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THE INCIDENCE OF THE COSTS OF CONTROLLING AUTOMOTIVE AIR POLLUTION

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ABSTRACT

The costs of controlling automotive air pollution under present federal policy are traced to families of different income levels. A user cost model of new and used car demand is utilized to determine the incidence of an increase in the price of new cars and induced changes in prices of used cars on new care purchasers and holders of the existing stock of cars. In contrast to two other studies, this method shows an unambiguously regressive incidence across income levels. Alternative strategies imposing control costs on all care owners are even more regressive; but a tax on gasoline is shown to be slightly progressive. Prospects to subsidize pollution control costs are discussed.

THE INCIDENCE OF THE COSTS OF CONTROLLING AUTOMOTIVE AIR POLLUTION

I. INTRODUCTION

The automobile is a major source of air pollution in the U.S. It is responsible for approximately two-thirds of all man-made emissions of carbon monoxides, and approximately half of the emissions of nitrogen oxides and hydrocarbons. In the Clean Air Act of 1970, Congress undertook a major revamping of federal policy toward air pollution control. Although there were major changes in the policy toward controlling emissions from stationary sources, these changes were overshadowed by the new strategy toward the automobile and its own contribution to air pollution. For the first time, Congress, itself, specified emission standards to be met by all new cars produced in the 1975 and subsequent model years.

Specifically, the Clean Air Act required that all new cars produced for the 1975 and later model years meet emission standards (maximum emissions per vehicle mile) which were no more than 10 percent of the standards in effect when the law was passed. These standards were to apply to emissions of carbon monoxide and hydrocarbons. A similar requirement was imposed on emissions of nitrogen oxides with the standard to be met in 1976 model year. The law permitted the administrator of the Environmental Protection Agency (EPA) to grant a one-year delay in the deadline for meeting these standards if auto manufacturers requested the delay and showed that meeting the original deadline was not technically feasible. Manufacturers have requested and received one year extensions of the 1975 deadline for carbon monoxide and hydrocarbons emissions and the 1976 deadline for nitrogen oxides.

The costs of meeting these standards will be substantial. EPA has estimated that design and equipment changes will increase the cost of new cars by between $200 and $300 over the 1970 models (Environmental Protection Agency, 1972). In addition, emission control devices decrease the fuel efficiency of new cars, resulting in an expected increase in fuel consumption of about 15 percent in comparison with the 1970 models. EPA estimates the total cost of installing emission control devices will be about $4 billion per year by 1976. Furthermore, annual operating and maintenance costs will be higher by 1976 by about $2.5 billion per year, and this figure will rise in subsequent years as the total number of cars with emission control devices installed rises from year to year.

The strategy for controlling automotive air pollution, as embodied in the Clean Air Act of 1970, raises several major issues which have become the focus of sharp debate in recent months. One issue concerns the technical feasibility of meeting the standards. In requesting an extension of the deadline, the auto companies argued that standards could not be met with existing technology. A more fundamental issue is the wisdom of Congress' choice of strategy. The emission standards for automobiles were meant to contribute to the attainment of ambient air quality standards throughout the country. Federal law requires that these ambient air quality standards be attained by no later than 1977. Since the emission standards apply only to new cars starting with the 1975 model year (1976 with the extension), and since new car production replaces only about 10 percent of the total stock of cars each year, only about 10-20 percent of the cars being driven in 1977 will be meeting the emission control standards. For a number of cities, it appears that this reduction in emissions will not be sufficient to attain the ambient air quality standards (New York Times, 1973). Thus a number of cities are faced with the problem of finding supplementary means of reducing total automotive emissions. In fact, some cities are faced with the problem that even after all the cars being driven in those urban areas are complying with the new standards, emissions will still be too high, and ambient air quality standards will not be met.

As these problems become more visible, attention is being turned to alternative strategies toward the automobile, either as a replacement for or a supplement to the emission standards approach. These alternatives would attempt to deal with one or more of the following problems:

(1) The Congressionally-mandated emission standards control emissions per mile driven, but do not control or influence the number of miles driven.

(2) The emission standards apply only to newly manufactured cars, so that the impact of the standards on total emissions depends on the rate at which present high-pollution vehicles are retired from the fleet and replaced by new low-pollution vehicles. Policy alternatives would consider controlling emissions from the existing fleet as well as from new cars.

(3) Since many parts of the country do not presently have significant automotive air pollution problems, the present emission standards impose costs on car buyers in some parts of the country for which there is no compensating benefit through reduction in air pollution damages. This is not only in some sense inequitable, but represents a substantial resource misallocation.

In addition to the questions of technical feasibility and effectiveness of the present strategy and possible alternatives, another issue being discussed is that of the income distribution effects or incidence of the costs of controlling automotive pollution. As society undertakes a significant reallocation of resources, such as represented by the move toward a cleaner environment, we should be concerned not only with the magnitude of costs and benefits, but also with questions of who gains and who loses.

On the benefit side, there have been some preliminary attempts to determine the incidence of the damages due to air pollution. These studies suggest that lower income families experience higher pollution levels, and therefore are likely to benefit relatively more from pollution reduction (Freeman, 1972: Zupan, 1973). However these studies have been limited by the difficulty in placing dollar values on damages due to pollution or benefits of pollution control.

Turning to the incidence of the costs of pollution control, economic theory, a priori reasoning, and some bits of evidence suggest that the costs of pollution control will be distributed in a regressive manner, i.e. that the cost per family will be a higher percentage of income for lower income families (Freeman, 1972). There are some data available to support this hypothesis. In a major study of the costs of air pollution control, EPA estimated the costs of meeting the present pollution control standards for the major classes of stationary sources of air pollution (Environmental Protection Agency, 1972). These estimates of pollution control costs were then used to project likely price increases by industrial categories. An input-output model was used to trace through these price increases to 12 categories of personal consumption expenditures. Finally, for each personal consumption expenditure category, the relationship between family income and expenditure was determined from the 1961 BLS survey of consumer expenditures. EPA concluded, "Since the percentage of income spent on food, tobacco, personal care, housing, household operation, and medical care generally declines with increases in family income, price increases in these categories would weigh most heavily on families in the lower income brackets" (Environmental Protection Agency, 1972, p. 5-9). Since these are the largest categories of personal consumption expenditure, the net effect is likely to be a mildly regressive pattern of incidence.

EPA's study suggests, however, that automotive pollution control costs represent a special case, and that when the distribution of these costs is taken into account, the results are different. EPA estimated the total annual costs of achieving the automotive emission standards, and allocated these costs to each income class, according to the Survey of Consumer Expenditures data on expenditures for transportation. EPA concluded:

> Expenditures for transportation are largest for the middle income groups on a percentage basis; the lower 24 percent of families and the upper 2 percent of these groups spends about three-fifths and four-fifths respectively of the middle income group's percentage of transportation expenditures. Because transportation costs are projected to increase the most (4.3%) and because they are a significant share of all income groups' PCE, the differential impacts of the price increases by income groups tend to be dominated by the distribution of transportation expenditures. For this reason, the middle and upper income groups would probably be affected to a greater extent on a percentage basis than those families in the lower and the very highest income group (Environmental Protection Agency, 1972, pp. 5-9, 5-10).

One must have some reservations about this conclusion, however. Pollution control costs were allocated by income class according to estimates of total transportation expenditures by households, but this total lumps together spending on purchases of both new and used cars, as well as operating expenditures. The present strategy imposes costs directly only on new car purchasers.

A second reservation concerns the interrelationship between new and used car prices, and the possibility that the price mechanism may shift some part of the pollution control costs on to other than new car buyers. Finally there is the phenomenon of multi-car ownership by families and the large number of used cars owned by upper income families. These all make it more difficult to draw inferences about the actual incidence of automotive pollution control costs from data on such a broad aggregate as transportation expenditures by income class.

More recently Nancy Dorfman has completed a study of the distribution of the overall costs of the federal air and water pollution control policies (Dorfman, 1973). Actual costs for meeting 1972 automobile emissions standards and estimates of the costs for 1976 and 1980 were distributed by income class on the assumption that used car prices would adjust to changes in new car prices so as to maintain the same relative prices and rates of price depreciation of cars of different ages; costs per family were found to be approximately proportional to income over the lower and middle income range, but with the lowest income class (under $2,000 per year) bearing a much higher burden relative to income, and the cost relative to income declining for families with over $15,000 per year income. These results are somewhat different from those reached in this study. The differences are due to differences in the data used as well as the use of a different model and assumptions regarding automobile price changes.

This paper has three major purposes. The first is to present a more careful analysis of the distribution of automotive pollution control costs under the present strategy (the Clean Air Act of 1970). This estimate of incidence will be based on an explicit model of new car and used car demand, prices, and user costs; and it will utilize data on the purchases and ownership of new and used cars according to income level. The second purpose is to consider the incidence of alternative strategies for controlling air pollution. Specifically, we will investigate policy alternatives which will impose pollution control requirements on all owners of cars rather than only new car buyers. Alternative strategies will include costs which are imposed uniformly on all cars, costs which vary systematically with the age of the car, and costs which are related to car usage. The third purpose is to utilize the incidence data developed here to assess the target efficiency of proposals to mitigate the possible regressive impact of pollution control costs through subsidies.

The next section discusses the patterns of car ownership and purchase by income level which are the bases for the incidence analysis. Section III discusses the concept of target efficiency. Sections IV and V present the analysis of the incidence of the present program and several alternative strategies.

II. CAR OWNERSHIP AND PURCHASES BY INCOME

The conventional wisdom is that the rich own mostly new cars and purchase new cars while the poor buy used cars and own mostly older cars. While this picture of car ownership and purchase patterns by income is essentially correct, it is an oversimplification which obscures more complex patterns of multiple car ownership and substantial purchases of used cars and ownership of older cars by upper income multi-car families.

The Current Population Survey has gathered quarterly data on purchases of new and used automobiles by income class and ownership of automobiles broken down by model year of car and numbers of cars per family by income class as of July of each year. The Current Population Survey data are enumerated by household. The income concept is family income defined to include: money wages and salaries, net income from business or farm, dividends and interest, rent, and any other money income received by members of the household, before deductions for taxes, social security, etc.

Let us look first at ownership by income class. Table 1 shows the percentage of households involved in car ownership, as well as a breakdown of the number of cars owned by each household. Over 90 percent of households with income over $7,500 own cars, and even at the $3,000-5,000 income class, 70 percent of households own at least one car. Multiple car ownership is a major characteristic of middle and upper income households. In fact a majority of households with incomes over $10,000 per year own two or more cars.

Table 2 presents data on ownership of cars by households by model year or age of car. Since the survey was taken in July of 1971, the 1971 model cars are "new." As the last column of the table shows, the median age of cars declines with increasing family income. However there are still substantial numbers of older cars owned by upper income households.

Table 3 makes this more apparent. It shows how cars of each vintage are distributed across income levels. The percentage of each age group owned by the lowest income class increases with age of car; but the

TABLE 1

Household Car Ownership by Number of Cars Owned, July 1971

Income Class ($)	Number of Households (000)	Percent Owning: One or More Cars	One Car	Two Cars	Three or More Cars
Under 3,000	10,700	43.6	38.0	5.1	0.5
3,000-4,999	9,600	70.2	58.9	10.8	0.5
5,000-7,499	11,500	85.2	62.8	20.3	2.1
7,500-9,999	9,300	91.3	58.4	28.1	4.8
10,000-14,999	12,800	94.9	48.6	38.7	7.6
15,000-and over	8,700	96.6	33.9	47.9	14.8

Source: U.S. Department of Commerce, Bureau of the Census, Consumer Buying Indicators, P-65, No. 40, May, 1972.

percentage decreases with age for the highest income class. Nevertheless while households with incomes over $10,000 represent only about 33 percent of all households, they own over 36 percent of all five year old and older automobiles.

Table 4 shows ownership patterns from a different perspective. For each income class, the table shows the percentage of households in that income class owning the car of a given vintage. For the $5,000 per year and over income classes, the rows sum to more than 100 percent because of multiple car ownership. The table confirms that the rich own new cars and the poor own old cars. For example barely 5 percent of households with under $5,000 a year income own a 1970 or 1971 model car; while close to 45 percent of $15,000 and over households are in this category. But again what is of interest is the lower right-hand corner of the table, and the substantial ownership of older cars by upper income households. While only about 45 percent of the under $5,000 per year households own a car aged 5 years or older, over 60 percent of the households in the over $5,000 a year category own cars of this older vintage. With the exception of the highest income and oldest age category, not only do upper income families own more new cars per family, but they own more old cars per family as well.

Data on car purchases by income level are consistent with the observed patterns of ownership. Table 5 shows household car purchases by income level for 1971. As expected, the percentage of households which purchased a new car in 1971 rises with income. But the percentage of households which purchased a used car also rises with income up to the $10,000 a year level.

TABLE 2

Household Car Ownership by Model Year,
July 1971
(000)

Income Class ($)	Number of Households	Total Cars Owned	Cars per Household	Model Year 1971	1970	1969	1968	1967	1966 and Earlier	Median Age of Car
Under 5,000	20,300	13,200	.65	400	700	900	1,000	1,100	9,100	>>4
5,000-9,999	20,800	24,600	1.18	1,400	2,400	2,600	2,800	2,300	13,100	>4
10,000-14,999	12,800	19,000	1.48	1,500	2,400	2,500	2,300	2,000	8,300	4
15,000-and over	8,700	15,200	1.75	1,600	2,200	2,500	2,100	1,600	5,200	3
Not Reported	2,200	2,300	1.05	200	200	300	200	200	1,200	>4
All Households	64,800	74,300	1.15	5,100	7,900	8,600	8,400	7,300	37,000	4

Source: U.S. Department of Commerce, Bureau of the Census, Consumer Buying Indicators, P-65, No. 40, May, 1972.

TABLE 3

Household Ownership of Cars by Model Year and Income Class, July 1971

		Percentage of Cars of Given Age Owned by Income Class				
Age (Years)	Model Year	Under 5,000	5,000-9,999	10,000-14,999	15,000 and Over	Income Not Reported
0	1971	7.8	27.5	29.4	31.4	3.9
1	1970	8.9	30.4	30.4	27.8	2.5
2	1969	10.5	30.2	29.1	29.1	3.5
3	1968	11.9	33.3	27.4	25.0	2.4
4	1967	15.1	31.5	27.4	21.9	2.7
5 or older	1966 or before	24.6	35.4	22.4	14.1	3.2
Percentage of Households in Income Class		31.3	32.9	19.8	13.4	3.4

Source: U.S. Department of Commerce, Bureau of the Census, Consumer Buying Indicators, P-65, No. 40, May, 1972.

TABLE 4

Household Ownership of Cars by Model Year and Income Class, July 1971

Household Income Level ($)	Percent of Households Owning Car of Model Year					
	1971	1970	1969	1968	1967	1966 or Before
Under 5,000	2.0	3.4	4.4	4.9	5.4	44.8
5,000-9,999	6.7	11.5	12.5	13.5	11.1	63.0
10,000-14,999	11.7	18.8	19.5	18.0	15.6	64.8
15,000-and over	18.4	25.3	28.7	24.1	18.4	59.8
Not Reported	9.1	9.1	13.6	9.1	9.1	54.5
All Households	7.9	12.2	13.3	13.0	11.3	57.1

Source: U.S. Department of Commerce, Bureau of the Census, Consumer Buying Indicators, P-65, No. 40, May, 1972.

III. TARGET EFFICIENCY

One reason for examining the incidence of automotive pollution control costs is that we (society) may decide that the pattern of incidence is inequitable; and we may wish to alter the pattern of incidence through some kind of subsidy scheme. Another reason for interest is that as the costs of meeting the 1976 automotive standards become more visible to consumers, and as costs of transportation controls and other policies necessary to meet ambient air quality standards in some areas become known, there may be considerable political reaction against the air pollution controls. It has been suggested that this kind of political backlash might be blunted by an appropriate program of subsidy. For example, A. Alan Post, the legislative analyst for the state of California, has said:

> Thus, if a disincentive or a direct regulatory action is to make the cost of essential transportation for low income workers and students prohibitively expensive, we will be confronted with the need to provide some form of exemption or subsidy for these people. Our experience to date has shown that disincentives or controls that make the cost of essential mobility prohibitive for any significant number of people are not politically acceptable (Post, 1973, p. 9).

Also, the Environmental Quality Laboratory at Cal Tech, in outlining their proposed strategies for meeting the air quality standards in the Los Angeles basin, included the following among their recommendations:

> Mandatory installation of an evaporative control device on gasoline-powered 1966-69 vehicles.... Since this device is estimated to cost approximately $150 to purchase and install, some subsidy or cost sharing would be required (Lees, 1972, p. 23).

Subsidies of this sort are among several possible strategies for changing the distribution of income. While subsidies will also have effects on resource allocation and economic efficiency, our concern here is with their evaluation in the context of redistributive or equity criteria. A

TABLE 5

Household Car Purchases by Income Level--1971

Income Class ($)	% of Households Purchasing A Car	% of Households Purchasing New Car	% of Households Purchasing Used Car	% of Buyers Who Choose New Car
Under 3,000	15.0	2.3	12.7	15.3
3,000-4,999	24.5	5.6	18.9	22.9
5,000-7,499	34.5	10.3	24.2	29.9
7,500-9,999	38.5	11.4	27.1	29.8
10,000-and over	48.0	22.4	25.6	46.7
All Households	34.9	12.6	22.3	36.1

Source: U.S. Department of Commerce, Bureau of the Census, Consumer Buying Indicators, P-65, No. 43, December, 1972.

number of criteria for judging income redistribution policies have been proposed and discussed in the literature. One such criterion has been proposed by Weisbrod, the target efficiency of the redistributive process (Weisbrod, 1969).

Target efficiency refers to the extent to which the actual distribution of the benefits of some redistributive program coincides with the desired distribution of benefits. Where some target population has been identified as the desired beneficiaries, one measure of target efficiency is the percentage of total program benefits which are delivered to the target population. This measure is termed "vertical efficiency." Horizontal efficiency can be measured in two ways. The first measures the coverage of the redistributive program, and is the percentage of members of the target group which actually receive benefits. Where the redistributive program has the aim of meeting some target level of need (e.g. minimum income, full subsidy of specified costs), a second measure of horizontal efficiency is possible. This is the dollar value of benefits received by the target group as a percentage of the total benefit <u>needs</u> of that target group.

Because of our interest in equity considerations, and because of the possibility that subsidy proposals will be seriously discussed, we will test the horizontal and vertical efficiencies of strategies to subsidize pollution control costs for automobiles. It will be assumed, for illustrative purposes, that the desired beneficiaries or target group consists of households with less than five thousand dollars per year income. This definition of the target group is dictated, in part, by the available data.

Any program to provide an across-the-board subsidy of all or some portion of automotive pollution control costs will have a lower vertical efficiency the greater the percentage of the overall burden of pollution control costs actually born by upper income groups.

An across-the-board subsidy of pollution control costs will have a virtually one hundred percent horizontal efficiency in terms of coverage, if the target class is defined as car owning (or car purchasing) households with less than five thousand dollars a year in income. However if the target group is defined to include all households with less than five thousand dollars a year income, i.e. if the pollution control subsidy program is seen to be part of a larger general income redistribution plan, the subsidy will have a relatively lower horizontal efficiency since it will not provide benefits to non-car-owning households.

In subsequent sections, after patterns of incidence of control costs have been determined, measures of vertical efficiency will be presented. In addition measures of horizontal efficiency or coverage will be presented where the target group is identified as all households with less than five thousand dollars a year income.

IV. MEETING THE 1976 NEW CAR STANDARDS

In this section a user cost model of the demand for cars is developed and used to analyze the relationship between user costs of new and used cars. The model shows that when the user cost of new cars is increased, for example because of pollution control equipment, there is an induced increase in both the prices and the user costs of used cars. Depending on the relative magnitudes of the price induced capital gains and user cost changes, some part of the cost of pollution control equipment may be shifted from new car buyers to holders of the existing stock of used cars. The model is used to determine the magnitude and the incidence of these changes: (a) during the first year when only new cars have pollution control equipment; and (b) at the end of the transition period when the uncontrolled stock of cars has been fully replaced by cars meeting the 1976 standards.

The empirical analysis uses 1971 as a base year. Car purchase and ownership data for 1971 are combined with the projected incremental cost of moving from 1971 emission levels to the 1976 standards. The period of transition between 1971 and 1976 is ignored. In other words the analysis is based on the assumption that new cars meeting the 1976 standards were available beginning with the 1972 model year.

This study, like many analyses of incidence or burden, does not attempt to take into account the effects of price changes on demand, or other second-order effects. Although changes in the relative prices of new and used cars are explicitly incorporated in the model, the empirical analysis assumes that consumers do not respond to these price changes by altering purchase patterns of new and used cars.[1]

A. The Costs of Control. There is considerable controversy over what will be the true costs of equipping 1976 model cars with the appropriate equipment to meet the emission standards. Auto manufacturers and oil companies in advertisements and public statements have cited figures far higher than those mentioned by independent sources and used by government officials in their analysis of the problem. Fortunately, since the concern of this study is with the relative burden of control costs among income classes, the accuracy of estimates of control costs per car is of only secondary importance. The estimates of control costs used here were published by EPA (Environmental Protection Agency, 1972).

The 1971 model cars already must meet certain emission control standards. EPA estimates that the cost of meeting these standards amounts to $32.50 per car. EPA has identified three technological alternatives for achieving the 1976 emission control standards. The additional costs per car for manufacturing and installing additional devices and making certain design changes to reduce emissions below the 1971 level are estimated to range between $196.50 and $318.50. The auto manuracturers have committed themselves to the most costly of these alternatives. Therefore it is assumed here that the manuracturing costs are increased by $320, and that this cost is fully reflected in the price of new cars to consumers.

EPA also estimates that emission control devices will reduce fuel efficiency leading to increased operating costs. In addition there will be incremental maintenance costs associated with these devices. Increased fuel consumption costs are estimated at $24.70 per year, and maintenance costs are estimated to increase by $11.40--all at 1970 prices. The total increase in operating and maintenance costs is $36.10 per year.[2]

B. A Naive Model of Incidence. Before turning to the more sophisticated user cost model, this section presents estimates of incidence based on the assumption that pollution control costs affect only new car purchase prices, and the price increases are borne fully by the purchasers of new cars. Two modifications of the data presented in earlier sections are utilized here. First, to take into account the increased operating and maintenance costs, this cost stream is discounted over a five year period at 10 percent, and the present value is added to the equipment costs of pollution control. Hence it is assumed that the total impact of pollution control on new car purchasers is equal to $320 plus $135, or $455 per car.

Second, since there is considerable variation in car purchase behavior from year to year, both in aggregate and with respect to income levels, the three year period 1970-72 was used to determine the average number of purchases per year per income level for both new and used cars.

Table 6 shows numbers of households, income per household, and percent purchasing new cars for each income class. The next column shows the costs per buyer ($455) as a percentage of family income for each income class. The impact of the pollution control costs is sharply regressive with the implicit tax rate falling from 26.5 percent of the lowest income level to only 2.5 percent at the highest income level.

The final column shows average cost per household as a percentage of family income. In this case, the total costs incurred by members of an income class are averaged over all members of that class whether or not they purchased a car. This measure is not as useful for welfare purposes because it obscures the differences between the impact on those who purchase cars and those who do not. However this is a widely used measure of incidence in other situations. And it will be useful in making comparisons with the incidence as determined by the user cost approach taken below. The incidence per household is mildly regressive overall; but it shows some degree of progressivity in the lower to middle income range.

Suppose that some fraction of the purchase price were subsidized by the government. How efficient would this subsidy be in delivering benefits to the assumed target group of under $5,000 per year households? Approximately 10 percent of the total cost of pollution control devices on

TABLE 6

The Incidence of the 1976 Standards--The Naive Model

Income Class ($)	Number of Households (000)	Income per Household ($)	Percent Purchasing New Car*	Cost per Buyer as a % of Family Income	Cost per Household as a % of Family Income
Under 3,000	10,800	1,714	2.6	26.5	.69
3,000-4,999	9,425	3,964	5.3	11.5	.61
5,000-7,499	11,475	6,215	10.0	7.3	.73
7,500-9,999	9,475	8,696	12.4	5.2	.65
10,000-and over	21,600	18,444	21.3	2.5	.53

*average for three years--1970-72

Source: Calculated from U.S. Department of Commerce, Bureau of Census, Consumer Buying Indicators, P-65 Series.

new cars would be borne by the target group. Hence the vertical efficiency of a subsidy of the purchase price would be only 10 percent, i.e. 10 percent of the total cost of the subsidy would go to the target group. If the purpose of the subsidy is to distribute benefits to all households of under $5,000 per year, the horizontal efficiency is also quite low. Only 3.9 percent of households in the target income class purchase new cars, thus horizontal efficiency is only 3.9 percent.

C. A User Cost Approach. The basic postulate of the user cost theory of the demand for capital goods is that the user's demand for the good is derived from the flow of services provided by the durable and that it is the price of these services or rental cost of the durable rather than its purchase price which governs demand.[3] User cost can be defined as the cost of having an automobile available for use for one year, and is equal to the reduction in market value of the automobile during the year plus the implicit interest cost of capital tied up in car ownership:

$$(1)\quad c_{(i,t)} = P_{(i,t)} - P_{(i+1,t+1)} + r\, P_{(i,t)}$$

where $c_{(i,t)}$ is the user cost of an i year old car in year t, P represents market price and r is the relevant interest rate of cost of capital.

The user cost approach is valuable for at least three reasons. First it permits the expression of the pollution control costs in annualized terms as an increase in user cost, rather than as an increase in capital cost as in the naive model above. Second, the user cost approach provides a method for expressing the total stock of used cars of all ages in terms of one year old equivalents.[4] And third, as will be shown below, the user cost approach permits the development of a demand model for determining relative price effects and the way in which they alter the incidence of pollution control cost.

Let us first consider the pattern of incidence in the first year of the new pollution control program, i.e. when only new cars have pollution control. The introduction of pollution control requirements which raise the purchase price of new cars will have two kinds of effects which are partly offsetting in terms of incidence. First, because used cars are close substitutes for new cars, there will be an induced increase in the price of used cars. This results in a once-and-for-all capital gain for all present owners of used cars, i.e. cars of ages i=1,...,n. Second, the changes in purchase prices of new and used cars will result in increases in the user costs to all present car owners and new car purchasers. In addition, since operating and maintenance costs for cars with pollution control devices are higher, the user costs for those who purchase new cars will be higher by that amount. The task now is to model these effects, and to utilize available data and reasonable assumptions to estimate their magnitude by income class.

First a model of new and used car demand is required to determine the magnitude and incidence of the capital gains resulting from the increase in the price of new cars. Abstracting from the effects of income and prices of all other goods, assume that in year t the quantity demanded of new cars, $D_{(0,t)}$ depends upon the purchase price of new cars, $P_{(0,t)}$ and the purchase price of one year used car equivalents, $P_{(1,t)}$.[5] Further, assume a constant elasticity relationship:

$$(2) \quad D_{(0,t)} = P_{(0,t)}^{a} \, P_{(1,t)}^{b} \qquad \begin{matrix} a < 0 \\ b > 0 \end{matrix}$$

In the used car market, the stock of used cars is exogenously determined by past investment decisions. The price of used cars must be such as to make individuals willing to hold the existing stock. The used car demand function takes the form:

$$(3) \quad P_{(1,t)} = S_{(t)}^{d} \, P_{(0,t)}^{e} \qquad \begin{matrix} d < 0 \\ e > 0 \end{matrix}$$

where the purchase price and stock of used cars are expressed in terms of one year old equivalents. To obtain the change in used car purchase prices resulting from any autonomous change in new car purchase prices, differentiate equation (3) with respect to new car prices, or:

$$(4) \quad \partial P_{(1,t)}/\partial P_{(0,t)} = e \, \frac{P_{(1,t)}}{P_{(0,t)}}$$

This expression will be referred to as the price shifter, or "s."

The value of s can be estimated from available empirical studies. Wykoff has estimated a form of equation (3). Although he concluded that "used car prices remain largely unexplained," because of low $\bar{R}^2$ and low "t" statistics, the elasticities calculated from the estimated coefficients seemed reasonable. The coefficient on new car prices, e in Equations (3) and (4) above, was estimated by Wykoff to be 0.34. Accordingly it is assumed here that e = 1/3. Dorfman has gathered data on new and used car prices from published sources (Dorfman, 1973). Her data showed that on a weighted average basis, the prices of one year old cars in 1973 were 75 percent of new car purchase prices. Combining these estimates, Equation (4) shows that for every $4 increase in the purchase of new cars, the price of one year equivalent used cars can be expected to rise by $1, i.e. s = 1/4.

This model of price shifting and estimated values for s can be used to determine the capital gain per car in the following way. The capital gain to the owner of a one year old equivalent used car is:

$$(5) \quad g_{(1,t)} = s\Delta P_{(0,t)}$$

Furthermore if it can be assumed that the relative prices of used cars of different ages remain constant, the capital gain for a car of age i is:

$$(6) \quad g_{(i,t)} = s\Delta P_{(0,t)} \left[P_{(i,t)} / P_{(1,t)} \right]$$

The same price increases that produce capital gains for used car owners lead to increases in user costs. The increase in user cost for a purchaser of a new car with pollution control is:

$$(7) \quad \Delta c_{(0,t)} = \left[P'_{(0,t)} - P_{(0,t)} \right] - \left[P'_{(1,t+1)} - P_{(1,t+1)} \right] + r \left[P'_{(0,t)} - P_{(0,t)} \right]$$

where the primes indicate purchase prices of cars with pollution control. Assume that the rate of depreciation of cars with pollution control is the same as has been observed in cars without pollution control. Then:

$$(8) \quad P'_{(1,t+1)} / P'_{(0,t)} = P_{(1,t+1)} / P_{0,t)} = h$$

and by substitution:

$$(9) \quad \Delta c_{(0,t)} = (1-h+r)\Delta P_{(0,t)}$$

In addition to this increase in the rental cost of a new car, new car buyers incur increased operating and maintenance costs as described above. These are added to the change in user cost measured by Equation (9).

To determine the changes in user costs imposed on owners of used cars, it is necessary to determine how user costs are affected by the changes in prices of used cars modelled above. Wykoff has analyzed the depreciation of user cost over time for automobiles during the 1960s (Wykoff, 1970). He found that after the first year of car life, user costs tended to decline at a constant rate such that:

$$(10) \quad c_{(i,t)}/c_{(1,t)} = e^{-d(i-1)}$$

where estimates of d, the constant depreciation rate, varied from .17 to .23 for standard and smaller models. The depreciation rate for expensive domestic cars was .27. In a different study, Wykoff developed models of new and used car demands where user cost variables replaced the price variables in the demand equation (Wykoff, 1973). He found that the user cost model explained new car demand as well as a model based on purchase price variables. Thus the price shifting model of Equation (4) can be reformulated in terms of user cost and a shifter, s', can be derived. This permits the derivation of the changes in user costs for all used cars for any given increase in the price of new cars. The changes in user cost are:

$$(11) \quad \Delta c_{(1,t)} = s'\Delta c_{(0,t)}$$

and

$$(12) \quad \Delta c_{(i,t)} = e^{-d(i-1)}\Delta c_{(1,t)}$$

The models of price changes, capital gains distribution, and changes in user costs are now complete. With assumptions as to the magnitudes of parameters, the models can be combined with data on purchase and ownership of cars to estimate the distribution of the cost of imposing pollution control standards during the first year.

As described above, the shifters, s and s', are assumed to be equal to 1/4. On the basis of data used by Dorfman (1973), the relative purchase price of one year old and new cars, h, is assumed to be equal to .74. The cost of capital, r, is assumed to be 10 percent. And finally, on the basis of data reported by Wykoff (1970), the rate of depreciation of user costs, d, is assumed to be equal to .2.

Assuming that pollution control requirements raised the price of new cars in 1972 by $320, the capital gains and user cost changes for owners of the existing stock of cars will be distributed among households as shown in Table 7. The holders of the existing stock of cars are made better off by the pollution control requirements, since the induced capital gain is roughly 2 1/2 times larger than the increase in user costs.[6] Although the net gain rises with income, the gain as a percentage of family income is highest for the lowest income class. The net gains are distributed in a progressive or pro-poor manner.

This surprising result that owners of used cars benefit in the first year from the imposition of pollution control is not particularly sensitive to the choice of values for the parameters and does not depend on s. The net gain to the owner of an i year old car is:

$$(13) \quad g_{(i,t)} - \Delta c_{(i,t)} = s\Delta P_{(0,t)} \left\{ \frac{P_{(i,t)}}{P_{(1,t)}} - \left[(1+r-h)e^{-d(i-1)} \right] \right\}$$

which will be greater than zero if:

TABLE 7

Incidence of the Capital Gains and User Cost Changes for Used Car Owners--The First Year

Income Class ($)	Income per Household ($)	Capital Gain per Household ($)	Change in User Cost per Household ($)	Capital Gain as % of Family Income (%)	Change in User Cost as % of Family Income (%)	Net Change as % of Family Income (%)
Under 5,000	2,674	+16.87	6.57	+.63	-.25	+.38
5,000-9,999	7,473	+38.14	14.62	+.51	-.20	+.31
10,000-14,999	12,151	+53.91	20.52	+.44	-.17	+.27
15,000-and over	25,404	+70.71	26.75	+.28	-.11	+.17

Source: Calculated from U.S. Department of Commerce, Bureau of Census, Consumer Buying Indicators, P-65 Series.

$$(14) \quad \frac{P_{(i,t)}}{P_{(1,t)}} > (1+r-h)e^{-d(i-1)}$$

and

$$(15) \quad s > 0, \ \Delta P_{(0,t)} > 0$$

Inequality (14) will hold for any reasonable set of values for the variables.[7]

It must be emphasized that the net gain shown in Table 7 is the result of a once-and-for-all capital gain experienced by used car owners in the first year following the imposition of pollution controls on new cars. While user costs will continue to rise, there will be no further offsetting capital gains in subsequent years. The new equilibrium pattern of user charges will be discussed below.

In addition to the capital gains and changes in user costs on used cars, those who choose to purchase new cars will bear a burden in the form of higher user costs. Equation (9) was used to translate the change in purchase price into a change in user costs for new car buyers. This increase in user costs was allocated by income class in accordance with the new car purchase data summarized in Table 5. The increase in operating and maintenance costs of $36 per year was added to the increase in user charges calculated by Equation (9). See Table 8. The pattern of incidence is very similar to that of the naive purchase price model in Table 6. The incidence is approximately proportional up to the $10,000 income level. This is because although the burden per buyer is regressive, the proportion of households buying new cars declines as income falls.

Although the purchase data and car ownership data are tabulated on the basis of different income classifications, it is possible to merge the gain and cost data to get at least a rough idea of the overall incidence of the combined first year gains to used car owners and costs to new car buyers. Because the stock of cars in existence at any point in time is far larger than the new car purchases in a given year, the gains calculated in Table 7 outweigh the costs shown in Table 8. The net gains distributed by three broad income categories are as follows:

	As a percentage of family income		
Income Class	Gain	Loss	Net
Under $5,000	+.38	-.21	+.17
$5,000-9,999	+.31	-.22	+.09
$10,000 and over	+.22	-.17	+.05

The overall incidence is dominated by the gains to used car owners. This offsets the proportional or slightly regressive distribution of user costs to new car buyers; and the net result is a pro-poor distribution of gains. Both the gains and costs are lowest for the high income group but since the purchase of new cars is more skewed by income level than is the ownership of cars, the highest income group bears a relatively larger share of the costs than it receives of the gains.

We now turn to the structure of user costs in the new equilibrium, when the stock of cars has been replaced by newer vintage cars with pollution control. It is assumed that throughout the period of transition there were no further changes in pollution control requirements or costs. Thus the user cost of new cars is the same as that given by Equation (9). Further it is assumed that the structure of user costs by age is the same as that which prevailed before the introduction of pollution control, and which was investigated by Wykoff (1970). Wykoff found that the depreciation rate in the first year was substantially higher than in subsequent years. He found

TABLE 8

The Incidence of User Costs for Buyers of New Cars

Income Class	Cost per Household ($)	Cost per Household as a % of Family Income
Under 3,000	3.90	.23
3,000-4,999	7.95	.20
5,000-7,499	15.00	.24
7,500-9,999	18.60	.21
10,000-and over	31.95	.17

Source: Calculated from U.S. Department of Commerce, Bureau of Census, Consumer Buying Indicators, P-65 Series.

a two step depreciation schedule which is described as follows:

$$(16) \quad c_{(1,t)}/c_{(0,t)} = e^{-\hat{d}} \text{ where } \hat{d} \simeq .35$$

and

$$(17) \quad c_{(i,t)}/c_{(1,t)} = e^{-d(i-1)} \text{ where } i \geq 1, \; d \simeq 2$$

Equations (16) and (17) were used to allocate user costs by income level on the assumption that the structure of ownership by age of car and income level was the same as that actually prevailing in 1971 and shown in Table 2. This allocation of costs is shown in Table 9.

There are several things to note about this distribution. First the costs per household are substantially higher than those shown in Tables 6-8. This is in part because there are no offsetting capital gains, and in part because all of the cars in the used car stock are assumed to have pollution control. Hence families cannot avoid the cost of pollution control in the long run by owning or purchasing a used car. Second the incidence pattern is unambiguously regressive. The change in the structure of incidence stems from the different assumed age structure of user costs. The implicit tax rate on the under $5,000 per year income group is almost three times the tax rate on the $15,000 and over group. In other words, when account is taken of the fact that ultimately all car owning households will bear part of the costs of pollution control, the incidence pattern becomes much more regressive than when one investigates only the incidence of new car purchase costs.

Again, the new car purchase data can be merged with the user cost data to obtain a rough picture of the incidence in the new equilibrium. See Table 10. Again the overall pattern is regressive. But the merging of the

TABLE 9

The Incidence of User Costs--Used Car Owners
All Cars Controlled

Income Level ($)	Cost per Household ($)	Cost per Household as a % of Family Income
Under 5,000	43.17	1.61
5,000-9,999	85.41	1.14
10,000-14,999	112.81	.93
15,000-and over	139.54	.55

Source: Calculated from U.S. Department of Commerce, Bureau of Census, Consumer Buying Indicators, P-65 Series.

TABLE 10

Overall Incidence--New and Used Car Owners
All Cars Controlled

Income Class ($)	Cost per Household	Cost per Household as a % of Family Income
Under 5,000	48.94	1.83
5,000-9,999	102.16	1.37
10,000-and over	155.73	.89

Source: Calculated from U.S. Department of Commerce, Bureau of Census, Consumer Buying Indicators, P-65 Series.

$15,000 and over income class with the $10,000-15,000 class obscures the low implicit tax rate on the highest income families.

The total increase in user cost in the new equilibrium is $6,466 million per year. Of this amount, approximately $1,000 or 15 percent is borne by the under $5,000 per year income group. Hence the vertical efficiency of an across-the-board subsidization of user costs would be about 15 percent. Also since only about 56 percent of households in the under $5,000 per year income group own cars, the horizontal efficiency of an across-the-board subsidy of user costs would be about 56 percent.

Alternatively, the subsidy could be directed at the purchase price of new cars. Since this subsidy would not cover the increased operating costs, it would have a slightly different distribution of its benefits than a full user cost subsidy. However the vertical efficiency of such a purchase price subsidy would not be substantially different from the 15 percent cited here.

V. THE INCIDENCE OF ALTERNATIVE CONTROL STRATEGIES

In the introduction it was suggested that the present strategy directed at achieving pollution control standards for new cars produced after 1976 may not be the most appropriate. It will be approximately five years before normal replacement of the existing stock of cars results in the majority of cars on the road having been designed and manufactured to meet the 1976 standards. Furthermore there are major unsolved problems concerning the durability and effectiveness of the pollution control technology which apparently has been chosen by the American manufacturers to meet these standards. Finally the federal standards do not take into account regional differences in the severity of the automotive air pollution problem. Some urban areas will probably have to take more severe action to control automotive emissions in order to meet the established ambient air quality standards (New York Times, 1973; Lees, 1972).

These factors have led some students of the problem to consider alternative control strategies which would be directed at controlling the emissions of all cars within the relevant jurisdiction. In this section the incidence of the costs of three alternative strategies of this type are examined. In each case the costs are purely hypothetical. No attempt has been made to relate costs to the achievement of actual air quality standards. Nor was there any attempt made to utilize engineering data to determine a "realistic" cost. But given the postulated hypothetical cost figures, the imputation of these costs among income groups is considered valid. For other control schemes which have the same distributional impact but different total cost levels, the incidence patterns portrayed here would still be relevant since the alternative programs would be proportional to those shown here.

Three kinds of control programs are considered.

(1) Uniform control costs per car--It is assumed that every car on the road is required to install or retro-fit the same emission control package, i.e., the increase in user costs is the same for all models and ages of cars.

(2) Uniform emissions standards for all cars--It was assumed that all cars must meet the same emissions standards, but that the costs of meeting these standards was a rising function of age of car.

(3) Costs related to use--The preceding strategies focus on emissions per mile, without attempting to control miles driven. A surcharge on gasoline purchases is one way of attempting to curtail automobile use as part of an overall air pollution control strategy.

A. Uniform Control Costs per Car. It was postulated that all cars would be required to incur the same level of control costs, and that the effect of these requirements would be to raise the user cost per car by $100 per year. The car ownership data were used to impute a control cost per owner and a control cost per household for each income level. The dollar amounts of these costs and costs as a percentage of family income are tabulated in Table 11.

The pattern of incidence is highly regressive. For the under $3,000 income class, the implicit tax rate per car owner is more than nine times the corresponding tax rate on the highest income level. Even neglecting the under $3,000 per year class which may include a high proportion of students and other voluntary, temporary poor, the implicit tax rate per owner and per household is still more highly regressive than that found for the federal policy.

The vertical efficiency of an across-the-board subsidy of pollution control costs can be measured by the percentage of total control costs which is born by the target group, i.e. the under $5,000 per year income class. Under the uniform control cost scheme, since the under $5,000 income class owns 18 percent of all cars owned by the household sector, they bear 18 percent of the total cost of the control imposed on the household sector. Hence the vertical efficiency of an across-the-board subsidy scheme would be 18 percent. Since 56 percent of households in the under $5,000 per year income class own one or more cars, the horizontal efficiency of a subsidy scheme is 56 percent.

B. Control Costs Rise with Age of Car. For this section, it was postulated that the cost of controlling emissions for 1971 model cars resulted in an

TABLE 11

Incidence of Uniform Control Cost per Car

Income Class ($)	Income per Household ($)	Control Cost per Owner $	Control Cost per Owner As a % of Family Income	Control Cost per Household $	Control Cost per Household As a % of Family Income
Under 3,000	1,714	114	6.65	49.70	2.90
3,000-4,999	3,964	117	2.95	82.00	2.07
5,000-7,499	6,215	129	2.08	109.70	1.77
7,500-9,999	8,696	141	1.62	129.20	1.49
10,000-14,999	12,151	157	1.29	148.79	1.22
15,000- and over	25,404	180	.71	174.10	.69

Source: Calculated from U.S. Department of Commerce, Bureau of Census, <u>Consumer Buying Indicators</u>, P-65 Series.

TABLE 12

Incidence of Rising Control Costs with Age of Car

Income Class ($)	Control Cost per Household ($)	Control Cost per Household As a % of Family Income
Under 5,000	80.59	3.01
5,000-9,999	134.52	1.80
10,000-14,999	159.06	1.31
15,000-and over	175.40	.69

Source: Calculated from U.S. Department of Commerce, Bureau of Census, Consumer Buying Indicators, P-65 Series.

increase in user costs of $40 per car per year, and that user costs increased linearly with age to a level of $140 per year for 1966 and earlier model cars. This pattern of user cost results in a total cost of control per year approximately the same as the uniform control cost per car strategy analyzed above.

Table 12 presents control costs per household in dollar magnitude and as a percentage of family income. Again the pattern of incidence is regressive. However this strategy does not impose absolutely larger costs on lower income households, as one might have thought. This is because although low income households tend to concentrate their ownership in the older age bracket, middle and upper income households own a larger number of the older vintage cars. The overall pattern of incidence is remarkably similar to that of the uniform control cost policy analyzed above. The implicit tax rate is slightly higher for the rising control cost strategy at the lowest income levels; but the tax rate is identical for both strategies at the highest income class.

A subsidy plan which subsidizes the same percentage of control costs for all car owners would have a vertical efficiency of 20 percent. In other words 20 percent of the subsidy would reach households in the $5,000 and under income class. And since 56 percent of the households in this income group own cars, the horizontal efficiency of such a subsidy program would be 56 percent.

An alternative subsidy scheme might cover only control costs for older vintage cars. For example the subsidy might cover some fraction of the increase in user costs for 1967 and earlier vintage cars only. The vertical efficiency of that plan is somewhat higher, but still a surprisingly low 24 percent. In other words 76 percent of the benefits of such a subsidy would go to others than the target income class. And of the 20.3 million households in the under $5,000 per year class, only 10.2 million or just over 50 percent would receive benefits from such a subsidy.

C. A Gasoline Tax. Gasoline purchase data by income class were available from the Brookings MERGE File for 1972.[8] A gasoline surtax was taken as representative of the several possible emissions control strategies directed at auto usage (miles driven) rather than auto ownership. A surtax of 20 cents per gallon was assumed in calculating Table 13; but the pattern of incidence would be the same for any strategy imposing costs on users in proportion to gasoline purchases.

Table 13 shows a pattern of incidence which is slightly progressive except at the extremes of the income distribution. The implicit tax rate rises from .84 percent for $2,000-3,999 per year class to 1.09 percent for the $15,000-19,999 class. This contrasts with the other control strategies analyzed here, all of which were regressive overall.

The data of Tables 11 and 13 are also relevant to the recent discussion of the distributional effects of alternative means of allocating scarce gasoline supplies. Allowing the price of gasoline to rise, or imposing a surtax to control demand would not apparently have the regressive impact cited by opponents of price or tax policies. However as Table 11 shows, the most commonly mentioned alternative, issuance of equal quantities of saleable rationing coupons to each car owner, would have far more favorable distributional effects. The coupon scheme would involve a substantial transfer of income from the government (in the case of the surtax alternative) or oil producers (where the alternative was a price increase) to car owners, with the value of the transfer being a larger percentage of income for lower income households.

VI. SUMMARY AND CONCLUSIONS

In this paper we have developed a user cost model of demand for new and used automobiles, and used this model to trace out the effects of an increase in the price of new automobiles caused by the imposition of automotive emissions standards. And we have compared the pattern of incidence that results from the present strategy with those which might result from alternative policies imposing requirements on all cars. EPA suggests that the burden on the 1976 emissions standards will fall relatively most heavily on middle-income groups. While this result is confirmed by the application of the naive model of new car purchases, the more comprehensive user-cost model shows that the final result will be an unambiguously regressive distribution of the burden. The user-cost approach is judged to be a better approximation of reality because it provides a framework for analyzing the effects of new car pollution control requirements on both new car owners and used car owners.

There are several limitations to the analysis presented here. First there is considerable uncertainty as to what will be the costs of meeting the new car standards by 1976. While most of the uncertainty regarding what technologies will be used has been resolved, there are still widely varying estimates as to the costs of utilizing these technologies. It is even difficult to reconcile estimates of control costs published by EPA at different times. Hence all of the estimates of incidence presented here must be construed as indicating the relative distribution of the burden more accurately than the absolute levels of the burden.

TABLE 13

Incidence of Gasoline Surtax--20¢ per Gallon

		Tax Cost per Household	
Income Class ($)	Mean Income ($)	$	As a % of Family Income
Under 2,000	1,062	13.72	1.29
2,000-3,999	3,061	25.66	.84
4,000-5,999	5,000	41.44	.83
6,000-7,999	7,143	66.58	.93
8,000-9,999	9,000	90.12	1.00
10,000-14,999	12,000	128.60	1.07
15,000-19,999	17,500	190.28	1.09
20,000-25,999	22,250	236.16	1.06
26,000-49,999	33,684	305.16	.91
50,000-and over	95,484	296.16	.31

Source: From data supplied by Nancy Dorfman from the Brookings MERGE File.

Second, it should be noted that the incidence analysis assumes no changes in the patterns of automobile purchases and ownership in response to changes in the price of automobiles relative to other goods, or changes in the relative user costs of different models and vintages of automobiles. To the extent that consumers respond to changes in relative prices and user costs, the incidence patterns will be modified. Not only might the total quantity demanded of automobiles change, but there are likely to be changes in the model mix as well. This will be both because of changes in the relative prices of models and because of different own-price and cross-elasticities of demand among models and vintages. Also the analysis abstracts from the possible effects of other forces such as rising fuel costs and rising costs of safety features, both of which are likely to confound the effects of pollution control requirements on the patterns of ownership and purchase.

Finally the analysis considers only the effects of emission control costs borne directly by households as they purchase cars for private use. About 30 percent of each year's new car production goes into commercial or governmental use. It is assumed that the emission control costs associated with these cars are passed on to consumers in a pattern similar to all other governmental and industrial pollution control costs.[9]

While all of the strategies analyzed here are regressive, the federal new-car strategy is substantially less regressive than the two alternatives imposing requirements on all cars. With the federal strategy, the burden as a percentage of income for the under $5,000 group was about 2 1/2 to 3 times the burden on the highest income group. But for the two alternative strategies analyzed, the relative burden was over four times higher than the burden on the highest income group. The analysis of target efficiency showed that the vertical efficiency of any across-the-board or general subsidy of pollution control costs would be quite low. The vertical efficiency of a subsidization of the costs of meeting the 1976 standards would direct only about 15 percent of its benefits to the under $5,000 per year income group. The vertical efficiencies of the uniform control costs and rising control costs with age strategies were 18 percent and 24 percent respectively.

Finally, it is important to look specifically at the burdens placed upon households in the lowest income class by each of these strategies. In the first year, the 1976 new car standards result in a net gain per household in the under $5,000 per year class of approximately $10. And since only about 56 percent of the household in this income class own cars, this works out to an approximately $18 gain per used car owner. On the other hand, each of the households in this income group purchasing a new car in the first year will experience an increase in the user cost of approximately $170. While this would be a large burden relative to income, households in this situation could avoid or at least reduce the burden by retaining their old car or purchasing a used car rather than a new car.

After the effects of the new car controls have been fully worked out, used car owners in the under $5,000 class would be experiencing a $43 increase in user cost per household, or a $77 increase in user cost per owner. During the transition period between the first imposition of controls and the final equilibrium, the burden per household or per owner would be gradually rising to this level.

If control costs are imposed on all cars, the only way a low income family can avoid the increase in user cost is to become a non-owner. The impact on low income households could be substantial. As Table 11 showed, in the uniform control cost case, car owners in the under $3,000 per year income class had control costs of $114 per household or 6.65 percent of family income. The incidence patterns are roughly similar for the case of rising control costs with age of car.

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FOOTNOTES

[1]For an analysis of the aggregate impact of meeting the 1976 standards which does consider changes in the pattern of purchases, see (Council on Environmental Quality, 1972).

[2]More recently EPA has concluded that one catalyst replacement will be required during the first 50,000 miles of use. Catalyst replacement costs are estimated at between $50 and $155 per car (Environmental Protection Agency, 1973, p. 4-8). These costs are not included in this study. Although this exclusion biases the estimated level of control cost, it does not materially affect the pattern of incidence of these costs.

[3]Wykoff has developed the user cost approach to model the demand for automobiles, see (Wykoff, 1970, 1973).

[4]Briefly, the stock of used cars, measured in terms of one year old equivalents is given by:

$$S_{(t)} = \sum_{1=1}^{n} S_{(i,t)} \, [c_{(i,t)}/c_{(1,t)}]$$

S is a weighted index, where the number of cars in each year group is weighted by the ratio of the user cost of cars of that age to the user cost of the one year equivalent. The definition can be expanded to take into account different models of the same vintage. See (Wykoff, 1973).

[5]This is Wykoff's "superior good" model in which new cars are qualitatively different from used cars by virtue of their newness alone. He found that this model explained new car purchases better than the alternative "stock adjustment" model which treats new cars simply as additions to the total stock of cars. See (Wykoff, 1973).

[6]In actuality this gain will be spread out over several years between 1972 and 1976 as emission standards gradually become more stringent and new car prices gradually rise.

[7]The exponential term on the right side of (14) is the ratio of user costs while the term on the left is the ratio of purchase prices. With the assumed values of r and h, the term in parentheses is substantially less than 1 (.36). Since the depreciation patterns for purchase price and user cost are likely to be similar, the inequality should hold in general.

[8]I am indebted to Nancy Dorfman for making these data available to me.

[9]See Environmental Protection Agency, 1972, and Dorfman, 1973.