1. VEHICLE RETIREMENT AND CALIFORNIA'S AIR POLLUTION CHALLENGE

AIR QUALITY IN LOS ANGELES AND CALIFORNIA'S OBLIGATIONS

Air pollution damages health and reduces the quality of life in California in general and the Los Angeles area in particular. This report analyzes the effects of an innovative and controversial air quality program whose fate is likely to be determined in the next few years. Under this program, up to 75,000 older cars and light trucks in Southern California would be bought and destroyed every year for 10 years. While it is widely acknowledged that key effects of the program could depend crucially on vehicle-market responses, our analysis is the first to predict these effects using a framework that accounts explicitly for such reactions.

Federal and state laws require aggressive measures to improve air quality. For example, the federal Clean Air Act (CAA) requires states with areas failing to meet National Ambient Air Quality Standards (NAAQS) to formulate and implement programs to meet these standards. One pollutant covered by the NAAQS is ozone, which is formed when reactive organic gases (ROG) and oxides of nitrogen (NOx) react chemically in the presence of sunlight. Ozone damages human health, vegetation, and structures.

States containing areas that do not meet federal ozone standards are required to submit for approval by the federal Environmental Protection Agency (EPA) State Implementation Plans (SIPs) for achieving compliance with ozone standards in accordance with schedules required by the CAA. In California, the South Coast Air Basin—which includes all of Orange County and the western, urbanized portions of Los Angeles, Riverside, and San Bernardino Counties—is California's only "extreme non-attainment area" and thus has a target date for compliance of 2010, which is later than for others areas in the state. California's 1994 SIP for Ozone (CARB, 1994) focuses on plans to attain compliance in the South Coast because that area is the key to compliance for the state.

ROG and NOx are emitted from both mobile sources (e.g., automobiles, trucks) and stationary sources (e.g., factories, power plants, dry-cleaning establishments). Light-duty vehicles (LDVs)—passenger cars and light-duty trucks[1]—are a critical part of the problem because they are believed to account for approximately 45 percent of combined ROG and NOx emissions in the

[1]Light-duty trucks are defined as those having a gross vehicle weight rating (GVWR) of 8,500 pounds or less.

South Coast.[2] LDVs release ROG and NOx into the air through both exhaust (tailpipe) emissions and evaporation of fuel.

This report analyzes a policy adopted in the 1994 SIP that targets a particularly important source of LDV emissions: older LDVs.

OLDER VEHICLES AND AIR QUALITY

Emissions from relatively old LDVs are an important source of California's ozone problem. For example, in the South Coast in 1998, LDVs at least 15 years old accounted for only 11 percent of total vehicle miles driven by LDVs but 39 percent of the total LDV emissions of ROG and NOx.[3] While vehicle inspection and maintenance (called "Smog Check" in California) programs attempt to limit emissions rates as LDVs age, these programs have historically been disappointments.[4]

On average, older LDVs emit much more ROG and NOx per mile than newer ones, because older LDVs were subject to less-stringent emission standards when they were new and emissions rates of vehicles tend to increase with accumulated mileage. While older LDVs are driven on average fewer miles per day, emission rates per mile increase with age much more rapidly. The net effect of these two forces is depicted in Figure 1.1—which displays per-vehicle emissions in 1998 of ROG plus NOx (in grams per day) for an average LDV of each model year (MY) from 1976 through 1998.[5]

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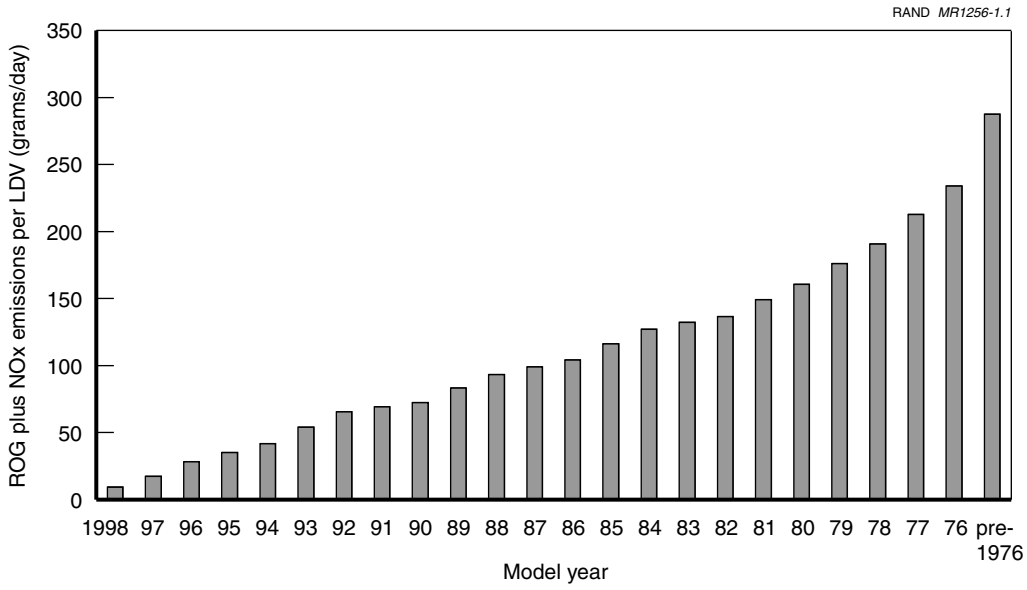
[2]Calculated using data from the California Air Resources Board (CARB, 1999a, pp. 36, 84).

[3]Estimated using data on South Coast vehicle stocks described below and data on miles driven per day and emissions rates per mile of LDVs of different model years from CARB's EMFAC 2000 model (CARB, 1999b).

[4]California has recently instituted Smog Check II, which is hoped to substantially reduce emissions from older LDVs. The effectiveness of Smog Check II has important implications for the benefits of the voluntary accelerated vehicle retirement (VAVR) program as currently designed and for the most efficacious designs of VAVR programs.

[5]The figures for each model year are the products of CARB estimates of emission rates (grams/mile) of ROG plus NOx and miles driven per day.



SOURCE: Authors' calculations from CARB (1999b).

Figure 1.1—Daily Emissions Rates in 1998 of LDVs of Different Vintages

THE VOLUNTARY VEHICLE RETIREMENT PROGRAM

The voluntary accelerated vehicle retirement (VAVR) program included in the 1994 California SIP for Ozone—often referred to as "measure M1" or the "M1 program"—is an innovative program aimed squarely at emissions generated by older vehicles in the South Coast.[6] The VAVR program was projected in the SIP to reduce total emissions of ROG plus NOx in the South Coast by 25 tons per day in 2010.[7] It became California law in October 1995 when Governor Wilson signed Senate Bill 501 (SB 501), which assigned responsibility for various early design and implementation tasks to the California Air Resources Board (CARB).

According to the SIP and SB 501, beginning in 1999 as many as 75,000 older, high-emitting LDVs operating in the South Coast would be purchased from their owners and destroyed every year through (at least) 2010.[8] The basic idea is to reduce emissions from older vehicles by "accelerating their retirement." The VAVR program is behind its original schedule, and eventual implementation is in doubt.

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[6]An excellent recent overview of the program and policy issues is CARB (1998a). We rely heavily on this report in describing the current status of the program.

[7]CARB (1994, p. B-2). The 25 tons per day is comprised of 14 and 11 tons per day of ROG and NOx, respectively. These amounts are about 2 and 3 percent of 1998 daily South Coast LDV emissions of ROG and NOx, respectively, as estimated from CARB (1999b).

[8]The SIP is a plan through 2010 only. As a result, whether the VAVR program would continue after the year 2010 is not addressed in the SIP, and we know of no substantial discussion of this issue.

Under the program, private entities—called "enterprises"—will purchase eligible vehicles from their owners and destroy the vehicles. The program is voluntary: (a) No LDV owner is required to sell a vehicle to an enterprise; (b) no business is forced to participate as an enterprise; and (c) sales are to be made at prices mutually agreeable to the buyers and sellers.

Briefly, CARB rules (CARB, 1998a, pp. 10-11) specify that to be eligible for retirement through the program a vehicle must

- be registered with the Department of Motors Vehicles (DMV) within the South Coast Air Quality Management District (SCAQMD)[9] for 24 consecutive months prior to the sale,
- not be out of compliance with Smog Check rules or due for a smog check within the next 90 days,[10]
- pass a functional and equipment inspection requiring the vehicle to be in reasonably good condition,[11] and
- be at least 15 years old.[12]

The objectives of these requirements are to screen out vehicles that would be scrapped soon anyway, be expected to accumulate little mileage in the future even if not scrapped soon, or be expected to be scrapped because of Smog Check requirements even if not purchased through the program.[13]

The incentive for private businesses (enterprises) to participate in the program is the intention of the state to buy *emission-reduction credits* that can be generated by destroying program-eligible LDVs. (CARB, 1998a, p. A-13).[14] To participate in the program as an enterprise, a business must either be an auto dismantler licensed by the state or have a binding agreement

[9]The SCAQMD includes the entire South Coast Air Basin (SCAB) plus the remaining parts of Los Angeles, Riverside, and San Bernardino counties.

[10]I.e., not identified as an unrepaired high emitter or gross emitter or operating with a repair-cost waiver. If the vehicle is due for a smog check within 90 days, it can become eligible for scrapping through the VAVR by passing Smog Check.

[11]For example the LDV must have been driven to the inspection site under its own power, the hood must open, all doors must be present and at least one operational, all originally supplied dashboard lights and gauges must be present, windshield wipers must work, and there can be no holes in the windshield or rear window (CARB, 1998a, p. A-4).

[12]This requirement is not stated explicitly as a program rule. However, emission credits for retirements in 1999 are listed for no model year later than 1984 and for retirements in 2000 none later than 1985 (CARB, 1998a, Appendix B).

[13]Uncertainty about the degree to which the Smog Check program will be successful in forcing repair or retirement of high-emitting LDVs—and the wisdom of disqualifying from the VAVR program LDVs that are not in Smog Check compliance—are discussed in the conclusion to this report.

[14]Emission-reduction credits purchased by the state will be used to meet the emission goals of SIP measure M1.

with a licensed dismantler to dispose of LDVs purchased under the program (CARB, 1998a, p. 12). For the scrapping of a vehicle to qualify for emissions credits and the enterprise to obtain revenues by selling credits to the state, the vehicle must be permanently destroyed by crushing or shredding and "vehicle parts or engine components may not be removed for resale or reuse" (CARB, 1998a, pp. 13–14).

The emissions credits generated by scrapping an LDV will depend on its age and are based on CARB's estimates of emissions levels from LDVs of that age. To date, CARB has specified emissions credits for LDVs scrapped in 1999 and 2000.[15] Figure 1.2 displays the emissions credits levels for ROG and NOx and their sum that applied to LDVs of the indicated ages in 1999. Note that credits for NOx are not very sensitive to LDV ages, but that credits for ROG do vary considerably with vehicle age, ranging from roughly 100 to 400 pounds per LDV scrapped. Little attention has been paid to the processes that will determine the prices the state will pay for emissions credits, but it seems that these processes will be geared towards achieving program targets at the lowest budgetary cost.[16]

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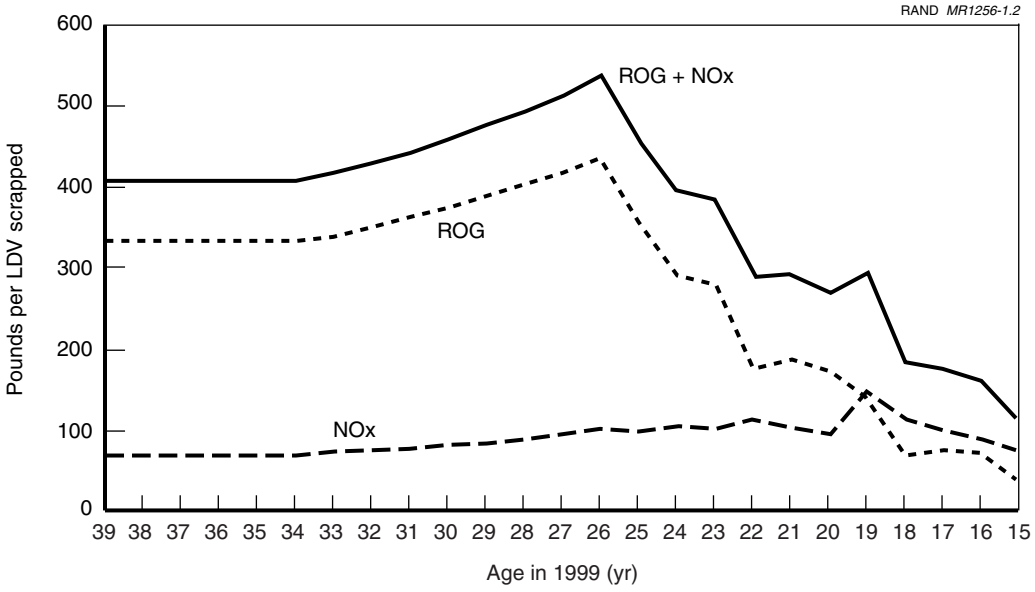
[15]CARB (1998a, Appendix B) sets out the rules for the M1 program. These rules also apply to VAVRs that air districts may choose to operate to generate emission credits for other purposes (e.g., to be purchased by operators of stationary emissions sources to use as offsets against emission reductions that would otherwise be required from these sources). Thus, even though the SIP M1 VAVR program—which is the focus of this report—had not been scheduled to begin until 2001, CARB issued emission credit levels for 1999 and 2000 based on the rules that had been adopted to apply to the M1 program.

[16]Once program funding is in place, CARB staff will "develop and initiate a standard state procurement process for purchasing available emission reduction credits" (CARB, 1998a, pp. 23–24).



SOURCE: CARB (1998a, Table B-1).

Figure 1.2—ROG and NOx Emissions Credits for LDVs Scrapped in 1999

Despite the fact that the SIP contains the program and SB 501 directs CARB to take the first steps, funding for the program has not been established, and implementation is in doubt. The SIP measure was adopted by CARB with the understanding that "a broad-based coalition of businesses and industries lead [sic] by the Western States Petroleum Association (WSPA) and the California Chamber of Commerce" would "secure the funding to implement" the program (CARB, 1998a, p. 4). As of this writing in October 2000, this had not occurred.[17]

While there have been several limited-duration VAVRs involving many fewer vehicles, a program of the size and duration of the one planned for the South Coast is unprecedented.[18]

[17]Very recently, however, the State of California has funded a smaller, statewide effort to scrap high-emitting vehicles that will operate in conjunction with the Smog Check program administered by the Bureau of Automotive Repair (BAR) of the California Department of Consumer Affairs. More specifically, over the course of four years, BAR's Consumer Assistance Program is expected to repair or scrap 50,000 "major polluters" and pay $1,000 for each vehicle scrapped (California Department of Consumer Affairs, 2000).

[18]VAVR programs implemented in the United States have all involved many fewer vehicles than the 75,000 per year proposed for the South Coast. They include a program instituted by UNOCAL in the South Coast in 1990 involving more than 8,000 vehicles and subsequent programs involving fewer than 500 vehicles each in Kern County (California), Chicago, Delaware, and Sacramento. See Alberini, Edelstein, Harrington, and McConnell (1994, pp. 2-7) for an overview of the Kern County and Chicago programs and Alberini, Edelstein, Harrington and McConnell (1994) and Alberini, Harrington and McConnell (1993, 1994, 1995) for extensive discussion and analysis of the Delaware program. Engineering-Science Inc. (1994) evaluates and provides details about the Sacramento program.

Thus, there is no analogous historical experience available to predict program effects. The current study predicts these effects using a simulation model that takes into account some program pitfalls that have been recognized but not analyzed satisfactorily.

CONCERNS ABOUT THE PROGRAM

Several concerns have been raised about the effectiveness and side effects of the program. Two key concerns about program effectiveness in reducing emissions in the South Coast are (a) because vehicles retired through the program may be very near the ends of their useful lives, accelerating their retirement will have minor effects on emissions; and (b) market responses to the program may cause older vehicles from outside the South Coast to migrate into the South Coast, thus eliminating or attenuating potential reductions in stocks of older vehicles in the region.[19]

A potential side effect of the program that is also a source of much concern is the possibility that elimination of large numbers of older vehicles will increase prices of older vehicles. This possibility is of special concern because buyers of older vehicles are believed to be disproportionately of low income.[20] Moreover, large price increases could lead owners to perform substantially more maintenance on older vehicles, thereby extending their lives.[21] While these potential pitfalls are well-recognized,[22] existing quantitative analyses of the SIP program—aimed at predicting emissions effects—have ignored market responses.[23] Since in-migration of older

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[19]Moyer, Pera, and Wool (1995) suggest that scrapping programs "geographically focused on non-attainment areas"—as the M1 program is—"will simply create a market demand for the import of low-cost vehicles from outside the region" (p. 2). Potential in-migration of vehicles "to qualify for the program" is mentioned by Alberini, Edelstein, Harrington, and McConnell (1994, p. 81), who studied a small-scale pilot program. Hahn (1995, p. 238) refers to the possibility of importation "replacing scrapped vehicles with imported clunkers" in the context of analyzing a hypothetical, one-time, large-scale program, and suggests tax-based countermeasures. Dixon and Garber (1996, pp. 189–192, 388–397) analyze in-migration theoretically in a static supply and demand framework, and focus on the potential for in-migration of older LDVs.

[20]Moyer, Pera, and Wool (1995) do not quantify potential price effects, but they suggest that price increases could be large enough to "cause loss of jobs and opportunities to find or create jobs."

[21]E.g., Moyer, Pera, and Wool (1995, p. 2). In the economics literature it is often assumed that an owner will invest in a repair required to keep a vehicle on the road if and only if the value of the repaired vehicle, net of the repair cost, exceeds the scrapping value of the vehicle (see, e.g., Manski and Goldin, 1983).

[22]For example, SB 501 requires assessments of net emission benefits to consider ". . . in-migration of other vehicles into the area and any tendencies to increased market value of used vehicles and prolonged useful life of existing vehicles, if any."

[23]Sierra Research (1995) predicts emissions impacts of the M1 program without considering potential effects on vehicle prices or migration of vehicles. Moyer, Pera and Wool (1995), on which CARB relies in its staff report on design of the program, discuss many of the issues we analyze without performing a "true market analysis of the effects of large scrapping [programs]." They also suggest that "[p]robably such a market assessment cannot be done" (p. 8). Kavalec and

vehicles threatens the air-quality goals of the program and potential price increases are of concern in and of themselves, this lack of analysis is troubling.[24]

PREVIOUS ANALYSES OF THE PROGRAM

Previous quantitative analyses of the SIP M1 program—Sierra Research (1995), Kavalec and Setiawan (1997), and CARB (1998a)—have focused on emissions. In estimating emissions effects, previous analysts have not taken into account reactions of vehicle markets to elimination of LDVs through the program. By failing to confront directly potential in-migration of LDVs into the South Coast, existing analyses may provide unreliable indications of emissions effects of the program. Moreover, by its very nature the issue of potential price effects of the program requires analysis of LDV markets. A brief description of how CARB has analyzed the emissions effects of the program provides perspective on pitfalls in the standard approach and the potential value of the current study.

The CARB approach to estimating emissions effects compares the emissions of the scrapped vehicles with emissions of a hypothetical "replacement vehicle." CARB (1998a, pp. 18–22) assumes that

- the emissions rate per mile of a vehicle retired through the program equals the average rate per mile for vehicles of the same age, as embedded in CARB's emissions models;
- the emissions rate per mile of the hypothetical replacement vehicle is the average emissions rate of all vehicles in the LDV fleet;
- the remaining life of the vehicle, had it not been retired, would have been 3 years;
- had it not been retired, the vehicle would have been driven the same number of miles per year as the average vehicle of its age; and
- the replacement vehicle is driven the same number of miles per year as the retired vehicle would have been driven.

Setiawan (1997) simulate the effects of the program concentrating on an "unlimited supply" case where "the availability of vehicles from outside the region or in lots completely offsets any price increase" (p. 97). Dixon and Garber (1996) analyze potential economic effects of the M1 program using a static supply and demand framework. The present study extends that theoretical analysis in several ways and develops quantitative predictions.

[24]Another concern raised about the program is that targeting high emitters would involve incentives to tamper with vehicles to increase emissions and qualify for the program. As currently designed, the program does not require high emissions for eligibility, and tampering does not appear to be a concern.

In some studies, emissions rates of scrapped LDVs are simply assumed with little explanation or foundation.[25] Sometimes they have been estimated on the basis of tests of vehicles actually scrapped.[26] What to assume about the emissions rate and miles driven by the replacement vehicle is particularly troublesome because—as is widely recognized—a single replacement vehicle is a fiction adopted to finesse a daunting complication. In particular, if a person who sells a vehicle to the VAVR program then buys a replacement vehicle, the seller of the latter vehicle may in turn buy a replacement vehicle, and so forth. Thus, the ultimate effect of the chain of transactions triggered by the sale of an LDV to the program is extremely difficult to conceptualize and has defied any satisfactory analysis.

CONTRIBUTION OF THIS STUDY

This study uses an economic market framework to analyze the effects of the program. Based on recent policy discussions, the program is assumed to begin operation in the year 2001 and to operate through 2010. Use of an economic framework allows us to predict price and emissions effects while taking explicit account of other market reactions to the program, such as in-migration. The analysis does not require the concept of a replacement vehicle because focusing on equilibrium at the market level enables us implicitly to account for the chains of transactions that will be set off when LDVs are sold to the program.

We analyze effects of the program on an annual basis starting in 2001 on various outcomes, including

- prices of used LDVs in the South Coast and elsewhere in California,
- migration of LDVs into the South Coast,
- the size and age composition of LDV stocks in the South Coast, and
- daily emissions of ROG and NOx from LDVs operating in the South Coast and elsewhere in California.

Lack of the requisite information prevents us from predicting the average remaining lives of vehicles that will be scrapped through the program. Instead, we analyze quantitatively how the effects of the program depend on average remaining lives.

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[25]For instance, Sierra Research (1995) assumes that scrapped vehicles will be "high emitters." At the time that study was conducted, the program was envisioned as targeting high-emitting LDVs, but the study contained no analysis of how such LDVs might be attracted to the program (and LDVs with lower emission rates excluded from participation) without creating incentives to tamper.

[26]CARB planned to use data from a 1000-vehicle VAVR pilot program to adjust assumed emission rates of retired vehicles, if necessary (CARB, 1998a, p. 20).

ORGANIZATION OF THE REPORT

The next section presents conceptual (theoretical) analyses. These analyses identify issues that must be confronted in an economic analysis of program effects and provide guidance for structuring and interpreting our quantitative analyses. By way of background, Section 3 presents descriptive empirical information on the sizes, locations, and age compositions of LDVs in California. Section 4 provides an overview of our approach to predicting program effects quantitatively; Section 5 provides more details on our methods. The results of our quantitative analyses are presented in Sections 6, 7, and 8. The first of these three sections concentrates on a base-case set of assumptions to develop point estimates of the sizes of program effects and conceptual insights about determinants of program effects and the evolution of these effects over time. Section 7 presents results from altering various assumptions, which allows us to develop insight into what assumptions are more and less critical to our basic conclusions and to assess ranges of uncertainty about the effect of the program on various outcomes. Section 8 presents and discusses our estimates of the cost effectiveness of the VAVR program. The final section summarizes our results and draws conclusions about the attractiveness of including a VAVR program in California's strategy for improving air quality in the South Coast.