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Improving air quality in California's San Joaquin Valley: The role of vehicle heterogeneity in optimal emissions abatement

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ABSTRACT

We exploit cross-sectional repair cost and emissions data to estimate an abatement cost schedule for vehicles participating in a program in California's San Joaquin Valley to reduce tailpipe emissions. We find that 1995 and older model year vehicles have a lower marginal abatement cost than newer vehicles across all emissions levels. Since older vehicles are also significantly more polluting, an optimal allocation of emissions-related repair funds should target these vehicles. Total emissions reductions could be improved by an estimated 20% if the program has to shift from the actual flat $500 voucher to the first-best vehicle-specific voucher scheme. A two-tier voucher based on vehicle model year would yield a 15% decrease in emissions over the flat voucher, achieving three fourths of the remaining potential abatement. We also use our estimated abatement cost schedule to provide a measure of the foregone emissions reductions for this fleet due to the current structure of the California Smog Check program. Optimally redistributing the total expenditure required to bring each vehicle to California Smog Check standards could further reduce emissions by an estimated 19–31%.

1. Introduction

California's San Joaquin Valley (SJV) has the nation's highest levels of ground-level ozone. It exceeded the 8 h National Ambient Air Quality Standard (NAAQS) more days from 2003 through 2007 than any other area in the United States and has been classified as an "extreme nonattainment" area by the United States Environmental Protection Agency [5]. High levels of ground-level ozone can lead to respiratory problems; according to the National Academy of Sciences, "short-term exposure to ambient ozone is likely to contribute to premature deaths" [10]. Failure to meet the ground-level ozone NAAQS has been estimated to cost the SJV $32.64 million in health costs each year [7].

Motor vehicles' tailpipe emissions are the largest single source of ozone forming pollutants nationwide, creating 56% of all nitrous oxides (NOx) and 45% of all volatile organic compounds (VOC) that react with sunlight to form ground-level ozone [14]. On-road vehicles are also responsible for 59% of all carbon monoxide (CO) emissions [13]. Exposure to high concentrations of CO inhibits the blood's ability to transport oxygen and can result in nausea, angina, and even death [12].

In California, regulators monitor vehicle emissions by subjecting vehicles to biennial testing known as the Smog Check program. This program requires vehicles to pass a three-part inspection (emissions test, visual test, and functional test) in order to be registered or sold within California. The functional and visual tests ensure that all emissions-related components and

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systems are operational while the emissions test measures the concentration of pollutants emitted from the vehicle's tailpipe. Though some flexibility exists as to the scope and modalities of the emissions test, for the majority of the state the program requires vehicles to comply with emissions cutpoints for hydrocarbons (HC, a type of VOC), CO and NOx.[1] Regulatory cutpoints for each of the monitored pollutants are based on vehicle characteristics, typically model year and weight.[2]

For the majority of vehicles in the SJV, biennial inspections using the Acceleration Simulation Mode (ASM) emissions test for HC, CO and NOx are required for vehicles that are at least six years old. Inspections are also required upon the sale of vehicles that are at least four years old.[3] But increases in population and miles driven are exacerbating the plight of regulators to bring the area in line with federal NAAQS. From 1990 to 2005, the population of the SJV grew by 37%, while the average of miles driven annually increased by 70% [5].

Yet another factor to contribute to the consistently high levels of air pollution in the SJV may be that some vehicles are driven without being in compliance with California Smog Check standards. Since a Smog Check certificate (received upon passing the inspection) is required for vehicle registration, non-compliant vehicles are also unregistered, which makes quantifying this phenomenon difficult. Even if non-compliance is rare, it may have a significant impact on air quality as these vehicles may have extremely high emissions levels.[4]

Valley Clean Air Now (Valley CAN) is a non-profit advocacy group involved in the reduction of vehicle tailpipe emissions in the SJV through their Tune In and Tune Up program (TI&TU). TI&TU events target vehicle owners that cannot afford to pay for emissions-related repairs and drive their vehicles regardless of registration status or compliance with the California Smog Check program.[5] According to Valley CAN's website, the TI&TU program is[6]

> A car clean up outreach effort to help eliminate mobile source pollutants generated by older, "out of tune" cars in the San Joaquin Valley. It is well known that the Valley is home to a large number of older cars, many of which do not have current smog certificates.

At a typical TI&TU event, Valley CAN identifies vehicles with high tailpipe emissions using a two-speed idle (TSI) test, and gives owners a $500 voucher for emissions-related testing and repairs at a Valley CAN-sanctioned gold shield repair shop.[7] From 2005 through 2009, Valley CAN held 10 TI&TU events throughout the SJV, passing out over 2,000 vouchers and markedly reducing the tailpipe emissions of treated vehicles [9]. Fifteen more events are scheduled through 2011 and 2012.

The primary goal of this article is to evaluate the cost-effectiveness of Valley CAN's TI&TU program.

To this end, we first use cross-sectional data on emissions-related repair costs and emissions abatement for a sample of vehicles participating in two recent TI&TU events held in Bakersfield, CA to estimate an emissions abatement cost schedule. The abatement cost schedule is specified as a parameterized latent class model where, conditional on initial and final emissions levels, abatement cost is allowed to vary according to vehicle model year and weight. We find that 1995 and older model year vehicles have a lower abatement cost than newer vehicles across all relevant emissions levels.

We then use the estimated abatement cost schedule to evaluate the cost-effectiveness of Valley CAN's current emissions reduction program. Formally, we model Valley CAN's objective as the maximization of expected emissions reductions among an exogenous fleet of vehicles, under a fixed budget (expectations being taken with respect to class probabilities). Our optimization problem is therefore dual to the classical approach to cost-effectiveness that consists of minimizing the cost of abatement under a fixed pollution reduction target. Just as the solution to this latter cost-minimization program is characterized by the equality of marginal abatement costs across all participating firms, the solution to our maximization program is characterized by the equality of expected marginal abatement (from an additional dollar) across all treated vehicles. As such, the resulting allocation is cost-effective, in the sense that the corresponding level of expected emissions reductions cannot be achieved at a lower cost than the initially assumed budget.

Using the vehicle fleet from Valley CAN's events in Bakersfield, CA, we find that total expected emissions reductions could be improved by an estimated 20% if the program were to shift from the current flat $500 voucher to the optimal vehicle-specific voucher scheme. A two-tier voucher scheme based on vehicle model year alone would allow to realize most of this additional abatement potential. This finding seems robust to various behavioral assumptions regarding the extent to which voucher funds are redeemed as well as the willingness of vehicle owners to contribute financially to repairs.

[1] Areas that are compliant with NAAQS or have low population densities are subjected to a less comprehensive inspection measuring only HC and CO. In some remote areas vehicles are only required to be inspected when sold.

[2] As of March 31, 2010, emissions cutpoints are make-, model year- and model-specific.

[3] In rural areas of the SJV with low population the two-speed idle (TSI) test may be used to measure vehicle emissions.

[4] This fact is confirmed by our data on tailpipe emissions in Bakersfield, CA. Among 270 vehicles tested, emissions ranged from 8 lbs/10,000 miles to 2800 lbs/10,000 miles.

[5] There is reason to believe that Valley CAN is successful at targeting vehicles that would not have undergone emissions-related repairs in the absence of a subsidy. Among the 270 vehicles participating in the 2009 Valley CAN event in Bakersfield, CA for which we have data, 80% did not have current registration status; 88% of those failed the Smog Check inspection.

[6] Accessed on July 20, 2011.

[7] Gold shield stations are a subset of high quality stations, authorized to test and conduct emissions-related repairs on all vehicles in California.