5. PREDICTING EFFECTS OF THE PROGRAM: DETAILS

In this section, we detail our maintained assumptions, base-case parameter values, and the assumptions used in the sensitivity analyses and their rationales. Some readers may wish to skip directly to Section 6, where we begin to present results.

ASSUMPTIONS USED THROUGHOUT THE ANALYSIS

Several assumptions and numerical values are unchanged over almost all simulation runs. These "maintained assumptions" are explained here.

The VAVR Program

The VAVR program is assumed to operate each year from 2001 through 2010. Under the with-program scenario, in each of these years we remove the same number of LDVs from the stock of age-eligible LDVs (LDVs at least 15 years old in that year) in the South Coast. The LDVs assumed to be scrapped through the program in any calendar year are allocated across the eligible model years in proportion to their predicted levels in the South Coast at the beginning of the year.[1] This assumption is likely to tend to understate the emissions effects of the program, because emissions credits increase with age over a broad range of ages (see Figure 1.2), which suggests that bounties will increase with age and, in turn, vehicles scrapped through the program are likely to be disproportionately old among age-eligible vehicles.[2] The assumption is made, nonetheless, because it tends to be conservative in projecting the emissions benefits of the program, and we see no basis for developing an alternative assumption that is not largely arbitrary.

Sizes of LDV Stocks Before the Program Begins

The stocks of used LDVs of each model year assumed to be present in the South Coast and in the rest of California at the beginning of 2001 are derived from the stocks projected for 1998 (see Table 3.1). Specifically, these stocks are inflated proportionately by multiplying them by

---

[1]That is, the same fraction of the South Coast stock of each age-eligible vintage is removed from the LDV stock.

[2]More specifically, as discussed in Section 2, enterprises participating in the VAVR program will sell emissions credits to the state, and LDVs generating more emissions credits will be worth more to these enterprises, all other things being equal. Competition among enterprises for LDVs to buy and scrap will tend to increase bounties for LDVs generating more emissions credits and, in turn, to increase the numbers of such vehicles offered to the program.

1.239, which aligns our total LDV stocks for the South Coast in 2001 with those assumed by CARB in its analyses.[3]

Growth over Time

To generate predictions that can be compared directly with emissions estimates of CARB, our model allows for economic and population growth over time in California and in the South Coast. Factors that are assumed to change for reasons outside the model—that is, because of the passage of time, not because of the program—are the levels of demand for new and used LDVs and the numbers of LDVs that migrate into the South Coast and the rest of California because of population growth. We use a growth rate of 1.5 percent per year for demand for used LDVs in both the South Coast and the rest of California. We also assume in both the with- and without-program scenarios that exogenous in-migration of LDVs in any year equals 1.5 percent of the stocks of each vintage for both regions. The value of 1.5 percent per year was chosen to be consistent with CARB's projections of 1.5 percent growth per year in total vehicle miles traveled (VMT) by LDVs in the South Coast.[4]

Total Vehicle Miles Traveled by LDVs

We assume in all model runs that total VMT by LDVs is the same in the with- and without-program scenarios for both the South Coast and the rest of California. As a result, the effects of the program on the age distribution of vehicles are the key to the emissions effects of the program, because the vehicle-age distribution determines the distribution of a constant total VMT among various vintages with different emissions rates per mile and miles driven per year. The constant-VMT assumption is consistent with the view that all trips that would have been made using vehicles that are scrapped through the VAVR program will be replaced by other LDV trips.

---

[3]In our analysis we ignore stocks of LDVs outside of California, thereby implicitly assuming that migration and price effects of the program are unaffected by those stocks. Responses to the program, however, would not end entirely at the border, because some LDV owners in Oregon or Nevada, say, would be on the verge of bringing their vehicles into California if prices in California were a bit higher. The potential effects of such responses seem rather minor, however, because there are no large stocks of LDVs outside California that are near population centers in California.

[4]The model CARB used to do its analysis of the M1 program (documented in CARB, 1995), provided to us in electronic form by CARB in February 1999, assumed that total VMT in the South Coast would increase 31 percent between 2001 and 2020. This corresponds to a 1.5 percent compounded annual growth rate.

A 1.5 percent growth rate is also consistent with recent trends at the state level in annual new LDV sales and total registrations. In particular, linear regression with 20 annual observations, of either ln (new LDV sales) or ln (total CA registrations) on a constant and a time trend yield estimated coefficients of the trend variable near 0.014, suggesting an annual growth rate of 1.4 percent.

This assumption is commonly used in predicting effects of VAVR programs. It tends, however, to underestimate effects of the program in reducing emissions because it seems likely that some trips that would have been taken in LDVs that are scrapped by the program would not be replaced by other LDV trips.[5]

Price Levels

All prices are expressed in 1999 dollars.

Demand Functions for Used LDVs

The model employs a separate demand function for all used LDVs aggregated over vintages for each year and for each of the two regions. Each of these demand functions is assumed to be of constant elasticity (log-linear) form,[6] with the price elasticity of demand for LDVs assumed to be the same in both regions.[7] The demand curve for each region in 2001 is calibrated by specifying its slope, which is the price elasticity of demand, and choosing its intercept so that the quantity demanded at the average price of used LDVs in 1999 is the quantity of used LDVs projected to be present in that region on January 1, 2001. The demand functions for subsequent years are determined by adding 0.015 to each of the two region-specific demand intercepts for the previous year, which approximates a 1.5 percent annual growth rate in demand because the quantities demanded are measured on a logarithmic scale.

Migration of LDVs into the South Coast

Reallocation of used LDVs between the South Coast and the rest of California is assumed to equalize used-LDV prices between the two regions. This price equalization could, in principle, be accomplished by reallocating the same total number of LDVs irrespective of their age compositions. Based on the reasoning detailed in Section 2, we assume that in-migration of LDVs into the South Coast in response to the program is composed of the same fraction of LDVs of each model year that is predicted to be present outside the South Coast.

---

[5]For example, some trips would not be replaced at all, some would be replaced by extra ride-sharing, and some would be replaced by transportation modes other than LDVs.

[6]Formally, the demand functions are assumed to be of the form $\ln Q_{it} = \alpha_{it} + \beta \ln P_{it}$ where Q_{it} = the quantity of LDVs demanded in region i (where i = South Coast or the rest of California) in year t, P_{it} = the price of used LDVs in region i in year t, β= the price elasticity of demand for used LDVs (assumed constant over years and across regions in any given model run), and α_{it} is the intercept of the demand function for region i in year t.

[7]The value of this elasticity is subjected to sensitivity analysis.

Quantities of LDVs Scrapped Naturally

Under the without-program scenario, natural scrapping is assumed to occur at rates used by CARB to forecast LDV stocks in future years.[8] More specifically, we use our calculated stocks of LDVs by age and the fraction of vehicles of each age that are retired within one year (based on CARB data) to calculate the number of LDVs of each vintage that would be retired in each calendar year from 2001 through 2020 in the absence of the VAVR program. For the with-program scenario, however, using these rates would not be appropriate because previous scrapping of LDVs through the program means that some of the vehicles scrapped naturally in the without-program scenario have previously been scrapped (i.e., their retirements have been "accelerated" through the program). To calculate natural scrapping in the with-program scenario, then, we reduce natural scrapping levels used in the without-program scenario to account for LDVs that had previously been retired. Specifically, for each program run, we assume (a) a value for the average remaining life of LDVs scrapped through the program and (b) for all vintages subject to VAVR scrapping, that the remaining vehicle lives of LDVs scrapped through the program are uniformly distributed over one to M years, where M is twice the assumed average remaining life for the entire pool of LDVs scrapped through the program. Using these assumptions we calculate the number of LDVs of each model year that are scrapped through the program and the current or future year in which they would have otherwise been scrapped naturally.[9] We then use, for each model year, the total number of accelerated vehicle retirements that would have otherwise occurred in a particular calendar year to reduce the natural scrapping levels used in the with-program run and use these reduced figures to represent the levels of natural scrapping that would occur with the program in operation.

[8]CARB estimates annual "retention rates"—the fraction of vehicles of each age that survive until the next year—using historical vehicle registration data from the DMV. Retention rates are as high as 0.98 for new vehicles (i.e., 2 percent of new LDVs disappear from the vehicle fleet within one year), decline gradually to 0.86 for vehicles 16 years old, and then rise gradually, reaching 0.90 for vehicles 23 years old. Retention rates for vehicles older than 23 years remain at 0.90 (CARB, 1995, p. 32). The annual scrapping rate is one minus the annual retention rate.

[9]For example, suppose that we assume that 75,000 LDVs scrapped through the program in a particular year would have remained on the road an average of 1.5 years. Assuming that vehicles are scrapped continuously throughout the year implies that LDVs scrapped in the current year, the next year, and the year after that would have remained on the road for averages of 0.5 years, 1.5 years, and 2.5 years, respectively. Then assuming a uniform distribution over remaining lives and an average remaining life of 1.5 years for all 75,000 LDVs implies that 25,000 LDVs would have been scrapped naturally in the current year, another 25,000 would have been scrapped naturally the following year, and the remaining 25,000 would have been scrapped in the second year after the current one.

New-LDV Sales Levels

In both the with- and without-program scenarios, new-LDV sales in each calendar year are projected by using the predicted change in average used-LDV prices to adjust the reference level of new-LDV sales for that year. This reference level is calculated for 2001 as the fitted value from a time-series regression of new-LDV sales in California.[10] For years after 2001, the reference level is calculated by assuming the reference level grows by 1.5 percent per year. We interpret the reference level in each year as what new-LDV sales would be if new-LDV prices were to change over time by the same dollar amounts as used-LDV prices change. This interpretation is based on the following assumptions:

- new LDVs are sold under competitive market conditions, and therefore prices of new LDVs will be determined by their costs of manufacture, distribution, promotion, selling, etc.; and
- these costs are constant over time in real terms.

Thus, new-LDV sales will exceed reference levels if used-LDV prices increase over time (in real terms), as they will, for example, in the within-program scenario. We estimate the increase in new-LDV sales resulting from any increase in used-LDV prices by assuming the following:

- a given dollar increase in used-LDV prices will increase the demand for new LDVs by the same amount as would a decrease in new-LDV prices of the same dollar amount, and
- a value for the price elasticity of demand for new vehicles.

We consider three alternative values for this elasticity, as detailed below.

Emissions Effects

Emissions of ozone precursors from LDVs in the South Coast and in the rest of California depend on the number of LDVs, their age distribution, emissions rates per mile for each vintage, and the miles driven per day for each vintage. The number and age distribution of LDVs in each region in each year are predicted by the model. To translate these predicted stocks into predicted daily emissions, we employ data on emissions rates per mile for LDVs of various model years in various calendar years derived from CARB's emissions model that we downloaded from its Internet site in November 1999 (CARB, 1999b). In the without-program case, we use CARB data

[10]We project new-LDV sales in 2001 by first regressing the logarithm of new-LDV sales in California between 1981 and 1997 (the last year for which data were available) on a constant and a time-trend variable. We then use the regression and a "smearing estimator" (for transforming the prediction in logarithms to a prediction in levels) to predict new-vehicle sales in 2001. The predicted level for 2001 captures long-term trends in new-car sales, rather than year-to-year fluctuations.

on daily miles driven per LDV of different ages. In the with-program case, we adjust daily mileage per LDV of all vintages in both regions by the same proportion so that VMT in the South Coast is the same in the with- and without-program scenarios.

BASE-CASE PARAMETER VALUES AND ALTERNATIVES

Average Used-Vehicle Price

The first parameter we consider is the average price of a used LDV in California in 1999. The concept of interest is the average—over all used LDVs in their actual conditions—of the values that individual LDV owners would agree upon if they were to transact directly with each other. There is no ready source of such information. Appendix A details how we estimated a value for this parameter and developed a plausible range for it. Here we briefly summarize the approach.

Our basic data source for used-LDV prices is the Kelley Blue Book (KBB) website.[11] During December 1998 and January 1999, we collected "trade-in" prices[12] for several model years for 82 selected LDV models in "good condition."[13] Weighted averaging of these prices over models and model years yielded a figure of $4,218. We view this figure as likely to understate the average price of interest. To get a sense of how much higher the average price might be, we also considered KBB "retail prices" for 20 of the 82 models for which we collected trade-in prices.[14] These are dealer asking prices for vehicles in excellent condition, and thus considerably overstate the price concept of interest to us.[15] We estimated the average retail price to be $7,545.

---

[11]These prices reflect data for the western United States.

[12]"Trade-in value represents what you might expect to receive from a dealer for this consumer owned vehicle." (Kelley Blue Book website: www.kbb.com).

[13]"A 'good' vehicle rating means the vehicle is free of any major defects. The paint, body and interior have only minor (if any) blemishes, and there are no major mechanical problems. ....A good vehicle may need some reconditioning to be sold at retail, however major reconditioning should be deducted from the value. Many cars owned by consumers fall into this category" (Kelley Blue Book website: www.kbb.com).

[14]Trade-in and retail prices were the only two types of prices reported on the KBB website.

[15]"Suggested retail represents the price a dealership might ask for this make and model vehicle. This represents a fully reconditioned vehicle in excellent condition. The retail price is not a trade-in or private-party value, but rather assumes that the dealer has absorbed the cost of making the vehicle ready for sale, reconditioning, advertising, sales commissions, arranging for financing and insurance and standing behind the vehicle for any mechanical or safety problems. Many late model vehicles at this price have passed an inspection program or carry a warranty..." (Kelley Blue Book website: www.kbb.com).

To compute a best guess of the true average price, we averaged the two figures putting a weight of 2/3 on the average trade-in price.[16] The resulting figure of $5,300 was rounded up to $5,500 to serve as the base-case value. Alternatives considered in the sensitivity analysis are $4,500 and $6,500, which we think of as lower and upper bounds on the parameter of interest.

Average New-LDV Price

The second parameter we examine is the average price of a new LDV in California in 1999. In the base case, we assume a value of $22,500, relying on data from the American Automobile Manufacturers Association summarized in Davis (1998, Table 4.11).[17] As alternatives, we used $20,000 and $25,000, which we think of as lower and upper bounds.

Size of the Program

The M1 program specified in the SIP involves annual scrapping of as many as 75,000 LDVs per year. In our base case, in the with-program scenario we assume that in every year from 2001 to 2010 the VAVR program removes from vehicle stocks in the South Coast 75,000 LDVs of at least 15 years of age. To gauge the sensitivity of the effects of the program to the size of the program, we also consider annual scrapping rates of 50,000 and 100,000 LDVs.

Elasticity of Demand for New Vehicles

Trandel (1991) and McCarthy (1996) report estimates of the elasticity of demand for new vehicles in the United States. More specifically, Trandel (1991, p. 523) estimates a value of about -1.4 using 210 observations aggregated over vehicle models, for model years 1983 to 1985. McCarthy (1996, Table 2), uses 1,564 observations of households' choices of models for model year 1989 and estimates elasticities of about -0.85. For the base case, we use a value of -1.0, weighting McCarthy's estimate more heavily than Trandel's because the former applies to a more recent model year. In sensitivity analyses we also consider values of -0.8 and -1.2, which we think of as lower and upper bounds.

Elasticity of Demand for Used Vehicles

Another parameter is the price elasticity of demand for all used LDVs in the aggregate. We were unable to locate any studies that seemed informative about the value of this elasticity, and this parameter is perhaps the one about which we are the most uncertain.

---

[16]We put more weight on trade-in prices because we believe the value of interest is considerably closer to trade-in than to retail.

[17]Specifically, this source reports a value of $20,444 for the national average price of a new car in 1997 and average annual increases of 4.3 percent during 1987–1997. To arrive at a value for 1999, we used this rate of increase for two years and rounded up to $22,500.

To develop base-case and bounding values, we reasoned as follows. An established economic principle is that, all other things being equal, the demand for a commodity will be less elastic the less close the available substitutes are. New LDVs have reasonably close substitutes, namely late-model used LDVs. How close are the substitutes available for all used LDVs in the aggregate? New LDVs are reasonably close substitutes for newer, used LDVs. The only close substitutes for older LDVs are other used LDVs, however. Thus, used LDVs in the aggregate have poorer substitutes—and should have less elastic demand—than new LDVs. Therefore, the elasticity of demand for all used LDVs in the aggregate should be considerably less than -1—i.e., our base-case value for the elasticity of demand for new LDVs—in absolute value. As a base case value we use -0.5, and as alternatives, we consider -0.75 and -0.25.

Remaining Lives of LDVs Scrapped Through the Program

What average values are plausible for the average remaining lives of LDVs scrapped through the VAVR program?[18] This is a matter of considerable uncertainty and controversy in the debate over the VAVR program. CARB (1998a, p. 21), arguing that it is appropriate to be conservative in estimating remaining lives of LDVs scrapped through the program (i.e., to err on the side of smaller values), concludes that a value of three years is appropriate. We use this value in our base case and consider two other values to assess the sensitivity of our results to the value of this parameter.

In fact, we think that the average remaining life of LDVs scrapped through the program may be less than three years, that is, that CARB may not have been conservative enough. While it is difficult to judge whether, given current LDV price levels, sufficient numbers of eligible LDVs would be offered to the program at the kinds of bounties currently envisioned,[19] the following line of reasoning suggests that the program may, in fact, attract many LDVs with less than three years of remaining life:

- Difficulties in developing funding for the program are likely to lead to strong pressures to contain program budget costs.
- Controlling program costs will require restraint on the prices the state will pay for credits.

[18]There is no information available (to anyone) on the fractions of LDVs of each cohort that are condition-eligible for the VAVR program, on their market values, or on what owners would be willing to accept to sell such vehicles to the program.

[19]Kavalec and Setiawan (1997, p. 102) predict bounties between $785 and $965 for a program than targets vehicles 10 years old and older. CARB's analysis suggests that it expects bounties to fall somewhere between $400 and $800 (CARB, 1998a, p. 34).

- Lower prices for credits would reduce the bounties that enterprises can pay for LDVs and still cover their costs.
- Limits on bounty levels, especially given program effects on price, may lead to relaxation of the current standards for eligibility, problems in enforcing whatever eligibility standards are implemented, or both.

In the sensitivity analysis, we consider average remaining lives of two and five years, which we think of as lower and upper bounds. A value less than two years does not seem plausible given the requirements on physical condition for LDVs to be eligible for the program. A value of more than five years does not seem plausible given the bounty levels of no more than $1,000 per LDV that are commonly envisioned.