Public Finance Solutions to Vehicle Emissions Problems in California

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Abstract

All urban centers in California violate the Federal standard for ozone. So far, the State has addressed vehicle emission problems with a variety of mandates. In contrast, economic theory suggests that costs of achieving air quality can be minimized by the use of incentive policies such as permits, taxes, or subsidies. The purpose of the research described in this monograph is to explore incentive programs that might be added to the State's repertoire of effective vehicle pollution reduction policies. The monograph is not very technical in nature, but it explains our theoretical approach, numerical simulation model, and statistical estimation.

We find that a single rate of tax on emissions is most efficient. A vehicle-specific gas tax or a miles-specific vehicle tax can attain the same efficient outcome. Uniform rates that incorporate heterogeneity are "second-best". A combination of three uniform rates can attain 71 percent of the gain from the emissions tax. A gas tax alone can attain 62 percent of the emissions tax gain. A subsidy to new vehicles would be regressive. A tax on gasoline is not regressive across the lowest incomes but is regressive from middle to high incomes.

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Summary

Over the last few decades, air quality in California has improved. Yet all urban centers and many other areas of the state still violate the Federal standard for ozone. Even more areas violate the stricter California State standard. The San Joaquin and South Central Coast Air Basins are considered to be in "serious" nonattainment of the standard, while Sacramento and the Southeast Desert Modified Air Quality Management Area are in "severe" nonattainment. As is well known, the Los Angles area is in "extreme" nonattainment of the national ozone standard.

So far, and with some success, the State of California has addressed vehicle emission problems with a variety of mandates and restrictions. These command and control (CAC) regulations can guarantee vehicle emission reductions, but they do not provide much flexibility. In contrast, economic theory suggests that costs of achieving any particular level of air quality can be minimized by the use of incentive policies such as permits, taxes, or subsidies. If an individual has to pay the price of a permit or pay a tax per unit of emissions, then that individual has the incentive to find all of the cheapest and most convenient ways to reduce emissions.

The purpose of the research described in this monograph is to explore incentive programs that might be added to the State's repertoire of effective vehicle pollution reduction policies. The monograph is not very technical in nature. Rather, it is meant to explain fully and intuitively some recent results in academic research, with full citations to technical working papers and publications in academic journals. After Chapter 1's introduction, Chapter 2 summarizes California's vehicle pollution trends over time, the attainment of standards, and the costs of doing so. Then Chapter 3 discusses actual vehicle pollution control policies in California, and Chapter 4 describes important criteria for the comparison of various CAC and incentive policies.

Methodology and Data

Our own framework of analysis begins with Chapter 5. Initially, we consider a world where an ideal emissions tax is available and perfectly enforceable, and we use it to calculate the theoretically-ideal set of driving behaviors that would minimize the costs of achieving a given air quality. We then suppose that the ideal emissions tax is *not* available, and we consider alternative instruments.

We take three approaches to this problem. First, in Chapter 5, we build a theoretical model to identify the circumstances under which a set of taxes and subsidies on market transactions is logically identical to the emissions tax. Second, in Chapter 6, we build a computer model to simulate the effects of alternative policy instruments that are not identical to the emissions tax. We use a large set of data that captures considerable heterogeneity among households, and we use specific assumptions about costs and tastes. Using this model, we then calculate the effects of each policy. Third, in Chapter 7, we develop statistical models to estimate demands for car characteristics and fuels. This estimation accounts for the simultaneity of these choices: the demand

for gasoline depends on the type of car, and the demand for each type of car depends on the price of gasoline.

To conduct our simulations and estimation, we use data from the 1994 Consumer Expenditure Survey (CEX) and the California Air Resources Board (CARB). The CEX includes each household's income, gasoline expenditures, other expenditures, and automobile characteristics including make, model, vintage, and number of cylinders. The CARB data contain information on the fuel efficiency and emissions of hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x) from 345 cars tested in California between November 1995 and March 1997. We match cars from the CEX with information on identical cars in the CARB data.

Major Findings

A single rate of tax on emissions is most efficient.

In the model described in Chapter 5, we find that a single rate of tax on emissions of all different consumers will minimize the total cost of pollution abatement, even as it induces each consumer to change behavior to a different extent for each method of pollution abatement (such as buying a smaller car, newer car, better pollution control equipment, cleaner gas, or less gas). But emissions are not a market transaction and are easy to hide. Next, therefore, we rule out the emissions tax and consider alternatives.

A vehicle-specific gas tax or a miles-specific vehicle tax can attain the same efficient outcome.

The same efficient outcome attained by an emissions tax can be achieved by other policies. In each case, such a policy must affect all the same behaviors in the same way. The second policy we consider is a complicated gas tax, one that depends on the characteristics of the vehicle at the pump. If purchasers realize *how* their payments depend on these choices, then the gas tax itself can present them with incentives to buy smaller cars, newer cars, more pollution control equipment, and less gasoline. On the other hand, for this tax to be assessed, cars would need to be equipped with tamper-resistant computer chips.

A tax on the vehicle that depends upon the characteristics of the vehicle and the miles driven each year also achieves the same efficient outcome. If vehicle size and age were the determinants of emissions per mile *(EPM)*, then a tax rate per mile for that vehicle could be calculated on the basis of its size and age, and then multiplied by the year's miles to calculate the tax due. On the other hand, this policy requires yearly odometer readings, and it is thus subject to tampering. Thus we turn to other policies that might be more feasible and enforceable but that might *not* achieve the first-best efficient outcome.

Uniform rates that incorporate heterogeneity are "second-best".

More-realistic alternatives might be limited to charging the same uniform rate for all consumers — one tax rate per unit of engine size, one tax rate that depends on vehicle age, and one tax rate on each grade of gasoline, no matter who buys it. Therefore the fourth policy we consider is a simple use of our formulas that were derived for individual-specific optimal tax rates. Policymakers could just insert into those formulas the average engine size, average vehicle age, and average mileage. This single set of tax rates based on those average characteristics could then be applied to everybody's engine size, vehicle age, and use of gasoline. This procedure does not take advantage of available information *other than* those simple averages.

In general, available data can be used to calculate not only average size, age, and mileage, but also the correlations among these variables. If individuals with bigger cars also tend to choose more than average mileage, or conversely, then that information can be used to adjust the tax rates in a way that improves their effectiveness, even while each of those tax rates is still limited to be uniform across all consumers. Therefore the fifth and final policy option considered in Chapter 5 is the set of constrained-optimal tax rates on engine size, vehicle age, and gasoline. This policy uses all available information, but it is still limited to uniform rates across all consumers. It therefore does not perform as well as the first-best emissions tax, but it is the "second-best" as it out-performs all other *available* incentive-based policies.

A combination of three uniform rates can attain 71 percent of the emissions tax gain.

In Chapter 6, we evaluate different combinations of tax rates on gasoline, engine size, and vehicle "newness". Since these solutions use the heterogeneity among a thousand households in our computer model, it effectively makes use of the extent to which the demand for miles may be correlated with engine size or with vehicle age.

Our main result, using this model, is that the second-best combination of tax rates on gasoline, engine size, and vehicle "newness" achieves a welfare gain that is 71 percent of the maximum gain obtained by the ideal-but-unavailable tax on emissions. A gas tax reduces demand for gasoline by inducing people to drive fewer miles *and* to buy smaller more fuel efficient cars. An additional subsidy to newness helps induce them to buy newer cars with lower emission rates.

The magnitudes of the gas tax and newness subsidy depend on the environmental damages of vehicle pollution. The magnitude of damages depends, among other things, on the composition and density of a region's population, and on a region's topography. Second-best rates would therefore differ across regions in California. We do not, therefore, recommend a specific dollar value for either a gas tax rate or a newness subsidy rate. We do, however, reach conclusions about the *relative* magnitudes of a gas tax rate versus a newness subsidy. The gas tax is large relative to the newness subsidy. The overall message here is that the gas tax is the single most effective tool to reduce emissions.

A gas tax alone can attain 62 percent of the emissions tax gain.

The gas tax alone can achieve 62 percent of the maximum gain obtained by the ideal-but-unavailable tax on emissions. Without the gas tax, the tax rate on engine size or on vehicle newness can only achieve about 20 percent of the gain of the ideal emissions tax. Thus we conclude that a gas tax is the key ingredient of any market-based incentive policy – or at least one that cannot employ the ideal emissions tax.

A subsidy to vehicle newness would be regressive.

In Chapter 7 we use statistical techniques to explore the distributional impacts of our alternative policies. This estimation tells us the effect of demographic and vehicle characteristics on the probability that a household will choose a vehicle or combination of vehicles. Households in California are more likely to own larger cars than those in the Northeastern U.S., and households with more income are more likely to own more cars, larger cars, and newer cars. Thus we estimate the extent to which a subsidy to newer cars is regressive. Though it increases the number of newer, cleaner cars, this subsidy to "newness" mostly helps those with high incomes.

A tax on gasoline is not regressive across the lowest incomes but is regressive across higher incomes.

We find that the demand for vehicle miles traveled is relatively unresponsive to its price, but our estimate of the price elasticity (-0.67) is somewhat larger than previous estimates. The estimated income elasticity (0.23) is similar to those in previous studies. For each one-percent increase of income, vehicle miles (and gasoline demand) increase by only 0.23 percent. An implication is that a gas tax is regressive; high-income families buy more gas and would pay more gas tax than low-income families, but their extra gas purchases and gas tax are less than their extra income. Thus their tax as a fraction of income falls.

That overall elasticity estimate tends to mask some specific effects of income on gas purchases, however, as income increases from poor to rich. The very poor do not own cars, and do not buy gasoline, so a tax on gasoline would not hurt the poorest families. Thus the gas tax is not regressive at the very poorest levels, but it is regressive across most of the rest of the income spectrum.