THE EFFICIENCY AND EQUITY OF VEHICLE EMISSIONS REGULATION:
EVIDENCE FROM CALIFORNIA'S RANDOM AUDITS

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INTRODUCTION

Starting with the Clean Air Act of 1970, the United States has increased regulation of mobile and stationary sources of pollution to increase the quality of the nation's supply. Such regulation has been successful. For example, ambient ozone smog has fallen 40 percent in Los Angeles between 1980 and 1991. The United States' regulatory experience can inform the decisions made by developing countries considering adopting more stringent environmental regulation.1 If the environment is a normal good, then economic growth will accelerate the demand for environmental regulation in developing countries.2 Thus, documenting U.S. environmental regulation successes and failures is important to inform environmental policy in developing countries.

This paper focuses on quantifying the benefits of used vehicle emissions testing regulation in California. Vehicle emissions testing targeted to reduce the emissions of high-polluting older cars could be quite successful because roughly 10 percent of the fleet produces over 50 percent of aggregate emissions. Large air quality improvements could be enjoyed if these vehicles could be altered to produce less emissions.3 Emissions testing regulation can improve air quality either by identifying and repairing high-polluting cars or by providing owners an incentive to invest in vehicle maintenance beyond what they would have invested in the absence of regulation. Regulation-induced pretest maintenance could improve county air quality and no vehicles would fail the test.4

To quantify the benefits of this regulation, one must calculate its "value added" and combine this with a hedonic or contingent valuation estimate of how much individuals are willing to pay for a marginal reduction in ambient ozone and carbon monoxide levels. In this paper, I use unique emissions data to impute the counter-factual of what vehicle emissions would have been in the absence of emissions testing. This counter-factual can be imputed because the state of California conducts random emissions audits for vehicles that are at different stages of the biannual testing cycle.5 Vehicles that do not expect to be tested represent a control group for how emissions fluctuate in the absence of testing. In California, and in states that test vehicle emissions, the average car regardless of its vintage passes the test.6 Thus, I estimate quantile regressions at both the median and the 90th and 90th quantiles to study whether the program has an impact on the super-emitters.

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TABLE 1
Means of Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>1982 Random Sample</th>
<th>1983 Random Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Year</td>
<td>84.3 (6.5)</td>
<td>84.6 (6.5)</td>
</tr>
<tr>
<td>Cid</td>
<td>3149 (5370)</td>
<td>3130 (1904)</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td>33269 (17258)</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>71.1 (346.2)</td>
<td>75.2 (234.2)</td>
</tr>
<tr>
<td>Mileage</td>
<td>75699 (64444)</td>
<td>74519 (72975)</td>
</tr>
<tr>
<td>Observations</td>
<td>2200</td>
<td>2990</td>
</tr>
</tbody>
</table>

Standard deviations are in parentheses. Cid is engine cubic centimeters displacement. Income is family median income by zip code. Hydrocarbons is vehicle hydrocarbon emissions measured in parts per million.

This paper attempts to answer two questions. Does current regulation lower high emitters' emissions? Who fails the test? It is rare to be able to study the equity consequences of environmental regulation. The California Random Testing data include the driver’s zip code. I merge on Census of Population and Housing median zip code family income to study how the probability of passing the test varies with income. Thus, this paper presents new empirical findings on the efficiency and equity implications of a costly regulation. I find that used vehicle emissions testing does not lower vehicle emissions and that the poor are more likely to fail. I present more optimistic evidence that emissions regulation of new cars has lowered the vehicle fleet's aggregate emissions as the stock of pre-1980s vintage makes exit the fleet and are replaced by a flow of lower emissions vintages. The implication for lesser developed countries (LDCs) that are experiencing increased urban air pollution (smog) because of sharp vehicle growth is to focus regulatory efforts on new vehicles. Unfortunately, if such regulation raises the price of new cars people will substitute toward higher-polluting used cars (Gruenspachot, 1982).

The next section of this paper presents my data sources. I then present evidence on trends in aggregate vehicle emissions followed by my regression results documenting this regulation's efficiency and equity implications. The final section concludes.

CALIFORNIA MICRO DATA

In 1992 and 1993, the California EPA conducted the Random Roadside Surveys. The Random Roadside data were a surprise. In each year, roughly 3000 drivers were stopped and tested. The drivers did not know that they were going to be tested. The data were collected so that state regulators could learn about vehicle emissions in between emissions tests.
that fail must be repaired and retested. Drivers can lower the probability of failing the test by investing in pretest maintenance. The private benefits of pretest maintenance investment is that the vehicle will not have to be retested. Retesting entails paying for another emissions test and taking another round trip to the emissions testing site.

Similar to other states, California does not impose a stringent "crime and punishment" approach for vehicle owners. Owners are unlikely to fail the test and conditional on failing face low repair ceilings. For example, cars built in 1970 have a pass rate of 77 percent. In 1993, 98 percent of the cars built in 1990 passed the emissions test. California law stipulated a non-tampering related repair cost ceilings of $50 for 1971 and earlier model years, $90 for model years 1972-74, $125 for model years 1975-1979, $175 for model years 1980-1989 and $300 for 1990 and later model years [California IAM, 1992]. California's vehicle emissions testing program features high probabilities of passing and low maximum repair expenditures for vehicles that fail. Thus, the expected cost of failing the test is low. A 1980 make faces the highest maximum expected cost of $42.8 while a 1970 make has a maximum expected cost of $11.5.

Clearly, existing incentives for owners to reduce their emissions are low. Each vehicle owner has an incentive to free-ride and underinvest in maintenance. To test this claim, I study the relationship between vehicle emissions and months until the next anticipated emissions test. Evidence of the current regulation's effectiveness would be a drop in vehicle emissions after the emissions test and then a continual rise until the next testing date, 24 months later. Additional evidence in favor of the program effect hypothesis would be a fall in vehicle emissions before the anticipated emissions test—an anticipation effect.

To study this program's impact, I fit a vehicle's emissions as a function of its characteristics and dummy variables that indicate how many months remain until its next emissions test. I estimate equation (1):

\[ E = B \times \text{vehicle emissions} + \sum_{i} \text{time}_i \times \alpha_i + U \]

In equation (1), \( E \) represents vehicle emissions and \( X \) includes a cubic in vehicle model year, mileage, and engine characteristics. \( time \) are dummy variables indicating whether the next emissions test will occur in \( j \) months.

Since the average and median driver's vehicle of any model year passes the test, a simple crime and punishment model would predict that the median driver should not react ante to the test, and since his vehicle does pass the test that the program will have no ex-post impact. Since the owner of the average emissions car has no incentive to invest in increased pretest maintenance, least squares estimates of equation (1) do not provide an interesting test of this regulation's impact. Least squares regression estimates whether the program has an impact on the average vehicle from any model year. The right tail of the emissions distribution, namely the quantiles greater than 75 percent, are at risk to fail. Thus, I estimate equation (1) using quantile regression. Quantile regression focuses on the marginal, not the average, car owner's behavior. Controlling for vehicle model year, mileage, and engine type, the quantile regressions isolate the emissions pattern for a standardized car against time until emissions test.

Figure 2 presents the hydrocarbon emissions for a standardized vehicle vintage (1976 makes) evolve over the testing cycle. Each figure has three lines, one for median emissions, one for the 80th quantile and one for the 90th quantile. Vehicle emissions at the first month indicate how emissions vary across the emissions distribution for a vehicle that was emissions tested one month before and its owner does not expect to have to go for another emissions test for 23 months. The median emissions represents a control group because these vehicles are not at risk to fail the test. The key point is that with the exception of the upward blip at 22 months, emissions do not vary over the testing cycle. Vehicles do not come out of compliance in the middle of the cycle, nor are emissions lower after testing (at month 23 or 24) nor do they dip in anticipation of a test (month 0 or 1). An anticipatory emissions decline would be more likely to occur if retaking the test required a significant fee. Given the low expected regulatory costs, drivers were not predicted to take pretest precautions to minimize their likelihood of failing.

**Who Fails the Test? Equity and the Incidence**

Using this unique California micro data, I have documented that emissions are falling with respect to model year but there is no evidence that emissions testing has an impact on emissions. I did not find evidence of an "emissions testing cycle" for high
emissions vehicles. Vehicle emissions did not rise between testing dates and then fall during the testing period. This is evidence that this regulation is failing an efficiency test. It appears to have no impact on air quality. A second criteria for judging regulation is its regressivity.

By merging income data to individual emissions micro data, I study the regulation's regressivity. I estimate a discrete-choice probit model where the dependent variable is whether the vehicle passed the test. The independent regressors include the vehicle's vintage, mileage, engine type, and the driver's income. In Figure 3, I graph the probability that a vehicle passes an emissions test as a function of its owner's income. The curve is sharply upward sloping. Richer people are much more likely to pass the test. Increasing income for $50,000 to $100,000 increases your probability of passing by over 15 percentage points. This is suggestive evidence that this regulation, even though not designed to be, is regressive.

DISCUSSION AND CONCLUSION

Since the current regulatory system does not punish high polluters, it implicitly grants them the property right to pollute. Unfortunately, a Coasian bargaining solution is unlikely to be achieved. Unlike individuals in a Coasian model of externalities featuring no transaction costs to bargaining, the individuals with the property rights are not able to sell them to the highest bidder. It is possible that there would be gains to trade between the "victims" and the super-emitters but no market mechanism exists to carry out those trades. A growing literature [Alberini, Harrington and McConnell, 1995; Hahn, 1995] has explored the benefits and costs of enacting micro-incentive programs such as "cash for clunkers" for removing older, high-polluting vehicles from the road. These are incentive programs that will improve air quality but implicitly recognize the polluter's right to pollute.17

This paper makes three points about the benefits of vehicle emissions testing regulation. First, vehicle emissions are falling with respect to model year. This suggests that as the oldest vehicles in the fleet are scrapped and are replaced by newer vintages, aggregate emissions will fall. Unfortunately, this paper presented no evidence that California vehicle emissions testing affects vehicle emissions. This finding is based on comparing the emissions of vehicles recently tested relative to vehicles that had their emissions test 12 months earlier. I find no evidence that vehicle emissions fall right after testing or fall right before in anticipation of taking the test. Finally, I presented some evidence that this regulation is regressive. Despite steps to minimize its impact on the poor, the poor are more likely to fail. Thus, on both efficiency and equity grounds this used car regulation is not achieving its goals. Fortunately, as pre-1986 makes exit the fleet aggregate emissions will continue to fall. If there are diminishing marginal returns to improved air quality, this raises the question of when used car regulation can be terminated.
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NOTES

I welcome discussion and can be contacted at Columbia University, 406 W. 118th Street, NY, NY 10027; Russell.mak@colubmia.edu. I thank Doris Costa, Mike Grigg, Jeff Plaut and workshop participants at Hamilton College, Princeton, and Columbia University. This is an unabridged version of a paper with the same title.


2. Groessl and Krueger’s (1995) finding of a “U-shaped” relation between environmental quality and per-capita GNP may partially be explained by the adoption of environmental regulations. The key counter-factual is to quantify what environmental quality would have been in the absence of regulation.

3. In some cities, such as Los Angeles, vehicles contribute 65 percent of the volatile organic compounds that are precursors in the production of ozone smog (Krupnick, 1993).

4. Emissions testing programs are costly. If 39% of the 120 million cars registered in the United States in 1992 (MVMA, 1992) are emissions tested each year and each driver must devote one hour to being tested, then the yearly time cost is 40 million hours. The administrative costs of the California program alone equal $1 billion per year (Sweeney, 1995).

5. For example, if we compare how the emissions of a 1989 vintage Cadillac that was randomly sampled 18 months before its next emissions test differ from the emissions of a 1989 vintage Cadillac just tested.

6. To guarantee that the program does not discriminate against the poor, the standards for emissions testing vary by vehicle vintage (such as a 1978 make or a 1978 make).

7. In California, emissions inspections are required upon initial registration, biannually upon registration renewal, and upon transfer of ownership. In California, vehicle emissions are tested by private firms, not by a centralized state tester. The vehicle emissions test has two components: an emissions test and an inspection. The former is unchallenged. Critics of this program argue that vehicle owners take corrective steps such as re-calibrating the decentralized vehicle testing stations such that the current program is not achieving its aim of reducing vehicle emissions.

8. Hydrocarbons are measured in parts per million. Hydrocarbons are a crucial input in determining on-road ambient ozone levels. Carbon monoxide is measured as a percentage of the exhaust gas.

9. I test whether the emissions testing program is influencing driver behavior by studying whether those drivers who expect to be tested in the next two months are driving lower-emission cars than observationally identical cars whose drivers do not expect to be emissions tested for another year.

10. For any given household in a zip code, mean zip code income is a proxy for actual family income. Clearly it is measured with error but under the assumption that the variance of household income within zip codes is small relative to the variance across zip codes, this variable can be used to obtain a lower bound estimate of income’s effect on passing the emissions test. The hydrocarbon data includes 1,276 observations and the carbon monoxide data includes 1,042 observations. There are 471 different zip codes represented in my data.


12. All regression results reported in this paper are available on request.

13. This sharp downward trend in emissions with respect to model year is not an aging effect. The regression explicitly controls for vehicle mileage and because I have data from two separate cross-sections (2x 1992 and 1993), I tested for, and could not reject, the hypothesis of no aging effect.

14. Finess the driver is unlikely to internalize the pollution externality in the absence of testing, vehicle maintenance will be minimal and emissions will rise. If drivers consistently invest in vehicle maintenance regardless of whether an emissions test is approaching, then the whole program would not be needed.

15. Note that this figure differs from Figure 1. Figure 1 traces out how emissions vary with respect to vehicle vintage. Figure 2 traces out how controlling for vintage, emissions vary over the testing cycle.

16. This graph is generated holding mileage and engine size at their mean levels.