Assessing the Economic Impacts of Large Scale Environmental Regulations in California

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Abstract

California is a leader in the use of environmental regulation and is now considering unilateral measures to reduce greenhouse gasses and conventional pollution from automobiles and trucks. These measures range from the aggressive use of conventional technologies to increase mileage to the use of fuel cell cars. This chapter takes the availability and cost estimates of fuel reducing and pollution reducing technologies as given and investigates the economic (apart from environmental) costs and benefits. The method of analysis is to use a computable general equilibrium model of the California economy.

Introduction

This chapter presents the methodology and results of assessing the impacts of large scale environmental policies on the California economy. California has an economy approximately the size of France, yet being a state rather than a nation, it has no monetary policy and only limited scope for fiscal policy. As a state, it also does not have well measured trade, workforce, or capital flows. The effect of these factors on estimates of policy cost will be explained below. The chapter proceeds from methodological issues, to runs of the policy model, and finally to a discussion of the impact on openness on costs.

The methodology employed is computable general equilibrium (CGE) modeling. CGE models are designed to capture the fundamental economic relationships between producers, consumers, and government.[1] The models are "computable" because numeric solutions are found using computers rather than solved for algebraically. They are "general" in the sense that all markets and all income flows in the economy are accounted for. They reflect "equilibrium" insofar as prices adjust to equilibrate the demand for and supply of goods, services, and factors of production (labor and capital).

The specific models employed here are modified versions of E-DRAM (Environmental-Dynamic Revenue Analysis Model). E-DRAM was built for the California Environmental Protection Agency's Air Resources Board (ARB) by researchers at the University of California, Berkeley (UCB). E-DRAM evolved from DRAM (Dynamic Revenue Analysis Model), which was developed jointly by the California Department of Finance (DOF) and Berkeley researchers to perform dynamic revenue analyses of proposed legislation as mandated by California State Senate Bill 1837 in 1994.

The types of regulations considered for pollution control vary considerably. The ubiquitous target is the control of motor vehicle emissions. California was the pioneer in requiring lower emissions from passenger cars. Since there was no reasonable way for California to clean up its air and meet the requirements of the Clean Air Act while using the Federal standards for automobiles, California was (and is) permitted to set more stringent standards than the Federal standards. Success in reducing auto emissions matched with California's continuing non-attainment requires further actions to clean up the air.

The actions to clean up the air are codified in the State Implementation Plan under the Clean Air Act, which is promulgated by CAL EPA/ARB and must be accepted by the US EPA. The major areas for reducing air pollution have been stationary sources, consumer chemicals, automobiles, and now trucks.

Stationary sources, like automobiles before them, have been very tightly regulated. The original means of regulation was to require emissions limits based upon known technologies. In the case of the South Coast Air Basin (LA), such regulations weren't stringent enough to clean the air. A cap and trade program, called RECLAIM, was instituted in that air basin for sulfur oxide (SOX) and nitrogen oxide (NOX) in order to reduce pollution beyond what could be accomplished with known technologies at reasonable cost. Each year, fewer permits are issued, which controls the output from the larger stationary sources at a predetermined level.

Automobiles, as was already mentioned, are already tightly controlled. Future controls include a mandate for zero emissions vehicles, though as of this writing it is not clear whether that mandate will continue in the face of nearly no emission hybrids, which are currently commercially viable.

Uncontrolled until recently, trucks, buses, construction equipment and other diesel equipment are now a major remaining source of pollution, particularly of less than 10 micron particulates. Further controls on this category of polluters are under consideration. There are many consumer products (like spray paint, hairspray, etc.) that are now falling under regulation, and further regulation is in store for this category of goods.

Taken together, these categories of goods account for much of the economic costs of air pollution control.

The California legislature has gone further, at least in its studies, than conventional pollution control, to an examination of strategies to reduce greenhouse gasses. Potential fuel saving or fuel substitution scenarios which we have evaluated for the legislature go much further in changing the makeup of output than previous regulations.

In California, air pollution control is a potentially large constraint on economic activity. The research reported in this chapter was done in the course of providing studies for the State Implementation Plan for the clean air act and for a series of petroleum sparing potential scenarios.

This chapter will consider three policy options, a tax option, a collection of policies aimed at pollution, and a collection of policies aimed at attaining fuel efficiency. They will be compared in the conclusion.

The next section is a non-technical description of E-DRAM. Section III outlines modifications made to E-DRAM for this project. Section IV presents baseline solutions to the model for the years 1999 and 2020. Section V evaluates various policy scenarios in 1999 and 2020. Section VI offers concluding remarks.

A Description of the E-DRAM Model

E-DRAM describes the relationship among California producers, California households, California governments, and the rest of the world. Rather than tracking each individual producer, household, or government agency in the economy, however, E-DRAM combines similar agents into single sectors. Constructing a cogent sectoring scheme, the first step of model construction, is discussed immediately below; this discussion is followed by a description of the key agents in the economy—producers and consumers.

For the E-DRAM model, the California economy has been divided into 93 distinct sectors: 29 industrial sectors, two factor sectors (labor and capital), nine consumer good sectors, nine household sectors, one investment sector, 45 government sectors, and one sector representing the rest of the world. These aggregates generally represent the major industrial and commercial sectors of the California economy, though a few are tailored to capture sectors of particular regulatory interest. For instance, production of internal combustion engines and consumer chemicals are each delineated as distinct sectors.[2]

Data for the industrial sectors originate from the U.S. Department of Commerce's Bureau of Economic Analysis (BEA), and is based on the Census of Business—a detailed survey of U.S. companies conducted every five years.[3] The survey contains information about intermediate purchases, factor (labor, capital, land and entrepreneurship) payments, and taxes. Although quite extensive, the survey only allows inference about groups of firms at the national level. The conversion of national data to updated California data is accomplished using a combination of state level employment data and estimates from DOF's econometric modeling.

Like firms, households are also aggregated. California households are divided into categories based upon their income. There are seven such categories in the model, each one corresponding to a California Personal Income Tax marginal tax rate (0, 1, 2, 4, 6, 8, and 9.3 percent). Household income data come from the California Franchise Tax Board Personal Income Tax "sanitized" sample. Data on consumption by income class is derived from national survey data.

Firms are assumed to maximize profits.

Households make two types of decisions: they decide to buy goods and services; they also decide to sell labor and capital services. They are assumed to maximize utility. Household demand functions are estimated from the U.S. Bureau of Labor Statistics' Consumer Expenditure Survey data. Labor supply is taken from published literature.

In addition to the household and firm decisions described, firms have an investment function that depends upon their aftertax rate of return and households have migration functions dependent, inter alia, on their after tax real wage.

Governments are represented in great detail. California government is assumed to have a balanced budget. Increased taxes fund education according to state law (Proposition 98) and the remaining funds are allocated in proportion to historic levels. Deductibility of state from federal income taxes is also accounted for.

The model calculates the prices (relative to a base of one) which clear all of the markets.

The figure below shows the flows in the model. For instance, households pay money (dotted line) for goods and services (solid line) and supply factors—labor and capital—(solid line) and receive income (dotted line).

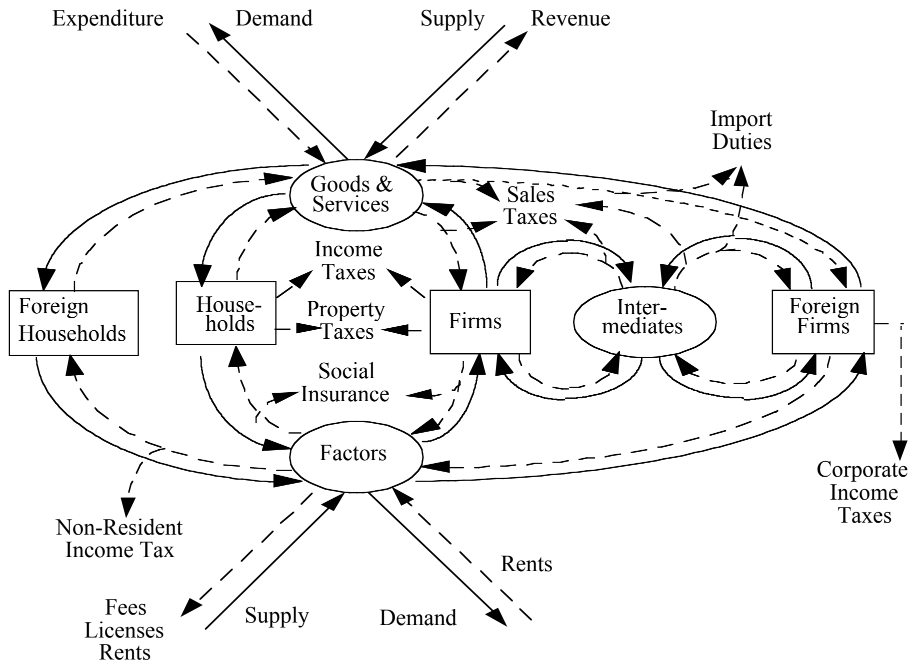

Figure 1. The Complete Circular-Flow Diagram

Regional and National Model Differences

Regional, or sub-national, CGE models are very similar in design to national and international models, but exhibit major differences in several key assumptions. The seven most important differences between national and regional CGE models are discussed below.

The first, and maybe most important, difference is that regional CGE models do not require that regional savings equal regional investment. When Californians save more than California investors want to use, excess savings flow out of the state. When the converse is true, savings flow into the state. Rational economic agents would not accept less interest on their savings from California investors if higher interest rates were available in other states or countries. Conversely, rational investors in California would not pay higher interest for the use of Californian savings if other states or countries offered lower rates.

The second difference is that regional economies trade a larger share of their output. Therefore, trade is more important in regional models. Note that interstate trade is part of the Rest of the World for California but ignored in national considerations of trade.

The third difference is that regional economies face larger and more volatile migration flows than nations. Regional and international migration to California is a major factor in the State's economy.

The fourth difference between national and regional CGEs is that regional economies have no control over monetary policy. The Federal Reserve is responsible for monetary policy and is a national institution.

The fifth difference is that in regional models taxes are interdependent through deductibility. Some local taxes are deductible from incomes subject to California personal income taxes and bank and corporation taxes. Some local and state taxes are deductible from incomes subject to federal personal income tax and may be eligible for deduction from corporate incomes for federal purposes. In E-DRAM, the personal tax deductibility is explicitly modeled. Since corporate deductibility is more uncertain and since the apportionment rules may reduce the connection to federal corporate taxes, corporate deductibility has not been included in E-DRAM.

Sixth, while good data for a CGE are hard to find at the national level, in many cases they are nonexistent for regional economies. The E-DRAM uses published economic and statistical literature to simulate much of the data important to our model. In some cases, such as labor supply, a wide variety of results are presented in the literature. This problem is addressed in three ways: (1) values are chosen so as to avoid the extremes, (2) the model is tested to determine the degree to which results are dependent upon our assumptions (this process is called “sensitivity analysis”), and (3) the use of published literature, especially of national results, has been minimized.

Seventh, the California CGE differs from a national CGE in that California faces a balanced-budget requirement. Even if this is ignored in the short run, bond markets tend to reflect this fact. When California issued bonds to cover short-term deficit spending in the early 1990s, bond ratings forced up the cost of borrowing. Ultimately, California would face unreasonable borrowing costs should it decide to maintain this level of borrowing.

Future Models and the Petroleum Sector

For examining petroleum dependency issues in particular, the E-DRAM built for ARB as described in Berck and Hess (Feb. 2000) is enhanced in three ways. First, Petroleum sector data is modified. Second, the 1998/1999 base year model is extrapolated out to 2020 and 2050 based on state population, personal income, and industry-specific forecasts. Third, parameters to adjust for technological change in the form of increased fuel efficiency and fuel displacement are incorporated into the model.

E-DRAM's original industrial accounts are national accounts scaled to the state level using California employment data. These accounts have been reconciled with more California-specific Petroleum sector figures, originally sourced from US Energy Information Administration data.

Estimates for 2020 and 2050 were obtained by first determining the overall demand for finished products. This was estimated from the CEC projections of baseline fuel demands (CEC, 2001). Fuel use was projected to grow at rates between 1.6% for gasoline and 3.4 percent for jet fuel. In line with recent experience, California refinery capacity is assumed to increase at one-half percent per year until 2020 and then not at all. Lack of additional refinery capacity is a consequence of environmental restrictions, including regulation under the Clean Air and Clean Water Acts. CEC estimates of the price of crude oil for 2020/bbl were $22.50, only slightly higher than today. Non-energy related items were increased at an average annual growth rate of 2.84% for the years 2000 to 2020; an average annual growth rate of 2.58% was assumed for 2020 to 2050.

DOF projections suggest a California population growth rate of 1.36% annually. Compounding this rate delivered scale factors for re-basing employment data. Based on these growth factors, a model was constructed for 2020. Since population growth is slower than output growth, the model assumes a modest degree of labor augmenting technical progress. Table 1 below displays some of the salient characteristics of the projections incorporated in the 2020 based model and allows comparison with the 1999 based model.

Table 1. Model Data for 1999 and 2020

	1999 Model	2020 Model
CA Output ($Billion)	1378.0905	3078.0223
CA Pers. Income ($Billion)	892.4894	2009.5373
Labor Demand (Millions)	14.0483	18.6605
Energy Minerals		
Output ($Billion)	5.8789	6.2086
Jobs (Millions)	0.0178	0.0182
Imports ($Billion)	17.5404	36.0105
Exports ($Billion)	0.4375	1.0965
Petroleum Refining		
Output ($Billion)	24.8156	39.3048
	0.0	0.0
Jobs (Millions)	220	292
	2.8	15.
Imports ($Billion)	058	6834
	6.4	11.
Exports ($Billion)	746	9979

Three Types of Policies

With these preliminaries behind us, three possible environmental policies will be described and evaluated. The first policy is a simply tax on fuel. While a tax is the answer most prescribed by economists to compensate for an externality, it does not perform in the context of an open economy nearly as well as other possible measures. The actual measures chosen to reduce pollution in California are standards for both mobile and stationary sources. The next experiment is a package of such measures, scaled to the same magnitude as the tax. The measures are broadly representative of the additional measures California is now considering to meet its obligations under the clean air act. The final experiment comes from a study of fuel saving policies and is far larger in its costs than either of the two previous measures.

Taxes

From the point of view of a State, the ideal tax on the petroleum industry is a sales tax on refinery product independent of origin. Such a tax does not disadvantage California refineries relative to out of state refineries and discourages use and refining, both polluting activities. California law makes it easier to levy a tax that is tied to an environmental purpose than to levy a general tax increase. It is doubtful that a tax that also fell upon out of state refiners could be justified under this tied theory by appealing to the environmental benefit of discouraging refining. To achieve the favored legislative treatment the tax would also need to be dedicated to an environmental purpose such as cleaning up refineries or brown fields. Here we consider the simple sales tax on petroleum, levied on all sales to California entities by the petroleum refining sector. The tax falls upon jet fuel (J4), diesel, and of course gasoline. Since the E-DRAM production technology is Leontief in intermediate goods, the model response is to consume less of the goods that are petroleum intensive. In this case, the possibility of fuel switching seems quite low, so the only avenue available to respond to high price is conservation. The model, however, fixes the technologies available and the higher prices do not call forth more high fuel-efficiency cars, trucks, and jets. In the consumer sector, the elasticity of demand is -.2, which accords well with published studies, although those studies also do not have a time period long enough for vehicle fleets to change.

The experimental tax is set at $500 million and it levied as a sales tax upon first the energy minerals sector and then the petroleum sector. The California demand for these sectors is 23 billion and 21 billion dollars respectively. The required sales tax rates are 2.2 and 2.4 percent respectively. California imports approximately three-quarters of its energy minerals, largely oil and gas. On the other hand, it is a net exporter of refined products. In these experiments, the revenues from the tax are spent in the same way as other general fund revenues. The results are in table 2. The tax on energy minerals decreases personal income by 970 million dollars while the tax on the refined product reduces personal income by the somewhat smaller 860 million dollars. The mechanism by which personal income is reduced is first by diverting income from people to the government, where it is spent, and second by making California products more expensive, reducing both external and internal demand. The reduction in demand in turn lowers real labor incomes and drives people out of the California labor market (either by being non-participants or by migration). The demand for labor decreases by 5,000 and 8,000 for the two taxes. The taxes on petroleum and on energy minerals have nearly the same effect on petroleum supply and demand. In theory the tax on energy minerals should have been superior since taxing petroleum allows the import of refined products and discourages export, but the model results are simply very close.

Adding a rebate of $500 million to the bank and corporation taxes brings personal income back above the base level. This is a clear double dividend effect. However, the increased level of economic activity brings with it additional pollution and that too returns to above the base line level. In this model pollution is more sensitive to the level of economic activity than to the price of the necessary input.

The inability of the model to produce a substantial decrease in pollution when a tax is applied is a direct result of a low elasticity of demand for refined product. The following simulations all have regulations that force changes in the technology, presumably changes that consumers and firms would not make without much more drastic price changes.

Table 2. Pollution Tax

	Today	Tax on ENMIN	Tax plus B&C	Tax on PETRO	Tax plus B&C
Pers. Income	891.7924	890.8225	892.1676	890.9243	892.27
Labor demand	14.04438	14.03724	14.04233	14.03626	14.04135
ENMIN Demand	22.98002	22.82141	22.82423	22.91646	22.91939
ENMIN Supply	5.880738	5.766593	5.768016	5.853002	5.854437
PETRO Demand	21.14617	21.08048	21.06924	21.01005	20.999
PETRO Supply	24.81637	24.57412	24.56372	24.66112	24.65092
NOX Tons Per Day	3071.29	3067.38	3071.977	3069.795	3074.395

Source: Computed. Notes: Pers. Income is personal income, ENMIN is the energy minerals sector, PETRO is the petroleum refining sector. All figures are for California only.

SIP Pre-studies

In preparing the State Implementation plan under the clean air act, CAL ARB examined a large number of pollution control scenarios. These differ from the fuel-saving scenarios discussed later, in targeting sectors of the economy beyond transportation and also in not having tangible fuel saving benefits. The scenario is evaluated here for the year 1999, and the 2020 results were very similar. The total cost of the control measures was scaled to be $500 million, which is somewhat less than the packages of measures currently under consideration. The policies consist of requiring that transport vehicles, consumer chemicals (like hairspray), and some other manufactured and service products be made in a more expensive and less polluting fashion. The additional expense is modeled as an increase in the purchases of intermediate goods by the sectors that produce these outputs. ARB estimates that the benefits to consumers from the measures would be more than twice the costs. The model doesn't account for these benefits of the measures, cleaner air, and as a result shows that people would emigrate from California. One way to include the benefits is simply to assume that the measures benefits would outweigh the costs in the migration decision, and therefore a second scenario was run in which migration was constrained to zero. In that case the losses in personal income were less. However, workers still have less disposable income and respond with lower labor force participation rates. Table 3 provides a short form of the results. These exercises show that the costs to the State of pollution control are greater than the static costs, but are still less than the benefits.

Table 3. Pre-Sip Studies

FUB99I	TODAY	SIP	No Migration
Ca Output ($Billion)	1377.413813	1376.4573	1376.6695
Change CA Output		-0.956513	-0.744352
CA Personal Income ($Billion)	891.792411	890.94384	891.09303
Change CA Pers. Inc.		-0.848567	-0.699381
Labor Demand (Millions)	14.044381	14.038663	14.040936

Reduce Petroleum Dependence Strategies

Below we analyze one of four alternate strategies for reducing California's petroleum dependence that were developed for the Legislature. The scenario chosen for analysis has the largest cost-benefit ratio. Each scenario is built around two elements: (1) reduced gasoline demand from improved light-duty vehicle fuel economy, and (2) diesel fuel displacement from gas-to-liquid (GTL) or Fischer Tropsch diesel fuels. The scenarios were constructed to try to "bound" the possible impacts to the California economy. Scenario 1 combines off-the-shelf fuel efficiency improvements in light-duty vehicles with a 33 percent blend of FTD in diesel fuel to meet ARB's future ULSD specification. Scenario 2 is like scenario 1, but includes more fuel saving technology. Conversely, Scenarios 3 and 4 incorporate more aggressive and therefore more costly fuel efficiency or displacement options. Scenario 2 is presented in detail below.

Each scenario is modeled and coded as some combination of increased transportation costs and altered—generally decreased—fuel costs. The rationale is that more efficient transportation is costlier to produce, but saves fuel.

The CEC estimates that residential use accounts for roughly 90% of gasoline consumption in the state. Hence, 90% of projected increases in engine costs are apportioned to household and 10% are apportioned to industries. Likewise, 90% of projected fuel savings are apportioned to households and 10% are apportioned to industries.

ACEE-Advanced Fuel Economy Improvements

Scenario 2 incorporates fuel economy technologies in light-duty vehicles. In this case, technology costs and benefits were determined from ACEEE analysis for advanced fuel economy improvements. It was assumed that these improvements would be implemented in all new light-duty passenger cars and trucks starting in 2008.

Table 4 shows our estimates of the economic inputs for modeling.

Table 4. Estimated Economic Inputs for Scenario 2: ACEE-Advanced Fuel Economy Improvements

Changes in Consumer Expenditures	Million 2002 $ 2020	Changes in Sector Revenue	Million 2002 $ 2020
Cost		Benefit	
Household (inc. vehicle cost)	4,197	Vehicle Mfg. (inc. vehicle revenue)	4,197
Household (inc. PZEV cost)	501	Vehicle Mfg. (inc. PZEV revenue)	501
Commercial (inc. GTL-diesel cost)	125	Foreign GTL Producer (inc. revenue)	125
Total Cost	4,824	Total Benefits	4,824
Benefits		Cost	
Household (dec. gasoline expenditure)	9,284	Refiners (decrease in revenue)	7,246
		California Excise Tax (dec. revenue)	1,019
		Federal Excise Tax (dec. revenue)	1,019
Total Benefits	9,284	Total Costs	9,284

Scenario 2 is implemented in the following manner.

The cost of consumer transportation (CTRNS) increases by 90% of projected consumer cost. These additional costs are inserted such that the new, higher amount of consumer transportation spending is expressed as the appropriate multiple of old spending.

The cost of industrial engines increases by 10% of the projected consumer cost, plus the commercial costs. These additional costs are inserted such that the new, higher amount of industrial spending on engines is expressed as the appropriate multiple of old spending.

Similarly, 90% of the projected savings from increased fuel efficiency accrue to consumers. These savings are inserted such that the new, lower amount of consumer fuel spending is expressed as the appropriate fraction of old spending.

10% of the projected savings from increased fuel efficiency accrue to industry. These savings are inserted such that the new, lower amount of industrial spending on fuel is expressed as the appropriate multiple of old spending.

Table 5 below compares selected results for base model and Scenario 2 runs of E-DRAM. Results show that Scenario 2 slightly reduces state output (by 0.26% in 2020) while leaving state personal income essentially unchanged. Real personal income remains constant while output falls because of increased consumer purchasing power due to improved fuel efficiency. Results indicate that the price of consumer fuel – interpreted as the price of vehicle miles traveled – is roughly 9% lower in Scenario 2 than in base.

Increased fuel efficiency reduces the demand for refined petroleum products. E-DRAM predicts petroleum sector output being 12% lower in 2020 under Scenario 2 vs.

base. Decreased petroleum sector output adversely affects upstream crude oil suppliers. The model predicts energy and mining sector output being 7% lower in 2020 under Scenario 2 than base.

Money freed from fuel expenditure is spent in other sectors. Scenario 2 raises both food and apparel sector output by 6-7% over base.

Table 5. Fuel Saving Technology

	BASE MODEL	SCNRIO2
CA Output ($Billion)	3078.0223	3070.0183
CA Personal Income ($Billion)	2009.5373	2010.4295
Labor Demand (Millions)	18.6605	18.7119
ENMIN		
Output ($Billion)	6.2086	5.7836
% Change Output	0.08%	-6.84%
Imports ($Billion)	36.0105	32.6693
% Change Imports	0.07%	-9.28%
Exports ($Billion)	1.0965	1.1419
% Change Exports	-0.07%	4.15%
Petro		
Output ($Billion)	39.3048	34.7300
% Change Output	0.07%	-11.64%
Imports ($Billion)	15.6834	15.3455
% Change Imports	0.01%	-2.15%
Exports ($Billion)	11.9979	12.2159
% Change Exports	-0.02%	1.82%

Sensitivity Analysis

The fuel saving scenario was subjected to several sensitivity analyses. Making the demand for fuel more elastic decreases the fuel savings because fuel saving is equivalent to decreasing the price of miles driven. Making the supply curve of the rest of the world of refined and crude product less elastic (2 to 0.1) shifts more of the burden of the decreased demand to the California energy sector and lowers state output. Conversely, if the decrease in demand were taken up in its entirety by decreased imports, all fuel saving scenarios would lead to much higher California output and income. The rationing of rights to use clean air in California is a reason to believe that California refineries are earning above market returns—more California competition is precluded. However, the same regulatory scheme increases the cost of operating locally and militates for the opposite conclusion. At present, the California refinery capital stock includes at least one economically marginal large refinery and on balance it is likely that a decrease in output would be taken up partially locally and partially from imported product. As far as the California welfare is concerned, this split is not known and crucial. The final sensitivity experiment was to increase the price of crude petroleum—it is held at its current value in the experiments, since forecasts for large increases have so far been false. With higher 20% higher crude prices, fuel saving results in about $20 billion more in income and output.

Conclusions

Prediction is always a sobering exercise, making apparent a very limited knowledge of future possibilities. Besides the usual problem of estimating workforce and output for twenty years hence, future CGEs require a host of details, including the technology (here pessimistically assumed to be constant at today's level for the use of intermediate goods), tastes (people are implicitly still assumed to want today's vehicle mix and SUV's), and trade relations. The last of these is particularly troubling for the petroleum saving strategies. The building of the model assumes that nearly all of California's energy will be imported at prices as favorable as today. It seems that if the whole world were modeled as growing as in the 2020 scenarios, the energy sector would require considerable non-oil output to meet the predicted demand at the predicted price. Generating the 2020 scenario and then asking how it would change with changed policy assumes a lot. It assumes that a 2020 economy can be achieved that looks a lot like a scaled version of a 2000 economy.

Taxes fare very poorly as an instrument for pollution control in this model. Low elasticity of demand for petroleum means that they have little deadweight loss, but also little effect. When a more distorting tax is rebated (Bank and Corporation Taxes, in this model) to keep a balanced budget, there is indeed a double dividend and income rises. However, there is also a double whammy, and pollution increases with income. A large income elasticity and small price elasticity make this result a certainty. This is a new reason why taxes don't work.

The pre-SIP study experiments are all about changing technology to be less polluting. These experiments introduce new (and less efficient from a money perspective) technologies. Most of these measures are not energy saving, and some are energy using, so a tax on petroleum will not call most of them into use. Indeed pollution has such large effects on health and crops that these measures are believed to have benefits in excess of twice their costs. The economy-wide costs are only slightly larger than the direct costs, particularly if one believes that people will remain in California with cleaner air.

Taken in sum, the result of these simulations is that pollution and energy control is possible at acceptable economic cost, even if unilaterally undertaken by California. The surprise in these simulations is how ineffective taxes are at controlling pollution or energy use. Put differently, the simulations show how much people are willing to pay to continue with larger vehicles.

End Notes

[1] The explanation which follows is closely adapted from "Dynamic Revenue Analysis for California" (Berck, *et. al.*, Summer 1996), available at www.dof.ca.gov/HTML/FS_DATA/dyna-rev/dynrev.htm; chapters cited in sections of this report refer to chapters of that document.

[2] The alcohol, tobacco, and horse racing sector, distinct in DRAM, is been folded into the foods sector in the latest version of E-DRAM.

[3] The survey is conducted in years ending in 2 and 7 and data is released after processing. E-DRAM uses data from the 1997 release, which contains processed 1992 survey data.