SUMMARY

Air pollution damages health and reduces the quality of life in California in general and California's South Coast Air Basin in particular.[1] The federal Clean Air Act requires California to develop and implement programs to enable the South Coast to meet national air-quality standards for ozone by the year 2010. California's plan for doing so is contained in the 1994 State Implementation Plan (SIP) for Ozone (California Air Resources Board (CARB), 1994). The SIP details a strategy for meeting air-quality goals by 2010 based in part on promising to implement some policies that have yet to be identified; meeting air-quality standards in the South Coast by 2010, or even several years later, is hardly assured.

Emissions from older light-duty vehicles (LDVs)—passenger cars and light-duty trucks—are a major part of the ozone problem. Ozone is formed when reactive organic gases (ROG) and oxides of nitrogen (NOx) react chemically in the presence of sunlight. In the South Coast, LDVs are believed to account for approximately 45 percent of total ROG and NOx emissions from all sources, and LDVs at least 15 years old account for roughly 40 percent of LDV emissions of these gases.

This report examines the effects of an innovative and controversial program included in the SIP that is aimed squarely at older LDVs. This is a "voluntary accelerated vehicle retirement" (VAVR) program to buy and scrap as many as 75,000 LDVs that are at least 15 years old every year from 2001 through 2010. According to the SIP, the goal of this "M1 program" is to reduce total emissions of ROG and NOx in the South Coast by 25 tons per day in 2010. The state has taken steps to design the program, but the necessary funding for full-scale implementation—roughly $100 million per year for 10 years—has not been secured. The fate of the program is very much in doubt.

Two concerns about the effects of this program have been widely acknowledged:

- how much prices of used vehicles will increase and
- the degree to which potential emission benefits will be attenuated by migration into the South Coast of older vehicles attracted by higher prices.

At their cores, both of these concerns pertain to how markets for LDVs will respond to the program. Our study is the first to develop market-based predictions of price effects or to analyze emission effects while also directly accounting for in-migration. Our analysis, then, provides a

[1]The South Coast Air Basin includes all of Orange County and the western, urbanized portions of Los Angeles, Riverside, and San Bernardino Counties.

more complete and reliable assessment of the desirability of the VAVR program than previously available.

ANALYTIC APPROACH

We analyze program effects with both conceptual (theoretical) and quantitative (empirical) methods. The conceptual analyses use supply and demand models adapted to allow for vehicles of different ages or "vintages" located in the South Coast and in the rest of California. These analyses provide a foundation for developing quantitative predictions by identifying factors that will determine various program effects and by providing a logical framework for constructing and evaluating quantitative models.

There is no precedent for a large-scale VAVR program operating over several years. Thus, no historical data are available to analyze the effects of such a program directly. Instead, we develop a multi-year simulation model of used-vehicle markets in the South Coast and the rest of the state. Parameter values are based on diverse and extensive, but sometimes sketchy, empirical information. We use the model to predict for each year from 2001 through 2020 the effects of the M1 program on

- used-LDV prices in California,
- numbers and age distributions of LDVs operating in the South Coast,
- daily quantities of total ROG and NOx emissions from LDVs operating in the South Coast, and
- costs per ton of emissions reductions.

We first predict the effect of the program using a base-case set of assumptions and then assess the degree of uncertainty about program effects.

Figure S.1 provides an overview of how predictions are computed. The model starts each year with sets of LDV stocks distinguished by vehicle vintage (age) for both the South Coast and for the rest of California. In the scenario with the VAVR program, 75,000 older LDVs are removed from the South Coast stocks each year from 2001 through 2010. Then, under both this scenario and a without-program scenario, LDV stocks in the South Coast and in the rest of California in each year from 2001 through 2020 are adjusted to account for

- LDVs brought into California by people moving into the state ("exogenous in-migration"), and
- used LDVs scrapped through all channels other than the VAVR program ("natural scrapping").

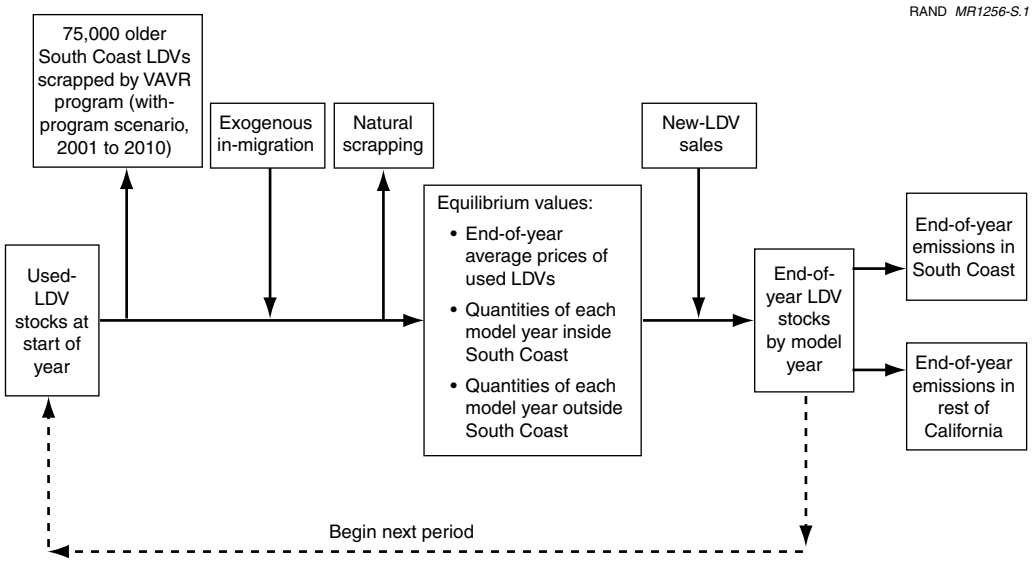

Figure S.1—Overview of Calculation of Used LDV Prices, LDV Quantities, and Emissions in any Calendar Year

Next, LDV prices and locations in equilibrium are computed using a supply-and-demand framework. To generate stocks of LDVs for the end of the period, we then add vehicles to represent new-LDV sales in California. Emission levels in the South Coast and in the rest of the state are calculated from end-of-year vehicle stocks, which are then carried over in the model to begin the prediction process for the next year.

We employed data from several sources to choose base-case parameter values and the ranges of values used to assess degrees of uncertainty about program effects. Used-LDV prices extracted from the Kelley Blue Book Internet site were employed to estimate average used-vehicle prices in California in 1999. Average prices for new LDVs in 1999 were specified using data from the American Automobile Manufacturers Association. Vehicle registration counts by model year and zip code from California's Department of Motor Vehicles were used to determine the age distributions and locations of LDVs in the South Coast and in the rest of California. Characteristics of demand for new and used LDVs are specified relying on econometric estimates reported in previous studies. Analyses of natural scrapping are based on year-to-year vehicle survival rates for LDVs of different ages developed by the California Air Resources Board (CARB). Emission effects are calculated using CARB projections of vehicle emissions per mile and miles driven per day for vehicles of different ages during the years 2001 to 2020.

FINDINGS

We first summarize lessons learned about effects of VAVR programs that are planned to operate for several years. We then summarize our quantitative predictions about effects of the VAVR program planned for the South Coast.

General Lessons About VAVR Programs

Increases in prices of used vehicles will be similar for all vintages. While concern about program-induced increases in prices has focused on vehicles old enough to qualify for the program, prices of newer used vehicles will also be affected because the markets for used vehicles of all ages are linked. In fact, we should expect the program to increase prices of all vintages by approximately the same dollar amount. This conclusion follows from the proposition that price differences across vehicles of different ages are determined by their physical differences and consumer valuations of these differences, neither of which will be greatly affected by the program.

Migration of vehicles into the program region will include vehicles of all vintages. The prospect of higher prices creates an incentive to bring LDVs into the region where the program operates. With similar dollar increases in prices for all vintages, the incentive to bring vehicles into the region is similar for all vintages since the extra transactions costs of selling LDVs over longer distances should be similar across vintages. Thus, any migration induced by the program will include both newer and older vehicles. The implications for emissions are significant: Even if large numbers of vehicles enter the region to replace those sold to the program, the replacement vehicles will be on average newer, and thus cleaner, than the vehicles scrapped through the program.

Increases in prices of used vehicles will tend to increase sales of new ones. Even a large, multi-year VAVR program should not affect prices of new vehicles, which—in markets with substantial competition among several manufacturers—will be determined by the costs of producing, transporting, and selling new vehicles. Used vehicles are substitutes for new vehicles, so an increase in used-LDV prices without an increase in new-LDV prices will increase sales of new LDVs.

Price and emissions effects of the program will stabilize over time. The cumulative effects of a program that scraps the same number of vehicles per year will increase over time, at least during the early years of program operation. The incremental effects in each successive year will become smaller and smaller, and the total effects will eventually cease to grow. This is because, over time, the program reduces stocks of older LDVs and thus also decreases the number of vehicles that retire naturally. Total effects may even decline before the program is discontinued.

Price and emissions effects will persist after the program ceases to operate. Once the program is discontinued, the number of vehicles leaving the fleet every year will abruptly decrease, and the size of the fleet will start to increase. Lingering effects of the program on emissions and vehicle prices will be felt until the size and age-composition of the fleet return to where they would have been if the program had never operated.

Effects of Scrapping 75,000 LDVs Per Year for 10 Years in the South Coast

In addition to empirically based parameter values, the quantitative model employs several assumptions suggested by our conceptual analyses. In the quantitative model, we assume the following:

- The program will increase the prices of used LDVs of different vintages by the same amount.
- Vehicle migration into the South Coast is composed of the same fraction of LDVs of each vintage.
- The migration and price effects of the program are unaffected by LDVs outside of California.[2]
- Vehicles migrate as long as there are any price differences across the state.[3]

Base-Case Predictions

Table S.1 presents base-case estimates of effects of the M1 program. Our base-case predictions of price and emission effects are subject to several sources of uncertainty that are also examined.

For the base case, we predict that by 2010 average used-LDV prices will be $66, or 1.1 percent, higher than they would be if the program is not implemented.[4] The number of vehicles in the South Coast is predicted to be lower by about 60,000 during the last year of the program, which is the net effect of a large decrease in the number vehicles 15 or more years old (147,000) and a somewhat smaller increase (87,000) in the number of newer vehicles. South Coast emissions of ozone precursors are predicted to be lower by 13 tons per day in 2010, about 3.8 percent of the total projected LDV emissions without the program. The program will also reduce emissions in the rest of the state, but by a considerably smaller percentage.

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[2]Any such effects appear to be minor because the vast majority of LDVs in California are located far from borders with other states.

[3]This assumption seems to be a useful approximation because much of the migration could be accomplished by chains of transactions in which the buyer is typically nearer to the South Coast than the seller but not far enough away to substantially increase the transactions cost of a sale.

[4]All dollar values are expressed in real, 1999 terms.

Table S.1

Base-Case Predictions of the Effects in 2010 of Scrapping 75,000 Older Vehicles per Year from 2001 to 2010 in the South Coast

Outcome in 2010	Effect of VAVR Program	Percentage Change
Average Used-LDV price	$66 per vehicle	1.1
Vehicles in South Coast		
Total LDVs	-60,000 vehicles	-0.5
0 to 14 years old	87,000 vehicles	0.9
15+ years old	-147,000 vehicles	-6.9
Emissions of ROG plus NOx		
South Coast	-13 tons per day	-3.8
Rest of California	-3 tons per day	-0.5

As illustrated in Figure S.2, the VAVR program is predicted to increase used-LDV prices over the first five years of the program, but at a decreasing rate. Price effects are predicted to be $79 in the fifth year of the program (2005), and then to decline gradually for the remaining five years of program operation to the $66 per vehicle reported in Table S.1. Figure S.3 displays a similar pattern for emissions. Emission reductions are also predicted to be largest for 2005, at a reduction of 18.8 tons of combined ROG and NOx per day. The predicted reductions decline gradually during the remaining five years of program operation to the 13 tons per day reported in Table S.1. After the program is discontinued in 2010, effects on used-LDV prices and emissions in the South Coast decline rapidly and are essentially eliminated by 2013 and 2014, respectively.

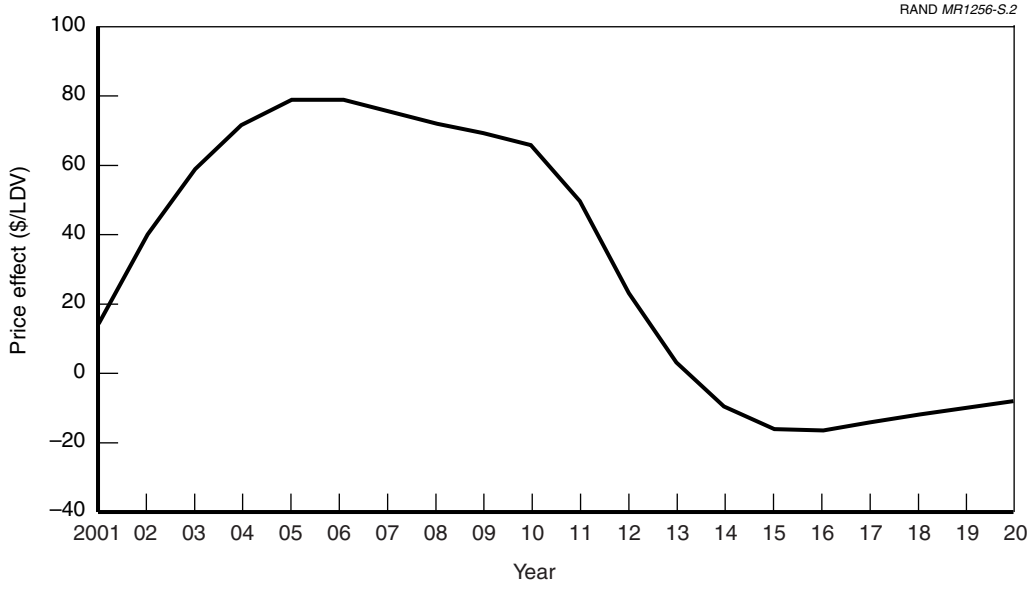

Figure S.2—Effects of the Program on Used-LDV Prices

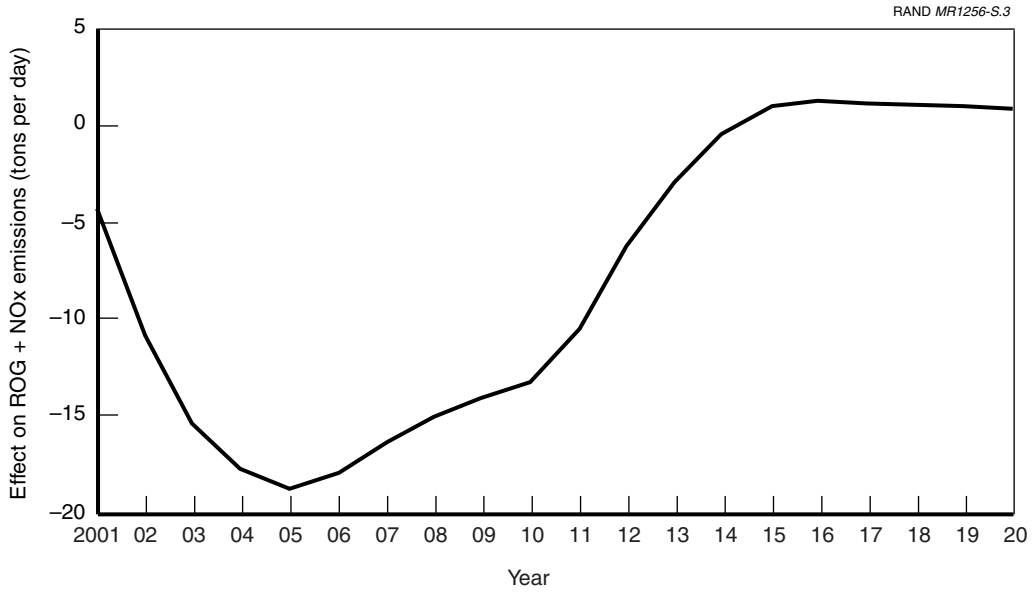

Figure S.3—Effect of the Program on Emissions in the South Coast

Credible Ranges for Program Effects

Any single estimate of a price or emission effect is subject to considerable uncertainty. Estimates of the ranges in which program effects can be confidently expected to fall are much more informative for policy purposes. To provide such information, we develop "credible ranges" for effects of the program in 2010. (See Table S.2.) We believe it highly likely that the effects of the program will fall in these ranges. Our credible range for the effect of the program on used-LDV prices in 2010 is $22 to $271 per vehicle.

Our credible range for South Coast emission reductions in 2010 is 8 to 28 tons per day. Thus, the M1 program target of 25 tons per day in 2010 incorporated in the SIP may not be achievable by scrapping 75,000 LDVs per year from 2001 to 2010. Several assumptions used throughout our analyses tend to make the model underpredict emissions reductions, however, and we thus expect that the South-Coast emissions effects of the program are likely to be closer to 28 tons per day than to 8 tons per day in 2010.

Cost Effectiveness of the Program

Would such emission reductions be worth their cost to California? To examine this issue, we consider the cost per ton of emission reductions of ROG plus NOx and develop a credible

Table S.2

Credible Ranges for Effects of Scrapping 75,000 Older Vehicles per Year from 2001 to 2010 in the South Coast

Outcome	Credible Range
Average price increase for used vehicles in 2010 ($/vehicle)	$22 to $271 per LDV
Emissions reductions in 2010 (tons per day ROG + NOx)	8 to 28 tons per day
Cost effectiveness of operating program from 2001 to 2010 ($/ton ROG+NOx)	$3,700 to $33,300 per ton

range for this "cost-effectiveness ratio."[5] These calculations include costs of the program over its entire history (2001 through 2010) and emissions reductions through 2020.

Our credible range for cost per ton of emission reduction is $3,700 to $33,300. (See last row of Table S.2.) These values compare favorably with ranges of cost-per-ton estimates for many elements of California's strategy for reducing LDV emissions that have already been implemented. More important for policy purposes, the cost effectiveness of the VAVR program is likely to be quite good relative to other *still-available* options for further reducing emissions of ozone precursors in the South Coast. Moreover, most of the values in our credible range of cost per ton for the VAVR program are similar to available dollar-per-ton estimates of the social (health and other) benefits of reducing South Coast emissions of ozone precursors.

In sum, the planned VAVR program appears to be a promising way to promote air quality in the South Coast.

Distribution of Costs Due to Price Increases

Potential price effects of the program have received policy attention primarily because of concerns that price increases could be very large, and that the burden would fall primarily on low-income households. Our estimates indicate that price effects will not be nearly as large as some seem to fear. Nonetheless, the high ends of our credible ranges of price effects ($295 in 2005 and $271 in 2010) could be substantial relative to the wealth or income of many households.

What households or individuals would be harmed by increases in the price of used vehicles? Not individuals who own vehicles that they will sell rather than scrap; the extra amount they will have to pay as buyers to replace such vehicles should be similar to the extra amount they will collect as sellers. Price increases will, however, hurt individuals or households that do

[5]Cost-effectiveness ratios are often used to compare policy options. If well constructed, such ratios can be very useful for policy analysis, but they are not without their shortcomings.

not own a vehicle but want to buy a used one (e.g., young people); want to increase the number of used vehicles that they own; or own a used vehicle that they plan to "drive into the ground." These groups will include many low-income households.

MOVING FORWARD

Our analysis leads us to conclude that the planned VAVR program should be implemented. An improved version would, of course, be even better. We conclude by suggesting aspects of the program that should be further examined and by commenting on obstacles to program implementation.

Potential for Improving Program Design

The program has extensive functional and equipment requirements for eligibility aimed at rejecting vehicles with little remaining life. However, the requirements can provide incentives for owners to *repair vehicles or add equipment so that the vehicle can be promptly scrapped*. Such responses would create pure economic waste. It seems worthwhile, then, to review these requirements and to eliminate any that may be unimportant or redundant for predicting remaining vehicle life.

Perhaps more important is the fact that current VAVR program criteria exclude from eligibility vehicles that are not in good smog-check standing. Appropriately, CARB seeks to avoid double counting of benefits for SIP accounting purposes and not to attribute to the VAVR program emission reductions that are actually attributable to the Smog Check II program. We fear, however, that this is a case of the SIP-accounting tail wagging the air-quality dog. In particular, the M1 eligibility rules may prevent many dirty vehicles that would *not* be scrapped because of the Smog Check program from being removed through the M1 program. A desirable function of a VAVR program is to provide an outlet for vehicles that fail to pass smog check but will remain on the road for extended periods nonetheless. Excluding relatively dirty vehicles from the M1 program eligibility could be counterproductive.

Overcoming Political Obstacles to Implementation

A coalition of early M1 program advocates was expected to identify and secure funding for the program—roughly $100 million per year for 10 years. This has not occurred. Use of state tax dollars may ultimately be required if the program is to be implemented.

Many other elements of California's strategy for reducing LDV emissions—such as reformulated gasoline, tighter emission standards for new vehicles, and the zero-emission vehicle mandate—do not require expenditures of much public money. Such measures are actually financed through resulting price increases for gasoline and new LDVs, which are costly to

consumers, and lost manufacturers' profits, which are costly to shareholders. Such "hidden taxes" have the political advantage of not requiring explicit allocations of public monies.[6]

Poor air quality in the South Coast has detrimental health and quality-of-life consequences. The M1 program promises to make an important contribution to air quality for a good price. If the program is not implemented, less cost-effective programs—or even ineffective ones—may replace it in the continuing struggle to move the South Coast towards compliance with federal air-quality standards. If so, Californians will suffer in terms of health, wealth, or both.

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[6]As well as the fact that a portion of these costs are borne by non-Californians, such as shareholders of oil and automobile companies.