Transportation Freight Transportation Agriculture Waste & Other	<u>Non-Transportation Commercial and Industrial Sectors</u>: Investment Expenditure Impacts: Compensation, Prices, and Costs Block→Capital Cost (amount) for individual REMI non-transportation commercial and industrial sectors→Increase in most sectors Investment Impacts on Equipment Supply Sectors: Output and Demand Block→Investment Spending (amount)→Producers Durable Equipment→Increase Interest Payment of Financing: Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase <u>Transportation Sectors</u>: Freight Transportation: Investment Expenditure Impacts: Compensation, Prices, and Costs Block→Capital Cost (amount) for Truck Transportation sector and Rail Transportation sector→Increase Investment Impacts on Transportation Equipment Mfg sectors: Output and Demand Block→Exogenous Final Demand (amount) of the Motor Vehicle Mfg sector, Motor Vehicle Parts Mfg sector, and Railroad Rolling Stock Mfg sector→Increase Interest Payment of Financing: Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase <u>Residential Sector</u>: *Energy Efficiency Appliances and Devices*: Investment Expenditure Impacts: Output and Demand Block→Consumer Spending (amount)→Kitchen & Other Household Appliances and Video & Audio Goods→Increase Investment Impacts on Equipment Supply Sectors: Through internal linkages of the Consumer Spending variable and Final Demand variable of affected manufacturing sectors. Interest Payment of Financing: Output and Demand Block→Consumer Spending (amount)→ Bank Service Charges →Increase Consumption Reallocation among Goods: Output and Demand Block→Consumption	Changes in the value of Device Investment can be treated as capital investment to energy efficiency equipment. The REMI Model has a much more disaggregated sectoring scheme than the ENERGY 2020 model. We distribute the energy efficiency investment expenditures among relevant REMI commercial and industrial sectors using sectoral energy consumption as weights. For the Truck Transportation sector, we split the capital investment 9:1 between Motor Vehicle Mfg sector and Motor Vehicle Parts Mfg sector. We assume 50% of the capital investment will come from financing and the interest payment accounts for around 30% of the total financed capital investment.

	Reallocation (amount)→All Consumption Categories→Decrease *Passenger Cars*: Investment Expenditure Impacts: Output and Demand Block→Consumer Spending (amount)→New Autos, Net Purchases of Used Autos, Other Motor Vehicles, and Motor Vehicle Parts→Decrease Investment Impacts on Vehicle and Vehicle Parts Suppliers: Through internal linkages of the Consumer Spending variable and Final Demand variable of affected manufacturing sectors. Interest Payment of Financing: Output and Demand Block→Consumer Spending (amount)→ Bank Service Charges →Decrease Consumption Reallocation among Goods: Output and Demand Block→Consumption Reallocation (amount)→All Consumption Categories→Increase	
2. Change in Annualized self Generation Investment of the following sectors: Residential Commercial Energy Intensive Industry Mining Other Industry Passenger Transportation Freight Transportation Agriculture Waste & Other	Commercial and Industrial Sectors: Investment Expenditure Impacts: Compensation, Prices, and Costs Block→Capital Cost (amount) for individual REMI commercial and industrial sectors→Increase in most sectors Construction and Equipment Mfg sectors: Output and Demand Block→Exogenous Final Demand (amount) of Construction sector and Engine, Turbine, Power Transmission Equipment Mfg sector→Increase Interest Payment of Financing: Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase	Again, we use the sectoral energy consumption as weights to distribute the investment cost across relevant REMI commercial and industrial sectors. We assume 50% of the investment will come from financing and the interest payment accounts for around 30% of the total financed investment.
3. Change in Annualized Process Investment of the following sectors: Residential Commercial Paper Chemicals Petroleum Nonmetallic Minerals Primary Metals	Non-Transportation Commercial and Industrial Sectors: Investment Expenditure Impacts: Compensation, Prices, and Costs Block→Capital Cost (amount) for individual REMI non-transportation commercial and industrial sectors→Increase Investment Impacts on Building Materials Supply Sectors: Output and Demand Block→Exogenous Final Demand (amount) of Construction sector, Glass and Glass Product Mfg sector, Plastics Product Mfg sector, Other Non-Metallic Mineral Product Mfg sector, Veneer, Plywood, and Engineered Wood Product Mfg sector, Clay Product and Refractory Mfg sector→Increase	Process investment is investment to improve building efficiency. Again, we use the sectoral energy consumption as weights to distribute the investment cost across relevant REMI commercial and industrial sectors. For the Industrial sectors, we assume that 50% of the investment goes to the

Mining Except Oil and Gas Oil and Gas Extraction Other Industry Passenger Transportation Freight Transportation Agriculture Waste & Other	Interest Payment of Financing: Output and Demand Block →Exogenous Final Demand (amount) for Monetary Authorities, Credit Intermediation sector→Increase <u>Residential Sector</u>: Investment Expenditure Impacts: Output and Demand Block→Consumer Spending (amount)→Other Durable House Furnishings→Increase Investment Impacts on Equipment Supply Sectors: Through internal linkages of the Consumer Spending variable and Final Demand variable of affected manufacturing sectors. Interest Payment of Financing: Output and Demand Block→Consumer Spending (amount)→ Bank Service Charges →Increase Consumption Reallocation among Goods: Output and Demand Block→Consumption Reallocation (amount)→All Consumption Categories→Decrease	Construction sector, 20% to Glass and Glass Product Mfg sector, 10% to Plastics Product Mfg sector, 10% to Other Non-Metallic Mineral Product Mfg sector, and 10% to Clay Product and Refractory Mfg sector. For the Commercial sectors, we assume that 40% of the investment goes to the Construction sector, 20% to Glass and Glass Product Mfg sector, 10% to Plastics Product Mfg sector, 10% to Other Non-Metallic Mineral Product Mfg sector, 10% to Veneer, Plywood, and Engineered Wood Product Mfg sector, and 10% to Clay Product and Refractory Mfg sector.
4. Change in O&M Expenditures of the following sectors: Residential Commercial Paper Chemicals Petroleum Nonmetallic Minerals Primary Metals Mining Except Oil and Gas Oil and Gas Extraction Other Industry Passenger Transportation Freight Transportation Agriculture Waste & Other	<u>Commercial and Industrial Sectors</u>: Cost Impacts: Compensation, Prices, and Costs Block→Production Cost (amount) for individual commercial and industrial sectors→Increase in most sectors Stimulus/Dampening Impacts: Output and Demand Block→Industry Sales (amount) for each relevant commercial and industrial sector (assume the O&M activities are performed by the same sector that increases the O&M expenditure) →Increase in most sectors <u>Residential Sector</u>: *O&M of Energy Efficiency Appliances and Devices*: Cost Impacts: Output and Demand Block→Consumer Spending (amount)→Other Household Operation→Increase Stimulus Impacts: Through internal linkages of the Consumer Spending variable and Final Demand variable of affected O&M services providing sectors. Consumption Reallocation: Output and Demand Block→Consumer Reallocation (amount)→All Consumption Categories→Decrease *O&M of Passenger Vehicles*: Cost Impacts: Output and Demand Block→Consumer Spending (amount)→Motor Vehicle Repair, Rental, Leasing→Decrease	Again, we use sectoral energy consumption as weights to distribute the O&M cost across relevant REMI commercial and industrial sectors. The original O&M expenditure results yielded by the ENERGY 2020 model are unrealistically large. An adjustment factor of 0.1 is applied to reduce the original O&M expenditures before feeding them into the REMI model (as recommended by CARB).

	Stimulus Impacts: Through internal linkages of the Consumer Spending variable and Final Demand variable of affected O&M services providing sectors. Consumption Reallocation: Output and Demand Block→Consumer Reallocation (amount)→All Consumption Categories→ Increase	
5. Change in Fuel Expenditures of the following sectors: Residential Commercial Paper Chemicals Petroleum Nonmetallic Minerals Primary Metals Mining Except Oil and Gas Oil and Gas Extraction Other Industry Passenger Transportation Freight Transportation Agriculture Waste & Other	<u>Non-Transportation Commercial and Industrial Sectors</u>: Cost Impacts: Compensation, Prices, and Costs Block→Electricity Fuel Cost (share) and NG Fuel Cost (share) for individual REMI non-transportation commercial and industrial sectors→Decrease Stimulus/Dampening Impacts to energy supply sectors: Output and Demand Block→Exogenous Final Demand (amount) of Electric Power Generation, Oil and Gas Extraction, Coal Mining, and Petroleum and Coal Products Manufacturing sectors→Decrease <u>Transportation Sectors</u>: Freight Transportation: Cost Impacts: Compensation, Prices, and Costs Block→ Residual Fuel Cost (amount) for the Truck Transportation sector→Decrease Stimulus/Dampening impacts to energy supply sectors: Output and Demand Block→Exogenous Final Demand (amount) of the Petroleum and Coal Products Manufacturing sector→Decrease <u>Residential Sector</u>: *Electricity and NG*: Output and Demand Block→Exogenous Final Demand (amount) of Electric Power Generation and Oil and Gas Extraction sectors→Decrease Consumption Reallocation: Output and Demand Block→Consumer Reallocation (amount)→All Consumption Categories→Increase *Gasoline*: Output and Demand Block→Exogenous Final Demand (amount) of Petroleum and Coal Products Manufacturing sector→Decrease Consumption Reallocation: Output and Demand Block→Consumer Reallocation (amount)→All Consumption Categories→Increase	Under the policy runs, the fuel expenditures (in dollar value terms) are estimated to go up for the non-transportation commercial sector, industrial sector, and residential sector. This is mainly because of the increased energy prices stemming from the high allowance price. However, energy use in quantity terms goes down. In the calculation, we use the fuel prices that exclude the effect of permits cost to compute the final demand change to the energy supply sectors. The (excluding permits) prices are obtained from the Complementary Policies Run.
6. Generating Utility Costs:	Annualized Investments: Investment Expenditure Impacts to the Power sector: Compensation, Prices, and Costs	Capital investment in power generation is split 60:40 between sectors that

Annualized Investments Fuel Expenditures O&M	Block →Capital Cost (amount) of Electric Power Generation sector→Increase Investment Impacts on Construction and Equipment Mfg sectors: Output and Demand Block→Exogenous Final Demand (amount) of Construction sector and Engine, Turbine, Power Transmission Equipment Mfg sector→Increase O&M: Cost Impacts to the Power sector: Compensation, Prices, and Costs Block →Production Cost (amount) of Electric Power Generation sector→Increase Stimulus/Dampening Impacts: Output and Demand Block→Industry Sales (amount) of Electric Power Generation sector (assume the O&M activities are performed by the Power Generation sector) →Increase Fuel Expenditures: Cost Impacts to the Power sector: Compensation, Prices, and Costs Block →Production Cost (amount) of Electric Power Generation sector→Decrease Stimulus/Dampening Impacts: Output and Demand Block→Final Demand (amount) of Coal Mining sector and Oil and Gas Extraction sector, Proprietors' Income of the Farm sector, and Industry Sales of Ag and Forestry sector →Decrease	provide generating equipment and the construction sector for large power plants (such as coal-fired power plants), and 80:20 for smaller installations (mainly renewables).

Appendix F. INCOME DISTRIBUTION MATRIX CONSTRUCTION DETAILS

The major limitation of U.S. BLS (2010) percentile grouping was that did not readily identify the highest and lowest earners. Hence the estimates covered only 82 percent of the population as the top and bottom 9 percent of labor incomes are not identified. Moreover, the wage estimates by occupation data presented a top limit of $145,600 per year for any given observation. This meant that the data were artificially skewed to the lower end of high earning sectors and occupations.

To remedy these constraints, an extended set of percentiles (1, 5, 20, 40, 60, 80, 95, 99) were interpolated using linear estimation. Because a number of sectors exhibited non-linear properties, interpolations were based upon a smaller set of the observations. For example, if the 90th percentile wage observation was clearly higher than the sample-derived projection for it, then the 95th and 99th percentile estimations would be predicted using the mean, 75th, and 90th percentile observations only. Where a percentile observation contained the artificial $145,600 per year cap, that percentile was re-estimated. If this percentile observation were the median or below, then the mean wage estimate was substituted; otherwise interpolation was based on neighboring bracket observations. For example, if the $145,600 were in the 25 percentile observation, interpolation of the median and 10 percentiles were estimated.

The extended set of wage percentiles was then multiplied by the number of employees in that sector, and weighted by the bracket ranges. These proportions assume a uniform distribution of percentiles. For example, the 50th percentile observation reflects 10 percent of the population because the midpoints between this observation and the neighboring estimates are 45 and 55. Finally, the total wage earnings by percentile and sector are allocated to the relevant income brackets. For example, the 99th percentile estimate would be weighted by the 3 percent proportion of employees in that sector and then assigned to the relevant bracket; e.g., if the wage-income estimate were $176,000, it would be assigned to the top bracket (>$150k), and added to any other weighted estimates that fall within that bracket.

One final limitation of the data used so far was that certain sectors are not included or sufficiently disaggregated. There was no data available for Water transportation, Pipeline transportation, and Funds trusts, and other financial activities. These sectors were assumed have the same proportional income distribution as similar sectors and were scaled across using California sector labor income ratios (IMPLAN, 2007). For "Water transportation," we used neighboring transportation sectors, for "Pipeline transportation," we used Natural gas distribution, and for "Funds trusts, and other financial vehicles" we used neighboring financial activity sectors. For 24 of the 54 REMI Manufacturing sectors (various sub-sectors within metals production and fabrication, machinery, transportation equipment, furniture, food products, chemicals), data were not available. Here, data from similar sectors within the California data set were used, and scaled according to the income distributions from the U.S. national level and IMPLAN labor income ratios. A similar approach is used to disaggregate sectors for which only higher level sector data are available, i.e. Farming, Mining, Mineral product manufacturing, Electrical equipment manufacturing, Food and Tobacco manufacturing, and Textiles.

As part of the dividend income scale up, we inflated the 1982 dividend matrix income brackets using the Personal Consumption Price Index.[a] The PCE Price Index is used by REMI to adjust for inflation, so we employed the same approach to maintain consistency. For the years 1982-2007, the PCE index nearly doubled, increasing by a factor of 1.9766. The resulting brackets are rounded off to the nearest $2,500, to be consistent with government data. The total for the scaled-up 1982 income brackets are then assigned to the 2007 income brackets relative to their range. For example, if the lowest scaled-up 1982 income bracket is $10,000 and below, yet the lowest 2007 bracket is $12,500, then the 2007 lowest bracket will consist of the all the 1982 lowest-bracket value plus the relevant proportion of the second lowest bracket (in this case, 1/4).

The remaining capital-related income can be identified through three further sources. First, there is income payments associated with inter-household financial activities, which include sales of capital assets, rental income, and estate income. California Department of Finance provided aggregate data on 2007 rental income, while the California Franchise Tax Board provided data on 2005 capital transactions, as shown in Appendix Table G1. These data are used as control totals to scale down the U.S. national income distribution data for sales of capital assets and rental income from IRS (2010) as presented in Appendix Table G2. Data for estate income are not provided at the California level, and hence U.S. national income distribution data (2010) is scaled down to the California level, relative to the other inter-household financial activity data presented above.

The second source of non-dividend capital income is payments from individual sectors…farm income, farm rental income, and royalties. California Department of Finance (2010) provided aggregate data on farm income. Farm rental is assumed to be an element of farm income. Royalty income comes from a number of sources, including natural resources, patents, know-how, trademarks, literature publishing, music, art, and software. Of these, we assumed that natural resources, literature publishing, and music are those areas generating royalty income directly to households; royalty rights for the other sources are most likely to be held by companies. As such we divided the total California royalty income (California Department of Finance, 2010) among the Mining sectors, as well as the "Independent artists, writers, and performers" sector, and the "Newspaper, periodical, book, and directory publishers" sector. We used California relative share of property income for these sectors from IMPLAN (2007) as more precise data are not available to compare the size of royalties for these industries. IMPLAN data were also used to scale down property income from the U.S. to California for these sectors. We used proportions of U.S. royalty income by adjusted gross income (SOI, 2010), as presented in Appendix Table G3, to distribute royalties across income brackets.

Third is interest income, income from business and professions, partnerships and small corporations, and sale of property all with multi-sector sources. The California Franchise Tax Board provides data for these sources with some level of disaggregation for income brackets; yet no such disaggregation is available by sector. As such, for interest income we followed the advice of Li et al (1999; p. 201): "In the absence of detailed data, it is reasonable to assume that the income distribution for these income types was structurally equivalent to dividend income." Here, we mirrored industry proportions of the dividend matrix, yet weighted the total figures and income brackets to reflect the California Franchise Tax Board data. For the remaining income sources, data provided by the California Franchise Tax Board on sole proprietorships by industry are used.

The row control totals – the sums of income payments by income bracket – are the combination of data from a number of sources noted above. Total income payments per bracket are calculated by multiplying mean income per income bracket by the number of households in each bracket. The mid-point of each bracket is increased by 10 percent to account for the fact that the mean income for all households ($135,577) is in the highest bracket, and hence the distribution of income is skewed heavily to the left. In other words, within each bracket there will be a greater number at the higher end of the bracket than at the lower end. For a lack of better data, increasing the mid-point by 10 percent is a reasonable estimate of the adjustment required to produce the new mean value for each bracket.[b] Labor and capital income shares – the proportion of total personal income received from labor and capital respectively, per bracket identified from CA Franchise Tax Board (2010) are then multiplied by California total income per bracket to estimate the labor and capital income bracket control totals for California. The column control totals – i.e. the sums of income payments by sector[c]– are drawn from the IMPLAN social accounting matrix, yet scaled down to reflect total household income, and adjusted to match capital and labor income shares for the economy.

[a]There is an explanation of the Bureau of Economic Analysis calculation process for the Personal Consumption Index available at: http://www.bea.gov/national/pdf/NIPAhandbookch5.pdf

[b]The adjusted value for the $52.5 to $62.5K bracket is higher than the upper limit of the bracket. To account for this issue, we average the proportion of adjusted values to the top limit for the two adjoining brackets, and use this to estimate the mean value. The highest bracket is a unique case here, as there is no mid-point between $150k and an unknown highest income. To estimate the mean for this bracket, we take the mean value for that bracket from CFTB and scale it up by a factor of 1.5 to account for the underreporting of taxable income (e.g., non-taxable interest payments and various "tax shelters" prevalent in this bracket).

[c]Conventionally, sectors are presented in columns, and therefore the column control totals are the sector totals (i.e. a row vector of the sums of each sector); row control totals are the income bracket totals.

Appendix G. Income Distribution Data

Table G1. Selected Capital Asset Transactions, 2005 (millions of 2007 dollars)

	Gains	Losses	Total
Rental Real Estate	$0	$0	$0
Commercial Real Estate	$0	$0	$0
Other Real Estate	$2,598	$32	$2,566
Other Assets	$4,480	$4,008	$472
Unknown Assets	$3,925	$768	$3,157
Total	$11,003	$4,808	$6,195

Source: California Franchise Tax Board, 2010.

Table G2. U.S. Household Financial Activities Income Distribution Matrix, 2007 (millions of 2007 dollars)

Income bracket	Sale of Capital Assets	Rental Income	Estate Income	Total Income
<12.5k	14,425	-11,086	-537	2,801
12.5-22.5k	3,314	-1,754	131	1,691
22.5-30k	2,829	-1,257	180	1,752
30-40k	3,797	-2,523	205	1,479
40-52.5k	6,021	-2,402	265	3,884
52.5-62.5k	6,647	-1,956	341	5,032
62.5-80k	12,228	-2,944	592	9,877
80-100k	15,681	-1,998	663	14,347
100-150k	35,100	-1,496	1,349	34,953
150k+	795,632	9,834	14,919	820,384
Total	895,674	-17,581	18,107	896,200

Source: U.S. Internal Revenue Service, 2010.

Table G3. U.S. Farm, Farm Rental, and Royalty Income Distribution Matrix, 2007 (millions of 2007 dollars)

Income bracket	Farm Income	Farm Rental Income	Royalty Income
<12.5k	-5,348	147	757
12.5-22.5k	-1,321	205	352
22.5-30k	-661	74	143
30-40k	-554	198	225
40-52.5k	-1,061	221	577
52.5-62.5k	-653	182	342
62.5-80k	-1,032	360	634
80-100k	-863	532	824
100-150k	-566	409	1,416
150k+	-2,633	1,073	12,368
Total	-14,693	3,401	17,640

Source: U.S. Internal Revenue Service, 2010.

Table G4: Example of Estimated Total Income

Income Brackets	CA Households per Bracket (thousands)	Income Bracket Adjusted Mean	Total Income per Bracket (millions)
<12.5k	1,080	6,875	7,425
12.5-22.5k	830	19,250	15,978
22.5-30k	2,040	28,875	58,905
30-40k	1,250	38,500	48,125
40-52.5k	920	50,875	46,805
52.5-62.5k	1,310	60,900	79,779
62.5-80k	1,560	78,375	122,265
80-100k	920	99,000	91,080
100-150k	1,430	137,500	196,625
150k+	1,170	649,474	759,884
Total	12,510		1,426,871

Source: CA Households per Bracket from IRS; rest are author’s calculations.

Appendix H. Sectoral Results

Table H1. Sectoral Output Impacts, 2020 (billion 2007$)

	Levels, 2020				% change from Baseline, 2020		
	Scenario				Scenario		
Sector	1a	1b	3		1a	1b	3
Agriculture	21.490	21.490	21.491		0.05%	0.05%	0.05%
Forestry; Fishing, hunting, trapping	0.532	0.532	0.532		11.87%	11.87%	11.92%
Logging	1.123	1.123	1.124		-0.38%	-0.38%	-0.31%
Support activities for agriculture and forestry	4.056	4.056	4.057		0.20%	0.20%	0.23%
Oil and gas extraction	9.761	9.764	9.923		-8.19%	-8.17%	-6.68%
Coal mining	0.005	0.005	0.005		-3.68%	-3.66%	-2.82%
Metal ore mining	0.063	0.063	0.063		-3.16%	-3.16%	-3.05%
Nonmetallic mineral mining and quarrying	1.430	1.432	1.437		-3.63%	-3.61%	-3.20%
Support activities for mining	1.683	1.683	1.689		-3.07%	-3.06%	-2.75%
Electric power generation, transmission, and distribution	31.997	32.014	33.108		-10.68%	-10.63%	-7.58%
Natural gas distribution	7.759	7.764	7.770		0.85%	0.92%	1.01%
Water, sewage, and other systems	1.454	1.454	1.456		0.84%	0.89%	1.01%
Construction	98.346	98.397	98.676		-0.27%	-0.21%	0.07%
Sawmills and wood preservation	1.086	1.087	1.088		-0.39%	-0.38%	-0.22%
Veneer, plywood, and engineered wood product manufacturing	0.939	0.939	0.941		-0.41%	-0.39%	-0.17%
Other wood product manufacturing	3.269	3.270	3.278		0.04%	0.06%	0.30%
Clay product and refractory manufacturing	0.468	0.468	0.487		-4.63%	-4.61%	-0.48%
Glass and glass product manufacturing	2.260	2.260	2.349		-1.58%	-1.57%	2.32%
Cement and concrete product manufacturing	4.222	4.223	4.320		-1.00%	-0.96%	1.32%
Lime, gypsum product manufacturing; Other nonmetallic mineral product manufacturing	1.806	1.806	1.874		-2.08%	-2.06%	1.60%
Iron and steel mills and ferroalloy manufacturing	1.451	1.451	1.458		-4.00%	-3.99%	-3.53%
Steel product manufacturing from purchased steel	0.672	0.672	0.674		-1.43%	-1.41%	-1.10%
Alumina and aluminum production and processing	1.288	1.288	1.292		-5.46%	-5.45%	-5.13%
Nonferrous metal (except aluminum) production and processing	0.524	0.524	0.526		-3.29%	-3.29%	-3.16%
Foundries	1.220	1.220	1.224		1.45%	1.46%	1.80%
Forging and stamping	1.917	1.917	1.921		0.21%	0.22%	0.45%
Cutlery and handtool manufacturing	0.399	0.399	0.400		-0.05%	-0.03%	0.38%
Architectural and structural metals manufacturing	6.395	6.396	6.409		-0.24%	-0.21%	-0.02%
Boiler, tank, and shipping container manufacturing	1.282	1.282	1.284		-0.67%	-0.65%	-0.50%
Hardware manufacturing	0.352	0.352	0.353		-1.14%	-1.13%	-0.86%
Spring and wire product manufacturing	0.329	0.329	0.331		-0.38%	-0.37%	0.02%
Machine shops; turned product; and screw, nut, and bolt manufacturing	6.426	6.427	6.444		-0.17%	-0.16%	0.11%

Coating, engraving, heat treating, and allied activities	2.323	2.323	2.333		-0.35%	-0.34%	0.12%
Other fabricated metal product manufacturing	2.882	2.882	2.889		-0.39%	-0.38%	-0.17%
Agriculture, construction, and mining machinery manufacturing	1.365	1.365	1.367		-1.08%	-1.07%	-0.98%
Industrial machinery manufacturing	3.827	3.827	3.828		-0.66%	-0.66%	-0.60%
Commercial and service industry machinery manufacturing	1.671	1.671	1.672		-0.84%	-0.83%	-0.79%
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	2.043	2.043	2.046		0.25%	0.27%	0.41%
Metalworking machinery manufacturing	1.929	1.929	1.932		-1.25%	-1.25%	-1.13%
Engine, turbine, power transmission equipment manufacturing	4.232	4.232	4.234		21.39%	21.39%	21.46%
Other general purpose machinery manufacturing	3.538	3.538	3.542		-0.89%	-0.88%	-0.80%
Computer and peripheral equipment manufacturing	260.702	260.703	260.797		-0.24%	-0.24%	-0.20%
Communications equipment manufacturing	21.467	21.467	21.469		-0.57%	-0.57%	-0.55%
Audio and video equipment manufacturing	2.068	2.068	2.073		-0.51%	-0.49%	-0.28%
Semiconductor and other electronic component manufacturing	104.750	104.751	104.801		-0.32%	-0.32%	-0.28%
Navigational, measuring, electromedical, and control instruments manufacturing	39.523	39.524	39.540		-0.24%	-0.24%	-0.20%
Manufacturing and reproducing magnetic and optical media	5.863	5.863	5.867		-0.24%	-0.24%	-0.18%
Electric lighting equipment manufacturing	1.463	1.464	1.470		0.01%	0.03%	0.47%
Household appliance manufacturing	0.638	0.638	0.639		1.93%	1.93%	2.15%
Electrical equipment manufacturing	1.544	1.544	1.548		-0.62%	-0.62%	-0.37%
Other electrical equipment and component manufacturing	4.000	4.001	4.016		-0.53%	-0.52%	-0.13%
Motor vehicle manufacturing	4.766	4.767	4.789		-1.71%	-1.69%	-1.23%
Motor vehicle body and trailer manufacturing	1.288	1.288	1.294		-1.73%	-1.72%	-1.25%
Motor vehicle parts manufacturing	5.030	5.030	5.043		-1.18%	-1.18%	-0.93%
Aerospace product and parts manufacturing	24.548	24.548	24.557		-0.31%	-0.31%	-0.28%
Railroad rolling stock manufacturing	0.095	0.095	0.095		0.12%	0.14%	0.42%
Ship and boat building	1.752	1.752	1.755		0.24%	0.25%	0.48%
Other transportation equipment manufacturing	1.101	1.102	1.104		0.05%	0.06%	0.35%
Household and institutional furniture and kitchen cabinet manufacturing	3.056	3.056	3.073		1.37%	1.36%	1.94%
Office furniture (including fixtures) manufacturing	1.638	1.638	1.639		-1.22%	-1.19%	-1.12%
Other furniture related product manufacturing	0.856	0.856	0.861		2.60%	2.55%	3.11%
Medical equipment and supplies manufacturing	30.812	30.820	31.179		0.92%	0.95%	2.13%
Other miscellaneous manufacturing	12.395	12.395	12.584		-0.87%	-0.87%	0.63%
Animal food manufacturing	2.523	2.524	2.527		-0.15%	-0.14%	-0.03%

Grain and oilseed milling	2.775	2.775	2.780		-0.30%	-0.29%	-0.11%
Sugar and confectionery product manufacturing	3.316	3.318	3.319		0.41%	0.46%	0.50%
Fruit and vegetable preserving and specialty food manufacturing	13.149	13.150	13.171		0.20%	0.21%	0.37%
Dairy product manufacturing	9.960	9.964	9.957		0.59%	0.64%	0.56%
Animal slaughtering and processing	8.304	8.306	8.308		0.27%	0.30%	0.32%
Seafood product preparation and packaging	0.668	0.668	0.668		0.44%	0.45%	0.50%
Bakeries and tortilla manufacturing	6.392	6.397	6.389		0.77%	0.85%	0.73%
Other food manufacturing	9.483	9.487	9.484		0.49%	0.54%	0.51%
Beverage manufacturing	20.089	20.093	20.106		0.22%	0.24%	0.31%
Tobacco manufacturing	0.066	0.066	0.066		0.28%	0.29%	0.49%
Fiber, yarn, and thread mills	0.052	0.052	0.052		-1.33%	-1.33%	-0.81%
Fabric mills	0.248	0.248	0.249		-2.00%	-2.00%	-1.40%
Textile and fabric finishing and fabric coating mills	0.500	0.500	0.507		-1.90%	-1.90%	-0.40%
Textile furnishings mills	2.000	2.000	2.007		0.35%	0.36%	0.74%
Other textile product mills	0.474	0.474	0.476		-0.22%	-0.21%	0.20%
Apparel knitting mills	0.232	0.232	0.232		-1.32%	-1.33%	-1.32%
Cut and sew apparel manufacturing	7.137	7.137	7.138		-0.81%	-0.81%	-0.80%
Apparel accessories and other apparel manufacturing	0.296	0.296	0.296		-0.90%	-0.90%	-0.88%
Leather, hide tanning, finishing; Other leather, allied product manufacturing	0.392	0.392	0.392		-1.27%	-1.27%	-1.24%
Footwear manufacturing	0.433	0.433	0.433		-1.14%	-1.14%	-1.06%
Pulp, paper, and paperboard mills	1.828	1.828	1.838		-2.98%	-2.98%	-2.50%
Converted paper product manufacturing	5.406	5.406	5.420		-0.20%	-0.19%	0.07%
Printing and related support activities	8.461	8.461	8.472		0.26%	0.27%	0.41%
Petroleum and coal products manufacturing	49.738	49.753	50.074		-4.42%	-4.39%	-3.77%
Basic chemical manufacturing	3.613	3.613	3.638		-4.87%	-4.86%	-4.20%
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	1.517	1.517	1.526		-3.79%	-3.79%	-3.23%
Pesticide, fertilizer, and other agricultural chemical manufacturing	0.712	0.712	0.718		-8.46%	-8.46%	-7.74%
Pharmaceutical and medicine manufacturing	36.603	36.626	36.681		0.45%	0.52%	0.67%
Paint, coating, and adhesive manufacturing	1.863	1.864	1.870		-0.61%	-0.59%	-0.24%
Soap, cleaning compound, and toilet preparation manufacturing	7.578	7.580	7.578		0.04%	0.06%	0.03%
Other chemical product and preparation manufacturing	2.056	2.056	2.062		-1.37%	-1.36%	-1.08%
Plastics product manufacturing	16.531	16.532	16.579		-0.26%	-0.25%	0.04%
Rubber product manufacturing	1.244	1.244	1.254		-2.52%	-2.51%	-1.70%
Wholesale trade	271.985	271.968	272.245		0.11%	0.11%	0.21%
Retail trade	291.326	291.255	291.586		0.55%	0.53%	0.64%
Air transportation	27.752	27.750	27.787		0.62%	0.61%	0.75%
Rail transportation	3.515	3.515	3.574		0.27%	0.27%	1.96%
Water transportation	1.726	1.726	1.727		-0.02%	-0.02%	-0.01%
Truck transportation	31.068	31.066	32.351		3.48%	3.47%	7.75%
Couriers and messengers	12.278	12.278	12.295		0.65%	0.66%	0.80%

Transit and ground passenger transportation	4.985	4.986	4.985		0.70%	0.71%	0.69%
Pipeline transportation	1.263	1.263	1.278		-2.51%	-2.47%	-1.34%
Scenic and sightseeing transportation and support activities for transportation	10.982	10.981	11.005		0.32%	0.31%	0.53%
Warehousing and storage	7.281	7.281	7.309		0.61%	0.62%	1.00%
Newspaper, periodical, book, and directory publishers	21.606	21.607	21.669		1.00%	1.01%	1.30%
Software publishers	99.353	99.355	99.407		-0.28%	-0.28%	-0.23%
Motion picture and sound recording industries	68.811	68.810	68.844		0.30%	0.30%	0.35%
Internet and other information services	64.847	64.850	64.948		0.53%	0.53%	0.69%
Broadcasting (except internet)	20.596	20.596	20.641		0.78%	0.79%	1.01%
Telecommunications	123.994	124.024	124.175		0.69%	0.72%	0.84%
Monetary authorities, credit intermediation	130.848	130.880	131.291		0.87%	0.90%	1.22%
Funds, trusts, and other financial vehicles	17.149	17.133	17.184		2.02%	1.92%	2.22%
Securities, commodity contracts, and other financial investments and related activities	118.729	118.765	119.113		1.39%	1.43%	1.72%
Insurance carriers	55.098	55.084	55.131		0.89%	0.86%	0.95%
Agencies, brokerages, and other insurance related activities	25.718	25.712	25.734		0.76%	0.74%	0.82%
Real estate	405.202	405.320	405.744		0.48%	0.51%	0.62%
Automotive equipment rental and leasing	4.304	4.303	4.303		-3.13%	-3.16%	-3.14%
Consumer goods rental and general rental centers	4.992	4.991	5.006		2.36%	2.34%	2.65%
Commercial and industrial machinery and equipment rental and leasing	8.199	8.199	8.215		0.29%	0.30%	0.50%
Lessors of nonfinancial intangible assets	58.200	58.201	58.260		-0.29%	-0.29%	-0.19%
Legal services	38.110	38.119	38.120		0.48%	0.50%	0.50%
Accounting, tax preparation, bookkeeping, and payroll services	27.734	27.737	27.759		0.31%	0.32%	0.40%
Architectural, engineering, and related services	45.179	45.189	45.232		-0.10%	-0.08%	0.01%
Specialized design services	8.884	8.884	8.898		1.30%	1.31%	1.47%
Computer systems design and related services	45.166	45.168	45.201		-0.36%	-0.35%	-0.28%
Management, scientific, and technical consulting services	53.665	53.671	53.736		0.29%	0.30%	0.42%
Scientific research and development services; Other professional, scientific, and technical services	83.059	83.062	83.157		0.23%	0.23%	0.35%
Advertising and related services	16.585	16.585	16.605		0.31%	0.31%	0.42%
Management of companies and enterprises	78.994	78.993	79.100		0.17%	0.16%	0.30%
Office administrative services; Facilities support services	23.525	23.527	23.543		0.30%	0.32%	0.38%
Employment services	33.389	33.392	33.420		0.26%	0.27%	0.35%
Business support services; Investigation and security services; Other support services	35.090	35.092	35.134		0.76%	0.76%	0.88%
Travel arrangement and reservation services	4.777	4.777	4.783		0.42%	0.42%	0.54%
Services to buildings and dwellings	28.820	28.824	28.857		0.90%	0.91%	1.03%
Waste collection; Waste treatment and	11.113	11.116	11.122		0.54%	0.58%	0.63%

disposal and waste management services							
Elementary and secondary schools; Junior colleges, colleges, universities, and professional schools; Other educational services	28.003	27.980	27.979		0.89%	0.80%	0.80%
Offices of health practitioners	77.766	77.786	78.030		2.28%	2.31%	2.63%
Outpatient, laboratory, and other ambulatory care services	19.223	19.226	19.227		1.10%	1.11%	1.12%
Home health care services	14.035	14.035	14.035		0.64%	0.65%	0.65%
Hospitals	83.911	83.921	83.859		0.73%	0.74%	0.67%
Nursing care facilities	8.700	8.701	8.695		0.74%	0.74%	0.68%
Residential care facilities	8.337	8.337	8.332		0.72%	0.73%	0.67%
Individual, family, community, and vocational rehabilitation services	17.477	17.470	17.459		0.85%	0.81%	0.74%
Child day care services	7.730	7.726	7.724		0.77%	0.72%	0.69%
Performing arts companies; Promoters of events, and agents and managers	4.937	4.936	4.937		0.60%	0.58%	0.59%
Spectator sports	3.338	3.338	3.343		0.90%	0.91%	1.09%
Independent artists, writers, and performers	12.555	12.555	12.562		0.17%	0.17%	0.22%
Museums, historical sites, and similar institutions	1.990	1.990	1.990		0.89%	0.86%	0.89%
Amusement, gambling, and recreation industries	37.189	37.181	37.207		0.78%	0.76%	0.83%
Accommodation	25.646	25.641	25.666		0.58%	0.56%	0.66%
Food services and drinking places	65.852	65.838	65.757		0.80%	0.77%	0.65%
Automotive repair and maintenance	20.490	20.484	20.494		-4.90%	-4.93%	-4.89%
Electronic and precision equipment repair and maintenance	3.808	3.808	3.812		0.77%	0.78%	0.89%
Commercial and industrial equipment (except automotive and electronic) repair and maintenance	5.057	5.057	5.065		0.15%	0.16%	0.31%
Personal and household goods repair and maintenance	2.834	2.834	2.842		3.31%	3.30%	3.61%
Personal care services	6.602	6.603	6.634		2.57%	2.60%	3.05%
Death care services	1.623	1.626	1.623		0.71%	0.90%	0.66%
Drycleaning and laundry services	3.549	3.546	3.555		1.77%	1.70%	1.94%
Other personal services	17.992	17.984	18.034		1.22%	1.17%	1.45%
Religious organizations; Grantmaking and giving services, and social advocacy organizations	11.867	11.862	11.856		0.78%	0.74%	0.69%
Civic, social, professional, and similar organizations	9.208	9.206	9.209		0.63%	0.62%	0.65%
Private households	2.975	2.973	2.978		1.87%	1.79%	1.98%
Government	226.496	226.694	226.265		0.47%	0.56%	0.37%

Appendix I. Sectoral Results

Table I1. Sectoral Employment Impacts, 2020 (thousands jobs)

	Levels, 2020				% change from Baseline, 2020		
	Scenario				Scenario		
Sector	1a	1b	3		1a	1b	3
Agriculture	199.821	199.821	199.821		0.00%	0.00%	0.00%
Forestry; Fishing, hunting, trapping	5.168	5.168	5.170		11.72%	11.72%	11.76%
Logging	3.263	3.263	3.266		-0.22%	-0.21%	-0.14%
Support activities for agriculture and forestry	185.317	185.318	185.356		0.21%	0.21%	0.23%
Oil and gas extraction	15.825	15.828	16.085		-8.09%	-8.07%	-6.57%
Coal mining	0.014	0.014	0.014		-3.55%	-3.53%	-2.69%
Metal ore mining	0.219	0.219	0.219		0.00%	0.01%	0.12%
Nonmetallic mineral mining and quarrying	5.694	5.695	5.720		-0.93%	-0.91%	-0.49%
Support activities for mining	7.262	7.262	7.285		-3.03%	-3.03%	-2.72%
Electric power generation, transmission, and distribution	26.102	26.116	27.006		-9.47%	-9.43%	-6.34%
Natural gas distribution	12.249	12.257	12.268		0.88%	0.95%	1.04%
Water, sewage, and other systems	7.587	7.590	7.599		0.85%	0.90%	1.02%
Construction	780.971	781.371	783.564		-0.22%	-0.17%	0.11%
Sawmills and wood preservation	3.038	3.038	3.043		-0.33%	-0.32%	-0.16%
Veneer, plywood, and engineered wood product manufacturing	4.405	4.406	4.415		-0.34%	-0.32%	-0.10%
Other wood product manufacturing	13.869	13.871	13.904		0.08%	0.10%	0.34%
Clay product and refractory manufacturing	1.972	1.973	2.058		-4.15%	-4.13%	0.00%
Glass and glass product manufacturing	4.831	4.831	5.021		-1.08%	-1.08%	2.82%
Cement and concrete product manufacturing	17.894	17.901	18.312		-0.69%	-0.65%	1.63%
Lime, gypsum product manufacturing; Other nonmetallic mineral product manufacturing	5.758	5.760	5.973		-1.60%	-1.58%	2.07%
Iron and steel mills and ferroalloy manufacturing	1.445	1.445	1.452		-2.99%	-2.98%	-2.52%
Steel product manufacturing from purchased steel	1.671	1.671	1.677		-1.13%	-1.12%	-0.80%
Alumina and aluminum production and processing	1.652	1.652	1.657		-4.12%	-4.12%	-3.79%
Nonferrous metal (except aluminum) production and processing	0.966	0.966	0.967		-2.95%	-2.95%	-2.82%
Foundries	3.780	3.781	3.793		1.76%	1.77%	2.12%
Forging and stamping	4.928	4.928	4.940		0.26%	0.27%	0.50%
Cutlery and handtool manufacturing	1.379	1.379	1.385		0.01%	0.02%	0.43%
Architectural and structural metals manufacturing	31.673	31.681	31.741		-0.21%	-0.19%	0.01%
Boiler, tank, and shipping container manufacturing	3.756	3.756	3.762		-0.62%	-0.60%	-0.45%
Hardware manufacturing	0.772	0.772	0.774		-1.07%	-1.06%	-0.79%
Spring and wire product manufacturing	1.330	1.330	1.336		-0.32%	-0.31%	0.07%
Machine shops; turned product; and screw, nut, and bolt manufacturing	20.171	20.173	20.227		-0.15%	-0.14%	0.13%

Coating, engraving, heat treating, and allied activities	9.030	9.031	9.072		-0.26%	-0.25%	0.21%
Other fabricated metal product manufacturing	11.021	11.023	11.046		-0.35%	-0.33%	-0.13%
Agriculture, construction, and mining machinery manufacturing	2.494	2.494	2.496		-1.00%	-1.00%	-0.90%
Industrial machinery manufacturing	8.623	8.623	8.627		-0.61%	-0.61%	-0.56%
Commercial and service industry machinery manufacturing	6.887	6.887	6.890		-0.78%	-0.77%	-0.73%
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	3.886	3.887	3.892		0.28%	0.30%	0.43%
Metalworking machinery manufacturing	6.514	6.514	6.522		-1.20%	-1.20%	-1.08%
Engine, turbine, power transmission equipment manufacturing	4.160	4.160	4.162		21.00%	21.00%	21.06%
Other general purpose machinery manufacturing	8.445	8.445	8.452		-0.86%	-0.85%	-0.76%
Computer and peripheral equipment manufacturing	12.366	12.366	12.370		-0.21%	-0.21%	-0.17%
Communications equipment manufacturing	16.818	16.818	16.820		-0.52%	-0.51%	-0.50%
Audio and video equipment manufacturing	2.196	2.196	2.201		-0.48%	-0.47%	-0.26%
Semiconductor and other electronic component manufacturing	34.253	34.253	34.269		-0.26%	-0.26%	-0.21%
Navigational, measuring, electromedical, and control instruments manufacturing	63.121	63.122	63.148		-0.23%	-0.22%	-0.18%
Manufacturing and reproducing magnetic and optical media	8.254	8.254	8.259		-0.16%	-0.15%	-0.09%
Electric lighting equipment manufacturing	4.445	4.445	4.465		0.04%	0.06%	0.50%
Household appliance manufacturing	0.882	0.882	0.884		1.95%	1.96%	2.17%
Electrical equipment manufacturing	4.676	4.676	4.688		-0.59%	-0.58%	-0.34%
Other electrical equipment and component manufacturing	9.430	9.430	9.467		-0.49%	-0.48%	-0.09%
Motor vehicle manufacturing	1.777	1.777	1.785		-1.69%	-1.67%	-1.21%
Motor vehicle body and trailer manufacturing	5.348	5.349	5.374		-1.65%	-1.64%	-1.18%
Motor vehicle parts manufacturing	10.345	10.346	10.372		-1.11%	-1.11%	-0.86%
Aerospace product and parts manufacturing	50.473	50.473	50.490		-0.29%	-0.29%	-0.26%
Railroad rolling stock manufacturing	0.213	0.213	0.214		0.17%	0.18%	0.46%
Ship and boat building	5.665	5.665	5.678		0.28%	0.29%	0.51%
Other transportation equipment manufacturing	1.633	1.633	1.638		0.11%	0.12%	0.41%
Household and institutional furniture and kitchen cabinet manufacturing	14.835	14.832	14.917		1.40%	1.38%	1.96%
Office furniture (including fixtures) manufacturing	5.161	5.163	5.166		-1.16%	-1.13%	-1.06%
Other furniture related product manufacturing	3.326	3.325	3.343		2.61%	2.55%	3.12%
Medical equipment and supplies manufacturing	49.878	49.892	50.471		0.93%	0.96%	2.13%
Other miscellaneous manufacturing	26.907	26.907	27.313		-0.82%	-0.82%	0.68%
Animal food manufacturing	1.975	1.975	1.977		-0.06%	-0.05%	0.06%

Grain and oilseed milling	2.756	2.756	2.761		-0.05%	-0.04%	0.14%
Sugar and confectionery product manufacturing	4.507	4.509	4.510		0.49%	0.54%	0.58%
Fruit and vegetable preserving and specialty food manufacturing	21.116	21.119	21.151		0.26%	0.27%	0.42%
Dairy product manufacturing	12.191	12.197	12.189		0.67%	0.72%	0.65%
Animal slaughtering and processing	22.339	22.345	22.349		0.36%	0.39%	0.41%
Seafood product preparation and packaging	2.043	2.043	2.044		0.51%	0.52%	0.57%
Bakeries and tortilla manufacturing	29.393	29.414	29.380		0.84%	0.91%	0.79%
Other food manufacturing	19.857	19.866	19.859		0.56%	0.61%	0.58%
Beverage manufacturing	30.231	30.237	30.258		0.28%	0.30%	0.37%
Tobacco manufacturing	0.076	0.076	0.076		0.31%	0.32%	0.52%
Fiber, yarn, and thread mills	0.176	0.176	0.177		-1.16%	-1.16%	-0.64%
Fabric mills	1.406	1.406	1.415		-1.83%	-1.83%	-1.23%
Textile and fabric finishing and fabric coating mills	2.540	2.540	2.579		-1.53%	-1.53%	-0.03%
Textile furnishings mills	4.420	4.420	4.437		0.39%	0.40%	0.78%
Other textile product mills	3.273	3.273	3.286		-0.17%	-0.17%	0.24%
Apparel knitting mills	0.970	0.970	0.970		-1.25%	-1.26%	-1.25%
Cut and sew apparel manufacturing	31.760	31.759	31.763		-0.75%	-0.76%	-0.74%
Apparel accessories and other apparel manufacturing	1.884	1.884	1.884		-0.88%	-0.88%	-0.86%
Leather, hide tanning, finishing; Other leather, allied product manufacturing	2.412	2.412	2.413		-1.20%	-1.20%	-1.17%
Footwear manufacturing	4.247	4.248	4.251		-1.10%	-1.09%	-1.01%
Pulp, paper, and paperboard mills	1.409	1.409	1.416		-2.42%	-2.42%	-1.94%
Converted paper product manufacturing	15.856	15.858	15.898		-0.01%	0.00%	0.26%
Printing and related support activities	52.061	52.063	52.138		0.29%	0.30%	0.44%
Petroleum and coal products manufacturing	7.851	7.853	7.904		-4.29%	-4.26%	-3.65%
Basic chemical manufacturing	2.805	2.805	2.824		-3.77%	-3.76%	-3.10%
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	1.612	1.613	1.622		-2.98%	-2.98%	-2.41%
Pesticide, fertilizer, and other agricultural chemical manufacturing	1.209	1.209	1.218		-7.24%	-7.24%	-6.52%
Pharmaceutical and medicine manufacturing	53.325	53.359	53.439		0.51%	0.57%	0.72%
Paint, coating, and adhesive manufacturing	3.676	3.677	3.689		-0.29%	-0.28%	0.07%
Soap, cleaning compound, and toilet preparation manufacturing	7.687	7.689	7.687		0.28%	0.30%	0.28%
Other chemical product and preparation manufacturing	3.196	3.197	3.206		-0.98%	-0.96%	-0.69%
Plastics product manufacturing	35.799	35.803	35.905		-0.10%	-0.09%	0.19%
Rubber product manufacturing	3.506	3.506	3.535		-2.29%	-2.28%	-1.48%
Wholesale trade	767.733	767.684	768.455		0.11%	0.11%	0.21%
Retail trade	1909.332	1908.874	1911.016		0.55%	0.53%	0.64%
Air transportation	43.937	43.933	43.991		0.62%	0.62%	0.75%
Rail transportation	10.182	10.183	10.353		0.34%	0.34%	2.02%
Water transportation	3.736	3.736	3.736		0.00%	0.00%	0.02%
Truck transportation	220.586	220.570	229.630		3.57%	3.57%	7.82%
Couriers and messengers	100.241	100.244	100.382		0.67%	0.68%	0.82%

Transit and ground passenger transportation	63.328	63.335	63.317		0.72%	0.73%	0.70%
Pipeline transportation	1.393	1.394	1.410		-2.47%	-2.43%	-1.30%
Scenic and sightseeing transportation and support activities for transportation	116.926	116.918	117.172		0.41%	0.40%	0.62%
Warehousing and storage	86.591	86.594	86.923		0.55%	0.55%	0.93%
Newspaper, periodical, book, and directory publishers	65.011	65.017	65.199		0.94%	0.95%	1.23%
Software publishers	48.974	48.975	49.000		-0.26%	-0.26%	-0.20%
Motion picture and sound recording industries	137.445	137.441	137.508		0.32%	0.31%	0.36%
Internet and other information services	56.419	56.421	56.506		0.53%	0.54%	0.69%
Broadcasting (except internet)	56.164	56.165	56.286		0.78%	0.78%	1.00%
Telecommunications	116.555	116.583	116.725		0.72%	0.74%	0.87%
Monetary authorities, credit intermediation	347.867	347.954	349.042		0.90%	0.93%	1.24%
Funds, trusts, and other financial vehicles	18.149	18.132	18.185		2.01%	1.91%	2.22%
Securities, commodity contracts, and other financial investments and related activities	288.322	288.409	289.247		1.38%	1.41%	1.70%
Insurance carriers	162.494	162.454	162.591		0.89%	0.86%	0.95%
Agencies, brokerages, and other insurance related activities	153.789	153.755	153.881		0.75%	0.73%	0.81%
Real estate	1340.117	1340.509	1341.902		0.52%	0.55%	0.65%
Automotive equipment rental and leasing	31.519	31.509	31.514		-3.01%	-3.04%	-3.03%
Consumer goods rental and general rental centers	50.708	50.698	50.848		2.30%	2.28%	2.58%
Commercial and industrial machinery and equipment rental and leasing	26.789	26.792	26.844		0.31%	0.32%	0.52%
Lessors of nonfinancial intangible assets	5.016	5.016	5.021		-0.19%	-0.19%	-0.09%
Legal services	296.327	296.400	296.411		0.48%	0.51%	0.51%
Accounting, tax preparation, bookkeeping, and payroll services	299.810	299.837	300.072		0.32%	0.33%	0.41%
Architectural, engineering, and related services	330.365	330.438	330.743		-0.09%	-0.07%	0.02%
Specialized design services	78.268	78.271	78.396		1.30%	1.30%	1.46%
Computer systems design and related services	394.071	394.094	394.371		-0.33%	-0.33%	-0.26%
Management, scientific, and technical consulting services	477.449	477.502	478.073		0.31%	0.32%	0.44%
Scientific research and development services; Other professional, scientific, and technical services	267.702	267.711	268.016		0.21%	0.21%	0.33%
Advertising and related services	134.566	134.566	134.720		0.32%	0.32%	0.44%
Management of companies and enterprises	248.405	248.403	248.737		0.15%	0.15%	0.28%
Office administrative services; Facilities support services	116.109	116.124	116.199		0.31%	0.32%	0.39%
Employment services	530.900	530.939	531.372		0.26%	0.26%	0.35%
Business support services; Investigation and security services; Other support services	421.987	422.005	422.506		0.75%	0.76%	0.88%
Travel arrangement and reservation services	50.857	50.856	50.913		0.40%	0.40%	0.51%
Services to buildings and dwellings	553.501	553.584	554.207		0.86%	0.88%	0.99%
Waste collection; Waste treatment and	54.572	54.591	54.616		0.42%	0.46%	0.50%

disposal and waste management services							
Elementary and secondary schools; Junior colleges, colleges, universities, and professional schools; Other educational services	576.347	575.889	575.848		0.86%	0.78%	0.77%
Offices of health practitioners	557.942	558.082	559.822		2.24%	2.27%	2.59%
Outpatient, laboratory, and other ambulatory care services	122.211	122.223	122.231		1.07%	1.08%	1.08%
Home health care services	213.385	213.391	213.399		0.62%	0.63%	0.63%
Hospitals	492.430	492.486	492.124		0.69%	0.70%	0.62%
Nursing care facilities	150.821	150.827	150.733		0.70%	0.70%	0.64%
Residential care facilities	213.905	213.921	213.798		0.69%	0.70%	0.65%
Individual, family, community, and vocational rehabilitation services	477.706	477.517	477.215		0.77%	0.73%	0.66%
Child day care services	227.562	227.461	227.391		0.74%	0.69%	0.66%
Performing arts companies; Promoters of events, and agents and managers	73.828	73.809	73.818		0.66%	0.63%	0.64%
Spectator sports	40.590	40.595	40.664		1.03%	1.04%	1.21%
Independent artists, writers, and performers	215.390	215.388	215.501		0.11%	0.11%	0.16%
Museums, historical sites, and similar institutions	24.861	24.853	24.861		0.83%	0.80%	0.83%
Amusement, gambling, and recreation industries	354.301	354.225	354.474		0.76%	0.73%	0.81%
Accommodation	275.074	275.022	275.296		0.56%	0.54%	0.64%
Food services and drinking places	1192.641	1192.398	1190.928		0.78%	0.76%	0.63%
Automotive repair and maintenance	242.177	242.109	242.208		-4.79%	-4.82%	-4.78%
Electronic and precision equipment repair and maintenance	21.541	21.543	21.565		0.79%	0.80%	0.90%
Commercial and industrial equipment (except automotive and electronic) repair and maintenance	23.591	23.593	23.629		0.16%	0.17%	0.32%
Personal and household goods repair and maintenance	22.435	22.433	22.500		3.33%	3.31%	3.63%
Personal care services	139.515	139.548	140.166		2.53%	2.55%	3.01%
Death care services	18.765	18.801	18.756		0.66%	0.86%	0.61%
Drycleaning and laundry services	50.788	50.755	50.869		1.74%	1.67%	1.90%
Other personal services	67.029	67.002	67.184		1.24%	1.20%	1.48%
Religious organizations; Grantmaking and giving services, and social advocacy organizations	313.178	313.057	312.905		0.74%	0.70%	0.65%
Civic, social, professional, and similar organizations	118.160	118.137	118.181		0.59%	0.57%	0.61%
Private households	320.829	320.591	321.187		1.82%	1.74%	1.93%
Government	2827.730	2830.322	2824.495		0.45%	0.54%	0.33%

Appendix J. Leakage Table

Table J1. Percentage Output Change in California and in Rest of U.S., 2020
(sectors with output decrease in CA and output increase in rest of U.S. are highlighted in red)

Sector	Scenario 1a		Scenario 1b		Scenario 3	
	Output Change in CA	Output Change in Rest of US	Output Change in CA	Output Change in Rest of US	Output Change in CA	Output Change in Rest of US
Forestry; Fishing, hunting, trapping	11.87%	-0.08%	11.87%	-0.08%	11.92%	-0.08%
Logging	-0.38%	-0.04%	-0.38%	-0.03%	-0.31%	-0.01%
Support activities for agriculture and forestry	0.20%	0.04%	0.20%	0.04%	0.23%	0.04%
Oil and gas extraction	-8.19%	-1.71%	-8.17%	-1.71%	-6.68%	-1.61%
Coal mining	-3.68%	-1.00%	-3.66%	-0.99%	-2.82%	-0.79%
Metal ore mining	-3.16%	-0.10%	-3.16%	-0.10%	-3.05%	-0.08%
Nonmetallic mineral mining and quarrying	-3.63%	0.00%	-3.61%	0.00%	**-3.20%**	**0.09%**
Support activities for mining	-3.07%	-1.03%	-3.06%	-1.02%	-2.75%	-0.94%
Electric power generation, transmission, and distribution	-10.68%	-0.31%	-10.63%	-0.31%	-7.58%	-0.31%
Natural gas distribution	0.85%	-0.01%	0.92%	-0.01%	1.01%	-0.01%
Water, sewage, and other systems	0.84%	0.01%	0.89%	0.01%	1.01%	0.01%
Construction	-0.27%	-0.12%	-0.21%	-0.12%	0.07%	-0.11%
Sawmills and wood preservation	-0.39%	-0.03%	-0.38%	-0.03%	**-0.22%**	**0.002%**
Veneer, plywood, and engineered wood product manufacturing	-0.41%	-0.03%	-0.39%	-0.03%	**-0.17%**	**0.0002%**
Other wood product manufacturing	0.04%	0.00%	0.06%	0.00%	0.30%	0.03%
Clay product and refractory manufacturing	-4.63%	-0.26%	-4.61%	-0.26%	-0.48%	-0.22%
Glass and glass product manufacturing	**-1.58%**	**0.03%**	**-1.58%**	**0.04%**	2.32%	0.06%
Cement and concrete product manufacturing	-1.00%	-0.03%	-0.96%	-0.02%	1.32%	0.01%
Lime, gypsum product manufacturing; Other nonmetallic mineral product manufacturing	-2.08%	-0.04%	-2.06%	-0.03%	1.60%	-0.01%
Iron and steel mills and ferroalloy manufacturing	-4.00%	-0.12%	-3.99%	-0.11%	-3.53%	-0.09%
Steel product manufacturing from purchased steel	-1.43%	-0.07%	-1.41%	-0.07%	-1.10%	-0.05%
Alumina and aluminum production and processing	-5.46%	-0.07%	-5.45%	-0.07%	-5.13%	-0.06%
Nonferrous metal (except aluminum) production and processing	-3.29%	-0.14%	-3.29%	-0.14%	-3.16%	-0.14%
Foundries	1.45%	0.03%	1.46%	0.03%	1.80%	0.05%
Forging and stamping	0.21%	0.01%	0.22%	0.02%	0.45%	0.03%
Cutlery and handtool manufacturing	**-0.05%**	**0.02%**	**-0.03%**	**0.02%**	0.38%	0.05%
Architectural and structural metals manufacturing	-0.24%	-0.06%	-0.21%	-0.06%	-0.02%	-0.05%
Boiler, tank, and shipping container manufacturing	-0.67%	-0.01%	-0.65%	-0.01%	-0.50%	0.00%
Hardware manufacturing	-1.14%	-0.05%	-1.13%	-0.05%	-0.86%	-0.04%
Spring and wire product manufacturing	-0.38%	-0.04%	-0.37%	-0.04%	0.02%	-0.01%
Machine shops; turned product; and screw, nut,	-0.17%	-0.05%	-0.16%	-0.05%	0.11%	-0.03%

and bolt manufacturing						
Coating, engraving, heat treating, and allied activities	-0.35%	-0.04%	-0.34%	-0.04%	0.12%	-0.02%
Other fabricated metal product manufacturing	-0.39%	-0.03%	-0.38%	-0.03%	-0.17%	-0.02%
Agriculture, construction, and mining machinery manufacturing	-1.08%	-0.15%	-1.07%	-0.14%	-0.98%	-0.13%
Industrial machinery manufacturing	-0.66%	-0.01%	-0.66%	-0.01%	-0.60%	-0.01%
Commercial and service industry machinery manufacturing	-0.84%	0.00%	-0.83%	0.00%	-0.79%	0.00%
Ventilation, heating, air-conditioning, and commercial refrigeration equipment manufacturing	0.25%	-0.01%	0.27%	-0.01%	0.41%	0.01%
Metalworking machinery manufacturing	-1.25%	-0.10%	-1.25%	-0.10%	-1.13%	-0.09%
Engine, turbine, power transmission equipment manufacturing	21.39%	-0.01%	21.39%	-0.01%	21.46%	0.00%
Other general purpose machinery manufacturing	-0.89%	-0.07%	-0.88%	-0.07%	-0.80%	-0.06%
Computer and peripheral equipment manufacturing	-0.24%	-0.05%	-0.24%	-0.05%	-0.20%	-0.05%
Communications equipment manufacturing	-0.57%	-0.03%	-0.57%	-0.03%	-0.55%	-0.03%
Audio and video equipment manufacturing	-0.51%	-0.07%	-0.49%	-0.07%	-0.28%	-0.07%
Semiconductor and other electronic component manufacturing	-0.32%	-0.01%	-0.32%	-0.01%	-0.28%	-0.01%
Navigational, measuring, electromedical, and control instruments manufacturing	-0.24%	-0.03%	-0.24%	-0.03%	-0.20%	-0.03%
Manufacturing and reproducing magnetic and optical media	**-0.24%**	**0.09%**	**-0.24%**	**0.09%**	**-0.18%**	**0.09%**
Electric lighting equipment manufacturing	0.01%	-0.02%	0.03%	-0.02%	0.47%	-0.01%
Household appliance manufacturing	1.93%	0.32%	1.94%	0.32%	2.15%	0.33%
Electrical equipment manufacturing	-0.62%	-0.04%	-0.62%	-0.04%	-0.37%	-0.03%
Other electrical equipment and component manufacturing	-0.53%	-0.03%	-0.52%	-0.03%	-0.13%	-0.02%
Motor vehicle manufacturing	-1.71%	-0.29%	-1.69%	-0.28%	-1.23%	-0.20%
Motor vehicle body and trailer manufacturing	-1.73%	-0.25%	-1.72%	-0.25%	-1.25%	-0.18%
Motor vehicle parts manufacturing	-1.18%	-0.11%	-1.18%	-0.11%	-0.93%	-0.08%
Aerospace product and parts manufacturing	-0.31%	-0.01%	-0.31%	-0.01%	-0.28%	-0.01%
Railroad rolling stock manufacturing	0.12%	-0.02%	0.14%	-0.01%	0.42%	0.01%
Ship and boat building	0.24%	0.00%	0.25%	0.00%	0.48%	0.01%
Other transportation equipment manufacturing	0.05%	-0.01%	0.06%	-0.01%	0.35%	0.00%
Household and institutional furniture and kitchen cabinet manufacturing	1.37%	0.07%	1.36%	0.07%	1.94%	0.11%
Office furniture (including fixtures) manufacturing	-1.22%	-0.11%	-1.19%	-0.11%	-1.12%	-0.10%
Other furniture related product manufacturing	2.60%	0.05%	2.55%	0.04%	3.11%	0.07%
Medical equipment and supplies manufacturing	0.92%	-0.01%	0.95%	-0.01%	2.13%	0.00%
Other miscellaneous manufacturing	-0.87%	0.00%	**-0.87%**	**0.001%**	0.63%	0.00%
Animal food manufacturing	**-0.15%**	**0.04%**	**-0.14%**	**0.04%**	**-0.03%**	**0.05%**
Grain and oilseed milling	**-0.30%**	**0.04%**	**-0.29%**	**0.04%**	**-0.11%**	**0.05%**
Sugar and confectionery product manufacturing	0.41%	0.02%	0.46%	0.02%	0.50%	0.02%

Fruit and vegetable preserving and specialty food manufacturing	0.20%	0.02%	0.21%	0.02%	0.37%	0.02%
Dairy product manufacturing	0.59%	0.02%	0.64%	0.02%	0.56%	0.02%
Animal slaughtering and processing	0.27%	0.06%	0.30%	0.06%	0.32%	0.06%
Seafood product preparation and packaging	0.44%	0.05%	0.46%	0.05%	0.50%	0.05%
Bakeries and tortilla manufacturing	0.77%	0.02%	0.85%	0.02%	0.73%	0.01%
Other food manufacturing	0.49%	0.01%	0.54%	0.01%	0.51%	0.01%
Beverage manufacturing	0.22%	0.02%	0.24%	0.02%	0.31%	0.02%
Tobacco manufacturing	0.28%	0.03%	0.29%	0.04%	0.49%	0.05%
Fiber, yarn, and thread mills	-1.33%	-0.04%	-1.33%	-0.04%	-0.81%	-0.01%
Fabric mills	-2.00%	-0.17%	-2.00%	-0.17%	-1.40%	-0.15%
Textile and fabric finishing and fabric coating mills	-1.90%	-0.03%	-1.90%	-0.03%	-0.40%	-0.01%
Textile furnishings mills	0.35%	0.03%	0.36%	0.04%	0.74%	0.06%
Other textile product mills	-0.22%	0.00%	**-0.21%**	**0.0003%**	0.20%	0.02%
Apparel knitting mills	-1.32%	-0.11%	-1.33%	-0.11%	-1.32%	-0.12%
Cut and sew apparel manufacturing	**-0.81%**	**0.11%**	**-0.81%**	**0.11%**	**-0.80%**	**0.10%**
Apparel accessories and other apparel manufacturing	-0.90%	-0.01%	-0.90%	-0.01%	-0.88%	-0.01%
Leather, hide tanning, finishing; Other leather, allied product manufacturing	-1.27%	-0.02%	-1.27%	-0.02%	-1.24%	-0.03%
Footwear manufacturing	-1.14%	-0.13%	-1.14%	-0.13%	-1.06%	-0.12%
Pulp, paper, and paperboard mills	-2.98%	-0.04%	-2.98%	-0.04%	-2.50%	-0.02%
Converted paper product manufacturing	**-0.20%**	**0.04%**	**-0.19%**	**0.04%**	0.07%	0.05%
Printing and related support activities	0.26%	0.03%	0.27%	0.03%	0.41%	0.04%
Petroleum and coal products manufacturing	-4.42%	0.00%	-4.39%	0.00%	**-3.77%**	**0.01%**
Basic chemical manufacturing	-4.87%	-0.06%	-4.86%	-0.06%	-4.20%	-0.04%
Resin, synthetic rubber, and artificial synthetic fibers and filaments manufacturing	-3.79%	-0.05%	-3.79%	-0.05%	-3.23%	-0.03%
Pesticide, fertilizer, and other agricultural chemical manufacturing	-8.46%	-0.42%	-8.46%	-0.42%	-7.74%	-0.42%
Pharmaceutical and medicine manufacturing	0.45%	0.00%	0.52%	0.00%	0.67%	0.00%
Paint, coating, and adhesive manufacturing	-0.61%	0.00%	**-0.59%**	**0.001%**	**-0.24%**	**0.02%**
Soap, cleaning compound, and toilet preparation manufacturing	0.04%	0.06%	0.06%	0.06%	0.03%	0.06%
Other chemical product and preparation manufacturing	-1.37%	0.00%	**-1.36%**	**0.005%**	**-1.08%**	**0.02%**
Plastics product manufacturing	**-0.26%**	**0.03%**	**-0.25%**	**0.03%**	0.04%	0.05%
Rubber product manufacturing	-2.52%	-0.16%	-2.51%	-0.16%	-1.70%	-0.13%
Wholesale trade	0.11%	-0.03%	0.11%	-0.03%	0.21%	-0.02%
Retail trade	0.55%	-0.02%	0.53%	-0.02%	0.64%	-0.01%
Air transportation	0.62%	0.04%	0.61%	0.04%	0.75%	0.06%
Rail transportation	0.27%	-0.09%	0.27%	-0.09%	1.96%	-0.05%
Water transportation	-0.02%	0.00%	-0.02%	0.00%	**-0.01%**	**0.0001%**
Truck transportation	3.48%	0.09%	3.47%	0.09%	7.75%	0.14%
Couriers and messengers	0.65%	0.00%	0.66%	0.00%	0.80%	0.01%

Transit and ground passenger transportation	0.70%	0.05%	0.71%	0.05%	0.69%	0.06%
Pipeline transportation	-2.51%	-0.37%	-2.47%	-0.36%	-1.34%	-0.29%
Scenic and sightseeing transportation and support activities for transportation	0.32%	0.01%	0.31%	0.01%	0.53%	0.02%
Warehousing and storage	0.61%	0.00%	0.62%	0.00%	1.00%	0.03%
Newspaper, periodical, book, and directory publishers	1.00%	0.06%	1.01%	0.06%	1.30%	0.09%
Software publishers	-0.28%	-0.07%	-0.28%	-0.07%	-0.23%	-0.06%
Motion picture and sound recording industries	0.30%	0.00%	0.30%	0.00%	0.35%	0.00%
Internet and other information services	0.53%	0.00%	0.53%	0.00%	0.69%	0.01%
Broadcasting (except internet)	0.78%	-0.02%	0.79%	-0.02%	1.01%	-0.01%
Telecommunications	0.69%	-0.02%	0.72%	-0.02%	0.84%	-0.01%
Monetary authorities, credit intermediation	0.87%	0.01%	0.90%	0.01%	1.22%	0.03%
Funds, trusts, and other financial vehicles	2.02%	0.00%	1.92%	0.00%	2.22%	0.01%
Securities, commodity contracts, and other financial investments and related activities	1.39%	0.06%	1.43%	0.07%	1.72%	0.09%
Insurance carriers	0.89%	0.02%	0.86%	0.02%	0.95%	0.03%
Agencies, brokerages, and other insurance related activities	0.76%	0.02%	0.74%	0.02%	0.82%	0.03%
Real estate	0.48%	-0.01%	0.51%	-0.01%	0.62%	0.00%
Automotive equipment rental and leasing	-3.13%	-0.12%	-3.16%	-0.12%	-3.14%	-0.12%
Consumer goods rental and general rental centers	2.36%	0.11%	2.34%	0.11%	2.65%	0.13%
Commercial and industrial machinery and equipment rental and leasing	0.29%	-0.04%	0.30%	-0.04%	0.50%	-0.02%
Lessors of nonfinancial intangible assets	-0.29%	-0.15%	-0.29%	-0.14%	-0.19%	-0.13%
Legal services	0.48%	0.00%	0.50%	0.00%	0.50%	0.00%
Accounting, tax preparation, bookkeeping, and payroll services	0.31%	0.00%	0.32%	0.00%	0.40%	0.01%
Architectural, engineering, and related services	-0.10%	-0.06%	-0.08%	-0.06%	0.01%	-0.06%
Specialized design services	1.30%	-0.02%	1.31%	-0.02%	1.47%	-0.01%
Computer systems design and related services	-0.36%	-0.07%	-0.35%	-0.07%	-0.28%	-0.06%
Management, scientific, and technical consulting services	0.29%	-0.02%	0.30%	-0.01%	0.42%	0.00%
Scientific research and development services; Other professional, scientific, and technical services	0.23%	-0.03%	0.23%	-0.03%	0.35%	-0.02%
Advertising and related services	0.31%	-0.01%	0.31%	-0.01%	0.42%	0.00%
Management of companies and enterprises	0.17%	-0.02%	0.17%	-0.02%	0.30%	-0.01%
Office administrative services; Facilities support services	0.30%	-0.01%	0.32%	-0.01%	0.38%	0.00%
Employment services	0.26%	-0.01%	0.27%	-0.01%	0.35%	0.00%
Business support services; Investigation and security services; Other support services	0.76%	0.00%	0.76%	0.00%	0.88%	0.01%
Travel arrangement and reservation services	0.42%	0.02%	0.42%	0.02%	0.54%	0.03%
Services to buildings and dwellings	0.90%	0.00%	0.91%	0.00%	1.03%	0.01%
Waste collection; Waste treatment and disposal and waste management services	0.54%	-0.01%	0.58%	-0.01%	0.63%	0.00%

Elementary and secondary schools; Junior colleges, colleges, universities, and professional schools; Other educational services	0.89%	0.01%	0.81%	0.01%	0.80%	0.01%
Offices of health practitioners	2.28%	0.10%	2.31%	0.10%	2.63%	0.13%
Outpatient, laboratory, and other ambulatory care services	1.10%	0.07%	1.11%	0.07%	1.12%	0.08%
Home health care services	0.64%	0.02%	0.65%	0.02%	0.65%	0.02%
Hospitals	0.73%	0.02%	0.74%	0.02%	0.67%	0.02%
Nursing care facilities	0.74%	0.05%	0.74%	0.05%	0.68%	0.05%
Residential care facilities	0.72%	0.04%	0.73%	0.04%	0.67%	0.04%
Individual, family, community, and vocational rehabilitation services	0.85%	0.02%	0.81%	0.02%	0.74%	0.02%
Child day care services	0.77%	0.03%	0.72%	0.03%	0.69%	0.03%
Performing arts companies; Promoters of events, and agents and managers	0.60%	0.05%	0.58%	0.05%	0.59%	0.05%
Spectator sports	0.90%	0.07%	0.92%	0.08%	1.09%	0.10%
Independent artists, writers, and performers	0.17%	0.02%	0.17%	0.02%	0.22%	0.03%
Museums, historical sites, and similar institutions	0.89%	0.01%	0.86%	0.01%	0.89%	0.02%
Amusement, gambling, and recreation industries	0.78%	0.04%	0.76%	0.04%	0.83%	0.04%
Accommodation	0.58%	0.05%	0.56%	0.05%	0.66%	0.06%
Food services and drinking places	0.80%	0.01%	0.78%	0.01%	0.65%	0.01%
Automotive repair and maintenance	-4.90%	-0.09%	-4.93%	-0.09%	-4.89%	-0.08%
Electronic and precision equipment repair and maintenance	0.77%	-0.02%	0.78%	-0.02%	0.89%	-0.01%
Commercial and industrial equipment (except automotive and electronic) repair and maintenance	0.15%	-0.01%	0.16%	-0.01%	0.31%	0.00%
Personal and household goods repair and maintenance	3.31%	0.09%	3.30%	0.09%	3.61%	0.11%
Personal care services	2.57%	0.15%	2.60%	0.15%	3.05%	0.19%
Death care services	0.71%	0.03%	0.91%	0.05%	0.66%	0.03%
Drycleaning and laundry services	1.77%	0.01%	1.70%	0.01%	1.94%	0.02%
Other personal services	1.22%	-0.03%	1.17%	-0.03%	1.45%	-0.02%
Religious organizations; Grantmaking and giving services, and social advocacy organizations	0.78%	0.04%	0.74%	0.04%	0.69%	0.03%
Civic, social, professional, and similar organizations	0.63%	0.02%	0.62%	0.02%	0.65%	0.03%
Private households	1.87%	-0.05%	1.79%	-0.05%	1.98%	-0.03%
Total	**0.19%**	**-0.03%**	**0.20%**	**-0.02%**	**0.41%**	**-0.01%**

Appendix K. Income Distribution Impacts for Selected Sectors

Appendix Table K1 shows the income distribution impacts of the ten sectors with greatest benefits from the revenue recycling in Scenario 1a. Column 2 of this table shows that sectoral outputs for Case 1/ Scenario 1a are consistently larger than Case 1/ pre-recycling. As shown in the last column of Table Appendix K1, these benefits are passed on to the highest income bracket at a disproportionate rate.

Appendix Table K1: Ten Sectors with Greatest Benefits from Revenue Recycling in Scenario 1a

Sectors	Output, Difference between Scenario 1a and Case 1 pre-recycling	Income, difference between Scenario 1a and Case 1 pre-recycling			
		62.5-80k	80-100k	100-150k	150k+
Retail trade	1.212	33.75	22.63	78.25	374.83
Government	0.999	119.07	95.91	194.92	263.65
Real estate	0.770	13.08	15.87	46.21	401.12
Wholesale trade	0.682	13.77	13.26	41.06	220.43
Construction	0.571	29.66	12.76	12.20	145.10
Offices of health practitioners	0.488	8.61	7.30	12.41	257.42
Monetary authorities, credit intermediation	0.446	16.53	9.24	30.28	193.90
Securities, commodity contracts, and other financial investments and related activities	0.440	17.77	12.30	59.31	46.41
Food services and drinking places	0.337	3.99	4.36	5.90	33.21
Telecommunications	0.335	6.41	4.61	13.03	113.40
⋮	⋮	⋮	⋮	⋮	⋮
Total	11.114	429.24	318.76	748.43	3303.98

Appendix Table K2 shows the top 10 sectors with the greatest positive differences and the top 10 with the greatest negative differences in terms of gross output impacts between Scenario 1a and 1b.

Appendix Table K2. Income Distribution Proportions of Sectors Most Influential to Gini Results

Sector	Difference in Gross Output Impacts (1a –1b)	Edition	<12.5k	12.5-22.5k	22.5-30k	30-40k	40-52.5k	52.5-62.5k	62.5-80k	80-100k	100-150k	150k+	Total
Top 10 Sectors Scenario 1a yields higher absolute gross output impacts than Scenario 1b													
Retail trade	64.78	Ref*	0.0%	1.4%	4.5%	3.5%	3.4%	3.9%	5.5%	3.7%	12.8%	61.2%	100.0%
		Sen*	0.0%	1.6%	5.0%	4.2%	4.1%	4.5%	6.3%	4.1%	12.2%	57.9%	100.0%
Education	26.09	Ref	0.0%	0.9%	5.5%	4.1%	3.9%	10.0%	11.5%	9.5%	18.2%	36.4%	100.0%
		Sen	0.0%	1.1%	6.0%	4.6%	4.5%	10.6%	12.3%	9.2%	15.3%	36.4%	100.0%
Wholesale trade	17.06	Ref	0.0%	0.7%	2.7%	2.2%	2.0%	3.1%	4.3%	4.1%	12.7%	68.1%	100.0%
		Sen	0.0%	0.9%	3.1%	2.8%	2.6%	3.8%	5.3%	4.7%	12.6%	64.1%	100.0%
Insurance carriers	16.38	Ref	0.4%	0.4%	3.8%	3.2%	3.2%	5.4%	8.3%	5.7%	18.9%	50.7%	100.0%
		Sen	0.3%	0.5%	4.2%	3.8%	3.8%	6.2%	9.3%	5.7%	18.1%	48.1%	100.0%
Funds, trusts, and other financial vehicles	16.11	Ref	1.6%	0.3%	3.8%	4.8%	3.8%	5.2%	8.2%	4.8%	17.8%	49.8%	100.0%
		Sen	1.5%	0.4%	4.2%	5.6%	4.5%	5.9%	9.2%	4.9%	16.8%	47.2%	100.0%
Food services and drinking places	15.05	Ref	0.3%	19.2%	27.3%	11.3%	3.3%	4.4%	2.9%	3.1%	4.3%	23.9%	100.0%
		Sen	0.2%	21.0%	28.0%	12.2%	3.7%	4.6%	3.2%	3.1%	4.6%	19.4%	100.0%
Amusement, gambling, and recreation industries	7.92	Ref	6.0%	3.9%	9.1%	5.8%	3.1%	4.9%	4.6%	2.4%	6.1%	54.0%	100.0%
		Sen	5.4%	4.5%	10.3%	6.7%	3.7%	5.4%	5.8%	3.9%	8.2%	46.2%	100.0%
Other personal services	7.49	Ref	0.1%	0.3%	0.6%	0.3%	0.3%	0.2%	1.1%	1.2%	3.1%	92.8%	100.0%
		Sen	0.1%	0.5%	2.0%	0.7%	0.7%	1.0%	3.4%	4.8%	9.9%	77.0%	100.0%
Individual, family services	7.18	Ref	0.4%	1.2%	5.7%	4.8%	3.4%	7.5%	9.8%	6.8%	11.0%	49.3%	100.0%
		Sen	0.4%	1.3%	6.0%	5.3%	3.9%	7.7%	10.1%	6.2%	9.0%	50.2%	100.0%
Automotive repair and maintenance	6.26	Ref	0.1%	0.1%	0.5%	0.5%	0.6%	1.1%	0.8%	1.1%	2.2%	93.1%	100.0%
		Sen	0.1%	0.1%	0.8%	0.6%	0.7%	1.3%	1.2%	1.4%	3.5%	90.4%	100.0%
Top 10 Sectors Scenario 1a yields lower absolute gross output impacts than Scenario 1b													
Gov & Other	-198.38	Ref	0.1%	0.5%	3.3%	3.6%	4.0%	10.0%	13.9%	11.2%	22.7%	30.7%	100.0%
		Sen	0.1%	0.5%	3.7%	4.3%	4.8%	12.2%	16.3%	12.2%	25.4%	20.5%	100.0%
Real estate	-124.85	Ref	0.3%	0.4%	1.4%	0.9%	0.9%	1.5%	2.6%	3.2%	9.2%	79.6%	100.0%
		Sen	0.3%	0.8%	3.3%	1.6%	1.6%	2.7%	5.7%	7.7%	17.4%	58.9%	100.0%
Construction	-63.01	Ref	0.0%	0.3%	4.0%	4.3%	4.7%	7.3%	11.8%	5.1%	4.8%	57.7%	100.0%
		Sen	0.3%	0.8%	3.3%	1.6%	1.6%	2.7%	5.7%	7.7%	17.4%	58.9%	100.0%
Securities, commodity …	-30.94	Ref	0.6%	0.5%	4.1%	4.2%	4.8%	7.0%	10.3%	7.1%	34.4%	26.9%	100.0%
		Sen	0.6%	0.4%	4.5%	4.9%	5.7%	7.5%	11.1%	6.8%	28.3%	30.2%	100.0%
Petroleum and coal products manufacturing	-29.20	Ref	2.0%	0.3%	2.3%	2.6%	2.6%	4.5%	7.5%	4.7%	7.0%	66.6%	100.0%
		Sen	1.9%	0.4%	2.8%	3.4%	3.4%	5.4%	9.3%	6.1%	8.8%	58.5%	100.0%
Monetary authorities, credit intermediation	-27.66	Ref	0.1%	0.2%	2.8%	3.6%	2.6%	3.6%	5.8%	3.2%	10.6%	67.5%	100.0%
		Sen	0.1%	0.3%	3.1%	4.4%	3.2%	4.6%	7.1%	3.6%	14.1%	59.5%	100.0%
Telecommunications	-26.57	Ref	0.1%	0.3%	1.6%	1.8%	1.5%	3.2%	4.3%	3.1%	8.7%	75.6%	100.0%
		Sen	0.1%	0.4%	2.3%	2.7%	2.3%	5.4%	7.4%	5.7%	14.3%	59.4%	100.0%
Pharmaceutical and medicine manufacturing	-25.66	Ref	0.5%	0.4%	1.7%	1.5%	1.5%	2.8%	5.6%	5.0%	12.6%	68.4%	100.0%
		Sen	0.5%	0.6%	2.6%	2.2%	2.2%	3.8%	7.3%	6.2%	12.5%	62.2%	100.0%
Offices of health practitioners	-19.84	Ref	0.2%	0.3%	2.4%	1.5%	1.3%	2.2%	2.8%	2.4%	4.0%	82.9%	100.0%
		Sen	0.1%	0.4%	2.6%	1.7%	1.5%	2.3%	3.0%	2.4%	4.3%	81.8%	100.0%
		Ref	1.2%	0.5%	1.9%	2.2%	1.7%	3.7%	8.5%	2.4%	4.7%	73.2%	100.0%

Electric power generation…	-18.76	Ref	1.2%	0.5%	1.9%	2.2%	1.7%	3.7%	8.5%	2.4%	4.7%	73.2%	100.0%
		Sen	1.2%	0.6%	2.6%	3.0%	2.4%	5.4%	11.2%	4.5%	8.5%	60.8%	100.0%
Economy-wide Average Income Distribution		**Ref 1a**	4.3%	1.2%	4.2%	3.0%	2.6%	3.6%	5.3%	3.8%	8.0%	59.8%	100.0%
		Sen 1a	5.0%	1.4%	4.9%	3.6%	3.2%	4.2%	6.3%	4.5%	9.5%	57.5%	100.0%
		Ref 1b	4.4%	1.2%	4.3%	3.0%	2.6%	3.6%	5.3%	3.8%	8.0%	60.1%	100.0%
		Sen 1b	5.0%	1.4%	4.9%	3.6%	3.2%	4.2%	6.3%	4.5%	9.5%	57.5%	100.0%

* "Ref" represents the reference income distribution case analyzed in this study. "Sen" represents the sensitivity test that decreases pre-policy, economy-wide income for the highest bracket by 7 percent.