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Abstract: Policymakers are currently looking more favorably on economic incentive approaches to reducing pollution, yet the enthusiasm for such approaches on efficiency grounds is usually tempered by concerns over equiqty, particularly with policies focusing on motor vehicles. In this paper, we assess the distributional impacts of vehicle fees based on (i) annual emissions, (ii) emission rates, in grams per mile, and (iii) annual miles travelled. We find that all three fees appear to be regressive, particularly on the basis of annual household income, but also on the basis of a constructed "lifetime income" measure. Emissions rate-based fees are the most regressive because poorer households often own older, dirtier vehicles. If the fees are used to substitute for existing vehicle registration fees, however, none of the three fees looks markedly different on a lifetime income basis from existing registration fees. This highlights one of the potential benefits of using a tax shift, rather than a tax increase, to help the environment.

Key words: emissions fees, lifetime income, Suits Index

JEL Classification Codes: Q2; H2

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I. Introduction

Regulation of emissions from motor vehicles in the United States has relied for the most part on traditional "command and control" approaches, with new car tailpipe emissions standards the dominant strategy. These approaches have been criticized by many observers as inflexible, poorly targeted to actual in-use emissions, not compatible with motorists' incentives, and ultimately very costly ways to reduce pollution (see Harrington, Walls, and McConnell, 1995; Kessler and Schroeer, 1993). These observers have suggested several economic incentive approaches as alternatives. One such approach that looks particularly promising is making vehicle owners pay fees based on an estimate of their vehicles' annual emissions.

Emissions fees give motorists the incentive to drive their vehicles less and to scrap or repair particularly dirty vehicles. In contrast, new car emissions standards, as well as inspection and maintenance (I&M) programs -- currently the primary means of controlling in-

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use emissions -- give no incentive to reduce driving.[2] And other economic incentive approaches have some drawbacks. Accelerated vehicle scrappage programs, in which older, dirty vehicles are bought and scrapped, give no incentive to reduce driving and no incentive to repair vehicles.[3] Gasoline taxes reduce driving in the short run, but in the long run lead to purchase of more fuel-efficient vehicles and more driving -- and thus more pollution.[4] In addition, they do not distinguish between dirty and clean vehicles.

Vehicle emissions fees have another advantage as well. Because they could be used to replace *existing* motor vehicle taxes, they could provide environmental benefits with no net increase in an average household's tax payments.[5] Such a tax shift rather than a tax increase might also make the policy more politically palatable. Vehicle owners already pay fees and taxes to register their vehicles; under a new but *revenue-neutral* policy, they would simply pay fees in a different way.

Of course, this means that there would be winners and losers -- some vehicle owners would pay more under an emissions-based system and some less. If the poor end up paying more, this might doom the policy -- or at least lead policymakers to search for ways to redistribute tax revenues. One of the most common criticisms of pollution taxes in general is that they are often believed to be inequitable -- i.e., low income households are thought to be

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[2] Moreover, because most I&M programs have a very small penalty for failure, they also provide little incentive to scrap or repair dirty vehicles.

[3] In fact, these programs could have some perverse incentives if the vehicle "bounty" is high enough: vehicle owners could hold onto their vehicles longer or let their vehicles deteriorate enough so that they qualify for the payment; they could also try to falsely register their vehicles in jurisdictions where such programs exist (see Alberini, et al.,1994, for more).

[4] Conventional pollutant emissions such as carbon monoxide (CO), hydrocarbons (HCs), and nitrogen oxides (NOx) are proportional to mileage because standards are set on a grams per mile, not grams per gallon, basis. In other words, cars of the same model year and thus subject to the same standards should have the same emissions rates, all else equal, regardless of their fuel efficiencies.

disproportionately harmed. In every debate over increasing U.S. gasoline taxes, numerous arguments are made about the detrimental impact on the poor. In this study, we assess the distributional impacts of revenue-neutral mileage-based and emissions-based vehicle registration fees. We do this using a household-level dataset that contains information on the make, model, and model year, along with annual mileage, of each vehicle in each of 1018 California households. We look at the incidence of moving from the status quo in California, a registration fee system based on vehicle values, to an environmentally motivated registration fee system. We choose to focus our empirical work on California because its registration fee system is straight-forward and has a feature typical of many U.S. states in that fees are a function of vehicle values.

To assess the distributional impacts, we use two measures of economic well-being, annual household income and lifetime income, a variable that we construct from information on households' education levels and other socioeconomic variables. Economists have long criticized the use of annual income as a measure of economic well-being since annual income depends heavily on where an individual is in his/her earnings life-cycle. We calculate current registration fees as a fraction of annual income and of lifetime income; we then look at three alternative revenue-neutral fees, a fee based on annual vehicle-miles-traveled (VMT), a fee based on emissions rates in grams per mile (g/mi), and a fee based on total emissions (g/mi multiplied by VMT).

In the following section, we discuss alternative approaches to assessing tax incidence based on annual income, annual total consumption expenditures, and a constructed measure of

[5] In fact, in addition to improving efficiency in the market for emissions, they might produce a "double dividend" by reducing deadweight losses generated by existing taxes. See Goulder (1994) for a general discussion of the double dividend.

lifetime income. We briefly discuss some findings in the literature using these different approaches and end showing our constructed lifetime income variable and how it compares with annual income. In section III, we describe the household-level dataset that we use to calculate registration fee payments by household and our data on vehicle emissions that we merge with the household data. In section IV, we discuss the different types of environmental registration fees that we analyze. In section V, we show our distributional findings. First, we show the incidence of existing vehicle registration fees in California and the three alternative environmental fees on an annual income basis. We then look at the four fees on a lifetime income basis. In section VI, we draw some overall conclusions from our work.

II. Measuring Incidence

Economists have long argued that using annual income as a basis for determining tax incidence is problematic because of the tendency for individuals to consume based on permanent income, or earnings over their life-cycle (Friedman, 1957; Modigliani and Brumberg, 1954). Most people tend to earn their highest incomes around middle age and their lowest incomes when they are young or old. Grouping people by annual income using cross-section data will lead to some young and old people in the lower income groups who may not belong there on the basis of lifetime income. Likewise, higher income groups will include some middle-aged people who may belong in a lower category if grouped by lifetime income.

Poterba (1989, 1991) uses annual total consumption expenditures as a proxy for lifetime income. He shows that taxes on gasoline, alcohol, and tobacco appear to be much less regressive when viewed as a percentage of total consumption expenditures rather than as a percentage of annual income. Metcalf (1993) uses a similar approach and finds that sales taxes appear to be equally as progressive as income taxes and property taxes appear to be approximately proportional to consumption expenditures.

Fullerton and Rogers (1993) calculate actual lifetime incomes for a sample of households using an 18-year span of data from the Panel Study of Income Dynamics (PSID). They categorize households based on this lifetime income variable and use a computable general equilibrium (CGE) model to assess the *lifetime* tax burden of several different taxes. Their approach is only feasible with panel data which we do not have. Moreover, use of a CGE model is probably overkill for small taxes such as our vehicle registration fee.

Rogers (1993) and Casperson and Metcalf (1994) present interesting alternatives when data are limited to cross-sections. Both studies use the PSID to estimate relationships between various demographic variables and lifetime income. They then apply those estimated relationships in a cross-section dataset. Both studies compute incidence by assessing *annual* tax payments as a fraction of lifetime income. In other words, they use their calculated lifetime incomes to better categorize each household's ability to pay, but unlike Fullerton and Rogers, they calculate an annual rather than a lifetime tax burden. Both studies find the taxes they look at to be less regressive on a lifetime income basis than on an annual income basis but more regressive than when viewed as a fraction of annual consumption.[6]

In our study, we adopt Rogers' approach and apply her regression results to our cross-section dataset. Rogers relies on her earlier work with Fullerton, regressing the calculated lifetime incomes for their PSID households -- i.e., the present value of annual income over the lifetime of the household -- against education level, education squared, and interactions between education level and dummy variables for whether the household is married, white, or female-headed.[7] Her results are reprinted in Table 1 below. We use them to predict lifetime income for each household in our dataset. We then annualize that lifetime income by computing a 60-year constant annuity using a 4 percent real interest rate

Our approach has several limitations. First, unlike the PSID, our dataset does not identify a household "head," only a "reference person." We assume the reference person is the head unless it is a married household and the reference person is female; in this case, we use information on the male spouse (to be consistent with the PSID which always assumes that the male is the head of the household). Second, we have a number of unmarried group households in our sample. As we stated in the previous footnote, Rogers uses the average income of the husband and wife in a married household, thus we must double our calculated lifetime incomes for married households to get a more accurate measure of household income. Although it is less than ideal, we do the same for group households. Third, Rogers' lifetime income variable is a *potential* lifetime income, calculated assuming everyone works the total number of hours available in each year (see Fullerton and Rogers, 1993, Chapter 4, for an explanation). Since we want to directly compare results using our calculated annualized lifetime income variable with results using annual income, we adjust the predictions we get from her regression.[8] The adjustment does not affect the relative position of the households and thus does not affect our regressivity results, but it is a rather ad hoc adjustment that is necessary because we do not know the number of hours worked by our households. Fourth, Fullerton and Rogers (1993)

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[6] Rogers analyzes gasoline, alcohol, tobacco, and utilities taxes; Casperson and Metcalf a value-added tax.

[7] She uses the education and race of the head of the household only, stating that these are very highly correlated with the education and race of the spouse. The PSID defines the head of the household as male, thus the female-headed household dummy will pick up *single*, female-headed households. For married households, her measure of household income is the average of the income of the husband and wife.

find that individual fixed effects are extremely important in panel data earning regressions. Since we do not have these fixed effects, our calculated lifetime incomes probably do not have the variability across households that true lifetime incomes would have. Finally, there is a general problem faced by anyone calculating lifetime incomes for a cross-section of households: one has virtually no choice but to assume that the status of the household in the cross-section has held and will continue to hold throughout its lifetime. In other words, a recently widowed elderly person will mistakenly be counted as single and a sophomore in college who eventually earns a degree will mistakenly be assigned 13 years of education. Without panel data, there is no good solution to this problem.

Despite these shortcomings, our measure of lifetime income seems reasonable. Most of the differences across households are explained by differences in education. Table 2 shows summary statistics for annual and lifetime income for our California households. The table shows both the annualized *potential* lifetime income as defined by Fullerton and Rogers (1993) and used by Rogers (1993) and the adjusted annualized lifetime income variable that we use in our distributional analysis below. The adjusted lifetime income has a mean identical to the mean of annual income (by construction), but the standard deviation is much smaller than the standard deviation of annual income. This is expected and is similar to the findings in Casperson and Metcalf and in Rogers. Somewhat surprisingly, our mean of lifetime income is less than the median. This may be a result of underestimating the lifetime income of households at the high end of the distribution.

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[8] Specifically, we multiply each predicted value by the ratio of the sum of annual incomes to the sum of the predicted lifetime incomes from the Rogers regression. This ensures that the mean adjusted annualized lifetime income is equal to the mean annual income for our sample.

IV. The California Data

We use the U.S. Department of Transportation's 1990 Nationwide Personal Transportation Survey (NPTS) as the basis of our analysis. The NPTS is a survey of 22,000 randomly selected U.S. households; it contains information on the make, model, and model year of each vehicle in each household, as well as a host of socioeconomic and demographic information about each household.[9] There are 2037 California households in the NPTS, but because of missing information on income and other unreliable data, we had to omit several observations. Our final California dataset includes 1018 households who own 1813 vehicles.

Table 3 shows some summary information about the California households and their vehicles. There are an average of 1.79 vehicles per household in California.[10] This includes some households -- 6.2 percent -- who own no vehicles. Annual registration fees in California are equal to 2 percent of vehicle value plus a flat annual fee of $25. Average fees in 1990 amounted to about 0.68 percent of annual income and a slightly lower fraction of lifetime income, 0.56 percent. This is a small fraction of income but registration fees in California are still a fairly sizable portion of the cost of owning and operating a vehicle. The average vehicle on the road in California in 1990 had a *Red Book* value of $5063 and cost $126 to register. As a comparison, average fuel costs amounted to about $700 per vehicle per year and insurance costs in California averaged about $870 (Insurance Information Institute, 1991), thus registration fees amounted to about 7 percent of annual vehicle operating costs, excluding

[9] See U.S. DOT/FHWA (1993) for general description of the NPTS and summary of information from it.

[10] This average is computed using the NPTS weighting factors, which ensure that adding observations will lead to a total that is representative of the population at large. This means that multiplying the average number of vehicles per household, 1.79, by the number of households in the sample, 1018, will not yield exactly the number of vehicles in the sample (multiplying 1.79 by the number of households in the population, however, will yield the number of vehicles in the population).

maintenance costs. Table 3 also shows that the average vehicle in California is driven 13,400 miles per year, slightly more than the national average of 12,700.[11]

Our emissions data come from a California dataset of over 90,000 vehicles that were subjected to remote sensing in 1991 (Stedman, et al., 1994).[12] The primary systematic way in which emissions vary across vehicles is by model year. Older vehicles were subject to less strict standards when they came off the assembly lines. More importantly, emissions systems deteriorate over time and sometimes break down completely; even vehicles that were very clean when new can be very high polluters after a few years, particularly if they are not well-maintained. We use the remote sensing data to compute average hydrocarbon (HC) emissions rates by vehicle age for cars and light-duty trucks.[13] We assign these averages to our NPTS vehicles. The weighted (by VMT) average of HC emissions in California in 1990 is 2.49 g/mi, six times the 1990 federal standard for new vehicles.

III. Environmentally-Based Vehicle Registration Fees

Various forms of emissions fees are being considered in the U.S. policy arena.[14] A fee based on total emissions would be the most efficient since it would encourage both reduced

[11] Some analysts have suggested that the NPTS, which relies on reported annual mileage figures from survey respondents rather than odometer readings, overestimates annual mileage (Lave, 1994). The 1995 NPTS, which is "in the field" at the date of this writing, is reportedly obtaining odometer readings (Liss, 1995).

[12] Remote sensing is a technology that combines roadside monitors that send infrared beams from one side of the road to a detector on the other side, measuring a vehicle's emissions, with a video camera that obtains a photograph or electronic identification of the license plate.

[13] Cars and trucks must be treated separately because until the 1994 model year, the federal standards for light-duty trucks were less stringent than those for cars. Minivans and sport-utility vehicles are classified as trucks. Carbon monoxide emissions are also available but since ozone is a more serious air quality problem, we focus on HCs (HCs and NOx combine in the atmosphere to form ozone). NOx emissions are not available from the remote sensing dataset.

[14] The EPA, in its proposed Federal Implementation Plan (FIP) for California includes a recommendation for some type of emissions fee. In response to the FIP, California revised its State Implementation Plan (SIP), which now includes a VMT fee (Wallerstein, 1995). This SIP is awaiting EPA approval. Maricopa County in Arizona has considered fees based on emissions rates and vehicle age (see Energy and Environmental Analysis, 1993, for

driving and repair and scrappage of dirty vehicles. In fact, the most efficient fee would be one that obtained emissions readings during actual driving in areas and at times of the day and year with serious air quality problems. The most serious air quality problem, ozone, is primarily a summer-time, urban area phenomenon, and a fee based on HC (and/or NOx) emissions differentiated in these ways would be ideal.[15]

Although a fee based on total emissions is likely to be most efficient, we also look at a VMT-based fee and a fee based on emissions rates. VMT fees may be more politically acceptable initially because the public tends to believe that existing inspection programs are already "taking care of" the emissions rate problem.[16] This means that any system based on emissions may meet with some strong resistance. Also, the incidence of a VMT fee would look a lot like the incidence of a gasoline tax increase, a policy that would be administratively the easiest to carry out.

On the other hand, increasing the cost of driving is never a popular policy as past resistance to gasoline tax increases suggests. Moreover, it is possible that an emissions fee would be used to substitute for existing I&M programs. In this case, a system focusing on emissions rates -- like existing I&M programs -- may be more acceptable. For these reasons, it

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an analysis). The President's Federal Advisory Committee on Reducing Greenhouse Gas Emissions from Motor Vehicles seriously considered promoting VMT fees as a way of reducing carbon dioxide emissions (see Policy Dialogue Advisory Committee, 1995).

[15] See Harrington, Walls, and McConnell (1995) for a discussion. Harrington and McConnell (1995) have shown the efficiency advantages of emissions fees over "command and control" regulations such as I&M.

[16] Deakin (1995) reports that members of several focus groups that she conducted in California expressed this view and voiced "outrage" when told of I&M waivers and different I&M pass/fail "cutpoints" for vehicles of different ages. In most states, a vehicle can fail an inspection but receive a waiver and still be driven if the owner has spent a specified amount of money (very low in most states) attempting to fix the car. (The 1990 Clean Air Act Amendments raised the required waiver limit to $450 but EPA appears to be backing off from that requirement, or at a minimum, moving to allow states to phase it in over time. See *CarLines,* 1995.) All states set different allowable emissions limits for vehicles of different ages, with older vehicles allowed to pollute at a higher rate. See Aroesty, et al. (1994) for a discussion of I&M problems in California.

seems important to analyze the distributional impacts of all three types of fees. Knowing their equity, as well as their efficiency, impacts should help identify the best fee.

If we divide total mileage by all passenger vehicles in California into total registration fees paid by these vehicles under the existing system, we end up with an average VMT-based registration fee of 0.94 cents per mile. This amounts to approximately 16 percent of 1990 fuel costs for an average vehicle in California (equivalent to a gasoline tax of about 19 cents per gallon). If we multiply our HC emissions rates by mileage for each vehicle and divide the resulting total emissions number into total registration fees paid under the existing system, we end up with an emissions fee of 0.46 cents per gram.[17] Finally, performing a similar calculation for emissions rates, we obtain an emissions rate fee of $50.72 per g/mi. The emissions rate fee is like an emissions fee calculated with the assumption that all vehicles are driven the same number of miles per year.[18]

IV. Distributional Findings

A. ***Annual Income Results.*** Table 4 shows average annual registration fee payments as a fraction of annual income by quintile under the current fee system and under the three environmental fees. Each quintile contains 20 percent of California households; quintile 1 is the poorest quintile and quintile 5 the richest.

On the basis of annual income, all of the fees appear regressive. Moreover, the three environmental fees look markedly more regressive than the current value-based registration

[17] 0.46 cents per gram is equivalent to approximately $4200 per ton which is probably less than the optimal emissions fee -- i.e., it is probably below the point where the marginal benefits of HC's reduced are equal to the marginal costs (see Small and Kazemi, 1995).
[18] One can verify using the numbers in Table 2 that the fees are revenue-neutral. The average household continues to pay approximately $226 per year in registration fees.

fee. Under the VMT fee, households in the lowest quintile pay, as a fraction of income, over twice what the average household pays -- 1.54 percent versus an average of 0.76 percent; they pay 2.5 times the average under the two emissions fees. Not only do households in the poorest quintile pay substantially more as a fraction of annual income with the two emissions fees than their counterparts in the richest quintile, they even pay more in absolute dollar terms on a per-vehicle basis. The average household in quintile 1 pays $172 per vehicle under a fee based on total emissions, while the average household in quintile 5 pays only $124 per vehicle.

The Suits Indexes for the three environmentally-based fees are dramatically different from the Suits Index for existing fees.[19] The existing registration fee has a Suits Index of -0.09; the VMT, emissions, and emissions rate fees have Suits Indexes of -0.15, -0.24, and -0.28, respectively. The two emissions fees thus exhibit quite a bit of regressivity.

Even though these are revenue-neutral fees, on the basis of annual income, their differential impacts over the existing California registration fee are fairly substantial. Under the total emissions fee, households in the bottom quintile would pay, on average, $92 more per year in registration fees ($182 per household versus only $90 under the existing system), an additional 1.1 percent of their incomes. Households in the top quintile, on the other hand, would pay $74 per year less in registration fees ($310 per household versus $384 under the existing system).

B. *Lifetime Income Results.* The lifetime income findings, shown in Table 5 (where quintiles are now defined on the basis of lifetime income), are quite different from the annual

[19] A Suits Index is the tax analog to the Gini coefficient. Values less than zero connote regressivity and values greater than zero progressivity; a Suits Index of zero indicates a proportional tax (see Suits, 1979). Interestingly, in Suits' original article, he computed his index for several taxes including vehicle registration fees and personal property taxes, grouped together, which he found to have an index of -0.12 using 1966 tax rates and income and -0.09 using 1970 tax rates and income.

income results. The VMT fee is not noticeably different from the existing registration fee system and both fees appear only slightly regressive. The Suits Index, on a lifetime income basis, for the VMT fee is -0.06, compared to -0.03 for the existing registration fee.

The two emissions fees are slightly more regressive than the existing registration fee: on average, as a fraction of their annualized lifetime income, households in the bottom quintile pay higher fees than do households in the top quintile, and the Suits Indexes fall to -0.11 for the fee based on total emissions and -0.14 for the emissions rate-based fee.

On a lifetime income basis, the differential impacts of the three environmental fees over the current system are very small. Under even the worst of the fees, the emissions rate-based fee, households in the poorest quintile pay only an additional $37 per year ($134 versus $97 under the existing system), less than one-half of one percent of their annualized lifetime income.

C. ***An Alternative Emissions Estimate.*** As we explained above, the emissions rates used to compute the two emissions-based fees are model-year averages calculated from our remote sensing dataset. Our results thus confirm a widely-held belief that poorer households -- as measured by annual income -- own older, dirtier vehicles. This holds up in the lifetime income results as well, since households in the bottom quintile are worse off under the emissions rate-based fee, though the impact is greatly diluted.

Using model year averages is less than ideal, however, since even within the same model year, vehicles can have quite different emissions.[20] An ideal dataset would contain actual in-use emissions for specific vehicles matched with income and other information on the

[20]According to the remote sensing data, 1975 cars, for example, have mean exhaust HC emissions of 5.2 g/mi, a standard deviation of 7.1 g/mi, and a maximum reading of 50.0 g/mi; 1990 cars have a mean of 0.9 g/mi, a standard deviation of 1.3 g/mi, and a maximum of 29.0 g/mi.

owners of those vehicles. Unfortunately, to our knowledge, no such dataset exists. We can, however, use the remote sensing data combined with income information by zip code (since we know the zip codes of each of the 90,000 vehicles that were sensed) to explore whether there is any systematic relationship between income and emissions rates.[21] We run OLS regressions of emissions rates on median household income by zip code, vehicle age, an interaction term between income and vehicle age, and a dummy variable equal to one for foreign vehicles and zero for domestic.[22] The results suggest that, even after controlling for vehicle age, higher incomes lead to lower emissions. They also suggest that the impact of vehicle age on emissions is lower in zip codes that have higher median incomes. For example, according to the regression results, aging a truck by one year should increase emissions by approximately 0.45 g/mi for a household making $25,000 per year but only by 0.28 g/mi for a household making $50,000 per year.[23]

If we use these results to form new HC emissions predictions for our California vehicles, the regressivity results change. Both the emissions rate-based fee and the total emissions fee look more regressive than they did when emissions were model-year averages. Even on a lifetime income basis, the two emissions fees -- particularly the rate-based fee -- now look noticeably more regressive than the existing registration fee system in California. The new Suits Indexes, on a lifetime income basis, are -0.16 for the total emissions fee (compared to -0.11 when emissions rates were model year averages) and -0.19 for the emissions rate fee (compared to -0.14). Under the rate-based fee, households in the bottom lifetime income

[21] The income information comes from CACI Marketing Systems' *The Sourcebook of Zip Code Demographics* (1991).

[22] We run separate regressions for cars and trucks; the results are shown in our discussion paper of the same title (Walls and Hanson, 1995).

quintile now pay 0.86 percent of lifetime income in emissions-based registration fees, 2.5 times what the richest quintile households pay. Under the existing registration fee system, households in the bottom and top quintiles pay virtually the same fraction of their lifetime incomes in fees, 0.5 percent.

The differential impacts over the existing system remain rather small for the fee based on total emissions but start to look important for the fee based on emissions rates. Households in the bottom lifetime income quintile would pay an extra $65 per year, on average, with a fee based on emissions rates, an additional 0.5 percent of their annualized lifetime income.

The finding of more regressivity shows up because poorer households apparently not only own older cars but the older cars they own are dirtier than average. This makes sense since the worst older cars are probably owned by lower income households and since those households are less likely to be able to afford repairs and maintenance. This is a potentially troubling finding from a public policy perspective, but we hesitate to draw too strong a conclusion based on the zip code level income information. What these results really indicate is the need for a micro-level dataset that contains emissions information. Such a dataset would shed more light on the important distributional impacts associated with emissions fees.

VI. Conclusions

Policymakers are currently looking more favorably on economic incentive approaches to reducing pollution, yet the enthusiasm for such approaches on efficiency grounds is usually

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[23] Not surprisingly, unexplained factors account for most of the variation in emissions -- the R's for the two regressions are only 0.16 (cars) and .15 (trucks).

tempered by concerns over equity. This is particularly the case with policies concerning motor vehicles.

In this paper, we find that fees based on emissions rates or total annual emissions are regressive, particularly on the basis of annual income, but also on the basis of a constructed lifetime income measure. Emissions rate-based fees are the most regressive because poorer households often own older, dirtier vehicles. A fee based on annual VMT is less regressive than the two emissions fees -- poorer households tend to drive fewer miles than wealthier households. On the basis of annual household income, all three fees look more regressive than current vehicle registration fees in California.

Using lifetime income greatly mutes these regressivity findings, and none of the fees looks markedly different on a lifetime income basis from current vehicle registration fees in California. This means that if the fees are used to substitute in a revenue-neutral fashion for existing registration fees, there would be only a small differential impact on California households. Using lifetime income, we find that a VMT fee would look about the same as current registration fees, while the two emissions-based fees look only slightly more regressive than current fees. These findings indicate the importance of tax *shifting* -- using an environmental tax to replace existing taxes can considerably lessen the negative distributional impacts arising from the environmental tax.

Using lifetime income rather than annual income is central to these results. If annual income is used as a measure of the household's economic well-being, all three fees look quite a bit more regressive than the current registration fee system.

Also important to the results is the assumption that vehicle emissions vary only by vehicle age and thus lower income households own dirtier vehicles only because they own older vehicles. We find, however, that even controlling for vehicle age, lower income households may own dirtier than average vehicles. This means that emissions fees might be more regressive than we found using age-based average emission rates. Policymakers concerned with both equity and efficiency may need to examine this issue in more detail.

Table 1. Roger's (1993) Estimated Lifetime Income Equation Using PSID Data

(sample size = 500 households; t-stats in parentheses)

Independent Variable	Estimated Coefficient
Constant	733120.72 (6.137)
Education	-47863.01 (-2.038)
$Education^2$	4697.85 (4.734)
Married * Education	-4150.51 (-1.121)
White * Education	-1629.20 (-.332)
Female * Education	-18847.91 (-4.108)
Adjusted R^2 = .28369; F = 40.525	

Table 2. Summary Statistics for Annual and Lifetime Income for California Households in 1990

	Annual Income	Annualized Potential Lifetime Income[1]	Adjusted Annualized Lifetime Income[2]
Mean	40,791	77,988	40,791
Median	37,500	80,827	42,276
Standard deviation	28,198	28,929	15,654
25th percentile	18,000	56,959	29,792
75th percentile	57,500	95,285	49,839

[1]Potential income is income calculated assuming each household works the total number of hours available in a year, 4000 hours (see Fullerton and Rogers, 1993, chapter 4).
[2]We adjust the potential lifetime income figures downward so that the mean equals the mean of annual income. See text for explanation.

Table 3. Vehicles, Annual Mileage, Emissions and Registration Fees in California in 1990

Number of households in sample	1018
Average number of vehicles per household	1.79
Average annual miles per vehicle	13,409
Average exhaust HC emissions[1]	2.49 g/mi
Percentage of households with zero vehicles	6.2%
Average annual registration fee per vehicle	$126
Average annual registration fee per household	$226
Median household annual income	$37,500
Average registration fee as percent of annual income	0.68%
Median household annualized lifetime income	$42,276
Average registration fee as percent of annualized lifetime income	0.56%

[1]This is a weighted average based on miles traveled; the unweighted average emissions rate is 2.80 g/mi

Table 4. Incidence of Alternative Registration Fees in California by Annual Income Quintile

Annual Fee as a Fraction of Annual Household Income				
Quintile	Existing Fee	VMT Fee	Emissions Fee	Emissions Rate Fee
1	1.13	1.54	2.27	2.35
2	0.67	0.72	0.83	1.01
3	0.61	0.57	0.56	0.64
4	0.55	0.54	0.50	0.46
5	0.47	0.43	0.38	0.34
Average	0.68%	0.76%	0.90%	0.95

Table 5. Incidence of Alternative Registration Fees in California by Lifetime Income Quintile

Annual Fee as a Fraction of Annualized Household Lifetime Income				
Quintile	Existing Fee	VMT Fee	Emissions Fee	Emissions Rate Fee
1	0.50	0.48	0.56	0.71
2	0.64	0.66	0.71	0.68
3	0.58	0.61	0.61	0.65
4	0.58	0.62	0.62	0.59
5	0.49	0.43	0.38	0.36
Average	0.56%	0.56%	0.58%	0.60%

References

Alberini, Anna, David Edelstein, Winston Harrington, and Virginia McConnell. 1994. "Reducing Emissions from Old Cars: The Economics of the Delaware Vehicle Retirement Program," Resources for the Future Discussion Paper 94-27 (April).

Aroesty, Jerry, et al. 1994. "Restructuring Smog Check: A Policy Synthesis," Unrestricted draft report, Rand Corporation (October).

CACI Marketing Systems. 1991. *The Sourcebook of Zip Code Demographics*, Fairfax, VA.

Car Lines. 1995. Issue 95-4, Arlington, VA, June 1995.

Casperson, Erik and Gilbert Metcalf. 1994. "Is a Value Added Tax Regressive? Annual Versus Lifetime Incidence Measures," *National Tax Journal*, vol. XLVII, no. 4 (December), pp. 731-747.

Deakin, Elizabeth. 1995. Deakin, Harvey, Skabardonis, Inc. personal communication (June).

Energy and Environmental Analysis. 1993. *Draft Working Paper on Emissions-Based Registration Fees.* Report prepared for Maricopa County, Arizona, Association of Governments (Arlington, VA, EEA).

Friedman, Milton. 1957. *A Theory of the Consumption Function.* (Princeton, NJ: Princeton University Press).

Fullerton, Don and Diane Lim Rogers. 1993. *Who Bears the Lifetime Tax Burden?* (Washington, DC: The Brookings Institution).

Goulder, Lawrence H. 1994. "Environmental Taxation and the 'Double Dividend:' A Reader's Guide," NBER Working Paper No. 4896 (Cambridge, MA: NBER) October.

Harrington, Winston, Margaret Walls, and Virginia McConnell. 1995. "Using Economic Incentives to Reduce Auto Pollution," *Issues in Science and Technology*, Winter.

Kessler, Jon and William Schroeer. 1993. "Meeting Mobility and Air Quality Goals: Strategies that Work," U.S. Environmental Protection Agency, Office of Policy Analysis, Final draft manuscript (October).

Lave, Charles. 1994. "State and National VMT Estimates: It Ain't Necessarily So," Draft manuscript, University of California-Irvine (March).

Liss, Susan. 1995. U.S. DOT/FHWA, Office of Highway Information Management. Personal communication (May).

Metcalf, Gilbert E. 1993. "The Lifetime Incidence of State and Local Taxes: Measuring Changes During the 1980s," NBER Working Paper No. 4252 (Cambridge, MA: NBER) January.

Modigliani, Franco and Richard Brumberg. 1954. "Utility Analysis and the Consumption Function: An Interpretation of Cross-Section Data," in *Post-Keynesian Economics*, ed. by Kenneth K. Kurihara (New Brunswick, NJ: Rutgers University Press), pp. 388-436.

Policy Dialogue Advisory Committee To Develop Options for Reducing Greenhouse Gas Emissions from Personal Motor Vehicles. 1995. *Draft Final Report* (Washington, DC: U.S. Environmental Protection Agency Air Docket, August 28).

Poterba, James M. 1989. "Lifetime Incidence and the Distributional Burden of Excise Taxes," *American Economic Review*, vol. 79, no. 2 (May), pp. 325-330.

Poterba, James M. 1991."Is the Gasoline Tax Regressive?" in *Tax Policy and the Economy 5*, pp. 145-164.

Rogers, Diane Lim. 1993. "Measuring the Distributional Effects of Corrective Taxation," Paper presented at a National Tax Association session of the Allied Social Science Association meetings, Boston, Massachusetts, January 3-5.

Stedman, Donald H. et al. 1994. "On-Road Remote Sensing of CO and HC Emissions in California: Final Report." Prepared for California Resources Board, Sacramento, California (February).

U.S. Department of Transportation, Federal Highway Administration. 1990. *Highway Statistics 1990* (Washington, DC: U.S. DOT/FHWA, Office of Highway Information Management).

U.S. Department of Transportation, Federal Highway Administration. 1993. *1990 NPTS Databook: Volumes I and II* (Washington, DC: U.S. DOT/FHWA, Office of Highway Information Management), Report Nos. FHWA-PL-94-010A and FHWA-PL-94-010B, November.

Wallerstein, Barry. 1995. South Coast Air Quality Management District. Personal communication (August).

Walls, Margaret and Jean Hanson. 1996. "Distributional Impacts of an Environmental Tax Shift: The Case of Motor Vehicle Emissions Taxes," Resources for the Future Discussion Paper 96-11 (January).

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