Uncertain Air Quality Impacts of Automobile Retirement Programs

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The increasing cost of additional air pollution control has stimulated a search for less expensive market-based regulatory approaches. One market-based approach widely embraced by regulators and politicians is the accelerated retirement and scrappage of old automobiles. Businesses are granted emissions reductions credits by air quality regulators in exchange for removing old and presumably high-polluting automobiles from the road. In reviewing the data from recent programs and exploring assumptions made in evaluations of such programs, it was found that the air quality benefits are uncertain and may be small and that the costs may be higher than those for many other emission control strategies. In some regions and under some conditions, accelerated retirement programs may be much more effective than in other regions and under other conditions.

The growing cost of additional air pollution control has stimulated a search for more efficient market-oriented policy instruments. One approach is to create a market for emissions, whereby emissions credits can be traded among polluters. An example is the marketable permit program created under the 1990 Clean Air Act Amendments for power plants that emit sulfur oxides; power plant operators earn credits for exceeding pollution performance standards. They may sell these credits to other power plant operators that fall short of performance standards. However most of these programs have not been in existence long enough for meaningful evaluation of their success to be made.

This paper examines a specific marketable permit program for which there are some data and which is simple enough to be analytically tractable: accelerated automobile retirement programs, whereby tradeable credits are issued for the early retirement and scrappage of old automobiles, which are thought to account for an inordinately large portion of total vehicle emissions. Such programs, which currently have great conceptual and political appeal, are thought to be more cost-effective than other strategies and are relatively easy to implement, and it is thought that they will stimulate the economy by increasing the sales of new automobiles.

The benefits of accelerated automobile retirement may be illusory, however. A retired vehicle may have been junked soon afterward anyway or might have sat idle, in which case the emissions benefits of accelerated retirement would be minimal. The poor knowledge of the uses of old automobiles and of the in-use emissions of old automobiles creates so much uncertainty as to make it impossible to predict with confidence the amount of emissions reductions achieved by accelerated retirement programs.

HISTORY

The first accelerated automobile retirement program was carried out in 1990 by the Los Angeles-based Unocal Corporation. The Unocal South Coast Recycled Auto Project (SCRAP) program solicited automobile owners in the South Coast Basin to turn in their old (pre-1971) automobiles for $700 cash. Over a 4-month period Unocal purchased and scrapped 8,376 automobiles. Subsequently other pilot programs have also been carried out, such as the Cash for Clunkers program conducted in 1992 in the Chicago area by the Illinois Environmental Protection Agency (IEPA) and the 1992 Delaware Vehicle Retirement Program conducted jointly by the U.S. Generating Company of Maryland and Resources for the Future. Each of the latter two programs scrapped and studied over 200 automobiles.

ANALYTICAL FRAMEWORK

It is difficult to determine the amount of emissions reduction attributable to such programs. Accurate quantification of the emissions reduction is difficult, given the poor understanding of key economic and social variables involved. Moreover some air quality plans already contemplate some mobile source emissions reductions, so to avoid double-counting emissions reductions, the air quality benefits accruing from accelerated retirement programs must be distinguished from those already assumed to occur under air quality plans (*1*).

To quantify the emissions reductions resulting from an accelerated retirement program, determinations need to be made with a reasonable degree of certainty. (a) How much earlier were the old automobiles retired than they otherwise would have been without the program? (b) How much would the automobiles have been driven if they had not been retired? (c) What were the emissions levels of the retired automobiles? (d) How were the vehicle miles traveled (VMT) of the retired automobiles replaced? (e) How many VMT will occur on the replacement automobiles, when there is one? (f) What will be the emissions levels of the replacement automobiles?

Unocal retained a marketing research firm, Fairbank, Bregman and Maullin (FB&M), to conduct a follow-up survey of SCRAP program participants to investigate these questions. Although the survey provides valuable insight into the answers to some of these questions, it does not answer them conclusively and moreover raises many other questions. The FB&M survey illustrates how difficult it is to make these determinations with certainty. What follows is an analysis of these areas of uncertainty.

How Much Earlier Were Old Automobiles Retired Than They Otherwise Would Have Been Without a Retirement Program?

Quantification of the amount of emissions benefit resulting from an accelerated retirement program requires a determination of the

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of estimation of the average remaining lives of automobiles are still necessary and still lacking.

The SCRAP program attempted to eliminate this uncertainty by asking the automobile owners directly. FB&M, in the SCRAP program follow-up survey, asked 800 SCRAP participants how long they believed their automobile would have lasted had they not turned it in for retirement under the SCRAP program (*7*). Nine percent reported that they were planning to scrap their automobiles anyway. Retirement of this 9 percent achieved no emissions reduction. The estimates of the remaining 91 percent of the respondents ranged from "less than 1 year" (11 percent) to "more than 6 years" (26 percent), with a median estimate of approximately 4 years (*7*). FB&M characterized these estimates of the remaining lives of their old automobiles as "optimistic," noting that respondents' estimates were higher than scrappage data would suggest (*7*).

Another method to reduce the uncertainty regarding the remaining life of an automobile is to require a mechanic's assessment of the condition of the automobile and of its expected remaining life (*8*). Although this method adds some objectivity, it has not been validated empirically.

The large standard deviations and uncertainty might not be an insurmountable problem if the sample of retired automobiles were a representative random sample of old automobiles. However retired automobiles will not be a random sample; because the remaining life of an automobile can be expected to vary inversely with the willingness of the owner to give up his or her automobile, there will exist a bias toward automobiles that have a lower-than-average remaining life. This finds support in the study by Alberini et al. (*4*), which found a strong correlation between the expected remaining life and the offer price that would be required to induce owners to give up their automobiles.

Without the statistical convenience of a random sample and given the large variance of the average remaining lives of old automobiles, the ability to predict the kinds of automobiles that will be turned in for early retirement is very poor. More data are needed before an accurate sample mean for the remaining lives of retired automobiles can be determined. Mobile source trading advocates may argue that it is still possible to ascertain an average that represents scrapped cars in the aggregate, but in light of the large uncertainties associated with old automobiles, it is doubtful that even this is possible.

How Much Would Automobiles Have Been Driven If They Had Not Been Retired?

Although the average mileage of automobiles by age is fairly well known, it is not known how much a retired automobile would have been used without the retirement program. Once again the problem is that such programs may attract the wrong automobiles—ones that are driven infrequently.

IEPA, in its 1992 Cash for Clunkers accelerated retirement program, relied upon odometer readings from the state's Division of Vehicle Inspection and Maintenance to ascertain the annual mileages of retired automobiles (*8*). Of the 207 automobiles of model years 1968 to 1979 retired by the Cash for Clunkers program, IEPA was able to obtain reliable manual mileage data for only 122 automobiles; many of the remaining automobiles were used very infrequently or not at all. These 122 automobiles had been driven an average of 7,908 mi during the last year, but the standard deviation was 5,776 mi (*9*). The distribution of VMT for these 122 automobiles is shown in Figure 1. Far from approximating a normal distribution, the irregular distribution shown in Figure 1 suggests that there is little predictability with respect to the VMT of retired automobiles. This irregular distribution, the large standard deviation, and the fact that IEPA was unable to obtain mileage data on almost half of the retired automobiles cast doubt on the usefulness of annual mileage data in predicting the results of future programs.

One way of establishing some reliability in the average annual mileage estimate is to obtain data from multiple sources. The Unocal SCRAP program obtained data on the average annual mileage of scrapped automobiles from three sources: (a) California Bureau of Automotive Repair records of smog inspections, (b) estimates from the CARB EMFAC-7E vehicle activity model, and (c) the FB&M telephone survey of SCRAP program participants (*10*). The smog records yielded an average annual mileage estimate of 5,689 mi, whereas the EMFAC-7E model projected the average annual mileage to be 5,368 mi. Telephone survey results varied significantly from those two projections, estimating an average annual mileage of 6,940 mi. The SCRAP program used an average of the first two estimates, yielding an average of 5,528 mi/year. Obtaining data from multiple sources, however, may not always be possible or practicable.

The South Coast Air Quality Management District (SCAQMD) is using a different approach in its Rule 1610 on vehicle scrapping (*11*). On the basis of CARB's BURDEN 7C vehicle activity model it simply assigns an annual mileage figure for each scrapped automobile on the basis of its model year, as follows:

Model Year	*Assumed Annual Mileage*
Pre-1972	4,600
1972–1974	4,700
1975–1981	6,500

To guard against the problem of scrapping already immobile automobiles, Rule 1610 also sets forth some selection requirements that must be satisfied before emissions reductions credits may be granted for an automobile: it requires that the automobile have been registered in the South Coast district as operable for 2 continuous years before scrapping, that it had been continuously insured for at least 1 year before scrapping or have been trans-

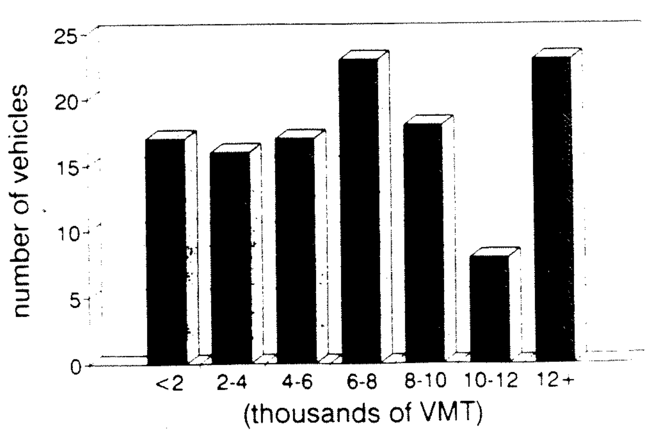

FIGURE 1 Distribution of VMT (IEPA Cash for Clunkers program).

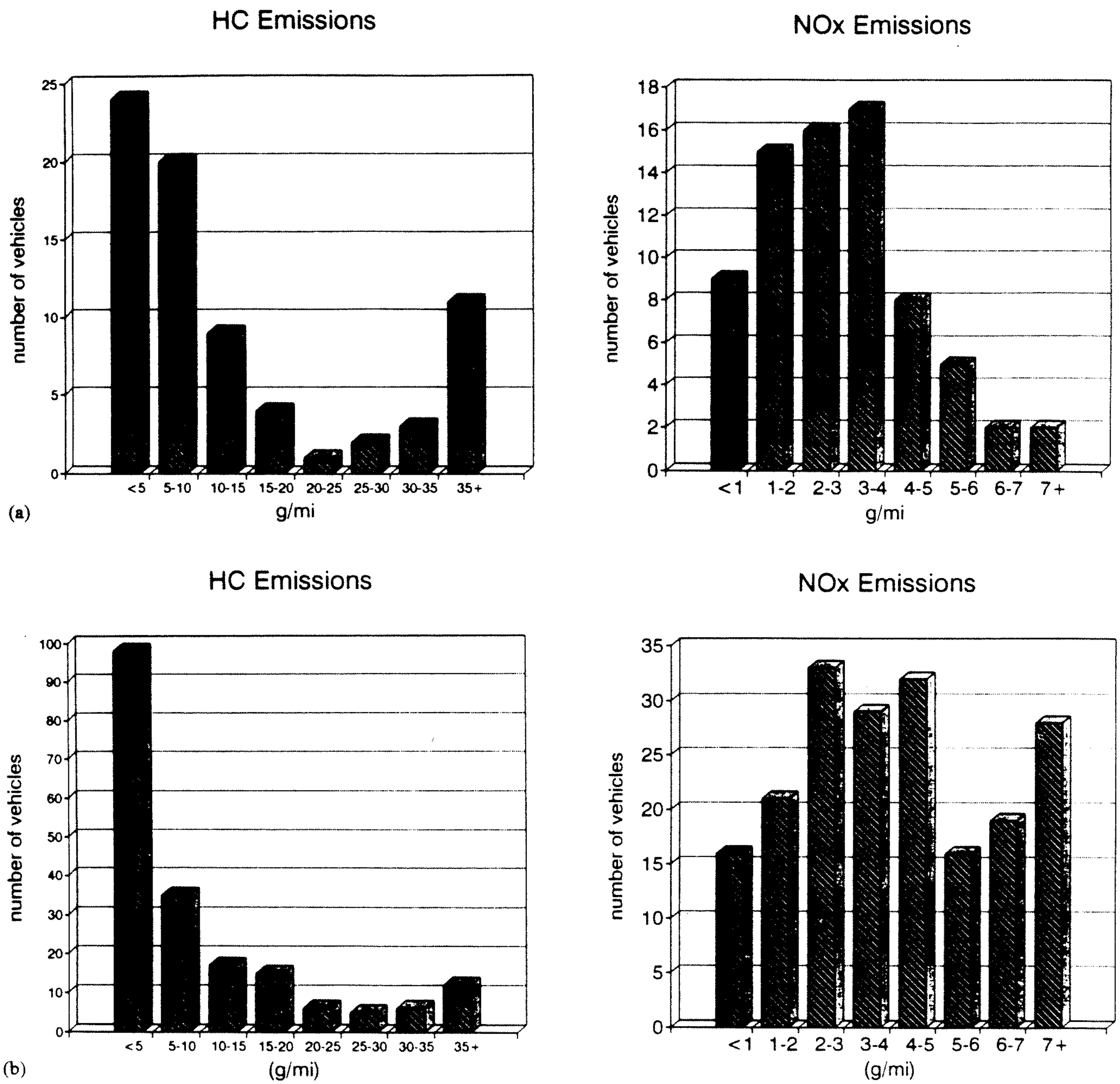

FIGURE 2 Distribution of emissions levels (*a*) of retired automobiles for Unocal SCRAP program and (*b*) IEPA Cash for Clunkers program.

erage" emissions levels. This seems a sensible assumption, yet like virtually all other assumptions that need to be made to justify mobile source emissions reductions programs, it has no empirical basis. Some of the following questions in this regard need to be answered: How many participants will replace their old automobiles with brand new automobiles? How many will replace them with used automobiles? How many will replace their old automobiles with increased use of other, older automobiles that they already own? Will the participant drive the replacement automobile more frequently than he or she did the old automobile? Would an active accelerated retirement program in one region suck in old automobiles from neighboring regions and negate the emissions reductions achieved by retirement?

In its follow-up survey of the SCRAP program, FB&M polled SCRAP program participants as to how they had replaced the miles driven on their old automobile. About 46 percent were driving a newly bought automobile, 42 percent were driving another automobile that they already owned, 8 percent were either getting rides or using public transportation, and 3 percent reported that they did not drive much anymore (*7*). Will this pattern persist in other programs? Would the amount of payment for the old automobiles affect this figure? Will the timing and repeated offerings

2. The average remaining life of an automobile turned in for retirement is 3 years;

3. The emissions rates of the retired automobiles conform to those measured in conjunction with the SCRAP program (Table 2);

4. Automobiles driven to replace the retired automobiles are driven an average of 9,800 mi/year, as SCAQMD assumes in Rule 1610; and

5. The average HC emissions rates of such replacement automobiles are 1.50 g/mi, as SCAQMD assumes in Rule 1610.

The calculation of the HC emissions reductions achieved under this baseline scenario is contained in line a of Table 3. A hypothetical program that retires 10,000 automobiles would reduce HC emissions from 2,528 tons (column E) to 486 tons (column H), a reduction of 2,042 tons (column I). Lines b through d of Table 3 contain the results of this same calculation when the baseline assumptions regarding the retired automobile are varied. For example, line b contains a range of possible values for the HC emissions of the retired autos (10 to 20 g/mi) and the resulting amounts of emissions reductions are set forth in column E. Lines e and f test the sensitivity of the calculation when the baseline assumptions regarding the replacement automobile are varied. Line g contains the extreme high and low estimates of HC emissions reductions, which are obtained by taking the most favorable and least favorable values of all independent variables; the low extreme is a mere 6 tons, and the high extreme is 6,893 tons, a nearly threefold increase over the emissions reductions from the baseline estimate. Lines h and i of Table 3 contain some more realistic high and low scenarios of HC emissions reductions, taking the most favorable reasonable values of all independent variables for the high scenario and the least favorable reasonable low values for the low scenario. These scenarios indicate that a reasonable range of high and low estimates of emissions reduction would be from 602 to 3,540 tons.

It is obvious that calculations of the amount of emissions reductions from an accelerated retirement program are highly sensitive to assumptions made regarding the characteristics and use of the retired automobiles, whereas they are less so for the assumptions regarding the replacement automobiles. These simple examples show that the risk and magnitude of error in the quantification of emissions reductions are large. They also suggest that the estimation problem is intractable: for any accelerated retirement program, the numbers that need to be calculated to quantify emissions reductions will invariably be small (and will get smaller as emissions standards are tightened in the future) and will have large variances. Worse still, any error associated with these small numbers will be magnified in an accelerated retirement program, because each error pertains to one of many automobiles scrapped in a retirement program.

COSTS OF EMISSIONS REDUCTIONS

Because of the large uncertainties inherent in estimates of emissions reductions, estimates of the cost-effectiveness of accelerated retirement programs are uncertain as well. Adding to the uncertainty problem is the lack of a widely accepted methodology for calculating the cost-effectiveness of emissions control strategies.

Several cost-effectiveness studies on accelerated retirement programs are reviewed in Table 4. The cost-effectiveness of a program is obtained by dividing the total program costs by the number of tons of pollutants reduced by the program. However there is no widely accepted methodology that determines which pollutants should be included in the calculation or that apportions the program costs among the different pollutants included. The CARB estimate simply adds together the tons of HC with the tons of NO_x to obtain the number of tons of pollutants reduced; this implicitly equates the value of a ton of HC reduced with a ton of NO_x reduced, a debatable assumption because the ozone-producing effects of HC and NO_x are not only unequal but inverse in some instances because of the unusual shape of ozone isopleths (*15*). The Sierra estimate (*16*) also adds into the calculation one-seventh of the tons of CO reduced. This assumption may or may not be appropriate, depending on whether there is a CO problem in the proposed area. The Sierra Research calculation also differs in that it assumes that the benefits of emissions control strategies are positive only in areas and at times when there are violations of clean air standards; this assumption has not been made in other cost-effectiveness estimates.

Calculation of the costs of accelerated retirement programs is also problematic. The governmental costs of administering such a program are uncertain. Although CARB simply assumes a flat cost of $100 per vehicle, it seems unlikely that this simple linear re-

TABLE 4 Cost-Effectiveness Estimates of Accelerated Retirement Programs

Study	Geographic Area	Cost-Effectiveness ($/ton)	Pollutants Considered
CARB (1993)	California	2,800	HC, NOx
IEPA (1993)	Chicago	2,989	HC, NOx
		3,461	HC
		21,951	NOx
Washington (1993)	Sacramento	1,303	HC
		5,619	NOx
		187	CO
Sierra Research (1994)	California	7,600	HC, NOx, CO
	U.S.	13,900	HC, NOx, CO

How successfully and honestly the inherent uncertainties of mobile source trading programs are dealt with will determine the success of such programs. It is too early to pass judgment on mobile source trading programs, but it is not too early to scrutinize the implementation of such programs and examine ways to improve their design to ensure that their adoption will truly result in air quality improvement.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the valuable assistance of Mary Brazell, Mark Simons, Barry Ellman, Glenn Passavant, Will Schroeer, Michael Riehle, David Coel, Steve Plotkin, Tom Evershenk, Roger Kanerva, Gale Newton, Randall Guensler, Michael Quanlu Wang, and the anonymous reviewers who enriched this paper with their comments and suggestions.

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Publication of this paper sponsored by Committee on Transportation and Air Quality.