FORECASTING LONG-RUN AUTOMOBILE DEMAND

Damian J. Kulash, Jack Faucett Associates, Inc.

This paper presents a method for forecasting long-run automobile sales. The method is structured so that alternative policies for improving automobile fuel economy can be analyzed. The core of this forecasting procedure embodies two equations: one for estimating total new automobile sales in some future year, and one for detailing the composition, by vehicle size class, of total sales. Several secondary equations are used to introduce the effects of population and affluence into the forecasting process, to combine the various costs associated with owning and operating a vehicle, and to estimate the rate at which vehicles are retired from service. Application of the procedures described here requires detailed consideration of the automobile fleet composition throughout each year of the forecast period. This paper is confined to the sales projection components of that process and does not attempt to describe the extensive fleet accounting mechanism that has been developed in order to apply this component.

OBJECTIVE

A wide range of programs including voluntary measures, standards, restrictions, and taxation policies have been proposed to help restrain future automobile gasoline consumption in the United States. In comparison to policies that would require substantial government involvement in the automobile market, steps that would improve the fuel economy of new automobiles find broad support because of their relatively minor impact on automobile ownership, ease of travel, and life-styles generally. There are, however, numerous alternative steps of this sort, and the implications of each are extremely difficult to project. This difficulty springs from the durability of the automobile stock, and the correspondingly long lags inherent in introducting a fleet with improved gasoline performance. Since about half of the automobile gasoline in this country is consumed by automobiles that were manufactured 4 or more years ago, policies that are tied to new vehicles alone can be evaluated realistically only by comparing their long-run effects. Furthermore, automotive technology cannot be changed rapidly and the timing and feasibility of potential fuel economy improvements are surrounded by considerable uncertainty. Public policy adds to the uncertainty. For example, the feasibility of diesel and stratified-charge engine technology is dependent on environmental policy as well as market and production factors. Finally, shifts in consumer automobile purchasing and travel patterns could reshape future patterns of gasoline consumption, and those factors are themselves heavily influenced by overall economic conditions, automobile industry pricing and marketing practices, gasoline prices, and numerous other forces.

To deal consistently with the interactions between technology, public policy, the automobile industry, and the marketplace, a modeling approach is virtually mandated: The intricacy of the task is far beyond that susceptible to casual estimation. At the same time, many elements of this process are poorly understood and inadequately documented, so that judgment can and must play a key role even within the context of an analytic model.

The approach presented in this paper represents a blending of many elements, some susceptible to rigorous analytic estimation and validation, some dependent on judgments tempered by review of past trends and relations, and some that combine the two.

Realizing the environment for which this methodology has been designed is critical to understanding the structure of the procedures developed. This model has been designed to predict long-run automobile demand, travel demand, and gasoline consumption as a function of policy-induced shifts in new automobile prices, new automobile fuel economies, and gasoline prices. Some of the implications of this context are sketched below.

Reliance on a Predictable or Controllable Basis

The procedures presented here are part of a long-range forecasting model. Many forces that operate throughout the forecasting period will influence the accuracy that they achieve. Economic theory, statistical techniques, and logic can help to identify the causes of observed market behavior in the past, and a realistic projection of future automobile market behavior must reflect these key events and factors—but only if they themselves can be reliably predicted or controlled. It is meaningless to base automobile projections on forces that cannot be charted with any greater reliability than automobile ownership, vehicle-kilometers, or gasoline consumption.

The other side of the coin is that those factors tied to the automobile market that are predictable should be exploited by forecasting methodology, as should those that would be controlled by the public policies being analyzed. The population of drivers, for example, can be predicted with reasonable certainty since the persons eligible to drive in 1990 were born before 1975, and the population of drivers in 2000 will be dictated for the most part by the fertility rate during the next 10 years.

Responsiveness to Fuel Economy Policy

Some of the proposed policies for conserving fuel would markedly alter new automobile prices, new automobile fuel economies, or gasoline prices. Because fuel economy differs substantially among vehicle classes, comparative policy evaluation requires that the composition of the automobile fleet be projected as well as its overall size.

Comparative Policy Evaluation

The model described here is intended to help design effective fuel economy policies. Ultimately, its function is to help to choose one course of governmental action as opposed to others, and its value is its ability to direct policy makers to the best policy choice. In this role, prediction errors that misrepresent the relative impacts of alternative policies are likely to be more dangerous than those that distort all projections proportionally.

Necessity for Extrapolation Beyond Past Experience

Given recent developments in the economy and the automobile industry in particular, it appears likely that the future may bring vehicle prices, performance levels, fuel economies, and product choice that lie well outside the range of previous experience. Any projection of market behavior under such circumstances is necessarily a hypothetical extrapolation. There are many bases on which such extrapolations might be made. The choice of the best form depends only partly on goodness of fit within the range of calibration: It also depends on the reasonableness of the underlying structure when extrapolated outside the range of calibration.

Although the lack of data is a frequently cited shortcoming throughout economic policy analysis, the deficiency in this case derives from the lack of variation inherent in past experience, not from any failure to monitor and record behavior. Consequently, the necessity for extrapolation is inherent and not amenable to relief through additional data collection.

Uncertainties Inherent in Basing Projections on Recorded Experience

Twenty-five years ago imported automobiles were conversation pieces; today they account for more than 20 percent of the new automobile market. In 1950 automobile air conditioners, power steering, and power brakes were almost unheard of, and automatic transmissions were just being introduced. Today the majority of new automobiles sold have power accessories and more than 9 out of 10 have automatic transmissions.

Twenty-five years earlier—1925—marked the beginning of automotive production and the widespread entry of the automobile into the American way of life. Twenty-five years before that the automobile was virtually nonexistent.

Predicting what will happen with respect to the automobile in the next 25 years is necessarily speculative and subject to forces that are impossible to predict. The next quarter of a century could well mark another era in automobile history. Breakthroughs in battery technology, deterioration of environmental quality, shortages of petroleum products, and numerous other possible, largely unchartable factors could be the dominant forces in shaping the future of this industry. At one extreme is the two-automobile strategy: internal-combustion-engine-powered intercity automobiles and small, fuel-conserving, environmentally benign intracity automobiles. An opposite extreme, in terms of sales behavior, could be reached by breakthroughs in durability—automobiles that have a lifetime of two or more times that of current vehicles. Both of these outcomes are not impossible within a 25-year time frame, and each would diverge in opposite directions from the base line implicit in extrapolating the automobile market trends of the last 10 to 15 years.

Nevertheless, if any future state of the automobile market is to be selected as the most likely, it appears at this stage to be one that resembles the last 25 years, at least in the general role that the automobile plays in daily life. This is not to say that design, propulsion system, size, fuel economy, power accessories, safety equipment, or antipollution technology will remain unchanged. On the contrary, significant alterations in these areas are likely and will be reflected by inputs to the model. Changes that would revolutionize the role of private transportation, however, are not assumed to lie ahead in this century. Correspondingly, the forecasting methodology to be presented here assumed that the role that the automobile has played in the past quarter century is likely to pervade future experience as well.

BACKGROUND

Population and Automobile Ownership

The size of the nation's automobile fleet is obviously closely related to its population and to its driving-age population in particular. However, during the last quarter century the automobile fleet has grown much more rapidly than population, as evident from the statistics given in Table 1. Automobile ownership per capita has almost doubled since 1950, and new automobile sales per capita have increased by nearly a quarter since then. Thus, population growth by itself falls far short of explaining the growth record of the automobile industry. Changing life-styles and increased consumer affluence have also played significant roles in that growth.

Affluence

Real disposable income per capita in the United States grew by an average of 2.3 percent per year between 1950 and 1975, a total increase of more than 75 percent during that period. As consumer incomes grew, so did automobile sales per capita. However, the automobile ownership by income group has been relatively constant over time (Table 2, 1). Although this pattern is probably not representative of the early fifties, it appears to have been remarkably unchanged since the early sixties.

The automobile ownership by income relation may be described by the following relation, estimated for the above 1970 data:

$$H_I = 0.01786\ I^{0.4743} \qquad \bar{r}^2 = 0.983 \qquad (1)$$

where

H_I = average automobile ownership per household of income I, and

I = income in 1967 constant dollars.

This relation has significant implications for long-run forecasting. As real income increases, so does the average number of automobiles owned, but at an ever diminishing rate. Thus, as the nation's families pass through the middle income regions, their automobile ownership will grow rapidly. But as they approach the upper income categories, the rate of growth will begin to slow. This suggests a sort of "income saturation," an effect that is further illustrated in Figure 1 (2). As household incomes rise to about \$5000, first automobile purchases rise rapidly. As they increase from \$5000 to \$10 000, a tendency toward ownership of two automobiles swings into dominance. Somewhere between \$12 000 and \$18 000 marks the threshold of three-or-more automobile ownership, but even at the high end of the income scale relatively few households (about 20 percent) select this course of action. The relative constancy of the curves at incomes above \$20 000 implies that automobile needs are almost completely served at that point and that further increases in income are matched by little additional automobile ownership.

Table 1. Automobile ownership and sales per capita.

Year	Population 15 to 73 Years of Age	Automobiles per Capita*	New Automobile Sales per Capita*
1950	106 966 000	0.309	0.059
1960	118 282 000	0.454	0.056
1970	138 323 000	0.549	0.061
1973	146 041 000	0.575	0.079

*Per capita statistics are based on the population in the 15 to 73 year age group. Population data are based on the U.S. Census; automobile data were computed from *Automotive News*.

Table 2. Automobile ownership by income group.

Avg Family Income* ($)	Avg Number of Automobiles Owned per Family 1960	1970
<1 000	0.281	0.297
1 000 to 1 999	0.426	0.426
2 000 to 2 999	0.638	0.609
3 000 to 3 999	0.802	0.693
4 000 to 4 999	0.893	0.840
5 000 to 5 999	1.046	0.890
6 000 to 7 499	1.122	1.093
7 500 to 9 999	1.271	1.323
10 000 to 14 999	1.576	1.596
≥15 000		1.890

*Incomes are reported in nominal dollars.

Figure 1. Automobile ownership versus household income.

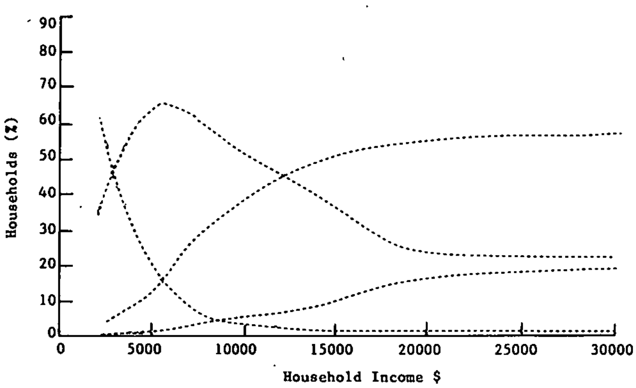

Table 3. Changes in related factors.

Item	1950	1970
Population, percent		
Living in urban places	64.0	73.5
24 years old or younger	41.6	45.9
Federal-aid highway, km	1 032 000	1 480 000
Female labor force, as percentage of female population	31.4	42.6
Avg household size	3.37	3.17

Life-Styles

Many changes in American life-styles in the last quarter century have influenced automobile travel needs. As reflected by data in Table 3 (3, 4, 5), the continued influx of population into cities, the rise of the suburbs, the boom in second homes, the increasing percentage of women entering the labor force, and the development of the Interstate highway system are a few of the developments that have altered automobile travel and ultimately automobile sales during the last quarter century.

Shifts in the social structure during the next quarter century could have a significant bearing on the role of the private automobile during that time. These shifts are difficult to predict, and their influence on automobile travel and sales is often poorly understood. Consequently, the effect of changing life-styles can make only a limited contribution to long-term forecasting relative to the automobile.

These are distinct differences in automobile ownership and usage patterns as a function of household location. Various censuses during the last 15 years have shown automobile ownership by suburban residents to be about 25 to 40 percent higher than for center city dwellers. There are also sharp differences in automobile ownership and use at the regional level. In New York City, where the costs of owning and operating an automobile are high and the public transportation is relatively good, automobile ownership is only 60 percent of the national average. Because of comparatively minor changes predicted in the distribution of population between now and 2000, these differences in automobile behavior by various geographic groups have a minor bearing on the nation's overall automobile fleet and its gasoline consumption. Furthermore, any loss of accuracy due to lack of geographic refinement is likely to be felt proportionally and not affect policy rankings.

FORECASTING TECHNIQUES

This section details the econometric equations that form the core of the automobile market projection methodology presented in this paper. It should be noted, however, that a large body of supporting computation is needed to apply these equations, which describe how automobile sales in some future year depend on the vehicle fleet that exists then as well as various economic and demographic factors. The composition of the future vehicle fleet is itself a function of automobile sales in previous years; in the case of long-term forecasts, the fleet composition is based heavily on projections of sales for earlier years of the forecast period. Thus, application of the procedures described here requires that the actual and projected population of vehicles at any future year be maintained by vehicle class and by model year detail and that scrappage and fleet size be computed on this detailed basis.

The calculation of fleet size and composition represents the bulk of the computational effort needed to use the methodology presented here. This computation is routine and straightforward, and details on it have been omitted in this paper so as to emphasize the market forecasting equations themselves.

Automobile Sales

As noted in the previous section, automobile ownership by real income group has held fairly constant since the early sixties. This ownership pattern can be used to obtain a rough estimate of the total fleet size as a function of the income distribution:

$$O_t^* = \Sigma_I H_I P_{It} R_t \quad (2)$$

where

O_t^* = target national automobile ownership, year t;
H_I = automobile ownership per household of income I, as defined in equation 1;
P_{It} = fraction of total household having income I, year t;
R_t = total number of households in the United States, year t; and
I = household income, the summation being made across all income groups.

Some automobile sales represent extensions to the previous fleet; others represent replacement of existing vehicles. If the total number of vehicles that are scrapped in a given year is D_t and if the total fleet size before they are scrapped is A_t, then the gap between the actual fleet size and the target fleet size would be $O_t^* - A_t + D_t$. This expression is adopted here as an index of consumer need for new automobiles based on population and affluence considerations. It will be combined with price factors, as described below, to form a structure for estimating new automobile sales.

Historic vehicle prices, although a tangible and measurable concept, present problems for statistical inference. Automobile prices, gasoline prices, and fuel economies all have a bearing on the overall cost of owning and operating a vehicle. But during the last 15 years, these three measures have all changed in highly interrelated ways, as reflected by simple correlation coefficients among them of 0.9 or greater. These interrelations make it difficult to use statistical techniques to separate the impact on sales of one price element relative to the others. On the other hand, automotive fuel economy policy proposals would influence various combinations of each of these elements, making it essential that the effect of each be isolated.

To bridge the gap between analytic requirements and statistical capability, a concept of generalized price was applied by which the three price elements were collapsed into a single measure, largely on theoretic grounds. The generalized price is defined by

$$Y_{c,t} = C_{c,t} + bG_t/F_{c,t} \quad (3)$$

where

$Y_{c,t}$ = generalized price of new vehicle of class c, year t,
$C_{c,t}$ = price of new vehicle of class c, year t,
G_t = price of gasoline, year t, dollars per liter,
$F_{c,t}$ = fuel economy of new vehicle of class c, year t, kilometers per liter, and
b = 52 853, a constant that reflects the lifetime, discounted, perceived automobile-kilometers.

That is, the generalized price is simply the automobile purchase price plus the gasoline operating cost computed for the lifetime of the car. The gasoline cost component is based on historic trends in vehicle-kilometers by age of vehicle. These trends are supported by the Federal Highway Administration study (2, Vol. 2, p. 14). These gasoline expenditures have been discounted at an annual rate of 10 percent to account for the fact that some of them will occur in future years. The discounted lifetime gasoline cost thus computed is then reduced by 20 percent to allow for incomplete consumer perceptions of this element at the time of vehicle purchase. The following equation was then estimated for new automobile sales:

$$N_t = 286\,721 \underset{(3.8325)}{} (O_t^* - A_t + D_t)^{\underset{(1.307)}{0.2178}} (X_t^*)^{\underset{(-3.862)}{-1.7039}} \quad (4)$$

$r^2 = 0.7807$ D.W. = 1.177
S.E.E. = 0.0417 df = 11

where

N_t = new automobile sales, year t; and
X_t^* = index of average generalized price for all vehicle classes, year t (1967 = 1.00).

Based on this equation and the associated adjustment mechanism, the following elasticities of new automobile sales to price were computed:

Term	Period	Price Elasticity
Short	1 year	-1.23
Medium	5 years	-0.78
Long	9 years	-0.68

Market Shares

Before historic evidence is analyzed with respect to automobile market shares by size class, a decision must be made on how vehicles should be grouped into shares. Although the automobile industry, consumers, and government agencies have developed automobile classifications for various purposes, there has not been any consistent definition of vehicle classes over time. Any division of the automobile market into a few classes involves some loss of essential detail. Grouping vehicles by fuel economy leads to classes that are heterogeneous with respect to market image, and grouping vehicles on the basis of price leads to classes that have high variability in terms of fuel economy. Of several vehicle characteristics tested in preparation for the analysis described here, weight appeared to provide the best framework for structuring vehicle categories: It tended to balance the problems of price and fuel economy variance within categories, and it exhibited a stable trend over time. The following weight classes were selected (1 kg = 2.2 lb):

Class	Weight (kg)
Small	<1386
Medium	1386 to 1591
Large	>1591

Past automobile sales were assigned to these classes, and sales-weighted prices and fuel economies were computed for each class and model year. The supporting data were taken from the 1960-1975 almanac issues of Automotive News.

Based on these data, a logit structure was estimated by using data from 1963 to 1973. This form includes a lagged share term since experience shows that consumers have a tendency to make successive purchases of the same class of vehicle, especially in the case of large automobile owners, as shown below (6):

Class	Percentage Repurchasing Same Class of Vehicle
Small	47.82
Medium	38.83
Large	84.90

The form of the share equation estimated is

$$\ln\left(\frac{Q_t^c}{1-Q_t^c}\right) = a_0 + a_1(D_1X_t^S) + a_2(D_2X_t^M) + a_3(D_3X_t^L) + a_4(D_2X_t^S) + a_5(D_3X_t^L) + a_6(D_1X_t^M) + a_7(D_3X_t^M) + a_8(D_1X_t^L) + a_9(D_2X_t^L) + a_{10}(D_1Q_{t-1}^c) + a_{11}(D_2Q_{t-1}^c) + a_{12}(D_3Q_{t-1}^c) \quad (5)$$

where

Q_t^c = market share of class c (c = small, medium, and large), time t;
X_t^S = ratio of generalized price of small automobiles to generalized price of all automobiles, time t;
X_t^M = ratio of generalized price of medium automobiles to generalized price of all automobiles, time t;
X_t^L = ratio of generalized price of large automobiles to generalized price of all automobiles, time t;
D_1 = dummy variable with value of one for small automobile observations and of zero otherwise;
D_2 = dummy variable with value of one for medium automobile observations and of zero otherwise;
D_3 = dummy variable with value of one for large automobile observations and of zero otherwise;
(Q_{t-1}^c) = previous year's market share; and
$a_0, a_{11}, \ldots, a_{13}$ = coefficients to be estimated.

The coefficient estimates for the market shares model were as follows:

$$\ln\left(\frac{Q_t^c}{1-Q_t^c}\right) = \underset{(-2.9858)}{-4.1749} - \underset{(-1.7728)}{1.8660}(D_1X_t^S) - \underset{(-0.6095)}{2.0765}(D_2X_t^M) - \underset{(-0.2651)}{0.4299}(D_3X_t^L) + \underset{(2.3772)}{3.5450}(D_2X_t^S) + \underset{(2.1158)}{3.5093}(D_1X_t^M) + \underset{(0.9024)}{1.8117}(D_3X_t^M) + \underset{(0.1103)}{0.2589}(D_2X_t^L) + \underset{(5.5060)}{5.6428}(Q_{t-1}^c) \quad (6)$$

$r^2 = 0.9473$ D.W. = 2.3907
S.E.E. = 0.2203 df = 21

All of the estimated coefficients are of the theoretically correct sign: Own-price variables have negative coefficients, while cross-price variables have positive coefficients. Two cross-price variables, small automobile prices on large automobile shares, have been omitted from the final specification because they almost invariably appeared with perverse signs and extremely low t-statistics. It was assumed, therefore, that the price elasticity between nonadjacent shares was zero. Also, the lag structure for market shares has been constrained to be the same for each class of automobile simply because such a lag structure performed better than the unconstrained version. Finally, although the estimated own-price coefficients for medium automobile shares and large automobile shares are only significant at a 25 percent and 40 percent level of error respectively, they are retained nonetheless under the reasonable theoretical belief that market shares are in fact affected by the prices of vehicles in that class. The cross-price coefficient for large automobile prices on medium automobile shares is thus also retained for logical consistency with the effect of large automobile prices on the large automobile market share.

The three separate market share equations in their final form are as follows:

$$Q_t^S = 1\Big/\left\{1 + \exp - [-4.1749 - 1.8660(X_t^S) + 3.5093(X_t^M) + 5.6428(Q_{t-1}^S)]\right\} \quad (7)$$

$$Q_t^M = 1\Big/\left\{1 + \exp - [-4.1749 - 2.0765(X_t^M) + 3.5450(X_t^S) + 0.2589(X_t^L) + 5.6428(Q_{t-1}^M)]\right\} \quad (8)$$

$$Q_t^L = 1\Big/\left\{1 + \exp - [-4.1749 - 0.4299(X_t^L) + 1.8117(X_t^M) + 5.6428(Q_{t-1}^L)]\right\} \quad (9)$$

These imply that the medium automobiles are more price elastic than large ones and that small automobiles are the most price elastic of all.

The logit functional form has the advantage of ensuring that fitted values of market shares from the three final equations will fall between zero and one. However, there is no assurance that the projections of the three shares will sum exactly to one in spite of the interdependence of the three equations that are linked by cross-price sensitivities. Ex post normalization of the shares must be carried out so that all three shares sum to unity.

Scrappage

Historically, vehicles have been retired from use at a rate that increases as the vehicle ages, up to about 11 years old. At that point, the average retirement rate holds roughly constant around 30 percent per year. The average scrappage rates for the last 14 years form the basis for the scrappage function employed within the model presented here, although vehicle prices and economic conditions are taken into account also, as described below.

Because of the flattening out of the scrappage function for automobiles 11 years or older, the average of the scrappage rates from years 12 to 15 was assumed to hold for vehicles 14 years old and older.

To the degree that vehicle prices and macroeconomic conditions influence vehicle scrappage decisions, this influence is apt to be disproportionately felt by older vehicles. Most scrappage is attributable to vehicles 9 years old or older. Even a proportional change in the scrappage rate for each age of vehicle would result in greater absolute changes among the older vehicles. Since economic factors lead to temporary postponements in scrappage among marginally economic vehicles, the automobiles most likely to be affected will be found among the oldest segment of the automotive stock.

To isolate the effect of economic conditions on vehicle scrappage, one would ideally examine their effect on each vintage of vehicle individually. Unfortunately, because of the number of parameters implicit in such an approach, many years of vehicular history would be needed, and estimates based on distant automotive scrappage history are not appropriate because of durability changes and shifts in consumption patterns that have evolved in recent years.

Instead of a process that alters the scrappage function for each vehicle age group individually, the approach presented here examines in aggregate that group of vehicles where most scrappage occurs, namely, vehicles 9 years old or older. All vehicles in this group were combined for purposes of estimation, and their scrappage rate was formulated as a function of new automobile prices and the unemployment rate.

Scrappage might be expected to vary with new automobile prices for several reasons. As new automobile prices rise, new automobiles become less accessible, creating a tendency to postpone new automobile purchases and to make do with existing stock. Alternatively, new automobile prices are observed to be positively correlated with used automobile prices so that a rise in new automobile prices may lead to an increase in used automobile prices because of shifts in the economics of consumer repair-replace decisions.

The unemployment rate was included because, a priori, it was expected that temporary shifts in macroeconomic conditions were likely to have a strong influence on whether consumers made their automobile purchases ahead of or behind some average schedule. The unemployment rate seemed to be among the most visible and volatile of the cyclical macroeconomic variables, making it a logical choice to serve as a barometer of prevailing economic moods.

The equation estimated for scrappage as a function of new automobile prices and the unemployment rate, based on experience since 1961, is shown below.

$$Z_{c,t} = \underset{(9.856)}{0.40675} - \underset{(-1.911)}{0.078433}\, C^{*}_{c,t} - \underset{(-3.052)}{0.015519}\, U_t \qquad (10)$$

$r^2 = 0.6587$ D.W. = 1.9087
S.E.E. = 0.01544 df = 10

where

$Z_{c,t}$ = scrappage rate for vehicles of class c 9 years old or older, year t;
$C^{*}_{c,t}$ = index of real price of new automobiles of class c, year t (1967 = 1.00); and
U_t = unemployment rate, year t.

The signs of both variables in the above equation appear rational; that is, an increase in new automobile prices tends to diminish scrappage of old automobiles, and an increase in the unemployment rate also tends to diminish scrappage.

The above equation is used to adjust the average scrappage rates for vehicles 9 years of age or older. It is divided by the mean rate for vehicles in that group to determine a relative scrappage factor, which is then used to adjust the average scrappage rate for each vehicle class and age group. D_t, the scrappage used in equation 4, is computed by using these adjusted scrappage rates by class and model year. Since this procedure is applied individually to each market class, t allows unusual price changes in any single class to be reflected by retirements in that class only. For example, an increase in the price of large automobiles would lead to diminished scrappage of large automobiles while small and medium automobile scrappage would be unaffected.

ACKNOWLEDGMENT

I wish to thank W. Carl Kester and Andrew Leiter for the important contributions they made to the work described here and the Federal Energy Administration's Office of Transportation Research for its support of this research effort. The sponsorship does not indicate endorsement of the opinions expressed here; I am responsible for those.

REFERENCES

1. Survey of Consumer Finances. Survey Research Center, University of Michigan.
2. Nationwide Personal Transportation Study. Federal Highway Administration.
3. Current Population Reports. U.S. Bureau of the Census.
4. Highway Statistics. Federal Highway Administration.
5. Census of Population. U.S. Bureau of the Census.
6. National Survey of October New Car Buyers. Rogers National Research.