

AN INVENTORY OF
SELECTED MATHEMATICAL MODELS
RELATING TO THE MOTOR VEHICLE
TRANSPORTATION SYSTEM
AND ASSOCIATED LITERATURE

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1.0 INTRODUCTION

This volume presents an inventory of selected mathematical models (econometric, accounting, physical, etc.) relating to the motor vehicle transportation system, and of literature related to the subject matter or objectives of the models. This is an update of an earlier volume¹ that contains descriptions of 78 models. This volume retains the original descriptions of most of the earlier models, contains updates of many of them, and adds several new models to the inventory. In addition, abstracts of some sixty-two documents that do not describe models, but are model-related, have been added. The models each describe some effect or society on the environment. Some of them have been assembled here because they are potentially useful in public policy analyses. Other models and all of the associated literature have been included because they have either advanced the development of models pertaining to the motor vehicle transportation system or they pertain to the public policies that may be analyzed by using models.

The inventory is a product of a project entitled "An Analytical Study of Mathematical Models of the Motor Vehicle System," sponsored by the Motor Vehicle Manufacturers Association (MVMA) and conducted by the Policy Analysis Division of Highway Safety Research Institute (HSRI) at The University of Michigan. The work for this volume was done during the period October 1978 through May 1979. The work for the earlier edition was done during the period March 1977 through June 1978. The project is to be a continuing one, and supplements to this edition will be published periodically.

1.1 Organization of This Volume

The purpose of this volume is twofold: (1) to present succinctly and in a structured way useful information about policy-oriented models of the motor vehicle transportation system, and (2) to present abstracts of reports pertaining to models in general or to descriptions of uses of specific models included in this report. Section 1.0 describes how the information contained in the report is organized and presented, and how it was collected. Section 2.0 contains the detailed reports on individual models collected through May 1979. Section 3.0 contains less-detailed abstracts on the model-related documents. Section 4.0 is a set of indexes that may be used to locate particular models or documents according to six different categories: personal authors, organizational authors, sponsors, keywords, model names, and report titles. Within Sections 2.0 and 3.0 the models and documents are arranged in the order in which they were collected by the HSRI staff. It is therefore necessary to use the indexes in Section 4.0 to make use of the information contained in this volume.

¹Richardson, B.C.; Joscelyn, K.B.; Golomb, D.H.; Luckey, M.M.; Segel, L.D., An inventory of selected mathematical models relating to the motor vehicle transportation system, Ann Arbor, Mich.: The University of Michigan Highway Safety Research Institute, Report no. UM-HSRI-78-28, September 1978.

1.2 Project Background and Objectives

The staff of the Highway Safety Research Institute in 1976 began an effort whose general objective has been to examine and describe mathematical models that have the potential to be used in formulating policy related to the motor vehicle transportation system. The specific objectives have been to:

- 1) find, collect, and describe existing mathematical models of the motor vehicle transportation system,
- 2) find, collect, and describe literature that supports model building or pertains to policies that affect the motor vehicle transportation systems,
- 3) provide the capability for exercising selected models via computer,
- 4) analyze selected models,
- 5) exercise the models under alternative future conditions or scenarios,
- 6) modify and integrate models in response to specific requirements, and
- 7) investigate the use of models in policy formulation.

This volume reports on the progress made to date on the first two of these objectives. As more literature is collected, supplements to this volume will be issued. In accordance with other objectives of the project, three other reports have² been prepared: a summary report of fiscal year 1978 project activity²; a report on the analysis of the Wharton Econometric Forecasting Associates' Automobile Demand Model³; and a report on the use of that model in federal policy studies⁴. An analysis of the Faucett Automobile Sector Forecasting Model is now underway.

²Richardson, B.C.; Joscelyn, K.B., Analytical study of mathematical models of the motor vehicle system: Phase III final report, Ann Arbor, Michigan: The University of Michigan Highway Safety Research Institute, Report no. UM-HSRI-78-54, November 1978.

³Golomb, D.H.; Luckey, M.M.; Saalberg, J.H.; Richardson, B.C.; Joscelyn, K.B., An analysis of the Wharton EFA automobile demand model, Ann Arbor, Michigan: UMI Research Press, an imprint of University Microfilms International, 1979.

⁴Saalberg, J.H.; Richardson, B.C.; Joscelyn, K.B., Federal policy applications of the Wharton EFA automobile demand model, Ann Arbor, Michigan: UMI Research Press, an imprint of University Microfilms International, 1979.

1.3 Compilation of This Volume

Several steps were required to compile this inventory. Models and supporting documents had to be (1) found and collected, (2) screened for relevancy, (3) classified by subject, and (4) reviewed to extract the information for this volume.

1.3.1 Finding and Collecting Documents

Literature was collected primarily in two ways: (1) by employing the usual acquisition procedures of the Highway Safety Research Institute library, and (2) by contacting authors and sponsors and requesting that reports on the models, their programs, or whatever form of documentation was available be sent to the project staff.

Four sources were used to find relevant literature: library catalogs, computer files, personal contacts with people in the field, and follow-up of references in reports on various models. All four sources uncovered several models not discovered by any of the other three.

For the library search the catalogs of the libraries of The University of Michigan were searched by topic for titles suggestive of suitable literature. A library search is the most familiar way to find the literature on a given subject, but it is limited by the probable incompleteness of the catalogs, the possible narrowness or inappropriateness of the topic terms chosen for the search, and the potential biases of the searcher in the interpretation of a title or report.

The second search, repeated periodically, was of several computer-based files of literature, including the Transportation Research Information Service (TRIS) data base, sponsored by the U.S. Department of Transportation and the Transportation Research Board, the National Technical Information Service (NTIS) data base, and the Compendex data base (Engineering Index). The latter two are accessible through the Lockheed DIALOG Retrieval Service. To find all potentially relevant models, the HSRI staff used broad search terms. Even so, several models previously known to be significant were not included in any of the citations produced by the computer file searches.

The project staff made personal contacts their third search method. They contacted authors, sponsors, and users of some of the models. Their contacts included individuals in key divisions within the Department of Transportation, the Environmental Protection Agency, the Department of Energy, and other federal organizations. Authors whose models appeared in the first edition of this report were contacted to obtain updates to the information originally presented and references to models not previously presented.

The fourth method the staff used to compile the inventory was to assemble information about additional models referred to in reports on other models. If these new models seemed germane, they were added to the inventory.

1.3.2 Screening for Relevancy

The documents found by these search methods were screened initially for their appropriateness to the project by checking their titles and by reviewing abstracts when these were available. Models relating to the motor vehicle transportation system were considered appropriate if they (1) described an effect on society or the environment, (2) were judged to be usable in policy-related analyses, or (3) had advanced the development of models pertaining to the motor vehicle transportation system. Associated documents were considered appropriate if they (1) related to the policies that can be analyzed using models, or (2) related to the advancement of models. Every effort was made by the project staff at this point to be as inclusive as possible.

The term "model" has been broadly used in this inventory. Any system of equations that is intended to represent a process or a system, such as the motor vehicle market, may be called a model. Taking this into account, the inventory includes models that consist merely of single-equation econometric regression specifications that were not intended to be used as policy evaluation tools when they were developed, and sophisticated programs with large data bases that have been developed specifically for policy analyses. The complex models are included here because they have the potential for being used in research and policy-making, especially by the federal government. The simple models have been included because they are representative of research that has advanced economic theory as it applies to automobile demand, fuel or energy consumption, market share, vehicle miles traveled, or other aspects of the motor vehicle system.

In general, the staff concentrated their efforts on identifying models and documents written after 1970. Some models written before then are included to illustrate the past state of the art, but no effort was made to compile a complete file of models built before 1970. The models included are generally of national rather than local applicability. However, several models that are based on local area data have been included primarily because they may be used in analyses of regions other than those on which they were based. Therefore, while there are travel demand models included in this inventory, local mode-split models are not included because they are usually calibrated for specific regions and are not generally used in national policymaking. Models developed outside of the United States are included if the possibility exists of using them in the U.S.

1.3.3 Classification by Subject

At the time of initial review, if a document did not appear to be relevant to the study, it was eliminated from further consideration. If it did appear relevant, it was assigned an accession number and cataloged by keywords.

Each of the models and documents has been assigned one or more keywords that describe their subject matter. The list of possible keywords appears in Table 1.

Table 1:	KEYWORDS
Accidents	Model Assessment
Air Pollution/Air Quality	National Economic Impact
Automobile Demand	Noise Pollution
Automobile Design	Pricing
Emissions	Scrappage
Energy Consumption	Trucks
Fleet Size	Vehicle Manufacturing Resource Utilization
Fuel Consumption	Vehicle Miles Traveled
Fuel Economy	Vehicle Operating Performance
Industrial Financial Performance	Vehicle User Costs/Vehicle Operating Costs
Market Share	Weight
Modal Split	

1.3.4 Abstracting and Reporting

Once it was decided to include a document in the inventory, it was reviewed again--in depth--to extract the information to be included in this volume. "Long-form" inventory reports were written for all the models included in the volume. They are presented in Section 2.0. "Short-form" abstracts were written for all documents that contain information pertaining generally to models or to the use of specific models, but that are themselves not considered to be "model documentation." These are included in Section 3.0.

The information in both types of summaries was derived primarily from the documents that are cited, but was supplemented by information received through contacts with model authors, sponsors, and users. Comments by model authors on the earlier edition of this volume have been incorporated into this edition.

1.4 Accuracy and Future Updates

Every effort was made to be as comprehensive as possible, but nevertheless it is likely that some models were overlooked in the search

process. Moreover, it is possible that some of the information obtained from representatives of sponsoring or model-using agencies or from authors was not always accurate and comprehensive. This is likely to have occurred because of staff turnover, unpublished modification or uses of models, non-disclosure of proprietary information, or the unfamiliarity of some persons in large organizations with activities in other branches. Since supplements to this volume are to be published periodically, the authors would appreciate receiving any information the reader may have pertaining to new models of the type reported here, updates or corrections to the summaries of models included in this inventory, or references to related literature.

1.5 Format of Information Reported

The inventory reports in section 2.0 and abstracts in section 3.0 follow standard formats, with similar information about each model or document summarized under a consistent outline of categorical headings. Information is not provided under all headings in every report either because the required information was unavailable or because a particular category of information was irrelevant in some cases. The level of detail for each report is dependent on the level of detail contained in the published documentation from which the information for the reports was extracted.

1.5.1 General Information

The following categories of information are contained in both the ("long-form") inventory reports and in the ("short-form") abstracts.

Accession Number: Each model or document is assigned a five-digit accession number. The first two digits represent the year in which the report was written and the last three the order in which the reports were received by HSRI project staff. It is the last three digits by which the reports are ordered in this volume. For example, 74-005 follows 75-004.

If there are a small number of distinct submodels within a model, each submodel is further designated by appending a letter (i.e., A, B, C, etc.) to the five-digit accession number. A separate inventory form is included for each submodel to facilitate more complete and accurate reporting.

The accession numbers of the non-model document abstracts in section 3.0 are prefixed by "S-" (a symbol referring to "supporting" material). This distinguishes model descriptions from descriptions of documents that are not on models as such.

Although the reports are ordered consecutively, there are gaps in the sequence of accession numbers. These gaps occur because some documents proved to be duplicates or irrelevant during the in-depth review process. These were deleted from the inventory, but only after the accession numbers had been assigned.

Sponsor: Included in this item are the name and address of the organization which sponsored the study or the construction of the model. If there was more than one sponsoring organization, each of these is included.

Organization Author: This designation includes the name and address of the organizational author or authors of the model or study. On the long-form reports in Section 2.0, this information will be found under the "AUTHOR" heading. On the short-form abstracts in Section 3.0 this information appears under the "PERFORMING ORGANIZATION" heading. The "AUTHOR" heading on the long-form reports also includes the names of personal authors.

Keywords: These refer to the basic subject matter of the study or the outputs that the model was built to produce. Every report is categorized according to one or more of the keywords listed in Table 1.

Reference: The sources for the information presented are cited. These citations generally follow this format: personal authors names, if there are any, report or paper title, organizational author or publication data, report number, date, and National Technical Information Service (NTIS) number, if there is one.

1.5.2 Detailed Information on Models

The following categories of information are found only on the long-form inventory reports of Section 2.0:

Model Name: The model name refers to the commonly recognized name of the model if it has one. Otherwise, the name of the report in which the model is presented is listed.

Summary: The first paragraph of each report is a summary statement about each model, including its name, author, date, sponsor, purpose, and if documented, its use in policy analysis.

Objective of Model: The objective of the model is the purpose for which the model was built. This often includes the relationships which are analyzed in the model.

Relationship to other Models: If the model is a submodel of a larger system this is explained here. Inputs from or outputs to other models are discussed.

Historical Background: Relevant history pertaining to the model is summarized, including the reasons for its development, models which preceded it and constituted developmental antecedents, and other work by its authors.

Assumptions: Basic assumptions made in the construction of the model, including primarily those reported by model authors, are indicated. These may include assumed relationships among variables and substitutability of variables, as well as similar imposed conditions.

Validation: This includes any information relating to the forecasting behavior and dynamic properties of the model which have been reported by model authors or others. Forecasting behavior refers to comparing actual values with predictions of the model. Dynamic properties refer to the time paths of changes in the endogenous variables of the model in response to a change in one or more of the exogenous variables of the model.

Limitations and Benefits: Limitations may include the fact that a model is out of date, that the relative importance of variables has changed over time, or other problems reported by the model authors. Benefits might include a successful, innovative approach to a particular analytic problem, or special abilities of the model.

Structure: This heading describes the analytical logic and flow of the submodels, equations, and input and output of the model. The form of key or representative equations may be presented.

Model Construction: This section will, for econometric models, discuss the sources of the historical data used to estimate the equations. For other types of models the theory, academic field, or branch of science upon which the model is based is presented.

Data Used In Running Model: The input data, parameters, or options that the user must specify to run the model are listed.

Computer Requirements: When available, information is provided pertaining to the computer requirements or specifications of the model including hardware, running time, programming language, etc.

1.5.3. Supporting Literature Information

The following items will be found only on the "short-form" abstracts of section 3.0:

Concerning Model: The names and accession numbers of models with which the abstracted document is concerned are listed. This is appropriate if the document reports on the use, validation, or assessment of a specific model reported in Section 2.0 of this report.

Abstract: This paragraph summarizes the contents of the document.

1.6 Indexes

In the fourth section of this volume, all of the models and documents are indexed.

Personal authors, organizational authors, sponsors, keywords, model names, and report titles are all listed alphabetically, in separate indexes, followed by the last three digits of the accession numbers.

In the case of joint authorship or sponsorship each author or sponsor is

listed separately. Not all documents or models have both personal and organizational authors and sponsors, and therefore not all of them appear on each list.

The keywords are not mutually exclusive, so a model or document may appear under several keywords.

To save the user the trouble of having to search through two sets of indexes, the models from Section 2.0 and the associated literature from Section 3.0 are included in each of the indexes. Once an accession number is acquired from the indexes, the user may find either a model inventory report in Section 2.0 or an abstract in Section 3.0. Within each section the reports or abstracts are in accession number order (by the last three digits), and the accession numbers appear in the upper corners of each page.

2.0 MODEL INVENTORY REPORTS

GENERALIZED AUTOMOBILE DESIGN MODEL

The Generalized Automobile Design Model, dated October 1974, was prepared by the Rand Corporation for the National Science Foundation. The model assesses the effects on resources, energy requirements, and auto ownership costs of changes in either auto size, performance, or design.

SPONSOR

National Science Foundation
Research Applied to National Needs
Washington, D.C. 20550

AUTHOR

Thomas F. Kirkwood and A.D. Lee
Rand Corporation
Santa Monica, Calif. 90406

KEYWORDS

Automobile design

OBJECTIVE OF MODEL

The model assesses the effects of auto size, performance, or design on resources, energy requirements in the production of autos, and the cost of auto ownership.

RELATIONSHIP TO OTHER MODELS

This model is a submodel of the Rand Automobile Energy Conservation Model, which includes the Automobile Fleet Mix Model (74-001B) and the New Car Sales/Auto Ownership/Vehicle Miles Traveled (NAV) Model (74-001C).

HISTORICAL BACKGROUND

In many experiments, a new engine or other design feature is installed in an existing auto body or chassis and the fuel economy of the new vehicle compared with the unmodified car. In such a test, not only the fuel economy, but the acceleration performance, and useful space in the two cars may differ. This model allows tests of this type to be used to determine the comparative fuel consumption of automobiles designed to the same performance and useful space.

ASSUMPTIONS

Each auto design produced by the model will have an engine with sufficient power to provide the desired acceleration, the auto body will have dimensions to include the desired size of passenger compartment, trunk, engine, and fuel tank, and the curb weight of the car will be the sum of the weight of its component parts.

VALIDATION

Actual and predicted values of curb weight, overall length, installed horsepower, and fuel economy for twelve actual 1973 autos are very close.

LIMITATIONS AND BENEFITS

The model can evaluate various design options, such as new engine types, tire design and pressure, aerodynamic design, new transmission types, new fuels, new materials, and changes in the sizes of passenger compartments and trunks.

STRUCTURE

The model consists of a set of equations for keeping track of the effects of changes in component weights, performance, and cost, and for summing the effects of these changes on overall costs and energy consumption.

The outputs of the model include:

- 1) a description of a car, including weight, overall dimensions, installed horsepower, fuel economy over two driving cycles, and purchase price.
- 2) a list and weights of the materials necessary to produce the car.
- 3) a list of all the energy consumed in producing, distributing, selling, and operating the auto throughout its assumed lifetime of ten years and 100,000 miles.
- 4) a breakdown of the total cost of buying and operating the auto throughout its lifetime.

MODEL CONSTRUCTION

The model was calibrated using actual data on the relationships between transmission efficiency, engine rpm, and road speed; specific fuel consumption and engine rated power; and vehicle component weights and the quantities which determine them.

DATA USED IN RUNNING MODEL

To run the model the desired passenger compartment dimensions, acceleration time, range without refueling, trunk volume, and air conditioning status must be supplied.

REFERENCE

Kirkwood, T.F.; Lee, A.D., A generalized model for comparing automobile design approaches to improved fuel economy, R-1562-NSF, Rand Corporation, Jan. 1975.

Wildhorn, S.; Burreight, B.K.; Enns, J.H.; Kirkwood, T.F., How to save gasoline: public policy alternatives for the automobile, Rand Corporation, prepared for the National Science Foundation, October 1974. NTIS No. PB-242 755.

AUTOMOBILE FLEET MIX MODEL

The Automobile Fleet Mix Model was prepared by the Rand Corporation. The model, dated October 1974, was sponsored by the National Science Foundation. The purpose of the model is to assess the impact of autos of new design or of reduced size on the characteristics of the overall fleet.

SPONSOR

National Science Foundation
Research Applied to National Needs
Washington, D.C. 20550

AUTHOR

S. Wildhorn, B.K. Burright, J.H. Enns, and T.F. Kirkwood
Rand Corporation
Santa Monica, Calif. 90406

KEYWORDS

Emissions, vehicle user costs/vehicle operating costs, energy consumption, fuel consumption, fleet size

OBJECTIVE OF MODEL

The objective of the model is to provide an assessment, by calendar year, of the impact on overall fleet characteristics of autos of new design or of reduced size that are introduced at specific rates.

RELATIONSHIP TO OTHER MODELS

This model is a submodel of the Rand Automobile Energy Conservation Model, which includes the Generalized Automobile Design Model (74-001A) and the New Car Sales/Auto Ownership/Vehicle Miles Traveled (NAV) Model (74-001C).

HISTORICAL BACKGROUND

The model was developed for three primary reasons: (1) previous studies were not comprehensive, (2) they did not compare price-change measures with measures that improve average auto fuel economy, and (3) they did not provide for the evaluation of alternative policy measures for inducing the adoption of beneficial technological changes.

The model was developed to estimate the changes in the auto fleet which would result from the changes in new car price, gasoline price,

and fuel economy ratings, which are estimated by the Automobile Design Model (74-001A) and the New Car Sales/Auto Ownership/Vehicle Miles Traveled (NAV) Model (74-001C).

STRUCTURE

The mix of the auto fleet each year from 1975 to 1995 is determined with the use of the equation:

$$N_{wiy} = N_{wi(y-1)} + T_{wy} B_{wiy} P_y - \sum_{j=0}^{18} K S_j (T_w B_{wi} P_y)_y + N_{f(y-1)} (1 - K S_y)$$

where:

N_{wiy} = number of autos in the fleet at the end of the year in weight class w with technological features i

T_{wy} = fraction of the annual production (in year y) in weight class w

B_{wiy} = fraction of the production (in year y) in weight class w with technological features i

P_y = total annual production in year y

K = scrappage rate correction factor to allow for the difference between anticipated scrappage rates and those based on past experience

S_j = fraction of autos of age j scrapped in their jth year

N_{fy} = number of autos in the original fleet (i.e., the fleet existing at the start of 1975), remaining at the end of year y

S_y = fraction of the original fleet retired in year y if retirement occurred at a rate typical of past experience

The total number of cars at the end of year y is obtained by summing over w and i.

Other equations are used to calculate fleet emissions, fleet fuel consumption, fleet scrappage rate, fleet annual cost, per vehicle annual cost of ownership, and fleet energy consumption.

MODEL CONSTRUCTION

This model is used in conjunction with production and scrappage rates in future years which are estimated from the NAV Model (74-001C).

74-001B

DATA USED IN RUNNING MODEL

Forecasts of the independent variables are required for future year estimates.

REFERENCE

Wildhorn, S.; Burrigh, B.K.; Enns, J.H.; Kirkwood, T.F., How to save gasoline: public policy alternatives for the automobile, Rand Corporation, prepared for the National Science Foundation, October 1974. NTIS No. PB-242 755.

NEW CAR SALES/AUTO OWNERSHIP/VEHICLE MILES TRAVELED
(NAV) MODEL

The New Car Sales/Auto Ownership/Vehicle Miles Traveled (NAV) Model, dated October 1974, was prepared by the Rand Corporation for the National Science Foundation. The model forecasts changes in aggregate new car sales, auto ownership (new cars, used cars, cars scrapped), vehicle miles traveled, and gasoline consumption over time.

SPONSOR

National Science Foundation
Research Applied to National Needs
Washington, D.C. 20550

AUTHOR

S. Wildhorn, B.K. Burright, J.H. Enns, and T.F. Kirkwood
Rand Corporation
Santa Monica, Calif. 90406

KEYWORDS

Automobile demand, fuel economy, fuel consumption, fleet size, vehicle miles traveled

OBJECTIVE OF MODEL

The model forecasts changes in aggregate new car sales, auto ownership (new cars, used cars, cars scrapped), vehicle miles traveled, and gasoline consumption over time. It is a long-run impact model.

RELATIONSHIP TO OTHER MODELS

This is a submodel of part of the Rand Automobile Energy Conservation Model, which includes the Generalized Automobile Design Model (74-001A) and the Automobile Fleet Mix Model (74-001B).

HISTORICAL BACKGROUND

The model was developed for three primary reasons: (1) previous studies were not comprehensive, (2) they did not compare price-change measures with measures that improve average auto fuel economy, and (3) they did not provide for the evaluation of alternative policy measures for inducing the adoption of beneficial technological changes.

74-001C

ASSUMPTIONS

The model assumes that the prices of new cars and of gasoline are fixed outside the model. Thus the supply of gasoline for automobile travel is assumed to be perfectly elastic.

VALIDATION

The model report compares actual and predicted values for the estimating period (1954-72), and for 1973. The model underpredicts new car sales by 3.5% and real used car prices by 8.7%.

LIMITATIONS AND BENEFITS

The model cannot be used to forecast future market equilibrium. It is used to make conditioned forecasts of how American families would adjust to changes in prices of new cars and gasoline.

STRUCTURE

The model is a recursive system estimated by ordinary least squares.

$$P_u = -0.8960 + 1.7268 (P_n) - 0.87122 (P_g) + 0.44809 (Y) \\ - 1.404 (A_{-1}) - 0.029592 (S), P_u > 0$$

$$N = -0.5080 - 0.20869 (P_n) + 0.09318 (P_u) + 0.73050 (Y/Y_{-1}) \\ + 0.01733 (S)$$

$$U = -0.05894 - 0.26645 (P_u) + 0.63665 (P_n) - 0.59339 (P_g) \\ + 0.22529 (Y) - 0.01186 (S), U \leq A_{t-1}$$

$$A = N + U$$

$$LE = 2.656 + 0.17015 (LP_g) - 0.02228 (D)$$

$$LM = 7.996 + 0.86405 (LA) - 0.44409 (LP_g) + 0.44409 (LE) + 0.03532 (D)$$

$$LG = LM - LE$$

where:

L = logarithmic value

P_u = index of real used car prices
 P_n = index of real new car prices
 P_g = index of real gasoline prices
 Y = permanent income per household
 A = this year's auto stock per household
 A_{-1} = last year's auto stock per household this year
 S = dummy variable for strikes in auto manufacturing
 N = annual new car sales per household
 U = used car ownership per household
 E = average miles per gallon in automobile travel
 D = dummy for federal regulation
 M = vehicle miles driven in automobiles per household
 G = gasoline consumption by automobile per household

MODEL CONSTRUCTION

This is an econometric model in which the equations for used car prices, new car prices, and used car ownership per household were estimated with annual data from 1954 to 1972. Those for average miles per gallon and vehicle miles traveled per household were estimated with annual data from 1956 to 1972. The sources of the data for the independent variables are indicated in the model report.

DATA USED IN RUNNING MODEL

Forecast values for new car price, gasoline price, number of households, and permanent income are required.

REFERENCE

Wildhorn, S.; Burrigh, B.K.; Enns, J.H.; Kirkwood, T.F., How to save gasoline: public policy alternatives for the automobile, Rand Corporation, prepared for the National Science Foundation, October 1974. NTIS No. PB-242 755.

Burrigh, B.K.; Enns, J.H., Economic models of the demand for motor fuel, Rand Corporation, R-1561-NSF, Jan. 1975.

NEW PASSENGER CAR SALES AND MARKET SHARES MODEL

The Chase Econometric Associates, Inc. model of new passenger car sales and market shares was prepared in 1974 for the Council on Environmental Quality. The model forecasts new car sales, in total and by size class, annually through 1986 for six tax and regulatory alternatives. It has been superseded by a new model. The new model is proprietary and is not included in this inventory.

SPONSOR

Council on Environmental Quality
722 Jackson Place, N.W.
Washington, D.C. 20006

AUTHOR

Chase Econometric Associates, Inc.
One Chase Manhattan Plaza
New York, N.Y. 10015

KEYWORDS

Automobile demand, market share

OBJECTIVE OF MODEL

The objective of the model is to forecast new passenger car sales, in total and by size class, through 1986 for six tax and regulatory alternatives.

RELATIONSHIP TO OTHER MODELS

This model is a submodel whose output is used in the gasoline consumption submodel (74-002B), which was also prepared by Chase Econometric Associates, Inc. as part of the same study. This model is used in conjunction with the Chase macroeconomic model.

HISTORICAL BACKGROUND

An earlier version of the model did not include the relative price of gas as an independent variable because it had not proved to be significant before the Arab oil embargo. It was, however, included in the model for 1973.

ASSUMPTIONS

The new car sales equation of the model assumes that a four-quarter weighted average is appropriate for both disposable income and the stock of passenger cars, depreciated at the annual rate of 4.7%. The market shares equation assumes that reasonable estimates are produced, although the data vary significantly only when a new line of cars is introduced. The forecasts assume that relative prices and miles per gallon remain unchanged at the 1973 levels, except for the effects of 1975 and 1976 emission controls, as predicted in Hittman Associates, Inc., A Study of Industry Response to Policy Measures Designed to Improve Automobile Fuel Economy. The forecasts of shares by subclass were normalized to sum to 100% for each year by accepting the luxury share equation and assuming the following values for standard class share: 10% in 1974, 5% in 1975, and 0% thereafter. In effect, the forecast assumes that "full-size" cars will be reduced in size to the current (1974) intermediate car size and disappear as a distinguishable class.

VALIDATION

The model report does not discuss specific validation efforts for this model.

LIMITATIONS AND BENEFITS

The price of gasoline was an insignificant independent variable prior to 1973, and consumers may have over-reacted to it in that year. Therefore, the new car registrations equation may now place undue emphasis on this variable. The market shares equations are not constrained to sum to 100%, but rather are normalized to achieve that result.

STRUCTURE

This econometric model consists of a single equation which predicts the total new passenger car registrations annually and five equations which predict the market share for five size-classes of cars. The total new car registrations equation, which is reproduced below, was estimated by ordinary least squares using quarterly data from 1957 to 1973.

$$\begin{aligned} \text{NCPR} = & 18.63 + \underset{(4.5)}{.0211} \sum_{i=0}^4 (.6)^i \left(\text{DI} - \frac{\text{TR}}{\text{PCI}} \right)_{-i} \\ & - \underset{(-2.7)}{7.86} \left(\frac{\text{PNC}}{\text{PCI}} \right) - \underset{(-4.6)}{.37} (\text{UN}) + \underset{(6.8)}{.90} (\text{DASTR}) \end{aligned}$$

74-002A

$$\begin{aligned} & - \frac{.058}{(-2.8)} \sum_{i=0}^4 (.6)^i (\text{KNCR})_{-i} - \frac{7.00}{(-2.3)} \left(\frac{\text{PCIGO}}{\text{PCI}} \right) \\ & - \frac{.36}{(-2.8)} \frac{1}{4} \sum_{i=0}^4 (\text{CRED})_{-i} + \frac{.46}{(2.3)} (\text{DDITC}) \end{aligned}$$

$$\bar{R}^2 = .96 \quad \text{DW} = 1.52$$

where t-statistics are in parentheses, and

NCPR = new passenger car registrations, millions, seasonally adjusted at annual rates

DI = personal disposable income, billions of 1958 dollars, seasonally adjusted at annual rates

TR = transfer payments to persons, billions of current dollars, seasonally adjusted at annual rates

PCI = consumer price index, 1958 = 1.0

PNC = consumer price index for new cars, 1958 = 1.0

UN = rate of unemployment, %

DASTR = dummy variable for auto strikes in 1964; 1967, 1970

KNCR = stock of new cars on a new car equivalent basis,

$$\text{KNCR} = \sum_{i=0}^{40} (.953)^i (\text{NCPR})_{-i}$$

PCIGO = consumer price index for gas and oil, 1958 = 1.0

CRED = Chase index of credit rationing

DDITC = dummy variable for cancellation and reinstatement of investment tax credit

Market-shares equations are then estimated for new car sales, classified as subcompact, compact, intermediate, standard, and luxury. The equation for intermediate cars, estimated using ordinary least squares for annual data from 1958 to 1972, is reproduced below.

$$\begin{aligned} \text{PCT}_{\text{IM}} = & -1.56 + \frac{.443}{(2.7)} \left(\frac{\text{MPG}_{\text{IM}}}{\text{MPG}_{\text{SC}}} \right) - \frac{.70}{(-4.5)} \left(\frac{\text{P}_{\text{IM}}}{\text{P}_{\text{ST}}} \right) \\ & + \frac{1.87}{(6.6)} \left(\frac{\text{PCIGO}}{\text{PCI}} \right) + \frac{.031}{(8.0)} (\text{T}) \end{aligned}$$

$$\bar{R}^2 = .89 \quad \text{DW} = 2.24$$

where t-statistics are in parentheses, and

PCT_{XX} = percent of total new car sales in the subclass XX

MPG_{XX} = miles per gallon for a particular subclass

P_{XX} = average price of a new car in a particular subclass

T = time trend

The remaining variable definitions appear above following the new car registrations equation.

Other share equations incorporate the unemployment rate as an independent variable.

MODEL CONSTRUCTION

To specify the model data for all variables from 1957 to 1973 are required. Some data are listed in the model report for the share equations. However, the remaining data must be obtained from Chase or assembled from some other source.

DATA USED IN RUNNING MODEL

The model requires forecast values for all independent variables. These forecasts are taken from the Chase macroeconomic forecast, although alternative assumptions could be used. The forecast values are included in Appendix II of the model report.

REFERENCE

The effect of tax and regulatory alternatives on car sales and gasoline consumption, Chase Econometric Associates, Inc., prepared for Council on Environmental Quality under Contract No. EQC004, Final Report, May 1974., NTIS No. PB-234 622.

GASOLINE CONSUMPTION MODEL

This gasoline consumption model was prepared in 1974 by Chase Econometric Associates, Inc. for the Council on Environmental Quality. It forecasts gasoline consumption annually through 1986 for six tax and regulatory alternatives. It has been superseded by a new model which is proprietary and not included in this inventory.

SPONSOR

Council on Environmental Quality
722 Jackson Place, NW
Washington, D.C. 20006

AUTHOR

Chase Econometric Associates, Inc.
One Chase Manhattan Plaza
New York, N.Y. 10015

KEYWORDS

Fleet size, scrappage, vehicle miles traveled, fuel consumption

OBJECTIVE OF MODEL

The model forecasts gasoline consumption annually through 1986 for six tax and regulatory alternatives.

RELATIONSHIP TO OTHER MODELS

This submodel requires input from the New Passenger Car Sales and Market Shares submodel (74-002A), which was prepared by Chase Econometric Associates, Inc. as part of the same study. It is used in conjunction with the Chase macroeconomic model.

ASSUMPTIONS

The model assumes that scrappage is based on a cubic time trend relationship, and that all cars of a single year survive at the same rate. The miles per gallon calculation assumes that, for the baseline case, 1973 mpg figures apply for all subsequent years, and that 1957 mpg figures apply for pre-1957 years.

VALIDATION

The author reports that the cubic scrappage equation tracks the actual survival rate of cars quite closely. The 1969-73 scrappage equations are adjusted to conform more closely to actual data, since predicted stock exceeded actual stock. No other validation efforts are reported.

LIMITATIONS AND BENEFITS

The scrappage rate is not influenced by any economic variables. The miles per gallon calculation is subject to a number of biases since there are no corrections made in the fuel economy rating for the model year and age of each model of car.

STRUCTURE

This econometric model first computes the annual automobile stock in the aggregate and by model year. These figures are used as input for the calculation of total vehicle miles traveled per year. Data and assumptions on average mileage per gallon for each model year are then used to calculate annual average mileage per gallon for all cars on the road in each forecast year. The VMT and mileage forecasts are then combined to generate annual forecasts of gasoline consumption through 1986. The scrappage rate is computed for each model year from an equation of the following form:

$$\frac{R_{MY,t}}{R_{MY}} = \alpha e^{B(T)^3}$$

where:

$R_{MY,t}$ = registrations in year t for model year MY

R_{MY} = total original registrations for model year MY

T = age of the model year car

α , B = coefficients

This equation is estimated using annual car registration data from 1951 to 1972 for model years 1951 to 1968. Calculated values of α and B are listed in the study report.

Vehicle miles traveled are explained by a single equation estimated using ordinary least squares for the period 1956 to 1972.

$$TVM = 3416.1 + \underset{(9.2)}{78.5} (CAR) - \underset{(-2.5)}{3944.5} \left(\frac{PCIGO}{PCI} \right) + \underset{(2.3)}{5181.0} (\Delta PCI)$$

74-002B

$$+ \frac{784.1}{(2.1)} (\text{PUVNC}_{-2}) + \frac{8.81}{(2.2)} (\Delta YW)$$

$$\bar{R}^2 = .996 \quad DW = 1.29$$

where t-statistics are in parentheses and

TVM = vehicle miles traveled

CAR = total number of personal passenger vehicles registered as of July

PCIGO = consumer price index of gasoline and oil, 1967 = 100

PCI = consumer price index of all goods and services, 1967 = 100

PUVNC = average price of new cars

YW = wages and salaries

Gasoline consumption is computed from the following formula:

$$\text{GAS}_T = \sum_{MY=1951}^T \left(\frac{R_{MY,t}}{\text{CAR}_T} \right) \left(\frac{\text{TVM}_T}{\text{MPG}_{MY}} \right)$$

where:

GAS_T = gasoline consumed by passenger vehicles in calendar year T

MPG_{MY} = miles per gallon for model year MY

and the other variables are as previously defined.

MODEL CONSTRUCTION

Passenger car registration data by model year as of July 1 are from the series prepared by R.L. Polk and Co. Vehicle miles traveled data are from the Federal Highway Administration for 1956 to 1972. Data for the other variables in the TVM equation must be collected for the period 1956 to 1972. Environmental Protection Agency surveillance program statistics on miles per gallon by model year are also required.

DATA USED IN RUNNING MODEL

The model requires new car sales and market share forecasts from the sales and market shares submodel (74-002A). Forecasts for the independent variables in the TVM equation were obtained from the Chase macroeconomic baseline forecast. Miles per gallon and price effects for the six scenarios are obtained from a study by Hittman Associates.

REFERENCE

The effect of tax and regulatory alternatives on car sales and gas consumption, Chase Econometric Associates, Inc., prepared for the Council, on Environmental Quality under Contract No. EQC004, Final Report, May 1974, NTIS No. PB-234 622.

Hittman Associates, Inc., A study of industry response to policy measures designed to improve automobile fuel economy.

TECHNOLOGY MODEL OF THE EEA GASOLINE CONSUMPTION MODEL

The Technology Model of the EEA Gasoline Consumption Model, dated July 1975, was prepared by Energy and Environmental Analysis, Inc. (EEA) for the Federal Energy Administration. The model computes new car fuel economy, weight, and price by manufacturer and size class for a variety of future fuel efficiency, emission, and safety standards. The model has been exercised for the Office of Technology Assessment in their study "Technology Assessment of Changes in the Use and Characteristics of the Automobile."

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KEYWORDS

Fuel economy, weight, pricing

OBJECTIVE OF MODEL

The objective of the model is to compute new car fuel economy, weight, and price using a baseline and various assumptions as to future efficiency, emissions, and safety standards.

RELATIONSHIP TO OTHER MODELS

The new car characteristics from this submodel serve as a basis for predicting new car sales, distribution of sales by market class and other parameters in the other submodels of the EEA Gasoline Consumption Model, 75-003B and 75-003C.

ASSUMPTIONS

The model assumes that each manufacturer maintains his 1974 percentage of car sales in each size class, although overall market position may change. The model also assumes certain calculated feasible non-engine improvements for each manufacturer. Percentage weight

changes are assumed to equal the percentage fuel economy changes, multiplied by a sensitivity factor for each size class. Finally, the model assumes that engine-related fuel economy improvements can be calculated from four emissions scenarios and three mutually exclusive emission control systems.

VALIDATION

No validation efforts are reported for the technology model. However, the overall model predicts actual gasoline consumption reasonably well through 1974.

LIMITATIONS AND BENEFITS

The model currently does not incorporate a specific fuel economy standard, although it can be modified to include such a standard.

STRUCTURE

This is an econometric model which computes new car fuel economy, weight, and price using a baseline and the most recent data on likely trends and industry capabilities. It incorporates five manufacturers (four domestic plus all foreign manufacturers) and six market classes (subcompact, compact, intermediate, standard, small luxury and large luxury). For each manufacturer and market class, sales-weighted harmonic averages of fuel economy, price, and weight are calculated for 1974. A fuel economy improvement schedule is then developed by manufacturer and market class. Engine-related improvements are projected for four emission scenarios using data from a recent EPA study. Annual projected cost, weight, and fuel economy changes are added to the 1974 baseline of each manufacturer. Finally, cost and fuel economy by class are calculated by salesweighting the economy and cost data using the 1974 sales distribution data.

MODEL CONSTRUCTION

The construction of this model requires 1974 sales, fuel economy, price, and weight data by automobile model. Alternative fuel economy improvement schedules are also required. Some of the data are included in the model report, and some are included in the accompanying computer program users' manual.

DATA USED IN RUNNING MODEL

The model requires a choice among the fuel economy, safety standard, and emission scenarios built into the model. Alternatively, specific assumptions as to price, fuel economy, etc. can be incorporated by altering the data file.

REFERENCE

Gasoline consumption model, Energy and Environmental Analysis, Inc., Vol. I, prepared for the Federal Energy Administration, Final Report, July 22, 1975.

Gasoline consumption model, Energy and Environmental Analysis, Inc., Vol. II: Users Manual, prepared for the Federal Energy Administration, Final Report, September 1975.

Tradeoffs associated with possible auto emission standards, Report to EPA prepared by Mobile Source Pollution Control Program, February 1975.

COMPUTER REQUIREMENTS

The model is programmed in the FORTRAN IV G language. It is accessible from a time-sharing computer terminal. An illegible printout of the model appears in the user's manual.

ECONOMICS SUBMODEL OF THE EEA GASOLINE CONSUMPTION MODEL

The Economics Submodel of the EEA Gasoline Consumption Model, dated July 1975, was prepared by Energy and Environmental Analysis, Inc. (EEA) for the Federal Energy Administration. It provides medium-(3-5 years) and long-term (through 1990) projections of gasoline consumption by passenger cars for alternative fuel economy, emissions and safety standards. The model has been exercised for the Office of Technology Assessment in their study "Technology Assessment of Changes in the Use and Characteristics of the Automobile."

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KEYWORDS

Automobile demand, market share, vehicle miles traveled, fuel consumption

OBJECTIVE OF MODEL

The model provides medium- (3-5 years) and long-term (through 1990) projections of gasoline consumption by passenger cars for alternative fuel economy, emissions, and safety standards.

RELATIONSHIP TO OTHER MODELS

This submodel of the EEA Gasoline Consumption Model requires input from the technology submodel (75-003A) and provides output for use in the emissions submodel (75-003C).

ASSUMPTIONS

The model assumes the average vehicle price to include the average cost of options actually purchased. The preliminary estimate of gasoline demand assumes that scrappage rate and vehicle miles of travel/car rates remain constant over time and are the same for every class of

car.

VALIDATION

The author notes that the equations generally fit historical data well. Predictions for 1974 are generally within 1% of actual values. The preliminary estimate of gasoline demand, however, consistently understates actual demand by thirteen to sixteen percent.

LIMITATIONS AND BENEFITS

The model measures the effect on gasoline consumption of changes in the pattern of usage of the existing fleet of vehicles.

STRUCTURE

This model of gasoline consumption contains four sections: (1) share of new car sales by class of vehicle, (2) vehicle miles of travel, (3) new car sales, and (4) modifications to vehicle population and pricing patterns. First, six "economic" car classes are specified by combining wheelbase and price data. Average price per vehicle class is calculated from the formula:

$$P = BP + \sum_i (P_i) (O_i)$$

where:

P = price of the model

BP = base price of the model

P_i = price of option i

O_i = percentage of models sold with option i

For each class of car a market share equation is estimated from 1960 to 1974. Independent variables tested in these equations include cyclical economic variables, new car price, fuel efficiency, and gasoline price. The share equation for sub-compacts is:

$$\begin{aligned} \text{SCS} = & \begin{matrix} -.26 & + & .0009 & (\Delta\text{YD}/\text{HH}) & - & 7.3 & (\Delta\text{YD}/\text{YD}) & + & .024 & (U) \\ (-4.4) & & (4.8) & & & (-4.0) & & & (5.6) \end{matrix} \\ & + \begin{matrix} .024 & \left[\frac{P(\text{GAS})}{\text{MPG}(\text{SUB})} \right] & + & .00096 & \left[\frac{\text{MPG}(\text{SUB})}{\text{MPG}(\text{COM})} \right] & [P(\text{GAS})] \\ (2.1) & & & (3.1) & & \end{matrix} \end{aligned}$$

$$\bar{R}^2 = .95$$

where t-statistics are in parentheses, and

SCS = sub-compact market share

YD = real disposable income

HH = number of households

U = unemployment rate

P(GAS) = price of gasoline per gallon

MPG(SUB) = mileage per gallon for the sub-compact class

MPG(COM) = mileage per gallon for the compact class

The share equations are estimated without constraints, but then are normalized to sum to one for each year.

VMT is estimated from the following equation:

$$\frac{VMT}{HH} = \frac{1.21}{(1.3)} + \frac{.21}{(4.4)} (U) + \frac{.0016}{(30.2)} \left(\frac{YD}{HH}\right) - \frac{25.6}{(2.2)} \left[\frac{P(GAS)}{(CPI)(MPG)}\right]$$

$$\bar{R}^2 = .99$$

where t-statistics are in parentheses, and

VMT = vehicle miles traveled

CPI = consumer price index

and the other variables are as previously defined.

New car sales are determined from the equation:

$$NCS = \frac{24.5}{(18.5)} + \frac{.036}{(5.3)} (\Delta VMT) - \frac{1.36}{(.7)} \left[\frac{P(NC)}{CPI}\right] - \frac{14.6}{(5.9)} \left[\frac{P(NC)}{P(UC)}\right] + \frac{1.98}{(2.6)} (\Delta VMT/STOCK) - \frac{.89}{(2.9)} (STRIKE)$$

$$\bar{R}^2 = .94$$

where t-statistics are in parentheses, and

NCS = new car sales

P(NC) = new car price

P(UC) = used car price

$\Delta VMT/STOCK$ = actual VMT/STOCK for the previous year minus estimated (or

"trend") VMT/STOCK

STRIKE = dummy variable for strike years

and other variables are as previously defined.

Finally a "preliminary" estimate of gasoline consumption is obtained for given levels of scrappage and VMT per car by age. The essential relationship is

$$V_{ij} = A_{ij} SA(k) SV(k)$$

where:

V_{ij} = relative VMT for year i and class j

A_{ij} = number of cars purchased in year i of class j

$SA(k)$ = vehicle scrappage factor for cars k years old

$SV(k)$ = relative VMT per car by age normalized by dividing by VMT/car in the current year.

This preliminary estimate is adjusted by the following equation:

$$\begin{aligned} \text{AGD} = & 28.5 - \frac{118}{(7.8)} \left[\frac{P(\text{GAS})}{\text{CPI} \times \text{MPG}(\text{STOCK})} \right] - \frac{.4}{(2.0)} (U) \\ & - \frac{19.6}{(2.4)} \left(\frac{\Delta \text{YD}}{\text{YD}} \right) - \frac{10.5}{(5.9)} \left[\frac{P(\text{NC})}{P(\text{UC})} \right] + \frac{3.0}{(3.6)} (\Delta \text{VMT}/\text{STOCK}) \\ & + 1.0 (\text{Estimated Gasoline Demand}) \end{aligned}$$

$$\bar{R}^2 = .86 \quad \text{DW} = 2.0$$

where t-statistics are in parentheses,

AGD = actual gasoline demand,

and the other variables are as previously defined.

MODEL CONSTRUCTION

The calibration of this model requires annual data from 1960 to 1974 for all variables. These data are not included in the model report.

DATA USED IN RUNNING MODEL

Projections of all independent variables and of government regulations are required. The users' manual lists all necessary data in Appendix D.

REFERENCE

Gasoline consumption model, Energy and Environmental Analysis, Inc., Vol. I, Final Report, prepared for the Federal Energy Administration, July 22, 1975.

Gasoline consumption model, Energy and Environmental Analysis, Inc., Vol. II: Users Manual, Final Report, prepared for the Federal Energy Administration, September 1975.

COMPUTER REQUIREMENTS

The program, written in FORTRAN IV G, operates interactively in time-sharing mode. The program requires 57,200 bytes of storage.

EMISSIONS SUBMODEL OF THE EEA GASOLINE CONSUMPTION MODEL

The Emissions Submodel of the EEA Gasoline Consumption Model, dated July 1975, was prepared by Energy and Environmental Analysis, Inc. (EEA) for the Federal Energy Administration. The model uses total vehicle miles of travel (VMT) predictions, characteristics of the automobile population, and emission factors to predict nationwide total automotive exhaust emissions of hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NO_x). It has been exercised for the Office of Technology Assessment in their study "Technology Assessment of Changes in the Use and Characteristics of the Automobile."

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KEYWORDS

Emissions

OBJECTIVE OF MODEL

The model uses total VMT predictions, characteristics of the automobile population, and emission factors to predict nationwide total automotive exhaust emissions of hydrocarbons (HC), carbon monoxide (CO), and nitrogen oxides (NO_x).

RELATIONSHIP TO OTHER MODELS

This model is a submodel of the EEA Gasoline Consumption Model, which includes the Technology Submodel (75-003A) and the Economics Submodel (75-003B).

ASSUMPTIONS

The model assumes that future emissions factors for all automobiles were accurately calculated by the Environmental Protection Agency. The amount of use for an individual car is assumed to be a function of only

the age of the car, with older cars traveling less. Historic data on use by age is assumed to apply in the future.

VALIDATION

Although no specific validation efforts are reported for the Emissions Submodel, the overall model predicts gasoline consumption reasonably well from 1960 to 1974.

LIMITATIONS AND BENEFITS

The forecasts of the model are at best only as reliable as the VMT projections obtained from the Economics Submodel. The model currently incorporates only four emission standard scenarios.

STRUCTURE

The model computes total automobile emissions based on projected VMT and the appropriate emissions rates, expressed as volume of emissions per mile traveled. Emissions rates for all vehicles through the 1976 model year are obtained from existing test data and from the preliminary edition of Supplement No. 5 for Compilation of Air Pollutant Emission Factors, EPA, April 15, 1975. The emission rates for vehicles manufactured after 1976 are determined by the selection of one of four different emission standard scenarios. Each standard implies a corresponding emission schedule by age of vehicle.

The model computes the percentage of total travel for each vehicle age group by multiplying historic data on travel for each vehicle age by the predicted number of cars in each age group on the road in a given year. Total vehicle miles traveled predicted in the Economics Submodel is distributed among cars on the road in each year according to these percentages. Emissions are calculated as miles traveled times the appropriate emission factor for each age group.

MODEL CONSTRUCTION

The model requires emission factors by vehicle age for all vehicles on the road in a given year. These data are listed in Appendix C of the users' manual. Projections of total VMT and cars on the road in a given year are obtained from the Economics Submodel.

DATA USED IN RUNNING MODEL

The model requires selection of one of four emission standards scenarios. Data describing these scenarios appear in Table VI-2 of the model report.

75-003C

REFERENCE

Gasoline consumption model, Energy and Environmental Analysis, Inc., Vol. I, Final Report, prepared for the Federal Energy Administration, July 22, 1975.

Gasoline consumption model, Energy and Environmental Analysis, Inc., Vol. II: Users Manual, Final Report, prepared for the Federal Energy Administration, September 1975.

COMPUTER REQUIREMENTS

The program, written in FORTRAN IV G, operates in an interactive time-sharing mode. It occupies 57,200 bytes of storage.

AUTOMOBILE SIMULATION MODEL
OF THE PROJECT INDEPENDENCE EVALUATION SYSTEM (PIES)

The Automobile Simulation Model was written in 1975 at the Federal Energy Administration (FEA) as part of the Project Independence Evaluation System (PIES). The purpose of the model is to examine the effects of several conservation policy options on gasoline consumption, new car sales, and total vehicle miles traveled. It has been used by the White House in the preparation of the National Energy Plan, by the Electric Power Research Institute for energy use forecasting, and by Washington State University in energy policy research.

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KEYWORDS

Vehicle miles traveled, automobile demand, fleet size, fuel economy, fuel consumption, vehicle user costs

OBJECTIVE OF MODEL

The objective of the model is to forecast the impact on gasoline consumption, on new car sales, and on total vehicle miles traveled of several conservation policy options applicable to passenger cars. The options include efficiency standards, technical changes, gasoline taxes, and tariff options.

RELATIONSHIP TO OTHER MODELS

The Automobile Simulation Model is one of three submodels of the Transportation Sector of the PIES energy demand model. Other submodels of the Transportation Sector are the Other Vehicles Model and the Natural Gas Transportation Model. Three other sectors (Household, Commercial, and Industrial) comprise the PIES energy demand model. Output from the FEA World Energy Model (75-004B) is used as input to PIES.

HISTORICAL BACKGROUND

Dr. Sweeney is now with the Department of Engineering--Economic Systems at Stanford University.

ASSUMPTIONS

The model is based on the following assumptions:

- 1) average MPG for each car vintage remains unchanged;
- 2) consumers calculate a desired stock of automobiles and buy new cars in order to adjust the total stock of cars from its existing level to its desired level;
- 3) gasoline prices (before taxes) are not influenced by policy options;
- 4) refinery yield constraints will not act as a significant bottleneck retarding the realization of the reductions; and
- 5) sufficient policy instruments exist to implement efficiency standards.

VALIDATION

The model has been run for the period 1975 to 1985 to test the impact of policy options on gasoline demand for passenger cars, vehicle miles of passenger cars, fuel efficiency of new cars, fuel efficiency of the fleet of cars, new automobile sales, and passenger car registrations. It was found that reductions in gasoline demand could be obtained by the use of efficiency standards, gasoline taxes, or tariffs. Gas taxes reduce demand through reductions in vehicle miles traveled and increased efficiency, in the short run.

LIMITATIONS AND BENEFITS

The model results only indicate shifts in demand for gasoline, not supply.

STRUCTURE

The econometric equations were developed from ordinary least squares techniques, except for vehicle miles traveled, which was developed using nonlinear least squares with first-order autoregressive transformation. The equations of the model are:

$$VMAUTO = N \times \exp\left[\begin{array}{c} .80967 \text{ (log[VMAUTO(-1)/N(-1)])} \\ (12.683) \end{array} \right]$$

$$\begin{aligned}
& + \begin{matrix} 6.5184 & - & .35775 & (\log[\text{COSTPM}]) \\ (12.1275) & & (-1.785) & \end{matrix} \\
& + \begin{matrix} .97561 & (\log[\text{YD58\%N}]) & + & .0026184 & (\text{RU}) \\ (11.1515) & & & (0.9352) & \end{matrix} \\
& - .80967 (6.5184 - .35775 [\log(\text{COSTPM}[-1])]) \\
& \quad + .97561 [\log(\text{YD58\%N}[-1])] + .0026184 [\text{RU}(-1)]
\end{aligned}$$

$$\bar{R}^2 = .9959$$

where t-statistics are in parentheses, and

COSTPM = cost per mile of driving an automobile

VMAUTO = total vehicle miles of all passenger cars on the road
(millions)

YD58%N = disposable income per person in 1958 dollars (thousands)

RU = unemployment rate as defined by the Bureau of Labor Statistics

N = total populations (millions)

$$\begin{aligned}
\text{NPCR} = N \times \exp[& \begin{matrix} 4.0792 & - & 3.7554 & (\log[\text{OMEGA}(-1)/N(-1)]) \\ (.6564) & & (-6.2754) & \end{matrix} \\
& + \begin{matrix} 2.3155 & (\log[\text{VMAUTO}/N]) \\ (2.4835) & \end{matrix} \\
& + \begin{matrix} 1.7780 & (\log[\text{YD58\%N}]) & - & .078164 & (\text{RU}) \\ (1.9503) & & & (-3.6297) & \end{matrix}
\end{aligned}$$

$$\bar{R}^2 = .8964$$

NPCR = new passenger car sales (thousands)

OMEGA = age adjusted stock of automobiles

$$\text{PCRAUTO} = \begin{matrix} .930943 & [\text{PCRAUTO}(-1)] & + & \text{NPCR} \\ (629.97) & & & \end{matrix}$$

$$\bar{R}^2 = .9991$$

PCRAUTO = stock of automobiles (thousands)

75-004A

$$\text{OMEGA} = \text{NPCR} + \text{DELTA} \times \text{B} \times \text{OMEGA}(-1)$$

DELTA = survival rate, the fraction of automobiles that survive from one year to the next, = .93

B = age adjustment factor, which adjusts for the fact that older cars are driven less, = .92

$$\begin{aligned} \text{MPGAUTO} = \exp[& 3.22175 \\ & (31.8728) \\ & + .68777 (\log[(\text{PGAS}[-1]/\text{CPI}[-1]) / \text{EFF}]) + (\log[\text{EFF}])] \\ & (7.5798) \end{aligned}$$

$$\bar{R}^2 = .8343$$

CPI = consumer price index

PGAS = price of gasoline in nominal dollars per gallon, including taxes

MPGAUTO = miles per gallon of new cars

EFF = measure of technical efficiency

$$\text{THETA} = \text{NPCR}/\text{MPGAUTO} + \text{DELTA} \times \text{B} \times \text{THETA}(-1)$$

THETA = fuel use per mile driven, allows miles per gallon of new cars to affect the miles per gallon of the stock

$$\text{AMPGAUTO} = \text{OMEGA}/\text{THETA}$$

AMPGAUTO = average miles per gallon of the stock of automobiles on the road

$$\begin{aligned} \text{COSTPM} = & (\text{RIDERSPC} \times \text{WGFAC} \times \text{AHEEA}/\text{CPI}) / (.5 [\text{AVSPEED}] + 10.0) \\ & + (\text{PGAS}/\text{CPI})/\text{AMPGAUTO} \end{aligned}$$

RIDERSPC = number of passengers per car (assumed to equal 1.3)

WGFAC = wage factor or the proportion of wages that people feel they lose while driving as opposed to work-related activities (assumed to equal 0.4)

AHEEA = per hour wage rate in nominal dollars

GASAUTO = VMAUTO/AMPGAUTO

GASAUTO = total gasoline consumption of all cars in gallons of gasoline
(millions)

MODEL CONSTRUCTION

Historical values of the independent variables were used in model estimation. Sources of these data were: the Federal Highway Administration, the Environmental Protection Agency, the "Nationwide Personal Transportation Study," the Motor Vehicle Manufacturers Association, the Department of Commerce, and the American Petroleum Institute.

DATA USED IN RUNNING MODEL

Forecasts of the following variables are required to run the model:

- 1) total population (millions),
- 2) cost per mile of driving an auto,
- 3) total vehicle miles of all autos on road,
- 4) unemployment rate as defined by Bureau of Labor Statistics,
- 5) new passenger car sales,
- 6) age adjusted stock of automobiles,
- 7) stock of automobiles,
- 8) price of gasoline,
- 9) consumer price index,
- 10) assumed miles per gallon,
- 11) average miles per gallon of the auto stock,
- 12) number of passengers/auto,
- 13) loss of wages resulting from driving,
- 14) per-hour wage rate, and
- 15) average speed on road.

The macroeconomic variables used by the author in forecasting were derived from the Data Resources, Inc. macroeconomic model.

REFERENCE

Sweeney, J., Passenger car use of gasoline: an analysis of policy options, Federal Energy Administration, Office of the Assistant Administrator for Policy and Analysis, Office of Energy Systems, February 7, 1975.

WORLD ENERGY MODEL

The World Energy Model was written by the Federal Energy Administration (FEA) in 1975. Its purpose is to generate forecasts of world crude oil prices and the U.S. crude oil imports at different levels of prices. Output from this model is used by the FEA as input to the Project Independence Evaluation System (PIES) model with which it is compatible.

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KEYWORDS

Energy consumption

OBJECTIVE OF MODEL

The objective of the World Energy Model is to generate forecasts of world crude oil prices and U.S. crude oil imports at different price levels.

RELATIONSHIP TO OTHER MODELS

Output from this model, as well as that from the Automobile Simulation Model (75-004A), is used as input to the PIES model.

STRUCTURE

The FEA World Energy Model is an econometric linear programming representation of the various segments of the world energy market, including demand, refining, transportation, supply, flows and pricing processes. The structure and methodology of the model is highly compatible with PIES. The model has eight submodels: macroeconomic, econometric demand forecasting, refinery, energy transformation, transportation, supply, economic, and equilibrium.

75-004B

REFERENCE

Ezzati, A., FEA world energy model, Federal Energy Administration, presented at the International Energy Analysis Seminar, June 9-10, 1975, Rosslyn, Virginia.

MODIFIED ROLLBACK PROGRAM

The Modified Rollback Program was written by the Environmental Protection Agency (EPA) in 1974. Its purpose is to calculate either both projected air quality and air pollutant emissions, or pollutant emissions only.

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KEYWORDS

Air pollution/air quality

OBJECTIVE OF MODEL

The objective of the model is to calculate air quality and air pollutant emissions, or pollutant emissions only. It is a long-range model.

RELATIONSHIP TO OTHER MODELS

The modified rollback model may be used in conjunction with an Environmental Protection Agency (EPA) health model. Output from the rollback model is used as input to the health model, which forecasts marginal increases in certain diseases due to increased levels of pollutants.

HISTORICAL BACKGROUND

The Environmental Protection Agency was established in 1970 to ensure that the provisions of the Clean Air Act and its 1970 amendments were carried out. The rollback model is one tool the EPA uses in their work.

ASSUMPTIONS

The model assumes that if emission sources were reduced by a certain fraction, air quality will improve by that fraction.

VALIDATION

The model's projections are compared to observed air quality in the Los Angeles area for the years 1964 to 1974. In general the model predicted past air quality trends, which were similar to measured values. Its ability to predict in the future is judged to be better for relative trends than for actual projected values.

LIMITATIONS AND BENEFITS

The assumption about the proportionality of emissions and air quality may not hold true in all situations.

STRUCTURE

$$X_j = B + (X_0 - B) \frac{\left(\sum_{i=1}^n Q_i G_{ij} F_{ij} K_i T_{ij} \right)}{\left(\sum_{i=1}^n Q_i K_i \right)}$$

where:

X_j = projected air quality concentration for calendar year j

B = background concentration

X_0 = base year air quality concentration

Q_i = base year emission inventory for source category i

G_{ij} = growth factor for source category i in year j

F_{ij} = emission factor ratio for source category i in year j

K_i = emission height factor for source category i

T_{ij} = transportation control factor, if applicable, for source category i in year j

n = number of source categories

i = source category index

j = calendar year index

MODEL CONSTRUCTION

The model is a set of physical theoretical relationships.

DATA USED IN RUNNING MODEL

The model user must choose and designate the areas for which an air quality projection is desired; designate the name, base year, and base year concentration of the pollutant for which an air quality projection is desired; choose as many as six mobile sources and six stationary source categories of the twenty-six available; and select base year emissions, compound growth rates, and compound retirement rates for each category chosen.

REFERENCE

Tuerk, E., Air quality, noise and health, Report of a Panel of the Interagency Task Force on Motor Vehicle Goals Beyond 1980, March 1976.

Modified rollback computer program, documentation, Draft, Environmental Protection Agency, Air Management Technology Branch, Monitoring and Data Analysis Division, Office of Air Quality Planning and Standards, April 7, 1977.

COMPUTER REQUIREMENTS

The model is written in FORTRAN for a UNIVAC computer. The instructions for running the program and the program listing are in the Modified Rollback computer program documentation.

HIGHWAY FUEL CONSUMPTION MODEL

The Highway Fuel Consumption Model was prepared in April 1974 by the Transportation Systems Center (TSC) for the U.S. Department of Transportation. The objective of the model is to provide an estimate of future vehicle population mixes by age of vehicle and fuel category, and to calculate the fuel consumption rate of such a vehicle distribution. It is a submodel of the Integrated TSC Automobile and Gasoline Demand Model, which forecasts new automobile sales, market share, gasoline use, and overall fleet efficiency.

SPONSOR

U.S. Department of Transportation
Office of the Assistant Secretary for Systems Development and
Technology, and Office of the Assistant Secretary for Policy and
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KEYWORDS

Vehicle miles traveled, fuel consumption, fleet size

OBJECTIVE OF MODEL

The objective of the model is to provide an estimate of future vehicle population mixes by age of vehicle and fuel category, and to calculate the fuel consumption rate of such a vehicle distribution.

RELATIONSHIP TO OTHER MODELS

A version of this model is a submodel of the Integrated TSC Automobile and Gasoline and Demand Model, which also includes 74-037A and B. It integrates the results of the other two submodels.

ASSUMPTIONS

The model assumes a standard decay rate as a function of age for all automobiles, and an annual increase of 2.6% per year in vehicle miles traveled.

VALIDATION

The model was tested for consistency of options in the computer program. Eleven scenario projections are presented in the report. However, the report does not discuss any validation efforts.

LIMITATIONS AND BENEFITS

The model does not forecast or predict gasoline consumption based on explanatory variables. It estimates, on the average, the sensitivity of total fuel consumption to changes in the fuel economies of new cars introduced into the vehicle population and the effects of the existing vehicle inventory. An accounting is made entirely from data supplied by the user or from other submodels.

STRUCTURE

The model consists of an algorithm that may be used to join the market share and gasoline submodels. The model calculates fuel consumption over time given the user-specified values of:

- 1) the distribution of initial year vehicle population by fuel economy,
- 2) vehicle miles driven per year as a function of vehicle age,
- 3) survival rates of the vehicles as a function of age,
- 4) projected vehicle population (or vehicle miles) as a function of time, and
- 5) projected fractional mix, by fuel categories, of new cars added to the vehicle population during each projected year.

Given the data, the model calculates new car sales for each projected year by subtracting surviving vehicles from the total vehicle population. New car sales are distributed by fuel category, and fuel consumption is calculated from the formula:

$$F_{ij} = \sum_{k=2}^{k_{\max}} N_{ijk} C_j M_{ik} + N_{ij1} C_j M_{i1}$$

where:

i = year

j = fuel consumption category

k = age of vehicle

F = fuel consumption

74-006

N = number of vehicles

C = fuel consumption, gal/mile

M = miles driven per year

MODEL CONSTRUCTION

This model is a set of physical theoretical relationships.

DATA USED IN RUNNING MODEL

The model requires initial year data for all variables, and projections of all the input variables for each forecast year. The data values for several scenarios are listed in the model report.

REFERENCE

Gould, H.H.; Malliaris, A.C., Highway fuel consumption computer model, (Version I), Final Report, Department of Transportation, Report no. DOT-TSC-OST-73-43, April 1974.

Barnhill, T.M., DOT highway fuel consumption model (Version I as revised), Motor Vehicle Manufacturers Association, 1975.

Chamberlain, C., Policy options: gas tax vs. gas rationing and/or auto excise tax TSC Working Paper, Report no. WP-SP-U2-65, 1974.

COMPUTER REQUIREMENTS

The model is programmed in FORTRAN. A program listing is included in the model report.

AUTO FLEET SUBMODEL

The Auto Fleet Submodel, dated February 1976, is a computer program used by the Transportation Systems Center (TSC) to implement the consumer sector of its modeling effort for the Task Force on Motor-Vehicle Goals Beyond 1980. It was prepared for TSC by Kentron Hawaii, Ltd. The model provides forecasts of fleet characteristics, emissions, mileage, and fuel data for three size-classes of cars and up to five "families" of structural specifications.

SPONSOR

U.S. Department of Transportation
Transportation Systems Center
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AUTHOR

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KEYWORDS

Automobile demand, market share, vehicle miles traveled, scrappage, emissions, fuel economy

OBJECTIVE OF MODEL

The Auto Fleet Submodel is designed to provide forecasts of fleet characteristics, emissions, mileage, and fuel data for three size-classes of cars and up to five "families" of structural specifications.

RELATIONSHIP TO OTHER MODELS

This model constitutes the consumer submodel of a larger modeling effort by TSC. The model receives inputs from other submodels which predict resource requirements and automobile production. It provides outputs to the auto design evaluation submodel and the environmental impact assessment submodel. In particular, the fleet model is used as input to ARAM (76-024A).

ASSUMPTIONS

The model assumes that up to five families of cars will exist at any one time. Families are defined by engine, transmission, and structural specifications, and by whether certain levels of emissions and safety standards are met.

VALIDATION

The model report does not describe any validation of the model.

STRUCTURE

The model forecasts fleet size, VMT, new car sales, fuel consumption, and emissions for a specified number of years. The model report does not describe the actual structure of the model.

MODEL CONSTRUCTION

The model requires the following data base:

- 1) data for the initial fleet (1975) by age, class, and family,
- 2) miles driven by age of car,
- 3) scrappage rate by age of car,
- 4) type of fuel used,
- 5) fuel efficiency by year, class, and family,
- 6) vehicle weight,
- 7) crashworthiness,
- 8) emission rates for three pollutants for each family,
- 9) new car price by year, class, and family,
- 10) emission category by family.

Data values used in the model are listed in Appendix A, pp. A-34 to A-36, and Appendix D, p. D-1 of the model report.

DATA USED IN RUNNING MODEL

For each year of the forecast the model requires input values for the unemployment rate, new car mix by class, sales mix by family, and descriptive data for each new family of cars. Total sales, total VMT, and total vehicle population can be input, or they can be forecast using

quarterly input values for population over the age of 16, price of new cars, total population, unemployment rate, Moody's AAA interest rate, and historical new car sales from 1965 to 1974. Annual values are required for the number of drivers, real disposable income, number of households, and real price of gasoline. Data values used are listed in the model report in Appendix D, pp. D-2 to D-5.

REFERENCE

Robb, A.F., Auto fleet submodel, Final Report, prepared by Kentron Hawaii, Ltd. for TSC/DOT under contract No. DOT/TSC-1146, February 23, 1976.

Robb, A.F., Update of user's manual for the fuel forecast program, External Memo KH10-F29200 - EM 581/75, November 14, 1975.

Rubinger, B.; Prensky, S., Computer-based resource accounting model for generating aggregate resource impacts of alternative automobile technologies volume I--fleet attributes model, TSC/DOT, Report no. DOT-TSC-OST-77-72, January 1978.

COMPUTER REQUIREMENTS

The model is programmed in FORTRAN IV (F40). A copy of the program is included in the model report.

A USER COST APPROACH TO NEW AUTOMOBILE PURCHASES

A User Cost Approach to New Automobile Purchases, dated January, 1973, was developed at Pomona College under a grant from the Ford Foundation. The objectives of the research were to investigate a superior goods approach to modeling new car purchases and to compare this approach with the commonly used "stock-adjustment" approach.

SPONSOR

Ford Foundation
Pomona College Research Committee Grant

AUTHOR

Frank C. Wykoff
Pomona College
Claremont, California

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objectives of this research are to examine a superior goods approach to modeling new car purchases and to compare this approach with the commonly used "stock-adjustment" approach. The hypothesis is tested that new cars are viewed by consumers as superior to used cars.

RELATIONSHIP TO OTHER MODELS

This model has no direct relationship to other models.

HISTORICAL BACKGROUND

There has been much econometric work investigating the user-cost element in corporate investment decisions. There are parallels between investment decisions by firms and durable purchase decisions by consumers, yet user-cost theory has not been applied to consumer goods.

ASSUMPTIONS

The following assumptions were made in the construction of the model:

- 1) Utility to the consumer is derived from the services of durable goods, and it is the price of the services, not the purchase

price, that determines the demand (the user-cost-of-capital theory).

- 2) The rental price of a car for a year is the opportunity cost of holding the car plus the loss of value of the car over the year.
- 3) New-car services are "superior goods" relative to used-car services.
- 4) Private transportation is a necessity.
- 5) Used cars will influence new-car demand through their implicit rental prices as inferior substitutes.
- 6) Used cars are not perfect substitutes for new cars but are perfect substitutes for other used cars.

VALIDATION

There are no validation procedures discussed in the article on the model. The data, however, appear to fit the model well. From the test results of the user cost and superior goods hypothesis several observations are possible:

- 1) New and used cars are not perfect substitutes and, therefore, purchases of the former cannot be treated as simple additions to existing stock of cars.
- 2) Price and income elasticities, goodness-of-fit comparisons of competing models, and depreciation patterns suggest new car services are qualitatively superior to those of used cars.
- 3) New car purchases are price inelastic when a user-cost approach is used to estimate automobile demand from rental prices.
- 4) New-car income elasticities are around one, indicating new cars are normal, not luxury goods.
- 5) Using the oversimplified stock-adjustment approach, sixty to eighty percent of new demand results in current-period purchases, indicating a lag adjustment should be made for this approach.
- 6) Rental prices compare favorably to purchase prices.
- 7) Rental price coefficients are smaller than those of purchase prices but also have smaller standard errors.
- 8) Rental price elasticities are smaller, and the estimates more precise, than those of purchase prices.

LIMITATIONS AND BENEFITS

It appears that behavior in the used car market cannot be explained totally as a residual from new car purchase decisions of the past.

STRUCTURE

The superior goods model is represented by two equations:

$$A = A(I, C, U)$$

where:

A = demand for new car purchases

I = consumers' income constraint

C = user cost of a new car

U = user cost of a used car

$$U = U(I, C, S)$$

where:

U = demand for used cars

I = consumers' income constraint

C = user cost of new car rentals

S = existing stock of cars

The equations were studied using a variety of functional forms: aggregate-linear, per-family-linear, and log-linear. Results were invariant over these forms.

MODEL CONSTRUCTION

Data including disposable income, number of families in U.S., total expenditures, consumer price index, and four to six month prime commercial paper rate were obtained from Survey of Current Business, Current Population Reports and the Federal Reserve Bulletin. Stock and new-purchase data by make and model year were obtained from R.L. Polk and Co., while new and used purchase prices by make and age were obtained from the Kelly Blue Book.

REFERENCE

Wykoff, F.C., A user cost approach to new automobile purchases, Review of Economic Studies, Volume 40, July 1973.

A METHOD FOR PROJECTING AGGREGATE AUTO MILES TRAVELED

A Method for Projecting Aggregate Auto Miles Traveled was prepared at the U.S. Department of Transportation (DOT), Transportation Systems Center (TSC) in 1975. It provides forecasts of vehicle miles traveled (VMT) that are sensitive to the price of gasoline and auto fuel economy.

SPONSOR

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Transportation Systems Center
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AUTHOR

Donald E. Ward and Linda Horan
U.S. Department of Transportation
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KEYWORDS

Vehicle miles traveled

OBJECTIVE OF MODEL

The objective of the model is to forecast VMT in a model that is sensitive to the price of gasoline and auto fuel economy.

RELATIONSHIP TO OTHER MODELS

The model has been used in conjunction with the model presented in Robert Mellman, "An Econometric Model of New Car Sales," TSC/DOT, Cambridge, Mass., October 1975 (75-013).

HISTORICAL BACKGROUND

The model was developed by TSC to provide forecasts of VMT until a more comprehensive model became available.

ASSUMPTIONS

The model assumes that a stock adjustment mechanism determines VMT.

VALIDATION

The model tracks annual VMT reasonably well from 1954 to 1974, with an R^2 of .99.

LIMITATIONS AND BENEFITS

The model has been superseded by the Environmental Impact Center's (EIC) VMT model (76-022A) and others.

STRUCTURE

The model consists of a single equation that is estimated by ordinary least squares with annual data from 1951 to 1974.

$$V(t) = \begin{matrix} 1590 & + & .6233 & [V(t-1)] & + & 2153 & (D) & + & .3936 & (R) \\ (1.06) & & (6.21) & & & (2.07) & & & (2.57) \\ & & - & 140580 & \left(\frac{P}{E}\right) \\ & & (-5.75) & & \end{matrix}$$

$$R^2 = .99$$

where t-statistics are in parentheses, and

$V(t)$ = vehicle miles traveled per household in year t

D = number of drivers per household

R = real disposable income per household (1958 dollars)

P = real price of gasoline (1967 dollars)

E = average fleet fuel efficiency (miles per gallon)

MODEL CONSTRUCTION

This model was calibrated using annual values for the independent variables from 1954 to 1974. The sources are not indicated in the report of the model.

DATA USED IN RUNNING MODEL

Assumptions are necessary for the future values of real disposable income per household, real price of gasoline, new car sales, and new car fuel economy. Representative assumptions are included in the model report.

75-011

REFERENCE

Ward, D.E.; Horan, L., A method for projecting aggregate auto miles traveled, Working Paper, TSC/DOT, WP-230-U.2-78, May 1975.

AN ECONOMETRIC MODEL OF NEW CAR SALES

An Econometric Model of New Car Sales, dated October 1975, was prepared at the Transportation Systems Center (TSC). The model was designed to be sensitive to macroeconomic conditions and to purchase price and fuel costs of automobiles.

SPONSOR

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AUTHOR

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KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of the model is to estimate the demand for new automobiles as a function of macroeconomic conditions and the purchase price and fuel costs of automobiles.

RELATIONSHIP TO OTHER MODELS

Input includes forecasts of the effect of user costs on vehicle miles traveled from Donald Ward and Linda Horan, A Method for Projecting Aggregate Auto Miles Traveled, Working Paper, TSC/DOT WP-230-U.2-78, May 1975 (75-011).

HISTORICAL BACKGROUND

The report was prepared under PPA No. OS 514, Requirements Analysis Subproject of Automobile Energy Efficiency Program sponsored by the Office of the Assistant Secretary for Systems Development and Technology, TST, U.S. DOT. Robert Mellman is now with Charles River Associates, Cambridge, Mass.

ASSUMPTIONS

User costs such as gasoline price and tax rate enter the model only indirectly through their impact on vehicle miles traveled. The stock of cars variable assumes a constant depreciation rate.

VALIDATION

All coefficients have the proper signs, and all but one are significant at the 95% level. The equation tracks actual car sales quite well from 1958 to 1975, with an R^2 of .88.

LIMITATIONS AND BENEFITS

The structure of the equation is due in large part to multicollinearity among several of the independent variables.

STRUCTURE

The equation is estimated using ordinary least squares for quarterly data from 1958 II to 1974 III.

$$\begin{aligned} \log\left(\frac{Q}{N16}\right) = & 17.90 - \frac{1.69}{(2.42)} \left[\log\left(\frac{P}{YD}\right)\right] + \frac{1.01}{(1.36)} \left[10\log\left(\frac{P}{YD}\right)_{-1}\right] \\ & - \frac{.41}{(5.52)} \left[\log(u)\right] - \frac{.50}{(3.85)} \left[\log(r)\right] - \frac{.46}{(2.81)} \left[\log\left(\frac{P}{P_u}\right)\right] \\ & + \frac{2.34}{(5.71)} \left[\log\left(\frac{VMT}{STOCK}\right)_{-1}\right] + \frac{.12}{(3.62)} (STRIKE) + \frac{.12}{(6.93)} (DSA) \end{aligned}$$

where t-statistics are in parentheses and

Q = quarterly sales of new cars

N16 = population over 16 years

YD = disposable income per capita, 1958 dollars

P = index of real new car price

u = national unemployment rate

r = Moody's AAA bond interest rate

P_u = index of real used car price

VMT = auto miles traveled per quarter

STOCK = stock of cars

DSA = seasonal adjustment dummy variable

STRIKE = auto industry strike dummy variable

MODEL CONSTRUCTION

This model was calibrated using quarterly data for all of the variables from 1958-II to 1974-III. The values of new car sales, income, unemployment, and the interest rate were obtained from Survey of Current Business. Vehicle miles traveled was taken from Highway Statistics, by The Federal Highway Administration. Population over sixteen years old was from the U.S. Bureau of the Census. New and used car prices were from the Bureau of Labor Statistics consumer price indices.

DATA USED IN RUNNING MODEL

The model requires forecasts of real car and real gasoline prices, of real disposable income, of gasoline taxes, and of average fuel efficiency.

REFERENCE

Mellman, R., An econometric model of new car sales, TSC, Report No. WP-210-U2-111, October 1975.

Ward, D.; Horan, L., A method for projecting aggregate auto miles traveled, TSC Working Paper WP-230-U.2-78, May 1975 (75-011), subject to change.

AUTOMOBILE SECTOR FORECASTING MODEL

The Automobile Sector Forecasting Model, commonly referred to as the Faucett Model, was written in 1976 by Jack Faucett Associates, Inc. under the sponsorship of the Federal Energy Administration. Its objective is to model the effects of alternate fuel economy policies on future gasoline consumption, vehicle miles traveled, new car sales, fleet size, fleet composition, stock of cars, new car prices, and fuel economy. It has been used by the Federal Energy Administration, the Energy Research and Development Administration, the White House, The Transportation Systems Center, by the Congressional Budget Office for evaluating the President's National Energy Plan, and by the National Highway Traffic Safety Administration (NHTSA) for studying the effects of passive restraints.

SPONSOR

Federal Energy Administration
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AUTHOR

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KEYWORDS

Automobile demand, vehicle miles traveled, scrappage, market shares, fuel consumption

OBJECTIVE OF MODEL

The objective of the model is to estimate the effects of alternative fuel economy policies on future gasoline consumption, vehicle miles traveled, new car sales, fleet size, fleet composition, stock of cars in use, new car prices, and fuel economy.

RELATIONSHIP TO OTHER MODELS

This model has no relationship to other models.

HISTORICAL BACKGROUND

The automobile demand block of the model was prepared for the Marketing and Mobility Panel of the Federal Interagency Task Force on Motor Vehicle Goals Beyond 1980. The automobile industry simulation block was subsequently developed under the sponsorship of the FEA.

Several versions of the computer program of the model exist. The differences involve the automobile industry simulation block, and in all of them the basic structure of the model is the same.

ASSUMPTIONS

The fundamental concept used to specify the model of new car sales is that of a short-run stock adjustment approach. In such a model, new car sales is assumed to be related to the gap between a "target" stock of automobiles at the beginning of the current period less those cars that will be scrapped during the year. The target automobile ownership is assumed to be positively related to household income. In addition, the rate at which automobile ownership per household increases decreases with rising income per household. To calculate the target ownership, the authors of the model observe that automobile ownership by income group is relatively stable over time and thus they assume that the relationship between target ownership and household income can be estimated cross-sectionally with 1970 data.

The proportions of miles traveled by cars by each age group of cars is also based on cross-sectional data and remain constant. The shares of the new car stock that are produced by the various automobile manufacturers are also assumed constant.

VALIDATION

The model has been run using twenty-one alternative input scenarios through the year 2000. All of the scenarios predict a fall in fuel consumption through 1985 and varying increases through 2000. Each scenario predicts a rise in VMT at varying rates. Increases and decreases in auto stock are predicted by different scenarios. Fuel economy standards are judged to be the best way of conserving fuel with fewer negative side effects.

A detailed analysis of this model has been performed by the Highway Safety Research Institute of the University of Michigan. A report on this study is in preparation.

LIMITATIONS AND BENEFITS

The alternative fuel economy policies that can be tested by the model are new car excise taxes and rebates, fuel economy standards and penalties, and influences on the price of gasoline.

STRUCTURE

The Faucett model is made up of two major components: an automobile industry simulation component and an automobile demand and travel forecasting component.

The automobile industry simulation component determines fuel economies and prices of three size classes of cars: small, mid-size, and large. These fuel economies and prices are calculated through a complex procedure which attempts to minimize the sum of: (1) the cost of a car to the consumer, (2) the cost of automobile travel to the consumer (this is inversely proportional to fuel economy), (3) the taxes to the consumer that may result under a tax/rebate program which is based on the fuel economy of cars, and (4) the civil penalties to the industry that can occur as a result of the fuel economy standards.

The demand and travel forecasting component determines the result of the price and fuel economy decisions on new car sales, travel demand, and gasoline consumption. This component of the model is based essentially on a stock-adjustment approach, and it is composed of several interrelated submodels including those for surviving cars on the road, generalized price, target auto ownership, new car sales, market shares, vehicle miles traveled, petroleum product consumption, vehicle price, and fuel economy. The model equations are as follows:

$$N_t = 286,721.3 (O^*_t - Autos_t - D_t) \cdot 2178 (X^*_t)^{-1.7039}$$

$$O^*_t = (\sum_I H_I P_{It}) HHL D_t$$

$$H_I = .017861 (I)^{.4743}$$

$$S_t = 1 / (1 + e^{-[-4.1749 - 1.8660 (X^S_t) + 3.5093 (X^M_t) + 5.6428 (S_{t-1})]})$$

$$M_t = 1 / (1 + e^{-[-4.1749 - 2.0765 (X^M_t) + 3.5450 (X^S_t) + .2589 (X^L_t) + 5.6428 (M_{t-1})]})$$

$$L_t = 1 / (1 + e^{-[-4.1749 - .4299 (X^L_t) + 1.8117 (X^M_t) + 5.6428 (L_{t-1})]})$$

$$SPG_t = .4068 - .0784 (P_n)_t - .0155 (U_t)$$

$$\frac{VMT}{HHLD_t} = -52979.8 + 15087 \left[\log\left(\frac{DI}{HHLD_t}\right) \right] \\ - 2204.24 (CPM_t) + 6337.24 \left(\frac{Autos}{HHLD_t} \right)$$

where:

N_t = total new car sales in year t

O^*_t = target ownership of automobiles in year t

$(Autos)_t$ = the stock of automobiles on hand as of January 1 of year t

H_I = the number of cars per household for income group I

D_t = the number of autos scrapped during year t

X^*_t = an index of the real generalized price of new cars, 1967 = 1.00

S_t, M_t, L_t = market shares of small, medium, and large cars, respectively, in year t

X^S_t, X^M_t, X^L_t = an index of the real generalized price of small, medium, and large cars, respectively, relative to that of all new cars in year t, 1967 = 1.00

SPG_t = the rate of scrappage in year t of vehicles eight or more years of age.

$(P_n)_t$ = an index of the real price of new cars in year t, 1967 = 1.00

U_t = the unemployment rate in year t

DI_t = total real disposable income in year t

VMT_t = total vehicle milestraveled in year t

CPM_t = an index of the fleet real gasoline costs per miles in year t, 1967 = 1.00

$HHLD_t$ = the total number of households existing in year t

P_{It} = fraction of total households in year t having income I

For each year, 1976-2000, the model outputs the following:

- 1) new car sales,

76-016

- 2) new car sales by size class,
- 3) average fuel economy by new car fleet,
- 4) fuel economy by class,
- 5) new car prices,
- 6) new car prices by class,
- 7) number of cars in operation,
- 8) cars in operation by size class,
- 9) cars scrapped during year,
- 10) gasoline price,
- 11) vehicle miles traveled,
- 12) total gasoline consumed, and
- 13) size class weighted average generalized price.

MODEL CONSTRUCTION

Data used to build the model were based on at least these sources:

- 1) Survey of Consumer Finances, Survey Research Center, The 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

DATA USED IN RUNNING MODEL

Data for these variables are required: gasoline prices and new car fuel economy policies (excise tax/rebate description, and fuel economy standards/penalties).

REFERENCE

Automobile sector forecasting model, Jack Faucett Associates, Inc., Documentation, submitted to the Federal Energy Administration, Final Report, JACKFAU-76-137-7, August 1976.

Fuel economy policies and their effects on automobile ownership, use, and fuel consumption, Jack Faucett Associates, Inc., submitted to the Federal Energy Administration, Final Report, JACKFAU-76-137-7, August 1976.

Difiglio, C.; Kulash, D., Marketing and mobility: report of a panel of the interagency task force on motor vehicle goals beyond 1980, Interim Report, March 1976.

COMPUTER REQUIREMENTS

The program is written in FORTRAN and is operational on the IBM 370. The programs are written for interactive use by a user at a remote terminal.

GENERAL PURPOSE AUTOMOTIVE VEHICLE PERFORMANCE AND ECONOMY SIMULATOR

GPSIM, General Purpose Automotive Vehicle Performance and Economy Simulator, has been under development by the Engineering staff of General Motors Corporation since 1960. Its purpose is to simulate automotive vehicle performance and economy. It is used in numerous divisions of General Motors Corporation.

SPONSOR

General Motors Corporation

AUTHOR

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Warren, Mich. 48090

KEYWORDS

Vehicle operating performance, automobile design

OBJECTIVE OF MODEL

The general objective of the model is to compute the operating conditions of the propulsion system and the performance and economy of the vehicle as the vehicle is operated in some prescribed manner.

Specific objectives are:

- 1) to provide a fast, economical method to compute vehicle performance and economy for a wide variety of production and experimental vehicles;
- 2) to provide a convenient user format, with easily understood input and output;
- 3) to run with a minimum of input data describing the vehicle, but to accept more complete data, if available;
- 4) to provide for easy location and diagnosis of input data errors.

RELATIONSHIP TO OTHER MODELS

There is no apparent relationship with other models.

HISTORICAL BACKGROUND

A vehicle simulation model was first developed by General Motors Engineering Staff in 1960. This model has been under continual development since then, the resulting program being GPSIM.

ASSUMPTIONS

GPSIM operates under five basic assumptions:

- 1) Tables can be used instead of a comprehensive set of equations to describe the performance of engines, converters, rotating losses, etc.
- 2) Steady-state engine and torque converter tests can be used to predict their dynamic operations.
- 3) Hydrodynamic laws of similarity apply to the torque converter.
- 4) Simplified shift models can be used to simulate transmission shifts; that is, the amount of energy transferred during the shift is important, but how it is transferred is unimportant.
- 5) Steady-state operating conditions for a vehicle can be placed in a set of tables, and the operating characteristics of that vehicle can then be accurately simulated by referring to these tables.

VALIDATION

A number of correlation studies have been made. When the input data accurately represents the test vehicle, correlation accuracies with 1 to 2% can be obtained.

LIMITATIONS AND BENEFITS

This model may be used to simulate vehicles with alternative engine types, such as gasoline or diesel, gas turbine, and electric motor.

STRUCTURE

This physical or engineering model consists of six basic equations:

$$TE = \frac{(ENGHP - ALOSSES) \times 375}{VMPH}$$

72-017

$$ACCEQV = \frac{TE - ROLRES}{WTEQV}$$

$$ACC = (ACCEQV - GRDEQV) \times ACCG$$

$$V = V_1 + ACC \times DT$$

$$D = D_1 + V_1 \times DT + \frac{ACC \times DT^2}{2}$$

$$AMPG = \frac{MILES}{GALLON}$$

where:

ACC = vehicle acceleration (ft/s²)

ACCEQV = equivalent acceleration (g)

ACCG = acceleration of gravity (32.17/s²)

ALOSSES = apparent driveline losses (hp)

AMPG = fuel economy (mpg)

D = distance at end of time interval (ft)

D₁ = distance at start of time interval (ft)

DT = length of time interval (s)

ENGHP = gross engine power (hp)

GALLONS = quality of fuel used (gallons)

GRDEQV = acceleration that has the same effect on vehicle as the given grade (g)

MILES = distance traveled (miles)

ROLRES = force required to maintain motion of vehicle on land (lbs)

TE = tractive effort (lbs)

V = vehicle velocity at end of time interval (ft/s)

V₁ = vehicle velocity at start of time interval (ft/s)

WTEQV = equivalent weight (lbs)

VMPH = vehicle speed (mph)

MODEL CONSTRUCTION

The model is based on a set of relationships derived from the basic laws of motion.

DATA USED IN RUNNING MODEL

Input data are divided into three categories: data blocks, specifications, and commands. A data block is a related group of data that describes a part of the vehicle, a route, a schedule, or some set of actions GPSIM is to take. Specifications are statements which alter the way GPSIM normally operates. A command is a statement that requires some action by GPSIM.

REFERENCE

Waters, W.C., General purpose automotive vehicle performance and economy simulator, General Motors Corp., Society of Automotive Engineers, Paper No. 720043, January 1972.,

GPSIM User Manual, Warren, Michigan: Engineering Staff, General Motors Corp., April 1979.

COMPUTER REQUIREMENTS

GPSIM is written in PL/1 and is operating (in 1979) on an IBM 370 Model 165 Computer. The program consists of about 75 external procedures containing a total of about 40,000 source statements. There are about 3 mega-bytes of machine instructions that are overlaid into about 500,000 bytes of core storage using dynamic storage techniques. Two to nine external files are used.

POLICY SEARCH MODEL FOR EVALUATING FUTURE
NATIONAL TRANSPORTATION STRATEGIES

The Policy Search Model for Evaluating Future National Transportational Strategies was developed by the Chicago Transit Authority and Northwestern University. The model projects the state of the national transportation system into the future under a variety of energy and environmental constraints.

AUTHOR

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Office of Research

Joseph L. Schofer
Northwestern University
Civil Engineering

KEYWORDS

Vehicle miles traveled, modal split, energy consumption

OBJECTIVE OF MODEL

The objective of this energy model is to provide support in the identification, evaluation, and selection of transportation policies at the national level. It projects the state of the national transportation system into the future under a variety of energy and environmental constraints.

RELATIONSHIP TO OTHER MODELS

The model bears no direct relationship to other transportation models.

ASSUMPTIONS

State variables are assumed to have default values which limit their maximum feasible increase or decrease. These constraints are based on historical trends and serve as policy and economic limitations on change. The model does not assume an economic growth trend. Rather, any trend, including reverses, may be specified.

VALIDATION

The model report does not discuss any validation of the model.

STRUCTURE

The model consists of a linear programming algorithm which maximizes an objective function subject to 121 constraints. The objective function is

$$\text{Max } \left(\sum_{i=1}^4 a_i x_i + k \sum_{j=1}^7 b_j y_j \right)$$

where:

x_i = per capita passenger miles by age group i

y_j = per capita ton miles by commodity group j

a_i, b_j , = priorities for travel report or shipment of a group, set by user

k = priority of passenger miles to ton miles, set by user

The constraints are classified into one of three sets: conservation, proportion, or limitation. A typical limitation constraint is

$$\sum_i a_i x_i \leq b$$

where:

x_i = passenger or ton miles for mode of travel i using a particular energy source

a_i = gallons per ton or passenger mile for mode i , input by user

b = projected supply of energy source, set by user.

The model incorporates 43 modes of transportation. For specified future scenarios, the model computes the most efficient use of each mode of transportation.

MODEL CONSTRUCTION

The model requires data with which to construct the linear constraints. These data are not included in the model report.

DATA USED IN RUNNING MODEL

The model requires projections of population, energy availability, and modal energy efficiencies. Values are not indicated in the report. The user must also specify desired shipment and travel priorities and maximum annual system changes.

REFERENCE

Bernard, M.J., III; Schofer, J.L., Policy search model for evaluating future transportation strategies under energy and environmental constraints, presented at the Intersociety Committee on Transportation Technical Session on Resource/Energy Strategies, Atlanta, July 16, 1975.

VEHICLE MILES TRAVELED MODEL

A Vehicle Miles Traveled Model was prepared by the Environmental Impact Center (EIC) Inc. for the Transportation Systems Center (TSC) as part of a revision of the TSC's Automotive Energy Efficiency Program (AEEP) Integrated Fleet Model. It is dated March 1976. The revised Integrated Fleet Model examines the overall impact of alternative energy and emissions policies on vehicle miles traveled, new car sales, fleet size, fuel economy, total fuel consumption, and air quality over the next fifteen years. TSC has used the model in the Fuel Economy Emissions Impact Study.

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KEYWORDS

Vehicle miles traveled

OBJECTIVE OF MODEL

The objective of the model is to provide forecasts of vehicle miles traveled as part of an integrated fleet model designed to examine the overall impact of alternative energy and emissions policies on vehicle miles traveled, new car sales, fleet size, fuel economy, total fuel consumption, and air quality over the next fifteen years.

RELATIONSHIP TO OTHER MODELS

This model is a submodel of the Automotive Energy Efficiency Program (AEEP) Integrated Fleet Model.

HISTORICAL BACKGROUND

TSC developed its own integrated fleet model, and later contracted with EIC Corporation to prepare a revised model that rectifies problems in the original model.

VALIDATION

The author reported that reasonable forecasts were obtained for several alternative future scenarios.

LIMITATIONS AND BENEFITS

This model is an improvement over the previous TSC vehicle miles traveled model. However, the model does not disaggregate by size of car.

STRUCTURE

The model consists of an identity defining VMT and a first difference equation for ΔVMT which is estimated by ordinary least squares for annual data from 1953 to 1974. These equations are:

$$VMT = VMT(-1) + \Delta VMT$$

$$\Delta VMT = 11.293 (\Delta HH) + .857 (\Delta Y) - 8273 (\Delta COST) - 45 (\Delta TRANS)$$

(3.2) (4.8) (-5.2) (-1.4)

$$R^2 = .86$$

where t-statistics are in parentheses, and

VMT = nationwide vehicle miles traveled in billions of miles

VMT(-1) = last year's VMT

Δ = a one-year change in the value of the variables, e.g., $\Delta VMT = VMT - VMT(-1)$

HH = number of households in the U.S., in millions

Y = real disposable personal income, in billions of 1967 dollars

COST = cost per mile of driving, in constant 1967 dollars, = PGAS/MPG

PGAS = real price of gasoline

MPG = average fleet-wide fuel economy in miles per gallon

TRANS = the total supply of transit (rail, trolley, and bus) measured in billions of vehicle miles

MODEL CONSTRUCTION

The model was calibrated using annual values for the independent variables from 1953 to 1974. The report does not indicate specific data sources.

DATA USED IN RUNNING MODEL

Assumptions are necessary as to the future values for the number of households, disposable income, the cost of driving, and the supply of transit. Alternative assumptions are included in this report.

REFERENCE

Refinements to the AEEP Integrated Fleet Model, EIC Corporation. prepared for TSC, Order No. TS11513, March 29, 1976.

NEW CAR SALES MODEL

The New Car Sales Model, dated March 1976, was prepared by Environmental Impact Center (EIC) Inc. for the Transportation Systems Center (TSC) as part of a revision of the Automotive Energy Efficiency Program (AEEP) Integrated Fleet Model. The revised Integrated Fleet Model examines the overall impact of alternative energy and emissions policies on vehicle miles traveled, new car sales, fleet size, fuel economy, total fuel consumption, and air quality over the next fifteen years. TSC has used the model in the Fuel Economy Emissions Impact Study.

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KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The model forecasts new car demand as part of an integrated fleet model designed to examine the overall impact of alternative energy and emissions policies on vehicle miles traveled, new car sales, fleet size, fuel economy, total fuel consumption, and air quality over the next fifteen years.

RELATIONSHIP TO OTHER MODELS

This model is a submodel of the Automotive Energy Efficiency Program (AEEP) Integrated Fleet Model.

HISTORICAL BACKGROUND

TSC developed its own integrated fleet model, and later contracted with EIC Corporation to prepare a revised version that rectifies problems in the original.

ASSUMPTIONS

The model assumes a linear functional form, which implies that elasticities are proportional to the values of the respective variables. It also assumes that the demand for new cars is derived from the demand for travel, as specified in the vehicle miles traveled variable.

VALIDATION

The authors reported that reasonable forecasts were obtained for several alternative future scenarios.

LIMITATIONS AND BENEFITS

This model includes improvements in equation specification over a previous TSC new car sales model; however, it does not disaggregate by size of car.

STRUCTURE

This econometric model consists of a single equation explaining new car sales in terms of five independent variables, including the value of VMT. The equation is estimated using ordinary least squares.

$$\begin{aligned} \text{NCAR} = & 3.94 - .00103 (\text{RPSTK}) + .0594 (\Delta Y) - .311 (u) \\ & (2.7) \quad (-1.7) \quad (6.7) \quad (-3.1) \\ & + .766 (\text{STRIKE}) + .00849 (\text{VMT}) \\ & (3.1) \quad (16.2) \end{aligned}$$

$$R^2 = .95 \quad \text{DW} = 2.15$$

where t-statistics are in parentheses, and

NCAR = annual new car sales in millions of cars

RPSTK = the sticker price of new cars in constant 1967 dollars

ΔY = annual change in real disposable personal income in billions of constant 1967 dollars

u = deviations from "normal" levels of unemployment (unemployment rate - 4.0)

STRIKE = dummy variable for strikes in automobile industry, = -1 in year of the strike, = 0 otherwise

VMT = annual national vehicle miles of travel measured in billions of miles.

MODEL CONSTRUCTION

The model was calibrated using annual values for the variables from 1953 to 1974. No specific data sources are indicated in this report, except for new car price, which came from Ward's Automotive Yearbook, for domestic car prices only.

DATA USED IN RUNNING MODEL

To run this submodel, the forecast of vehicle miles traveled (VMT) from the VMT submodel is necessary, as are forecasts of new car price, income change, and unemployment.

REFERENCE

Refinements to the AEEP integrated fleet model, EIC Corporation., prepared for TSC, Order No. TS11513, March 29, 1976.

FLEET MODEL

The Fleet Model, dated March 1976, was prepared for Transportation Systems Center (TSC) by the Environmental Impact Center (EIC) Inc. as part of a revision of the Automotive Energy Efficiency Program (AEEP) Integrated Fleet Model. The revised model examines the overall impact of alternative energy and emissions policies on vehicle miles traveled, new car sales, fleet size, fuel economy, total fuel consumption, and air quality over the next fifteen years. TSC has used the model in the Fuel Economy Emissions Impact Study.

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KEYWORDS

Fleet Size

OBJECTIVE OF MODEL

The model forecasts automobile fleet size as part of an integrated fleet model designed to examine the overall impact of alternative energy and emissions policies on vehicle miles traveled, new car sales, fleet size, fuel economy, total fuel consumption, and air quality over the next fifteen years.

RELATIONSHIP TO OTHER MODELS

This model is a submodel of the Automotive Energy Efficiency Program (AEEP) Integrated Fleet Model.

HISTORICAL BACKGROUND

TSC developed its own integrated fleet model, and later contracted with EIC Corporation to prepare a revised model that rectifies a number of problems with equation specification in the original model.

ASSUMPTIONS

The model assumes that a stock adjustment mechanism determines fleet size.

VALIDATION

The authors reported that reasonable forecasts were obtained for several alternative future scenarios.

LIMITATIONS AND BENEFITS

This model includes improvements in the specification of equations over a previous fleet model. It does not include determinants of the scrappage rate. The model does not disaggregate by size of car.

STRUCTURE

This econometric model consists of a single trend-type fleet equation estimated by ordinary least squares.

$$\text{FLEET} = -10.8 + .667 [\text{FLEET}(-1)] + .0160 (Y) + .473 (\text{HH})$$

(-2.3)
(7.4)
(2.4)
(2.7)

$$R^2 = .999$$

where t-statistics are in parentheses, and

FLEET = the total number of cars registered in millions

FLEET(-1) = last year's fleet size

Y = real disposable personal income measured in billions of constant 1967 dollars

HH = number of households in U.S. in millions

MODEL CONSTRUCTION

The model was calibrated using annual values for the independent variables from 1953 to 1974. This report does not indicate specific data sources.

DATA USED IN RUNNING MODEL

Forecasts of income and number of households are required.

REFERENCE

Refinements to the AEEP integrated fleet model, EIC Corporation.,
prepared for TSC, Order No. TS11513, March 29, 1976.

APS: AUTOMOTIVE PROPULSION SIMULATOR

The Automotive Propulsion Simulator (APS) was developed in 1974 at the University of Wisconsin under the sponsorship of the U.S. Department of Transportation. It simulates the physical systems of automobile engines and transmissions, using a dynamic digital computer program and a real-time program with input from a human "driver." It may be used to model fuel consumption, emissions, and vehicle operating performance.

SPONSOR

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KEYWORDS

Emissions, fuel economy, air pollution/air quality, vehicle operating performance

OBJECTIVE OF MODEL

The model is designed to simulate dynamically vehicle fuel consumption, emissions, and other performance characteristics. It may be used to test the performance of engines of varying types (including alternative power plants) and specifications.

RELATIONSHIP TO OTHER MODELS

In addition to the APS digital computer program, there is a real-time interactive program attached to a driving simulator. A human operator's reactions to engine and tire noise can thus be used as human factors inputs to the model, resulting in a more realistic simulation.

ASSUMPTIONS

The model is calibrated according to the proven performance specifications of a set of automobiles. Where data are not available, certain conditions are assumed. For example, there is no automatic choke information, so the vehicle is assumed to start out completely

warmed to operating temperatures.

VALIDATION

Simulations of vehicle engines were compared with measurements made of the actual performance of these engines. Predicted and actual values for MPG fuel consumption are quite close, but are less so for emissions.

LIMITATIONS AND BENEFITS

The model depends on the specifications of engine performance that can be acquired and used to build its various components. These data are not readily available, as they may come only from auto manufacturers. As new data are acquired, however, the model can be expanded to include new engine components to be simulated.

STRUCTURE

This is a physical system model. The human driver or the automatic driver provides a throttle setting. This, with engine speed, produces engine torque, which is combined with transmission torque and accessory demand, to compute engine acceleration. Engine speed, torque converter output, transmission torque, rear axle and tractive torque are then computed. This is combined with road load to get vehicle acceleration after the effective vehicle mass has been found. Velocity, driveshaft speed, and torque-converter-output-speed are obtained, and a new engine torque is thus computed. This cycle is repeated ten times per second. Fuel consumption and emissions are computed as a function of engine speed and torque at every instant.

MODEL CONSTRUCTION

Complete vehicle specifications on five autos and emissions maps on several others were used to build the model. Data are presented in graph form in the model report.

DATA USED IN RUNNING MODEL

Engine size factors, torque ratios, and other engine parameters are inputs to the model.

REFERENCE

Beachley, N.H.; Frank, A.A., Increased fuel economy in transportation Systems by use of energy management, Final Report, Vols. I-III, Department of Transportation, Report No. DOT-TST-75-2, Dec. 1974. NTIS No. PB-248 777.

COMPUTER REQUIREMENTS

Vols. II and III of the model report provide a detailed explanation of the structure of the programs and exhaustively documented copies of the program code. The programs are written in FORTRAN II. Vol. II contains the Automotive Simulation Program and the Performance Analysis Program. Vol. III contains the Real-Time (Hybrid and Computer) Simulation Program.

MATERIALS AND ENERGY RESOURCE ACCOUNTING MODEL (ARAM)

The Materials and Energy Resource Accounting Model (ARAM), dated February 1976, was prepared by The Charles Stark Draper Laboratory, Inc. for the Transportation Systems Center of the U.S. Department of Transportation. It forecasts the future materials and energy requirements for alternative automobile technologies. ARAM is a submodel of the Resources Accounting Model, which has been used by the Task Force on Motor Vehicle Goals Beyond 1980 for impact assessment of future automobile production and usage scenarios as part of the overall effort to examine long-range energy goals for the motor vehicle fleet that are compatible with environmental, safety, and economic objectives.

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KEYWORDS

Vehicle manufacturing resource utilization, energy consumption

OBJECTIVE OF MODEL

The objective of the model is to assess the impact of future automobile technology options on resources. It tracks the total scenario of resource requirements for materials and energy and presents this information for assessment.

RELATIONSHIP TO OTHER MODELS

The model is a submodel of the Resources Accounting Model, which is part of the overall modeling effort undertaken by the Task Force on Motor Vehicle Goals Beyond 1980. ARAM requires input from the Fleet Model (76-007).

HISTORICAL BACKGROUND

The Task Force on Motor Vehicle Goals Beyond 1980 was created in May 1975 to examine long-range energy goals for the motor vehicle fleet that are compatible with environmental, safety, and economic objectives.

ASSUMPTIONS

The model assumes that the efficiency of converting heat energy to electricity is 40%. Also, the model assumes annual values for the net import fraction of each type of auto. The model excludes net car imports from the materials and energy calculations.

VALIDATION

The model report does not indicate whether any validation of the model was performed.

STRUCTURE

This model employs a family-tree approach to resource accounting. It traces materials or energy types on a physical unit basis from their finished form back through intermediate stages of production to their raw material origins. The model forecasts the annual demand for imported processed materials, imported raw materials, domestic raw materials, and domestic scrap materials, and it forecasts the energy requirements for the processing of the materials, the fabrication of the automobiles, and the operation of the automobiles. The model itself consists of a set of 24 accounting relationships. A representative equation appears below:

$$TMP_{jk} = \sum_i (P_{ik}) (QM_{ijk})$$

where:

i = an index of family type of automobile

j = an index of materials

k = an index of years

TMP_{jk} = annual materials requirements for domestic auto production

P_{ik} = all classes of vehicles of family i produced in year k

QM_{ijk} = weighted average of material j requirement over all classes of vehicles of family i produced in year k

MODEL CONSTRUCTION

The model includes internal data on the energy required for materials processing, the materials waste ratio, the scrap fraction, and import fractions for both processed and raw material imports. The data values for a first set of scenarios for a variety of materials, including metals, glass, rubber, plastics, paints, etc. are included in the model report. The sources for these data were reports from the Chrysler Corporation, the University of Chicago, the National Commission on Materials Policy, and the Department of Commerce.

DATA USED IN RUNNING MODEL

The model requires input data from three sources:

- 1) Internal data are required on materials processing energy, the materials waste ratio, the scrap fraction, and import fractions for both processed and raw material imports. Values used and the data sources appear in the model report on pp. 13-17.
- 2) Input is required from another program, MATCOM, on the required weight of each material per auto and on fabrication energy requirements per auto. MATCOM calculates per-vehicle material requirements based on given curb weight, vehicle structure, and engine type.
- 3) Input data are required from the Fleet Accounting Model (another submodel of the Resources Accounting Model) for annual sales by auto family type and class, for autos retired annually by type and class, and for the annual gallons of fuel necessary to operate all autos by type and class.

REFERENCE

DeWolf, J.B.; Davis C.; Heinemann, P.C.; Prohaska, J.T., Computer-based resource accounting model for automobile technology impact assessment, Draft, prepared by The Charles Stark Draper Laboratory, Inc., for TSC under Contract No. DOT-TSC-1021, February 1976.

Rubinger, B.; Prensky, S., A computer-based resource accounting model for generating the aggregate resource impacts of alternative automobile technologies, TSC, Working Paper, Report No. DOT-TSC-OS-714-WP-77-7, June 1977.

Rubinger, B.; Prensky, S., Computer based resource accounting model for generating aggregate resource impacts of alternative automobile technologies-Volume I-fleet attributes model, U.S. Department of Transportation Report no. DOT-TSC-OST-77-2, January 1978.

76-024A

COMPUTER REQUIREMENTS

The computer programs are written in FORTRAN and PL/1, and were designed to run on an IBM 360/75.

CAPITAL AND LABOR RESOURCE ACCOUNTING MODEL (INRAM)

The Capital and Labor Resource Accounting Model (INRAM), dated February 1976, was prepared by The Charles Stark Draper Laboratory, Inc., for the Transportation Systems Center (TSC). It computes total future capital and labor requirements for the automobile industry based on possible future automotive technologies. The Task Force on Motor Vehicle Goals Beyond 1980 used the model for impact assessment as part of the overall effort to examine long-range energy goals for the motor vehicle fleet that are compatible with environmental, safety, and economic objectives.

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KEYWORDS

Vehicle manufacturing resource utilization

OBJECTIVE OF MODEL

The model computes total future capital and labor requirements for the automobile industry based on possible future automotive technologies.

RELATIONSHIP TO OTHER MODELS

This model is a submodel of the Resource Accounting Model, which is part of the overall modeling effort undertaken by the Task Force on Motor Vehicle Goals Beyond 1980. It uses input-output analysis to predict future capital and labor requirements. The basic input-output model, INFORUM, was developed at the University of Maryland by C. Almon. An input-output model incorporates coefficients describing the inter-industry and final demand flow of products in the economy. INRAM utilizes data supplied by ARAM (76-024A) to alter selected coefficients in Almon's model as required by the different economic and technological environment induced by a given scenario.

HISTORICAL BACKGROUND

The Task Force on Motor Vehicle Goals Beyond 1980 was created in May 1975 to examine long-range energy goals for the motor vehicle fleet that are compatible with environmental, safety, and economic objectives.

ASSUMPTIONS

The model assumes that the input-output methodology is appropriate for forecasting the capital and labor requirements of various automobile technology and usage scenarios. Also, it presently assumes that only a limited number of coefficients in Almon's model require modification.

VALIDATION

The model report notes that the input coefficient modification equations are being validated on historical data. In the existing report they are unvalidated.

STRUCTURE

The model uses input-output analysis to predict capital and labor requirements. Fourteen coefficients from the INFORUM Model were modified in the INRAM report. The general formula for computing modifications appears below:

$$A_{ij}^k = A_{ij}^{75} \left[R_{ij} \left(\frac{TM_{ij}^k / p^k}{TM_{ij}^{75} / p^{75}} \right) + (1 - R_{ij}) \right]$$

where:

A_{ij}^k = input-output coefficient in year k for the ith producing industry and the jth consuming industry

A_{ij}^{75} = base year (1975) value of the coefficient

R_{ij} = fraction of output in industry j which is used in the production of new autos

TM_{ij}^k = material in physical units used in industry j as produced in industry i for the annual production of autos in year k

p^k = number of autos produced in year k

TM_{ij}^{75} = base year (1975) value of material in physical units consumed by industry j as produced by industry i for the production of new autos

p^{75} = base year (1975) number of autos produced

Preliminary market share values were assumed for R based on 1972 data. Almon's model currently produces output for 1972 to 1985.

MODEL CONSTRUCTION

Almon's input-output model requires a large amount of data, which are incorporated into the computer program. INRAM requires ARAM output, so that all data necessary to build ARAM must be available.

Data are also required on motor vehicle capital investment requirements. These do not appear in the model report.

DATA USED IN RUNNING MODEL

Annual forecasts from ARAM are required for: requirements for up to thirty materials used in domestic auto production, number of autos produced domestically, new car sales, and fleet operating energy.

The input-output model requires exogenous assumptions regarding the future annual values of disposable income per capita, population, long-term investment rate, rent/construction cost index, households, investment tax credit, average foreign currency price, labor force, and civilian unemployment rate.

REFERENCE

DeWolf, J.B.; Davis, C.; Heineman, P.; Prohaska, J.T., Computer-based resource accounting model for automobile technology, impact assessment, Draft, Vol. I, prepared by the Charles Stark Draper Laboratory, Inc., for TSC under Contract No. DOT-TSC-1021, February 1976.

Almon, C.; et al., 1985: Inter-industry forecasts of the american economy, Lexington Books, Lexington, Mass., 1974.

Rubinger, B.; Prensky, S. A computer-based resource accounting model for generating the aggregate resource impacts of alternative automobile technologies, TSC, Working Paper, Report No. DOT-TSC-OS-714-WP-77-7, June 1977.

Rubinger, B.; Prensky, S., Computer-based resource accounting model for generating aggregate resource impacts of alternative automobile technologies-Volume I-fleet attributes model, U.S. Department of Transportation Report no. DOT-TSC-OST-77-72, January 1978.

76-024B

COMPUTER REQUIREMENTS

Almon's input-output model is designed to run on a UNIVAC 1106 with an EXEC 8 operating system. The model is quite large.

CRA HEDONIC MARKET SHARE MODEL

The CRA Hedonic Market Share Model, dated October 1976, was prepared by Charles River Associates (CRA), Inc. for the Bureau of International Labor Affairs, Department of Labor (DOL). The model estimates the effects of changes in imported car prices on foreign and domestic automobile market shares. CRA and DOL have used the model as part of an assessment of economic effects of potential changes in U.S. tariffs and of the imposition of quotas by the U.S. on imports of foreign cars. The model is also being used by CRA for the National Highway Traffic Safety Administration in a study of the impact of fuel economy and car size on market shares and competition among automobile companies.

SPONSOR

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KEYWORDS

Pricing, market share, vehicle manufacturing resource utilization, automobile demand

OBJECTIVE OF MODEL

The model estimates the effects of changes in imported car prices on foreign and domestic market shares, domestic automobile production and prices, and employment in the U.S. automobile industry.

RELATIONSHIP TO OTHER MODELS

The model has no relationship to other models.

HISTORICAL BACKGROUND

Current trade barriers against automobile imports are low. This study was prompted by increased public and Congressional interest in using trade barriers to reduce unemployment, which had resulted from the 1974-75 slump in the U.S. automobile industry.

ASSUMPTIONS

The estimating technique assumes that individual consumers vary in their demand for particular automobile characteristics, including price, because of differences in income, use patterns, and personal tastes. The model also assumes that market size is fixed and that the utility function is linear. Finally, it assumes that consumer tastes are stable as prices are changing.

VALIDATION

The predictions derived from the model have not been validated by comparison with actual historical experience. The author does note that the results are similar to estimates from time series regressions included in the report and to predictions derived by questionnaire techniques in a study by Market Facts, Inc.

LIMITATIONS AND BENEFITS

For the share estimates to be reasonable, the set of automobile models included must cover nearly the entire market. Also, in order to estimate new car sales, estimates of the total price elasticity of new car demand must be obtained from other sources.

STRUCTURE

The model estimates the distribution of consumer tastes and then uses the estimates to predict the market share distribution produced by a change in prices and characteristics of automobiles. The model is too extensive to reproduce here in its entirety. Therefore, a brief discussion follows.

The model begins with the assumption:

$$U_{ij} = U(C_j, P_j, \alpha_i)$$

where:

U_{ij} = is the utility of individual consumer i from purchase of model j

C_j = is a vector of characteristics of model j

P_j = is the price of model j

α_i = is a set of parameters mapping C_j and P_j into U_{ij}

The utility function is assumed to be linear, so that the α_i 's represent marginal rates of substitution between the characteristics and price. Then α is viewed as a vector of random variables, generating a probability distribution for the choice among automobile models.

The model assumes a simple functional form for the probability distribution of the α 's, and seeks to find the distribution of consumers' utility functions which reproduces the market shares actually observed for individual models.

MODEL CONSTRUCTION

This model is constructed on input data, including price, physical characteristics, and new car sales between April 1974 and August 1974 for 106 car makes and models. A list of the variables and data sources appears in the model report.

DATA USED IN RUNNING MODEL

Forecasts of the increase in import prices and the prices and characteristics of new cars by market segment are necessary to run the model.

REFERENCE

Impact of trade policies on the U.S. automobile market, Charles River Associates, prepared for Bureau of International Labor Affairs, U.S. Department of Labor, CRA Report No. 219, October 1976.

The development of a methodology for predicting the demand for new goods with illustrative applications to residential heat pumps, Charles River Associates, under Contract No. RP 488-1 for the Electric Power Research Institute, July 1976.

COMPUTER REQUIREMENTS

The computer program consists of an algorithm for numerical evaluation of probability integrals using the Monte-Carlo method. The computer program is written in machine code, and it requires several hand calculations at various points in the maximum likelihood and Monte-Carlo procedures.

75-027A

SPECULATER: SIMULATION PROGRAM EXAMINING THE CAUSALITIES UNDERLYING
LAND, AGRICULTURE, TRANSPORTATION, AND ENERGY RELATIONSHIPS

The SPECULATER model, prepared in 1975 at the University of California at Davis, simulates the relationships between urban and national transportation, the oil industry, and the wheat industry. The project was sponsored by the National Science Foundation. The model can be used to predict fuel consumption and transportation modal split using a variety of transportation-related and non-transportation-related assumptions.

SPONSOR

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KEYWORDS

Vehicle miles traveled, vehicle user costs/vehicle operating costs,
energy consumption, modal split

OBJECTIVE OF MODEL

The model predicts oil and gas consumption, modal split, and urban and agricultural land area, under the basic assumption that agricultural exports will increase to offset the unfavorable trade balance due to increased fuel imports.

RELATIONSHIP TO OTHER MODELS

This model's simulation is national in scope. Some of its outputs are used in the accompanying regional-scope model SAM: Sacramento Area Model (75-027B).

HISTORICAL BACKGROUND

K.E.F. Watt, The Titanic Effect, 1974, originally described the relationship between petroleum imports and agricultural exports. This relationship was used as one of the major hypotheses in designing the

model.

ASSUMPTIONS

The basic assumption is that U.S. wheat exports will be increased and encouraged in order to offset the unfavorable balance of trade due to the high cost of oil imports.

VALIDATION

A large variety of scenarios using different input levels of the exogenous variables were run. Most of the following conditions were found to be unaffected by the scenarios used: the rate of urban sprawl, the urban population density, the adequacy of U.S. food supply, the increased use of public transportation, a decrease in energy consumption, and an increase in agricultural activity.

LIMITATIONS AND BENEFITS

The report describing the model includes sections on the theory and methodology of simulation modeling, which would be of aid in modifying this model or building other models. This model is unconventional in that it draws relationships between very indirectly related segments of the economy.

STRUCTURE

Numerous interlocking relationships are described between several sectors of the economy, including the national transportation industry, the oil industry, the wheat industry, and the composite urban area, which is made up of 101 cities containing 43% of the U.S. population. Variables involved include: the prices of fuels and grains, population, the volume of imports and exports, consumption, production, transportation modal splits, and the rate of land conversion from agricultural to urban use. The volume of wheat exports is partly a function of the cost of oil imports, implying a political relationship in what is otherwise an algebraic model.

MODEL CONSTRUCTION

This is a dynamic simulation operations research model, describing cause and effect relationships. Actual historical data have been used to identify parameters. The numerous equations and parameters for each variable used in the model are described in the text of the model report.

DATA USED IN RUNNING MODEL

The following variables are exogenous to the model, and their values are supplied in the report: migration rates, price of gasoline, mode availability, population growth rate, price of corn, U.S. oil production, price of imported oil, residual foreign demand for wheat, and wheat yields.

REFERENCE

Young J.W.; Mitchiner, J.L.; Watt, K.E.F.; Ayers, C.; Brewer, J.W., Land use, energy flow, and policy making in society: final report, University of California at Davis, September 1, 1975. NTIS No. PB-251 537.

SACRAMENTO AREA MODEL (SAM)

The Sacramento Area Model (SAM) is meant to be used in conjunction with the SPECULATER model. Both were developed at the University of California at Davis, in 1975, under a grant from the National Science Foundation. The model can be used to predict vehicle miles traveled and modal split for a metropolitan region given a variety of transportation-related and non-transportation-related assumptions.

SPONSOR

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KEYWORDS

Vehicle miles traveled, vehicle user costs/vehicle operating costs, energy consumption, modal split

OBJECTIVE OF MODEL

The model predicts vehicle miles traveled per capita, public transit usage per capita, freeway and public transit availability, and land conversion rate.

RELATIONSHIP TO OTHER MODELS

This model is regional in scope and uses outputs from the accompanying national-scope model, SPECULATER (75-027A).

ASSUMPTIONS

As this model uses results from SPECULATER as inputs, any combination of national-level assumptions can be used as inputs to it. Assumptions may be made about the availability of transportation modes in a metropolitan region.

VALIDATION

A large variety of scenarios using different input levels of the exogenous variables and of the results from the SPECULATOR model were used in model runs. It was found that the level of public transit usage was affected by the price of gasoline.

LIMITATIONS AND BENEFITS

This model can be used, in conjunction with SPECULATOR, to examine the effects of national phenomena on a local regional area and to evaluate local strategies. While it was developed for the Sacramento area, it is probably transferable to other regions of the country.

One limitation of the model is that if output from SPECULATOR is used as input to SAM, then the quality of forecasts from SAM are contingent upon the quality of SPECULATOR.

STRUCTURE

The model was designed with the Sacramento, Calif. metropolitan area in mind, but presumably could be used for other regions. Urban area transportation mode availability, transportation fuel supply per capita, and per capita transportation fuel consumption are input as results from SPECULATOR. Transit funding, employment location index, transit fare, and demographic variables are exogenous. Public transit and freeway availability and the land conversion rate (agricultural use to urban use) may be either exogenous or predicted variables.

MODEL CONSTRUCTION

This is a dynamic simulation operations research model, describing cause and effect relationships. Actual historical data have been used to identify parameters. Equations and parameters for each variable used in the model are described in the model report.

DATA USED IN RUNNING MODEL

The numerous equations and parameters for each variable used in running the model are described in the model report. Data must be supplied for demographic and transit availability variables.

REFERENCE

Young, J.W.; Mitchiner, J.L.; Watt, K.E.F.; Ayers, C.; Brewer, J.W., Land use, energy flow, and policy making in society: final report, University of California at Davis, September 1, 1975. NTIS No. PB-251 537.

COMPUTER REQUIREMENTS

A User's Manual and card deck consistent with an IBM 360/370 machine are available from John W. Brewer, University of California, Davis, Calif. 95616.

TRANSPORTATION AND AIR SHED SIMULATION MODEL (TASSIM MODEL)

The Transportation and Air Shed Simulation Model (TASSIM) integrates an urban transportation planning model, vehicle emission factors, and simple air diffusion models in a simulation framework that can be used to analyze the air quality effects of transportation policies. It was developed in 1974 at Harvard University under the sponsorship of the U.S. Department of Transportation. The model was used in 1974 by the National Academy of Sciences in the report, The Costs and Benefits of Automobile Emission Control, prepared for the U.S. Senate Committee on Public Works. It has also been used to evaluate the impact of various transportation policies in the Boston and Los Angeles areas.

SPONSOR

U.S. Department of Transportation
Office of the Secretary
Washington, D.C. 20590

AUTHOR

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KEYWORDS

Air pollution/air quality, emissions

OBJECTIVE OF MODEL

The objective of the TASSIM model is to integrate an urban transportation model, vehicle emission factors, and simple air diffusion models in a simulation framework that can be used to analyze the impacts of various transportation policies on air quality. The model is capable of simulating concentrations of carbon monoxide, hydrocarbons, oxides of nitrogen, and particulate matter in as many as 200 distinct zones within a metropolitan area.

RELATIONSHIP TO OTHER MODELS

The model is constructed to be compatible with the Federal Highway Administration's standard Urban Transportation Planning (UTP) model in order to minimize data problems and to insure that parameters from existing models can be used.

HISTORICAL BACKGROUND

The TASSIM model was originally developed under a university research grant from the National Science Foundation entitled "The Automobile and the Regulation of its Impact on the Environment." The model was improved, expanded, and calibrated under a contract from the Department of Transportation.

VALIDATION

Calculated annual air quality values from the TASSIM model were compared with 1971 annual measurements from eighteen monitoring sites in the Boston region. The results for sulfur dioxide and particulate matter were fairly consistent. The results for the oxides of nitrogen were not as consistent. This problem is attributed to the sampling technique of this pollutant.

LIMITATIONS AND BENEFITS

Two primary automotive pollutants, hydrocarbons and oxides of nitrogen, combine in the presence of sunlight to form photochemical oxidants. Although photochemical oxidants are important secondary pollutants, the reaction processes to produce these pollutants are not well known and, therefore, these processes are not represented in the model.

STRUCTURE

The TASSIM model is comprised of three major components: a transportation submodel, an emission submodel, and an air diffusion submodel.

The transportation submodel forecasts the interzonal distribution of trips and then distributes the trips over the highway and transit network. Included in this model are the calculation of auto vehicle miles traveled per zone as well as auto vehicle cold starts per zone. These variables are necessary inputs to the emission submodel.

The emission submodel transforms information on vehicle flows and speeds in each area into area emissions. The speeds on each link of the transportation network are exogenous, and the relation between vehicle speed and emissions per mile is based on functions compiled by the Environmental Protection Agency.

The diffusion submodel generates pollutant concentrations in each zone based on emissions and meteorological factors.

MODEL CONSTRUCTION

The model must be calibrated for each region to which it is applied. The types of data needed include trip generation equation parameters, socio-economic data for each zone, average annual wind speed, the percentage of time the wind is blowing in each of sixteen directions, non-mobile area source emissions by zone for each pollutant, modal split information, etc.

DATA USED IN RUNNING MODEL

Essentially the data necessary to calibrate the model are also required to run the model.

REFERENCE

Ingram, G.; Fauth, G., TASSIM: A transportation and air shed, simulation model Vol. I: case study of the Boston region, prepared for DOT, May 1974. NTIS No. PB-232 933.

Ingram, G.; Fauth, G., TASSIM: A transportation and air shed simulation model Vol. II: program user's guide, prepared for DOT, May 1974. NTIS No. PB-232 934.

Fauth, G.; Kroch, E., Additional traffic assignment options for the TASSIM model, prepared for DOT, November 1975.

Grad, F.P., et al, The automobile and the regulation of its impact on the environment, University of Oklahoma Press, 1975.

COMPUTER REQUIREMENTS

The model is written in FORTRAN and was designed to be run on an IBM 370. The source code may be obtained from the model authors at Harvard University.

CONSUMER DEMAND FOR CARS IN THE USA

The Consumer Demand for Cars in the USA model was prepared in 1975 at Cambridge University. The objective of the model is to examine the factors that determine the consumer demand for automobiles in the United States.

AUTHOR

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KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of the model is to examine the factors that determine the consumer demand for automobiles in the United States. The entire study is primarily intended to provide a connected account of the automobile market that will be useful to anyone interested in the industry.

RELATIONSHIP TO OTHER MODELS

There is no relationship to other models.

HISTORICAL BACKGROUND

This study was prepared as the author's Ph.D. thesis at Cambridge University. Some of the work was performed at MIT, where he was a Kennedy Scholar.

ASSUMPTIONS

The study is comprised of three parts: ownership, replacement, and purchase of automobile models. The ownership model assumes that time-series responses can be derived from cross-section estimates. The model omits cost as an explanatory variable and assumes a positive ownership probability for incomes above zero.

The replacement model assumes a low elasticity of substitution between new and used cars, so that stock depletion cannot explain replacement purchases of new cars.

The short-run purchases model assumes that consumers respond to personal expectations, as reflected in survey attitude indicators, and to confidence in the economy as a whole, as reflected in macro-economic indicators.

VALIDATION

The author compares his results with those from a number of other studies. The ownership model generates predictions which do not agree well with actual pre-World War II data.

LIMITATIONS AND BENEFITS

The model is not designed as a complete econometric set of forecasting equations. In fact, the author cautions that the ownership model may not be appropriate for extrapolation purposes. The model does present a new interpretation of the replacement demand for autos, and it emphasizes the importance of consumer expectations for short-run demand prediction.

STRUCTURE

This study develops and estimates three complementary econometric models that explain ownership, replacement, and purchase of automobiles. The ownership model explains the proportion of single- and multiple-car families by income group in terms of income and time trends. The equation below is estimated using generalized least squares for pooled cross-section and time series data for 1953-69.

$$P(Q_{jt}) = -6.254 - .1157 (t) + .8264 [\log(Y_{jt})] \\ \quad \quad \quad (-3.3) \quad (-3.9) \quad \quad (18.7) \\ \quad \quad \quad + .01495 (t) [\log(Y_{jt})] - .2466 (D) \\ \quad \quad \quad (4.3) \quad \quad \quad (-3.9)$$

$$R^2 = .969$$

where t-statistics are in parentheses, and

$P(q_{jt})$ = proportion of families in income group j who own a car in year t

t = time trend

Y_{jt} = mean real income by income group j in year t

D = dummy variable with value 1 prior to 1963, and 0 elsewhere

The replacement model which follows is estimated using ordinary least squares for annual data from 1950 to 1969.

$$\log(U) = \begin{matrix} .9905 & [\log(G)] & - & .1913 & [\log(\frac{P}{P_{-1}})] \\ (22.4) & & & (-2.5) & \end{matrix} \\ + \begin{matrix} .3757 & [\log(\frac{Y}{Y_{-1}})] \\ (3.0) & \end{matrix}$$

$$R^2 = .90 \quad DW = 2.2$$

where t-statistics are in parentheses, and

U = new car purchases for replacement

G = normal replacement pressure

P = new car price index

Y = real disposable income per capita

Finally, data disaggregated by income group are used to estimate several equations relevant to the short-run purchase demand for automobiles. Expectations are explicitly included in the model, leading to the conclusion that no stable demand function exists in the short run.

MODEL CONSTRUCTION

This model is calibrated using annual data for various periods in the 1950s and 1960s on a number of variables, including income, population, price of new cars, and consumer attitudes. The data sources and actual data values appear in the model report.

DATA USED IN RUNNING MODEL

The model requires forecasts of the future values of all independent variables.

REFERENCE

Smith, R.P., Consumer demand for cars in the USA, Cambridge University Press, Cambridge, England, 1975.

ENGINEERING MODEL OF FUTURE MOTOR VEHICLES (EMFMV)

The Engineering Model of Future Motor Vehicles (EMFMV) was originally prepared by Volkswagenwerk AG in February 1977 for the U.S. Department of Transportation. The objective of the model is to project vehicle weight changes caused by planned alterations of certain substructures in order to increase vehicle safety.

SPONSOR

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National Highway Traffic Safety Administration
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AUTHOR

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KEYWORDS

Automobile design, vehicle operating performance

OBJECTIVE OF MODEL

The objective of the model is to project vehicle weight changes caused by planned alterations of certain substructures in order to increase vehicle safety.

RELATIONSHIP TO OTHER MODELS

The model bears no direct relationship to other models.

HISTORICAL BACKGROUND

The objective of the study was to develop a comprehensive engineering model of future motor vehicles which provides a realistic and uniform basis for developing safety requirements and assessing their future effects. An extension to the study involved the expansion of the passenger car data base to include multi-purpose vehicles and light trucks, and improvements to the computer programs.

ASSUMPTIONS

The weight-weight interdependency analysis incorporates the following assumptions:

- 1) Vehicle structure is optimized according to the state of the art.
- 2) Design change does not influence the main geometric dimensions of the body structure.
- 3) Changes in weight of a subsystem require changes throughout the vehicle body.
- 4) Static deformation of the vehicle will be held constant in the new models.

VALIDATION

No specific validation efforts are indicated in the model report. However, the report states that the regression analysis of subsystem weight changes has been validated in Don Adams, et al., "High Strength Materials and Vehicle Weight Reduction Analysis," SAE 750 221, Detroit, Mich., February 1975.

LIMITATIONS AND BENEFITS

The weight-weight interdependency analysis applies only to slight load redistributions and moderate design changes. The EMFMV is currently limited to passenger cars, although variables and data sources have been recommended for a future data file on light trucks and multi-purpose vehicles.

STRUCTURE

The EMFMV contains an extensive data base consisting of up to 104 variables for approximately 4,000 individual automobile makes and models from 1965 to 1977. The data available are classified as descriptive vehicle data, exterior dimensions data, interior dimensions data for the engine, luggage compartment, and passenger compartment, weight data, or other engineering data. For hypothetical weight changes in vehicle components, instituted for reasons of safety or economy, the model calculates secondary weight changes and the new vehicle weight distribution. This calculation can be performed by a regression analysis of the following form:

$$\log(m_i) = \log(a_{0i}) + a_{1i} [\log(m)]$$

where:

m_i = mass of subsystem i

m = total vehicle mass

Dependent and independent variables are selected as appropriate. Alternatively, a non-statistical weight-weight estimation procedure is employed. This procedure increases sheet-metal thickness in proportion to the increased external forces acting on each component, thus maintaining constant static deformation. This procedure produces new body subsystem weights, and the regression analysis is then used to determine chassis subsystem weight changes.

MODEL CONSTRUCTION

This engineering model requires up to 104 variables for approximately 4,000 individual automobile makes and models from 1965 to 1977. These data are not readily available. A data book was developed to give a brief introduction to the program system and the contents of the data base as updated January 1978.

DATA USED IN RUNNING MODEL

Assumptions are required as to the increase in weight of selected vehicle subsystems.

REFERENCE

Danckert, H.; Grove, H.W.; Schmidt, R., Engineering model of future motor vehicles, prepared by Volkswagenwerk AG for the U.S. Department of Transportation, Report No. DOT HS-802 290, February 1977.

Grove, H.W., Engineering model of future motor vehicles volume I: final report, prepared by Volkswagenwerk AG for the U.S. Department of Transportation, Report no. DOT HS-803 445.

Grove, H.W., Engineering model of future motor vehicles volume II: data book, prepared by Volkswagenwerk AG for the U.S. Department of Transportation, Report no. DOT HS-803 446.

COMPUTER REQUIREMENTS

The program is available, for a fee, on the McDonnell Douglas Automation Company (MCAUTO) computer system in St. Louis. A program listing in FORTRAN IV is included in the model report.

DEMAND FOR NEW AUTOMOBILES IN THE UNITED STATES 1929-1956

A model of the Demand for New Automobiles in the United States 1929-1956 was developed at the University of Michigan in 1958 under a grant from the Ford Motor Company. The objective of the model is to formulate a demand function for automobiles that incorporates consumer credit conditions and the accumulated stock of cars as explanatory variables. The model advanced the state of the art for modeling efforts in this field. It is now, however, out of date.

SPONSOR

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AUTHOR

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KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of the model is to formulate a demand function for automobiles that incorporates consumer credit conditions and the accumulated stock of cars as explanatory variables.

RELATIONSHIP TO OTHER MODELS

The model bears no direct relationship to other models.

ASSUMPTIONS

The model assumes that the supply of used cars is a linear function of the sale of new cars. It also assumes that the existing stock of cars is a proper independent variable, and that the change in income level is not a necessary independent variable.

HISTORICAL BACKGROUND

The author is now at Michigan State University.

VALIDATION

The author reports close agreement between actual and calculated demand for the estimation period. The model also predicts a sales level in 1957 of about 6.0 million, compared with a preliminary actual estimate of 6.1 million.

LIMITATIONS AND BENEFITS

The model is considerably out of date and has been superseded by later models. It does not consider the effects of gasoline price or fuel efficiency regulations on new car demand.

STRUCTURE

The model consists of a four-equation system explaining the demand for and supply of new and used cars. Three of the equations are combined to obtain an expression for the demand for new cars, the influence of the used car market being implicitly taken into account. The equation is then estimated in first difference form using ordinary least squares. The result for the period 1929-1941, 1949-1956 follows:

$$\begin{aligned} \Delta R = & .115 + \frac{.106}{(.011)} (\Delta Y) - \frac{.234}{(.088)} \left(\Delta \frac{P}{M} \right) \\ & - \frac{.507}{(.086)} (\Delta S) - \frac{.827}{(.261)} (\Delta X) \end{aligned}$$

where standard errors are in parentheses, and

R = retail sales of new cars

Y = real disposable income

P = real retail price of new cars

M = average credit terms, in months

S = stock of used cars

X = dummy variable for 1941 and 1952

MODEL CONSTRUCTION

This model was calibrated using historical data from 1929-1956. These are listed in the model report. Data sources are also indicated.

DATA USED IN RUNNING MODEL

Assumptions about the future values of independent variables must be made, and the model can be extended beyond 1956 with actual data.

REFERENCE

Suits, D.B., The demand for new automobiles in the United States 1929-1956, Review of Economics and Statistics, Vol. 39, November 1958.

A MODEL OF THE AUTOMOBILE INDUSTRY RESPONSE TO GOVERNMENT REGULATIONS

A Model of the Automobile Industry Response to Government Regulations (Pugh-Roberts Model) was prepared by Pugh-Roberts Associates, Inc. for the U.S. Department of Transportation, Transportation Systems Center (TSC) in 1977. The model was developed for the purpose of forecasting and analyzing the behavior of the automobile industry in a variety of policy and economic situations.

SPONSOR

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AUTHOR

Kenneth G. Cooper, James M. Lyneis, and
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KEYWORDS

Pricing, industrial financial performance, automobile demand, market share, scrappage

OBJECTIVE OF MODEL

The model forecasts, by computer simulation, the consequences of changing economic conditions, and fuel efficiency, emission, and safety regulations on the four major U.S. automobile manufacturers and on the manufacturers of imported cars. Simulating these effects in terms of profitability, market share, capital investment required, and the prices and features of automobiles sold, the model forecasts (1) industry decisions on product strategies, (2) the likelihood that each manufacturer would meet the mandate under various regulatory conditions, and (3) the financial effects of the industry's attempts to comply with government regulation. The results of these industry decisions are then used to simulate consumer decisions regarding the purchase and use of automobiles.

RELATIONSHIP TO OTHER MODELS

The model has no direct relationship to other models.

HISTORICAL BACKGROUND

The model was developed as a part of the Transportation Energy Policies Project at TSC. It complements two ongoing automobile industry investigations at TSC, the Transportation Energy Efficiency Program (TEEP), and the Automobile Fuel Economy Regulatory (AFER) Program.

VALIDATION

The model report notes that for 1970-76 the actual variable values are simulated with "reasonable accuracy."

STRUCTURE

The model consists of a simulation of the behavior of consumers and firms in the automobile industry. The consumer sector simulates demand for new cars by size and manufacturer. The industry sector simulates production capacity, selection of new car features, price, management concerns, production costs, and investment costs. The model includes several thousand variables. The exogenous values are set at 1970 actual values at the beginning of the simulation. The production capacity equation, which follows, is representative of equations in the model.

$$LL = NLL \times ETA \times ECPI \times ECRE$$

where:

LL = line life (years)

NLL = normal line life (years)

ETA = effect of technological adequacy

ECPI = effect of concern for product image

ECRE = effect of concern for return on equity

Values are assumed for ETA, ECPI, and ECRE and were subjectively derived through interviews, published reports, assembled data, and other sources of technical expertise at TSC.

MODEL CONSTRUCTION

The model is a series of algebraic relationships. It requires 1970 values for all exogenous variables, as well as time series of variables representing government regulations and national economic conditions. Some of these variable values are apparently available only from Pugh-Roberts.

DATA USED IN RUNNING MODEL

Assumptions about the future values of household disposable income, number of households, inflation, and gasoline price are necessary, as are assumptions about future government regulations on fuel efficiency, safety, and emissions, and about future corporate performance goals.

REFERENCE

Cooper, K.G.; Lyneis, J.M.; Pugh A.L., III, A model of the automobile industry response to government regulations, prepared by Pugh-Roberts Associates, Inc. under contract No. DOT-TSC-1183 for TSC, January 31, 1977.

COMPUTER REQUIREMENTS

The model is quite large and is programmed in the computer language DYNAMO, a non-standard computer language. Documentation of this language appears in Alexander L. Pugh III, Dynamo Users Manual, MIT Press, Cambridge, Mass., 1976.

TRANS (TRANSPORTATION RESOURCE ALLOCATION STUDY) - URBAN MODEL

The Transportation Resource Allocation Study Urban Model, commonly referred to as the TRANS-Urban Model, evolved over several years prior to 1975. It was developed by the Department of Transportation with the support of contractors for the purpose of assessing national urban transportation policy alternatives. It was used in the 1974 National Transportation Study to assess the effects of alternative funding and pricing policies for the nation's sixty-four largest urbanized areas.

SPONSOR

U.S. Department of Transportation
Washington, D.C.

AUTHOR

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KEYWORDS

Vehicle miles traveled, modal split, vehicle user costs, accidents, emissions, fuel consumption

OBJECTIVE OF MODEL

The objective of the model is to assess national urban transportation policy alternatives relating to both highways and transit. It may be used to evaluate the implications of four general types of alternatives: proportions of highway and transit investment, level of total investment, pricing alternatives (e.g. transit fares and parking rates), and automobile occupancy rates.

RELATIONSHIP TO OTHER MODELS

There is no relationship to other models except earlier versions of the TRANS model from which the current model evolved.

HISTORICAL BACKGROUND

Earlier versions of the TRANS model were highway-oriented and primarily concerned with treating highway investment tradeoffs under varying transit usage assumptions. The latest version is multi-modal

and contains an energy module.

ASSUMPTIONS

Several variables were held constant over the analysis period for which the model was used. These include fatality rates, gasoline consumption rates, residential and business dislocation rates, and capital and operating costs. These variables could be changed in the model if the information justifying this were available.

VALIDATION

The model was validated by testing it against existing conditions in 1972, although this has not been documented.

The model was also run for five alternative transportation programs for the 19-year period 1972-1990.

LIMITATIONS AND BENEFITS

The model's author reports that the model is useful in analyzing alternative urban transportation programs and policies on a nationwide level. The model results, however, represent area-wide averages, and no attempt was made to determine how the results vary within urban areas.

STRUCTURE

The TRANS-Urban Model System is a set of analytical procedures for evaluating alternative levels and mixes of transportation investments in urbanized areas. It operates at an aggregate level, treating each urban area as a basic unit of analysis. The model input is a specification of a level of investment. Travel projections are made as a function of socio-economic variables and the transportation system supply alternative. Travel is distributed by mode and time of day, with system-performance measures estimated on the basis of the interaction between supply and demand. User effects (such as changes in travel time) are calculated for each mode, along with such external effects as fatalities, dislocations, air pollution emissions, and gasoline consumption.

The output of the model includes the resulting level of highway and transit facilities, travel demand by mode, system performance, and external impacts including fatalities, land consumed, air pollution, dislocation, and energy consumed.

MODEL CONSTRUCTION

The data used to build the model included, among other data, output from micro-level modal split simulations using a hypothetical urbanized

region of 2.5 million persons and a generalized micro-modal split model developed from actual applications to three real cities. Other model components were built from data in the National Highway Needs Studies and the National Transportation Studies, as well as from individual urban area transportation study data.

DATA USED IN RUNNING MODEL

To run the model it is only necessary to select policies to be tested, such as the effects of the level and mix of capital funds for transportation investments among four types of transportation facilities: freeways, surface arterials, conventional bus, and rapid transit (both bus and rail), or the percentage change in transit funding.

REFERENCE

Weiner, E., Assessing national urban transportation policy alternatives, Transportation Research, Vol. 10, pp. 159-178, 1976.

Weiner, E.; Kassoﬀ, H.; Gendell, D.S., A multi-modal national urban transportation policy planning model Highway Research Record No. 458, 1973.

Weiner, E., The TRANS-urban model system and its application to the 1972 national transportation study, Proceedings of the First International Conference on Transportation Research, Brugges, Belgium, March 1974.

GASOLINE DEMAND MODEL

The Gasoline Demand Model was prepared in 1974 by the staff of the U.S. Department of Transportation, Transportation Systems Center (TSC) for their internal use. The objective of the model is to estimate the demand for gasoline, using a distributed lag mechanism. It is a submodel of the Integrated TSC Automobile and Gasoline Model, which can be used to provide forecasts of new automobile sales, market share, gasoline use, and overall fleet efficiency.

SPONSOR

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AUTHOR

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KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The objective of the model is to estimate the demand for gasoline, using a distributed lag mechanism.

RELATIONSHIP TO OTHER MODELS

The model is a submodel of the Integrated TSC Automobile and Gasoline Model, which consists of 74-037A and B, and 74-006.

HISTORICAL BACKGROUND

The model was developed as part of the research effort prompted by the gasoline shortages during the winter of 1973-74.

ASSUMPTIONS

The model assumes that a stock adjustment mechanism is appropriate for the gasoline market. Further, it assumes that the same adjustment pattern applies to each state over a twenty-year period.

VALIDATION

The model report does not discuss the validation of this model.

STRUCTURE

The model estimates the demand for gasoline, using a linear Koyck distributed lag specification in a cross-section time series analysis from 1952 to 1972. The ordinary least squares of the equation follows.

$$\begin{aligned} \text{GAS} = & .03064 (Y) - 131.5 (GP) + .824 (\text{GAS}_{-1}) \\ & (11.68) \quad (-7.43) \quad (41.6) \\ & - 8.80 (\text{MPGY}) + \sum_{i=10}^{58} b_i (\text{DUM}_i) \\ & (-3.17) \end{aligned}$$

$$R^2 = .99$$

where t-statistics are in parentheses, and

GAS = gasoline use per capita

Y = real disposable income per capita

GP = real price of gasoline

MPGY = fleet efficiency variable

b_i = the coefficient of DUM for state i

DUM_i = dummy variable for state i

MODEL CONSTRUCTION

The model was calibrated using annual data by state for all variables from 1952 to 1972. The model report does not indicate sources, except that gasoline sales data come from the Federal Highway Administration.

DATA USED IN RUNNING MODEL

The model forecasts gasoline demand for specified assumptions regarding the values of income, gasoline price, and fleet efficiency.

74-037A

REFERENCE

Chamberlain, C., Policy options: gas tax vs. gas rationing and/or auto excise tax, TSC, Working Paper, Report No. WP-SP-U2-65, 1974.

A PRELIMINARY MODEL OF AUTO CHOICE BY
CLASS OF CAR: AGGREGATE STATE DATA

A Preliminary Model of Auto Choice by Class of Car: Aggregate State Data, dated January 1974, was prepared by the U.S. Department of Transportation, Transportation Systems Center (TSC) for internal use. It tests consumer sensitivity to differences in sales tax charges for new cars and gasoline costs, holding income and urbanization constant. It is a submodel of the Integrated Transportation Systems Center (TSC) Automobile and Gasoline Model.

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KEYWORDS

Market share

OBJECTIVE OF MODEL

The model tests consumer sensitivity to differences in sales tax charges for new cars and gasoline costs, holding income and urbanization constant. This preliminary model may be used to analyze the effect on consumer auto selection of an excise tax on fuel inefficient cars.

RELATIONSHIP TO OTHER MODELS

The model is a submodel of the Integrated TSC Automobile and Gasoline Model, which consists of 74-037A and B, and 74-006.

HISTORICAL BACKGROUND

It has been found that in Europe there exists a direct relationship between the proportion of small cars and both the level of taxes on large cars and the price of gasoline. This study attempts to examine

and quantify these relationships for the U.S.

ASSUMPTIONS

The model assumes that logit analysis is appropriate for determination of market shares. Since a cross-section formulation is estimated, titling or sales tax rates are used as a proxy to measure price sensitivity. Also, a size classification of cars is assumed, based in part on a price classification. Finally, the sum of market shares is not constrained so that the fitted values will sum to unity.

VALIDATION

No validation efforts are indicated in the model report.

LIMITATIONS AND BENEFITS

The tax rate variable introduces only absolute rather than relative price fluctuations into the model. Also, cross-section estimates for one year may be inappropriate for time series forecasts.

STRUCTURE

The model consists of a logit equation for the market share of each of five classes of cars. Each equation is estimated by ordinary least squares using annual state cross-section data for 1972. The estimated relationship for compacts and subcompacts follows.

$$\log\left(\frac{P_s}{1-P_s}\right) = -3.52 + 4.24 (X_1) + .14 (X_2) \\ \quad \quad \quad (.55) \quad (26.3) \quad \quad \quad (2.44) \\ \quad \quad \quad - 2.21 (X_3) + .08 (X_4) \\ \quad \quad \quad (5.11) \quad \quad \quad (.02)$$

where t-statistics are in parentheses and

P_s = proportion of cars of type s registered in each state

X_1 = percent urban population

X_2 = initial registration tax rate

X_3 = per capita state income

X_4 = regular grade gasoline price

The equation was divided by the square root of population as an adjustment for heteroscedasticity.

MODEL CONSTRUCTION

The model is calibrated using aggregate state data for all variables in 1972. Tax rates by state are included in the model report. Data sources for other variables are not indicated.

DATA USED IN RUNNING MODEL

The model attempts to measure long-run adjustments to differences across states. To estimate the impact on market share, assumptions are necessary as to future gasoline price and tax changes.

REFERENCE

Chamberlain, C., A preliminary model of auto choice by class of car: aggregate state data, Discussion Paper, Report DP-SP-28, TSC, January 1974.

Chamberlain, C., Policy options: gas tax vs. gas rationing and/or auto excise tax, Working Paper, Report No. WP-SP-U2-65, TSC, 1974.

MARKET SHARE MODEL

The Market Share Model was prepared in 1974 by the U.S. Department of Transportation, Transportation Systems Center (TSC). Its purpose is to predict the market share of six classes of automobiles. It is a working model and viewed by TSC as being developmental.

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AUTHOR

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KEYWORDS

Market share

OBJECTIVE OF MODEL

The objective of the model is to predict the market share of six classes of automobiles: subcompacts, compacts, intermediates, standards, high-price standards, and luxury models.

RELATIONSHIP TO OTHER MODELS

An earlier version of the market share model was developed by Charlotte Chamberlain of TSC.

HISTORICAL BACKGROUND

Model development was undertaken by TSC to improve their earlier version of the model.

ASSUMPTIONS

It is assumed that consumers are sensitive not to the price of gasoline per se, but to the cost of driving, which is the product of fuel price and fuel efficiency, and that potential new car buyers view a

dollar of cost the same, whether it is for base auto price or for titling charges.

VALIDATION

The model was run for 1974, and the results compared reasonably with observed market shares.

STRUCTURE

The following equation represents the Market Share Model for the standard size class of vehicles:

$$\begin{aligned} \log[\text{Standards}/(\text{Total Sales} - \text{Standards})] &= 1.37 (\text{Rate}) \\ &- 9.37 \times 10^{-5} (\text{PCPY}) - .023 (\text{PGAS}) + .886 (\text{ENC}) + .126 (\text{WNC}) \\ &- .091 (\text{ESC}) - .036 (\text{WSC}) - .631 (\text{Pacific}) - .388 (\text{Mountain}) \\ &- .240 (\text{S. Atlantic}) - .163 (\text{Mid Atlantic}) - .332 (\text{New England}) \end{aligned}$$

where:

Rate = rate of initial registration and sales taxes

PCPY = per capita personal income

PGAS = reported pump price of gasoline

ENC, WNC, etc. = dummy variables for census regions

Other equations were prepared for the six other size classes, but the estimated equations were not presented in the report on the model. Model output includes the percent of new car sales of each of the six types of vehicles.

MODEL CONSTRUCTION

The model was calibrated on 1972 cross-sectional (state) data for registrations and economic factors. The sum of shares is constrained to 100% by an ex-post normalization.

DATA USED IN RUNNING MODEL

Future values of the independent variables are required to run the model.

74-039A

REFERENCE

Schuessler, R.; Smith R., Working models of fuel consumption, emissions, and safety related to auto usage and purchasing behavior, TSC, Working Paper, WP-230-U2-52, November 1974, subject to change. Paper, WP-230-U2-52, November 1974, subject to change.

AGGREGATE SALES MODEL

The Aggregate Sales Model was developed in 1974 by the Transportation Systems Center (TSC). Its purpose is to forecast aggregate new car sales, and it is viewed by TSC as being a working model.

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KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of the model is to forecast aggregate new car sales.

RELATIONSHIP TO OTHER MODELS

There is no apparent relationship to other models.

LIMITATIONS AND BENEFITS

Prior work in this field was insensitive to fuel efficiency. The authors suggest two possible directions for future work. First, the use of quarterly data and a more recent time period would minimize the problems of changing behavioral parameters over time. Second, extracting the fuel cost elasticity from a cross-sectional estimation of the model might eliminate the problem of trend correlation in the data series.

STRUCTURE

The model is a state-of-the-art stock adjustment model. The estimated equation is:

74-039B

$$\begin{aligned} \text{NCR} = & 11378.1 + .0462 (\text{PCE}) - .40372 (\text{K}_{-1}) \\ & (2.07) \quad (7.49) \quad (-6.22) \\ & - 69030 [\text{PGAS}(\text{adjusted})] - 4091.31 (\text{PCAR}) \\ & (-.62) \quad (-1.66) \\ & - 505.477 (\text{V}) + 144.373 (\text{U}_{-1}) \\ & (-5.67) \quad (1.62) \\ & - 2864.72 (\text{KWAR}) \\ & (-6.22) \end{aligned}$$

$$\bar{R}^2 = .9713 \quad \text{DW} = 2.01$$

where:

NCR = new car registrations (thousands)

PGAS(adjusted) = real cost of driving one mile in a sales-weighted "average" new car (price of gas/average gallons per mile)

PCE = personal consumption expenditures (1967 dollars)

PCAR = CPI for new cars/CPI

U = unemployment rate

U₋₁ = unemployment rate lagged one year

KWAR = dummy variable for Korean War period

K₋₁ = stock of automobiles in new car equivalents at end of previous year

$$\begin{aligned} K_{-1} = & \sum_1^{16} \text{NCR}_{-i} \times (\text{survival factor})_i \\ & \times (\text{depreciation factor})_i \end{aligned}$$

where:

(survival factor)_i = historically observed survival rate of cars of age i

(depreciation factor)_i = factor which depreciates vehicles at rate of 25% per year (exponentially)

MODEL CONSTRUCTION

The data used to build the model were from the period 1950 to 1973. The gas price was adjusted for estimated fuel efficiency changes over the estimation period.

DATA USED IN RUNNING MODEL

Estimates of forecasts of future values of the independent variables are needed to run the model.

REFERENCE

Schuessler, R.; Smith R., Working models of fuel consumption, emissions and safety related to auto usage and purchasing behavior, TSC, Working Paper, W.P. 230-U2-52, subject to change, November 1974.

VEHICLE-MILES MODEL

The Vehicle-Miles Model was developed in 1974 at the Transportation Systems Center (TSC). Its purpose is to forecast nationwide vehicle miles of travel. It is viewed by TSC as a working model.

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KEYWORDS

Vehicle miles traveled

OBJECTIVE OF MODEL

The objective of the model is to forecast nationwide vehicle miles of travel (VMT).

RELATIONSHIP TO OTHER MODELS

There is no relationship to other models.

VALIDATION

The model has been run for 1974.

LIMITATIONS AND BENEFITS

The authors report that the model does not account for fuel efficiency changes. This is less of a problem in this model, however, than in some others since the durable nature of automobiles tends to dampen changes in efficiency from year to year, and because not only new cars but also existing cars in the fleet are included in the model.

STRUCTURE

Three equations were estimated for VMT using three different 1974 estimates: 1% increase in VMT over 1973, a 1% decrease, and no change. The three equations are, respectively:

$$\text{VMT} = -56246 + 7.02 (\text{Cars}) - 1.09 \times 10^5 (\text{PGAS}) \\ + 1.96 \times 10^8 (\text{RDPY/POP})$$

$$\text{VMT} = 34918 + 6.98 (\text{Cars}) - 1.78 \times 10^5 (\text{PGAS}) \\ + 1.87 \times 10^8 (\text{RDPY/POP})$$

$$\text{VMT} = -10664 + 7.00 (\text{Cars}) - 1.43 \times 10^5 (\text{PGAS}) \\ + 1.91 \times 10^8 (\text{RDPY/POP})$$

where:

VMT = total vehicle miles traveled

Cars = number of cars in the fleet estimated from sales data and expected scrappage

PGAS = (CPI for gas)/CPI

RDPY/POP = per capita real personal disposable income

MODEL CONSTRUCTION

To estimate the equations, 20 years of Federal Highway Administration data through 1974 were used. Three equations were estimated using different values for the 1974 VMT. These 1974 estimates were a 1% increase in total VMT over 1973, a 1% decrease, and no change. The reasons for this were (1) when the data series through 1973 was used, the 1974 forecast was far too sensitive to gas price, and (2) the model was developed when only preliminary 1974 counts were available.

DATA USED IN RUNNING MODEL

Future values of the independent variables are necessary to run the model.

REFERENCE

Schuessler, R.; Smith, R., Working models of fuel consumption, emissions, and safety related to auto usage and purchasing behavior, TSC, Working Paper, WP-230-U2-52, subject to change, November 1974.

QUARTERLY DEMAND FOR GASOLINE MODEL

The Quarterly Demand for Gasoline Model was prepared in 1973 by Data Resources, Inc. and was sponsored by the Environmental Protection Agency and the Council on Environmental Quality. Its purpose is to forecast short-term quarterly demand for gasoline. This has been estimated by using four separate sets of historical gasoline consumption data.

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KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The objective of the model is to calculate how the demand for gasoline will respond to alternative levels of prices and incomes for two years into the future.

RELATIONSHIP TO OTHER MODELS

The model may be used in conjunction with the Data Resources, Inc. (DRI) macroeconomic model of the U.S. economy.

VALIDATION

The model was run for 1972 through the third quarter of 1975. The results indicate clearly the possibility for substantial reduction in the consumption of gasoline as a result of tax or price changes. The model over-predicted gasoline consumption in those areas of the country where there was great discussion of the gasoline shortage during the spring of 1973.

LIMITATIONS AND BENEFITS

The authors state that the best way to approach the estimation of the demand for gasoline is first to examine the demand for the use of motor vehicles and from that to estimate the demand for gasoline. The data required to perform this analysis were not available, however, and therefore, the authors estimated a direct rather than derived demand function.

The model was estimated in 1973, before the energy crisis, and indicates that reductions in gasoline consumption would result from price increases. However, it is known that the demand for gasoline is relatively price inelastic.

STRUCTURE

An econometric model of the quarterly demand for gasoline was estimated by the error components technique, using four sets of gasoline consumption data. The one equation presented here was estimated by using Federal Highway Administration highway gasoline data.

$$q_t = .886 - .151 (P_{t-1}) - .129 (P_t - P_{t-1}) \\ + .452 (Y_{t-1}) + .435 (Y_t - Y_{t-1}) + .555 (q_{t-1})$$

$$R^2 = .92$$

where:

q = quantity

P = price

Y = income

MODEL CONSTRUCTION

Four fuel consumption data bases were used to estimate four separate equations of the form above. These were API (American Petroleum Institute) gasoline, API motor gasoline, FHWA motor fuel, and FHWA highway gasoline. Price data from Platt's Oil Price Service were used and modified by a national deflator. Income data were per capita personal income data from the Regional Economics Division of the Bureau of Economic Analysis, U.S. Department of Commerce, and were deflated by the rate of aggregate national personal income to national disposable personal income.

DATA USED IN RUNNING MODEL

Future values of the independent variables are necessary to run the model. These include lagged gasoline consumption, lagged income, lagged

73-040

price of gasoline, change in income, and change in the price of gasoline.

REFERENCE

A study of the quarterly demand for gasoline, and impacts of alternative gasoline taxes, Data Resources, Inc., prepared for the Environmental Protection Agency and the Council on Environmental Quality, December 1973.

Verleger, P.K., Jr.; Sheehan, D.P., A study of the demand for gasoline, in Dale W. Jorgenson, ed., Econometric Studies of U.S. Energy Policy, Data Resources Series Vol. 1, Amsterdam: North Holland Publishing Co., 1976.

AN ANNUAL MODEL OF PASSENGER CAR GAS CONSUMPTION IN THE U.S.

An Annual Model of Passenger Car Gas Consumption was written in 1973 at the U.S. Department of Transportation, Transportation Systems Center (TSC). It is a working level model and has been superseded.

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KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The objective of the model is to quantify consumer sensitivity to gasoline price changes so as to be able to predict the impacts of policy initiatives such as gasoline excise taxes.

RELATIONSHIP TO OTHER MODELS

There is no relationship to other models.

HISTORICAL BACKGROUND

The author reviewed two existing gasoline consumption models, by Houthakker and Verleger (H-V) and by Fields of the FHWA. Since neither of these were appropriate for the policy-related needs of TSC, this alternate model was developed.

ASSUMPTIONS

Gasoline demand is influenced by the price of gas only indirectly through the demand for automobiles. The price of gasoline affects new auto purchases, but gas consumption among auto owners is highly

insensitive to gas price changes. Consumer demand for gasoline is not a demand for a final product, but rather is a factor of production in the output of vehicle travel. Thus firm factor demand theory rather than consumer choice theory is used in modeling gasoline demand here.

VALIDATION

The model was run for 1973 through 1975 to predict future gasoline consumption, given varying rates of price inflation, real income rise, and gasoline price rise. The results showed that a large price rise will decrease the growth of gasoline demand to reverse its current trend. A large excise tax on gasoline in a normal economy will have a small negative impact (1.1% per year) on the rate of growth of gasoline demand, while in an economy in an economic downturn with high inflation, the decrease in the demand for gasoline would be 4.7% per year.

LIMITATIONS AND BENEFITS

Not all coefficients are significant at the 10% level. The author of the model felt that long-run use of it was unjustified because the long-run price elasticities implied in the model were unreliable for large price increases.

STRUCTURE

The estimated model equation is:

$$\begin{aligned}
 \text{PCGAS} = & 1.83914 \times 10^5 - 11815.8 (\text{MPGY}) + 72.2815 (Y) \\
 & (6.8574) \quad (-7.04209) \quad (10.0751) \\
 & - 1.141 \times 10^7 (\text{RPGY}/\text{CPI}) + .10727 [\text{PCGAS}(-1)] \\
 & (-1.74947) \quad (1.00616) \\
 & - 2861.94 (\text{PCARA}/\text{CPI}) \\
 & (-0.86897)
 \end{aligned}$$

where t-statistics are in parentheses, and

PCGAS = motor fuel consumption, millions of gallons

CPI = consumer price index (1958 = 100)

MPGY = average miles per gallon of U.S. passenger cars

PCARA = index of new car prices

RPGY = retail price of gas (excluding taxes)

Y = real personal disposable income (1958 dollars)

MODEL CONSTRUCTION

The model was calibrated using data as follows: The variables motor fuel consumption and average miles per gallon of U.S. passenger cars were taken from the Statistical Abstracts of the U.S. The consumer price index and the index of new car prices were from the Survey of Current Business. Real disposable income was taken from the Federal Reserve Bulletin. The retail price of gasoline excluding taxes is the average price of regular gasoline in 55 cities and is from the Survey of Current Business.

DATA USED IN RUNNING MODEL

Estimated or forecast future values of the independent variables are necessary to run the model.

REFERENCE

Chamberlain, C., Models of gasoline demand, TSC, Draft, Report No. RP-SP-21, subject to change, October 1973.

U.S. BUS AND TRUCK POPULATION MODEL

The U.S. Bus and Truck Population Model was prepared as part of a master's thesis submitted to Michigan Technological University in 1973. It evaluates the immediate and long-range effects of federally imposed emission standards on trucks and buses. The model estimates the present and future contribution of trucks and buses to total air pollution.

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KEYWORDS

Trucks, emissions, fuel consumption, vehicle miles traveled (VMT), scrappage

OBJECTIVE OF MODEL

The objective of the model is to evaluate the immediate and long-range effects of federally imposed emission standards on trucks and buses. The model estimates the present and future contribution of trucks and buses to total air pollution.

RELATIONSHIP TO OTHER MODELS

The model has no direct relationship to other models.

HISTORICAL BACKGROUND

The model was developed because of the prospective introduction in 1973 of emission standards for trucks and buses similar to those for automobiles.

ASSUMPTIONS

The model assumes that vehicle model year corresponds with the calendar year.

VALIDATION

The author reports that model output matches well with historical data for the period 1958-70. Sensitivity analysis for various input parameters indicated, for example, that in 1990 the high projection of total factory sales, which exceeds the median projection by 42%,

produces a 30% differential in vehicle population and 28% differential in nitrogen dioxide emissions.

LIMITATIONS AND BENEFITS

The model emphasizes that truck and bus emissions are a significant component of the total emission level. The model outputs are rather sensitive to projected future sales levels. Economic factors do not enter the causal relationships of the model.

STRUCTURE

The model consists of a series of submodels for factory sales, scrappage, mileage, fuel usage, vehicle population, and air pollution. In the sales submodel, historical sales data are plotted by weight class of truck for the years 1932-1970. Projections are then made for total sales and sales by class annually to the year 2000. These projections are derived from a 1963 study of America's future resource requirements and availabilities and on the basis of communications with two major truck manufacturers. Sales figures, combined with the calculated scrappage, yield total truck and bus population annually to the year 2000. Mileage per year per vehicle is estimated by class and age, and combined with estimates of average miles per gallon to yield annual fuel consumption. Finally, air pollution estimates are obtained for various average emission rates. Some projections used in this report are plotted on graphs, while others are simply listed by year.

MODEL CONSTRUCTION

The model is calibrated using historical data on scrappage rates, total factory sales, age distribution of the vehicle population, new vehicle average miles per year, average miles per gallon, and average emission rates for various pollutants. The report includes necessary data values.

DATA USED IN RUNNING MODEL

The model requires projections of the annual values of all input variables.

REFERENCE

Tingley, D.S., The formulation and development of a united states truck and bus population model with an analysis of the fuel usage and air pollution contributions, master's thesis submitted to Michigan Technological University, 1973.

73-043

COMPUTER REQUIREMENTS

The computer model was written in FORTRAN for use on Michigan Technological University's IBM 360/44 computer. A program list is included in the model report.

WHARTON E.F.A. AUTOMOBILE DEMAND MODEL

The Wharton E.F.A. Automobile Demand Model, commonly known as the Wharton model, is perhaps the most complex econometric model of long-run automobile demand being used today. The Department of Transportation has used the model for policy analysis, as have the Council of Economic Advisors, the White House, the Department of Energy, the Congressional Research Service, the International Trade Commission, the Office of Technology Assessment, and the Environmental Protection Agency. The model was designed to study the effects on the long-run size and composition of U.S. automobile demand and stock, given various policy proposals and alternative socio-economic futures. In particular, the model may be used to evaluate the effects of twelve categories of automobile taxes, eighteen economic variables that affect the automobile market, and fifteen separate demographic trends.

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KEYWORDS

Automobile demand, scrappage, market shares, vehicle miles traveled, pricing

OBJECTIVE OF MODEL

The objective of the model is to study the impact of altered assumptions concerning such factors as the efficiency and weight of new cars, gasoline prices, and automobile-related tax laws on the long-run size and composition of U.S. automobile demand and stock, through the year 2000.

RELATIONSHIP TO OTHER MODELS

This model is self-contained.

ASSUMPTIONS

As with any large model, many assumptions were made in constructing the model. Therefore, only the major assumptions are presented here.

The predictions of the size and composition of automobile demand (sales) and total stock depend on the predictions of the desired variables: desired stock and desired stock shares. (A "desired" level is the long-run, steady state or equilibrium level that would exist if all factors, such as demographics, taxes, and the like, which affect automobile demand were held constant.) The importance of the desired variables is discussed below in STRUCTURE.

To estimate the equations for desired stock and desired stock shares, Wharton used 1972 cross-section data by state. The assumption is made in this estimation that the actual stock and stock shares were approximately equal to their desired or "equilibrium" levels in 1972. This assumption is defended in the report with several arguments: the year 1972 was immediately prior to the oil crisis precipitated by the 1973 OPEC boycott; the economy was reasonably stable; pollution controls had yet to have an effect; and smaller domestic cars had been in the market for several years.

To estimate the equations for new car registrations, scrappage, and new car market shares, it was necessary to produce a time-series of the desired variables. This was done by setting the independent variables of the desired equations to their historical values and using the equations to predict the desired time-series. But these equations did not produce a "reasonable" time-series. Thus, Wharton made a series of major assumptions to adjust the historical values of desired stock and shares to more reasonable values. These assumptions were based, as Wharton argues, on the major economic and demographic differences between the year 1972 and earlier years.

VALIDATION

The extensive within-sample historical validation of the model performed by Wharton was unfortunately not included in the published report. Forecasts of the model for 1975-1978 can be compared with actual experience for that period.

A detailed analysis of this model has been performed by the Highway Safety Research Institute of the University of Michigan. See Golomb, D.H., et al. 1979. An analysis of the Wharton EFA automobile demand model. Ann Arbor, Michigan: The University of Michigan report no. UM-HSRI-79-2.

LIMITATIONS AND BENEFITS

The model is intended for long-run analysis of automobile demand rather than for precise yearly estimates of the demand.

STRUCTURE

The Wharton auto demand model is a long-run equilibrium, econometric model--that is, it is designed to forecast the long-run equilibrium levels of the size and composition of U.S. automobile demand and stock. It is a very large and complex model containing almost 400 mathematical statements involving about 600 variables. Of its mathematical statements, about three hundred are identities and over eighty are statistically derived.

Although the model is complex, much of the basic theory underlying it is typical of auto demand models which have been constructed over the last 20 years. The central concept underlying the model is that the automobile market operates by a stock adjustment process. Fundamental to the working of a stock adjustment is the assumption that gross expenditure on a commodity such as automobiles, measured in units sold, can be calculated from the difference between a desired stock and the stock already in existence, taking into account the need to replace old stock as it wears out.

The model operates as follows: From the appropriate exogenous input a capitalized cost per mile for each size-class of vehicle is computed. There are five size-classes defined in the model, from subcompacts to luxury cars. The capitalized cost per mile is essentially the present value of all costs associated with the purchase, sale, and operation of a car (a ten-year lifetime and a lifetime mileage of 100,000 is assumed). This variable, along with the ratio of family income to automobile costs, income distribution, and various demographic factors, is used to determine the desired stock values of the five size-classes of vehicles.

The desired shares are used to compute an average capitalized cost per mile. This average, along with income per family, income distribution, various demographic factors, and non-automobile related transportation indicators, is used to determine desired stock per family.

Total desired stock is used to forecast new car sales (based on new car registrations) and scrappage, and the desired shares are used to forecast new car market shares by size-class. A stock adjustment process is used to link the desired levels to the actual levels.

Also included in the model are equations for VMT per family, new and used car prices, used car transactions, and total stock by age.

Several of the key equations of the model are as follows:

Desired Stock

$$\ln(\text{KEND}/\text{FM}) = -1.90959 + 0.563344 [\ln(\text{RDIP4}/\text{FM})]$$

(2.40) (3.13)

$$- 0.100994 [\ln(\text{PER15}/(100 - \text{PER15}))] - 0.199527 [\ln(\text{CPMTTCAP}/\text{PC})]$$

(1.92) (.84)

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$$+ 0.421187 [\ln(LD/FM)] - 0.0536642 [\ln(MTWNA/FM)]$$

(3.07) (1.48)

$$+ 0.0990056 (NPMET/100)$$

(1.61)

$$\bar{R}^2 = 0.461 \quad SEE = 0.596$$

where t-statistics are in parentheses, and

KEND/FM = number of cars in operation at year end over number of family units

RDIP4/FM = permanent family income

PER15+ = percentage of families (excluding unrelated individuals) earning 15,000 dollars or more in 1970 dollars

CPMTTCAP = desired share weighted cost per mile (includes all classes: domestic and foreign)

LD/FM = number of licensed drivers over number of family units

PC = consumer price index, all items

MTWNA/FM = number of persons not using an automobile to travel to work over number of family units

NPMET = percentage of population living in SMSAs

Mid-Size Class Desired Share

$$\ln\left(\frac{SHRM}{1-SHRM}\right) = 0.211089 - 1.98095 [\ln(CPMM/T-M)]$$

(0.39) (4.57)

$$- .161133 [\ln(YDI/FM/CT*Q)] + 0.785861 [\ln(FM3+4/FM)]$$

(1.31) (4.73)

$$+ 0.162809 (DUMNEW) - 0.125991 (DUMMTN)$$

(4.01) (3.65)

$$\bar{R}^2 = 0.683 \quad SEE = 0.0779$$

SHRM = desired share of mid-size cars

CPMM/T-M = cost per mile for mid-size cars over desired share weighted cost per mile for all other classes

YDI/FM/SC*Q = dollar disposable income over number of family units over fixed weighted cost per mile

FM3+4/FM = number of 3 and 4 member families over number of family units

DUMNEW = dummy, = 1.0 for New England states, = 0.0 otherwise

DUMMTN = dummy, = 1.0 for Mountain states, = 0.0 otherwise

New Car Sales

$$\ln\left(\frac{\text{OMVUANR}}{\text{OPMVUAYEND}(-1) - \text{SCMVUA}}\right) =$$

$$+ 3.79294 \left[\ln\left(\frac{\text{KEND*AY}}{\text{OPMVUAYEND}(-1) - \text{SCMVUA}}\right) - 0.255190 (\text{DUMAUTOS}) \right]$$

(9.90) (2.49)

$$+ 6.03907 \left[\ln\left(\frac{\text{RDI/FM}}{\text{RDIP4/FM}}\right) \right]$$

(8.30)

$$- 1.26683 \left[\ln\left(\frac{\text{PUTOTNRL}}{\text{PUTOTNR}(-1)}\right) \right] - 2.9151$$

(3.45) (35.2)

$$\bar{R}^2 = 0.864 \quad \text{SEE} = 0.0473 \quad \text{DW} = 2.28$$

OMVUANR = new car registrations

OPMVUAYEND = year-end stock of cars in operation

SCMVUA = total auto scrappage

KEND*AY = desired stock

DUMAUTOS = strike dummy variable

RDI/FM = real disposable income per family

RDIP4/FM = permanent family income

PUTOTNRL = previous year average new car price, sales weighted

PUTOTNR = new car price, average, weighted by previous year sales

Scrappage

$$\ln\left(\frac{\text{SCMVUA} - \text{SCMVAGIV}}{\text{OPMVUAYEND}(-1) + \text{OMVUANR}}\right) = -6.98289$$

(7.99)

$$- 3.82763 \left[\ln\left(\frac{\text{KEND*AY}}{\text{OPMVUAYEND}(-1) + \text{OMVUANR}}\right) \right]$$

(4.50)

$$+ 2.91080 \left[\ln(\text{AVAGE0-20}) \right] - .145089 \left[\ln\left(\frac{\text{PUOLD}}{\text{PSCRAPAV}}\right) \right]$$

(5.32) (2.20)

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$$- .338149 [\ln(\text{NRUT})] + \sum_{i=0}^2 a_i [\ln(\frac{\text{VMT/K}}{\text{VMT/K}(-1)})_{-i}]$$

(4.33)

$$a_0 = 2.23399, a_1 = 4.19538, a_2 = 3.45071$$

(2.42) (3.60) (2.86)

$$\bar{R}^2 = .923 \quad \text{SE} = .0462 \quad \text{DW} = 2.60$$

SCMVUA = total auto scrappage

SCMVAGIV = given scrappage for cars over 20 years old

OPMVUAYEND = year-end stock of cars in operation

OMVUANR = new car registrations

KEND*AY = desired stock

AVAGE0-20 = average age of stock, vintages 0 through 20

PUOLD = average price of old cars

PSCRAPAV = scrap-metal price

NRUT = unemployment rate

VMT/K = ratio of vehicle miles traveled to mid-year cars in operation

Mid-Size Class Share of New Car Sales

$$\ln\left(\frac{\text{SHRMDNR}}{1 - \text{SHRMDNR}}\right) = \ln\left(\frac{\text{SHRM*A}}{1 - \text{SHRM*A}}\right) - 0.00198516$$

(0.66)

$$- 0.873077 \left[\ln\left(\frac{\text{TMDK-SC}}{1 - \text{TMDK-SC}}\right) - \ln\left(\frac{\text{SHRM*A}}{1 - \text{SHRM*A}}\right) \right]$$

(82.94)

$$\bar{R}^2 = 0.997 \quad \text{SEE} = 0.0101 \quad \text{DW} = 1.26$$

SHRMDNR = share of new registrations, mid-size class

SHRM*A = desired stock share, mid-size class

TMDK-SC = share of stock, mid-size class, after scrappage, shares adjusted to sum to one

Vehicle Miles Traveled

$$\ln(\text{VMT/FM}) = \ln(\text{WTDVINT/FM}) + 0.418327$$

(1.19)

$$- 0.206013 [\ln(\text{PRGAS/AVMPGVINT/PC})]$$

(3.07)

$$+ 0.118999 [\ln(\text{PER}15+/100 - \text{PER}15+)] - 0.467538 [\ln(\text{RDIP}4/\text{FM})]$$

(5.99) (3.42)

$$\bar{R}^2 = 0.852 \qquad \text{SEE} = .014 \qquad \text{DW} = 1.662$$

VMT/FM = vehicle miles traveled per family by car

WTDMVINT/FM = constant (1972) mileage-weighted sum of vehicle miles by vintage

PRGAS = retail gasoline price per gallon including taxes

AVMPGVINT = vintage-weighted average fleet miles per gallon

PC = consumer price index, total, 1972 = 1.0

PER15+ = percentage of families with real incomes of 15,000 dollars or more (1970 dollars)

RDIP4/FM = permanent income per family, weighted sum of current and lagged real disposable family income

MODEL CONSTRUCTION

The data base used to build the model is quite extensive and well-documented in the third volume of the model report.

DATA USED IN RUNNING MODEL

There are about 30 types of input variables which can be categorized into four major groups: economic variables, demographic variables, transportation mode assumptions, and auto characteristics assumptions. Forecasts of most of the economic input variables are obtainable directly from Wharton E.F.A.'s Annual Long-Term Econometric Model. Forecasts of most of the demographic variables are available from the Bureau of the Census. A table of model input is provided below:

A. Economic Activity and Price Assumptions:

- 1) personal income
- 2) income tax payments
- 3) transfer payments
- 4) unemployment rate
- 5) employment
- 6) consumer price indices (including CPIs related to auto operation and maintenance)

- 7) retail gasoline price (including tax)
- 8) interest rates
- 9) auto ownership and operation tax rates by size class
- 10) domestic auto production cost index
- 11) foreign auto export price
- 12) transportation price index
- 13) scrap metal price index

B. Demographic Assumptions:

- 1) number of family units
- 2) family size distribution
- 3) percent of population living in SMSA's
- 4) population by region
- 5) population 20-29 years old
- 6) number of licensed drivers

C. Transportation Mode Assumptions:

- 1) growth in urban transit passengers relative to employment
- 2) growth in urban transit passengers relative to transit travelers to work
- 3) growth in non-auto, non-transit travelers to work relative to employment

D. Auto Characteristics Assumptions:

- 1) curb weights for new cars by class
- 2) engine displacements for new cars by class
- 3) number of cylinders for new cars by class
- 4) transmission types for new cars by class
- 5) MPG efficiency factors for new cars by class
- 6) urban fraction of vehicle miles traveled
- 7) used cars price decay parameters

8) ratios class prices to average, domestics

REFERENCE

Schink, G.R.; Loxley, C.J., An analysis of the automobile market: modeling the long-run determinants of demand for automobiles, three volumes, Wharton E.F.A. Inc., February 1977.

COMPUTER REQUIREMENTS

The model program is written in FORTRAN and requires over 150 pages of disk storage.

TRANSPORTATION SAFETY ANALYSIS MODEL (HIGHWAY SUBMODEL)

The Transportation Safety Analysis Model was developed in 1976 by The Center for the Environment and Man, Inc. under the sponsorship of the Transportation Systems Center (TC). Its Highway Submodel expresses highway accident deaths as a function of vehicle miles traveled, and it forecasts highway accident deaths for five classes of highways.

SPONSOR

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

AUTHOR

Hans C. Joksch
Center for the Environment and Man, Inc.
275 Windsor Street
Hartford, Conn. 06120

KEYWORDS

Accidents

OBJECTIVE OF MODEL

The objective of the model is to forecast highway accident deaths on different types of highways as a function of vehicle miles traveled on those highway types. The highway types are: rural interstate, urban interstate, main rural roads, other rural roads, and urban highways and streets.

RELATIONSHIP TO OTHER MODELS

The Transportation Safety Analysis Model is composed of three sub-models, one for each of the following modes: air, rail, and highway. They are of a similar structure, but not functionally dependent upon each other.

HISTORICAL BACKGROUND

The model was developed in order to explore the consequences of alternative policy decisions relating to the highway environment. The model presented here is a first-level, or preliminary, model which was developed using existing data and relationships. A second-level model has been outlined which employs more extensive relationships. However,

currently it is not possible to calibrate this second-level model with the existing data.

ASSUMPTIONS

It is assumed that fatalities depend on traffic density, which is a function of vehicle miles traveled and highway type. This is in contrast to conventional approaches in which deaths are a function of VMT and accident rates that are based on past experience. Also, for forecasting purposes, 1973 highway mileage figures have been held constant until 1990.

VALIDATION

The model projections for 1974 and 1975 for total motor vehicle deaths were about 5,000 higher than actual occurrences. Two reasons for this suggested by the author are the 1974-1975 recession and the implementation of the 55 mph speed limit.

LIMITATIONS AND BENEFITS

Because of the paucity of historical data, the model does not present an accurate representation of the real-world situation. The author indicates this and proposes a second-level model.

STRUCTURE

The model consists of the following single equation:

$$\frac{\text{Deaths}}{\text{HM}_{h,s,t}} = \text{VIO}_t \left[(\text{TFA}[I]_{h,t}) (A[I]_h) + (\text{TFB}[I]_{h,t}) (B[I]_h) \left(\frac{\text{VMT}_{h,s,t}}{\text{HM}_{h,s,t}} \right) \right]$$

where the parameters are defined as follows:

VIO_t = vehicle interaction factor for year t

$A(I)_h$ = regression intercept for highway type h in traffic density range I

$B(I)_h$ = regression slope for highway type h in traffic density range I

$\text{TFA}(I)_{h,t}$ = time factor for $A(I)_h$ in year t

$\text{TFB}(I)_{h,t}$ = time factor for $B(I)_h$ in year t

$\text{VMT}_{h,s,t}$ = vehicle miles traveled (in millions) for highway type h in states s in year t

76-047

$HM_{h,s,t}$ = highway mileage for highway type h in state s in year t

MODEL CONSTRUCTION

Data on fatalities per highway mile by highway type and vehicle miles traveled per highway mile by highway type were used to construct the model.

DATA USED IN RUNNING MODEL

The model requires forecasts of vehicle miles traveled by road type, state and vehicle type, vehicle population by type (auto, truck, bus), highway mileage by state and road type, and vehicle factors.

REFERENCE

Joksch, H.C., Transportation safety analysis, The Center for the Environment and Man, prepared for TSC, Final Report, Nov. 1976. This document lists the computer program and specifies the model input requirements.

COMPUTER REQUIREMENTS

The model is written in FORTRAN.

AN ANALYSIS OF THE PRIVATE AND COMMERCIAL DEMAND FOR GASOLINE

A model analyzing the private and commercial demand for gasoline, dated February 1974, was prepared at Michigan State University. The model specifies the supply side of the market and can be used to estimate the price elasticities of private and commercial demand for gasoline. These elasticities are used to analyze the effect of changes in the price of gasoline and to predict market-clearing gasoline prices under various conditions.

AUTHOR

James B. Ramsey, R. Rasche, and B. Allen
Michigan State University
Department of Economics
East Lansing, Mich.

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The objective is to estimate the intermediate run (one year) price elasticities of the private and commercial demand for gasoline in a model which specifies the supply side of the market. These elasticities are then used to analyze the effect of changes in the price of gasoline and to predict market-clearing gasoline prices under various conditions.

RELATIONSHIP TO OTHER MODELS

The model bears no direct relationship to any other models.

HISTORICAL BACKGROUND

The study was motivated by the apparent necessity in 1973 for a policy choice between gasoline rationing and allowing the price of gasoline to rise to clear the market.

Professor Ramsey is now the chairman of the Department of Economics at New York University.

ASSUMPTIONS

The model assumes that the supply of gasoline depends on the relative prices of all distillates and the total supply of crude oil available. These variables are assumed to be exogenous. Total private demand is assumed to increase in direct proportion to the number of households at

given real prices and income. The authors state that the theory underlying the model has been tested elsewhere. The model is static, assuming that equilibrium is achieved in the gasoline market within one year.

VALIDATION

Using actual data values of the independent variables for 1970 to 1972, the model estimated annual private demand per household for gasoline within one standard error of the actual value, although the actual value consistently exceeded the forecast.

LIMITATIONS AND BENEFITS

The model does not explicitly incorporate changes in automobile fuel efficiency. The equilibrium and supply assumptions may not be appropriate for the post-1973 period. Nevertheless, the demand and supply specification is a useful approach, as is the division of demand into private and commercial sectors.

STRUCTURE

The structural specification of the model consists of a supply equation, equations for private and commercial demand, and two identities. The two demand equations which follow were estimated by two-stage least squares, using annual observations from 1946 to 1969.

$$\log(Q) = 2.047 - \frac{.222 (P_g)}{(-1.82)} + \frac{.117 (P_t)}{(1.49)} \\ - \frac{4.034 (t_p)}{(4.74)} - \frac{1.078 (y^{-1})}{(11.75)}$$

$$R^2 = .98 \quad DW = .96$$

$$\log(Q_c) = 2.12 - \frac{1.03 (P_{cg})}{(-2.16)} + \frac{1.88 (P_d)}{(2.58)} \\ + \frac{.65 (f_c)}{(2.20)}$$

$$R^2 = .89 \quad DW = 1.91$$

where t-statistics are in parentheses, and

Q = annual private demand per household for gasoline

Q_c = annual commercial demand for gasoline

P_g = retail price of gasoline deflated by Consumer Price Index (CPI)

P_t = price index of train travel deflated by CPI

t_p = proportion of the population in the 16-24 age group

y = real disposable income per household

P_{cg} = retail price of gasoline deflated by the price index of truck freight rates

P_d = price index of diesel fuel deflated by the price index of truck freight rates

f_c = index of total ton miles demanded of all freight carriers

MODEL CONSTRUCTION

The model is constructed using annual data for all variables from 1946 to 1969. The necessary variables and data sources for them are listed in the Appendix to the model report.

DATA USED IN RUNNING MODEL

The model is used primarily to generate price elasticities. In order to run the model for future periods, forecasts are required for values of all the independent variables. Such forecasts are not included in the model report.

REFERENCE

Ramsey, J.B.; Rasche, R.; Allen, B., An analysis of the private and commercial demand for gasoline, Department of Economics, Michigan State University, February 18, 1974.

INFREQUENT PURCHASE BEHAVIOR IN A STOCK ADJUSTMENT MODEL

"The Empirical Implications of Infrequent Purchase Behavior in a Stock Adjustment Model" was written by Richard B. Westin and appeared in the American Economic Review in 1975. The objective of the auto demand model is to analyze the infrequent purchase behavior of new car buyers. This new discretionary replacement model is compared with the conventional stock adjustment model, and the policy implications of both are discussed.

AUTHOR

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Scarborough College

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of this model of auto demand is to test the empirical implications of infrequent purchase behavior. Individual purchasers of new automobiles enter the market at infrequent intervals and are inactive the rest of the time. In this regard, the traditional assumption of the stock adjustment model that replacement demand is equal to depreciation on the existing stock becomes questionable. Many holders of automobiles have no intention of entering the new car market in the near future and, therefore, do not translate their loss of services from their used car stock into effective demand for new cars.

RELATIONSHIP TO OTHER MODELS

There is no direct operating relationship to other models.

HISTORICAL BACKGROUND

This model was developed in connection with the author's doctoral dissertation at the University of Minnesota entitled, "An Echo Theory of Automobile Demand," 1971. The author is now with the World Bank in Washington, D.C.

ASSUMPTIONS

The discretionary replacement model assumes auto demand can be divided into two components: replacement demand and nonreplacement demand. Replacement demand is assumed to depend on the existing stock

of cars by vintage and on discretionary variables that affect the timing of normal replacement demand. Nonreplacement demand is assumed to be a function of economic variables such as disposable and permanent income and the relative price of new automobiles.

VALIDATION

Using historical data, the discretionary replacement model was tested against the conventional stock adjustment model. In general, the a priori predictions of the discretionary replacement model are borne out by the data. In particular, the coefficients of the discretionary variables show discretionary purchase timing to be an off-setting short-run phenomenon around a longer replacement cycle. When proper specification is made of short-run variations in purchase timing, it is shown that the stock effect of the existing fleet is quite small, particularly for newer stock. This result is in sharp contrast to the predictions of the stock adjustment model. The coefficients of the lagged stock variables are positive for the newer stock, which is consistent with the theory of the discretionary replacement model.

LIMITATIONS AND BENEFITS

The estimated results indicate no substantial differences between the explanatory power of the discretionary replacement model and the traditional stock adjustment model. The predictive implications of the two competing models, summarized as price and income elasticities, are significantly different, however. Theoretical reasons are given for these contrasting results, with the argument being that the high explanatory power of the stock adjustment model covers systematic bias in the estimated coefficients.

From a theoretical point of view the discretionary replacement model considers an aspect of consumer durable goods demand that has been generally neglected. The model explicitly takes account of the fact that individual purchasers of durable goods commonly enter the market only at infrequent intervals and are inactive the rest of the time. This implies that the assumption that current replacement demand is equal to current depreciation on the entire existing stock is questionable. Many holders of durables have no intention of entering the market and do not translate the loss of services from their present stock into effective demand for new stock.

STRUCTURE

The structure of the discretionary replacement model is as follows:

$$N_t = N^*_t + \sum_{i=1}^T (a_i - c_i) V_{t-i} + B (D_t - D_{t-1})$$

where:

N_t = number of new cars purchased

N^*_t = nonreplacement demand

a_i = proportion of cars of age i that are replaced with new cars

c_i = coefficient representing the saturation effect of the existing stock on nonreplacement demand

V_{t-i} = number of cars of vintage $t-i$ existing in period t

D_t = discretionary variable

B = coefficient on discretionary variable

MODEL CONSTRUCTION

The model is constructed using data sources which are documented in the data appendix of the paper. In general, most of the data come from the Survey of Current Business.

DATA USED IN RUNNING MODEL

Estimated or forecast values for all the independent variables of the model are necessary to generate predictions for auto demand.

REFERENCE

Westin, R.B., Empirical implications of infrequent purchase behavior in a stock adjustment model, American Economic Review, Vol. 65, No. 3, pp. 384-396.

Westin, R.B., An echo theory of auto demand, Ph.D. thesis submitted at the University of Minnesota, March 1971.

GASOLINE USE MODEL

The Gasoline Use Model, dated 1975, was prepared by the Urban Institute for the National Science Foundation. The objective of the model is to formulate and estimate a gasoline demand equation. It was used by the author to provide estimates of the price elasticity of demand for gasoline.

SPONSOR

National Science Foundation
Research Applied to National Needs
Washington D.C. 20550

AUTHOR

Robert G. McGillivray
Urban Institute
Washington, D.C.

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The objective of the model is to formulate and estimate a gasoline demand equation and ultimately to provide estimates of the price elasticity of the demand for gasoline.

RELATIONSHIP TO OTHER MODELS

The model has no direct relationship to other models. It is a variant of the natural gas model in P. Balestra and M. Nerlove, "Pooling Cross-Section and Time Series Data in the Estimation of a Dynamic Model: The Demand for Natural Gas," Econometrica, Vol. 34, No. 3, July 1966, pp. 585-612.

HISTORICAL BACKGROUND

This model is the outgrowth of a review of previous gasoline demand models, many of which ignore adjustments in ownership, purchase, and use of automobiles.

ASSUMPTIONS

The model assumes that new automobile purchases, use of the automobile stock, and gasoline price are predetermined.

VALIDATION

The model was run to forecast gasoline consumption in 1970-1972 using actual values for the independent variables. The author reports that the forecasts are quite close to, though uniformly larger than, the actual values.

LIMITATIONS AND BENEFITS

The model does not apply to the period from late 1973 to early 1974 because of the extreme shift in the supply of gasoline. The model can be used for future forecasting only with some assumption or forecast from another model as to the level of new car sales.

STRUCTURE

This econometric model consists of a single equation for gasoline demand which is estimated by ordinary least squares using annual data from 1951 to 1969.

$$G_t = -111.68 - 1.79 (P_{gt}) + 818.69 (A_t) \\ (-2.99) \quad (-2.99) \quad (7.04) \\ + .32 (L_t) + .70 (G_{t-1}) \\ (5.15) \quad (12.73)$$

where t-statistics are in parentheses, and

G_t = passenger-car gasoline consumption, per capita, in gallons, in year t

P_{gt} = price of gasoline, deflated, in year t

A_t = new-passenger-car registrations, per capita, in automobiles, in year t

L_t = average gasoline consumption per automobile, in gallons, in year t

MODEL CONSTRUCTION

The model is estimated using data from 1951 to 1969. Data sources and the actual data values are listed in the model report.

DATA USED IN RUNNING MODEL

The model requires forecasts of the independent variables (or their actual values) after 1969.

REFERENCE

McGillivray, R.G., Gasoline use by automobiles, Transportation Research Record No. 561, 1976.

MODELING THE RESPONSE OF THE DOMESTIC
AUTOMOBILE INDUSTRY TO MANDATES FOR
INCREASED FUEL ECONOMY: AN INDUSTRY MODEL

Modeling the Response of the Domestic Automobile Industry to Mandates for Increased Fuel Economy: An Industry Model was written in 1977 by the Rand Corporation under the sponsorship of the National Science Foundation. The purpose of the model is to project the long-run response of the automobile industry to the fuel economy standards mandated by the Energy Policy and Conservation Act of 1975. The model estimates the equilibrium changes in prices, costs, sales, profits, individual and aggregate fuel economies, and governmental revenues when various levels of fuel economy mandates are imposed for 1985.

SPONSOR

National Science Foundation
Washington, D.C. 20550

AUTHOR

J.P. Stucker, B.K. Burright, and W.E. Mooz
Rand Corporation
Santa Monica, Calif. 90406

KEYWORDS

Automobile demand, fuel economy, pricing

OBJECTIVE OF MODEL

The purpose of the model is to represent the automobile industry's behavior in response to various fuel economy mandates by the year 1985, assuming that the industry can start its adjustments, plans, and processes today (in 1977). The industry's behavior is modeled in terms of changes in its sales, prices, revenues, fuel economies, costs, and profits.

HISTORICAL BACKGROUND

This model was developed to analyze the response of the domestic automobile industry to mandates for increased new car fuel economy as legislated in the Energy Policy and Conservation Act of 1975.

ASSUMPTIONS

The model assumes that the domestic automobile industry acts as if it were a single firm (monopoly assumption) which maximizes its profits by

choosing the fuel economy level and number of each type of car it produces and sells. It was calibrated on the assumption that in 1976 the industry was nearly at long-term equilibrium.

VALIDATION

The model was examined for sensitivity to cost level estimates by testing how the behavior of the industry was affected by changes in the tax rate associated with the fuel economy mandate. It was found that a fine of less than 20 dollars per mpg would cause fuel economy improvements, but not enough to meet the mandated mpg standard.

LIMITATIONS AND BENEFITS

This is one of a few models developed to analyze the industry's response to the fuel economy mandates. The authors point out two limitations of the model:

- 1) the model assumes the industry acts as a monopoly and should be replaced with a model that more accurately reflects the oligopolistic nature of the industry; and
- 2) the parameters of the model are not based on time-series information that reflects the continual dynamic adjustments taking place in the industry's markets.

STRUCTURE

The model assumes that the domestic automobile industry acts as a single firm that produces and sells three types of cars: large, mid-size, and small. This firm's objective is to maximize the joint profits of its members, as follows:

$$\text{Maximize Profits: } L = (R-C) (1-d) - F$$

where:

L = profits

R = total revenue of industry

C = total costs of industry (production and selling)

d = corporate income tax rate

F = total industry fuel economy fine

Revenue, costs, and the fuel economy fine are defined by the following equations:

$$\text{Revenue: } R = p^b Q^b + p^m Q^m + p^s Q^s$$

where:

p^i = new car price of car type i , i = big, mid-size, small

Q^i = new car sales of car type i ,

$$= \alpha_0^i p^{b\alpha_1^i} p^{m\alpha_2^i} p^{s\alpha_3^i} E^{b\alpha_4^i} E^{m\alpha_5^i} E^{s\alpha_6^i}$$

E^i = new car fuel economy of car type i

α_j^i = demand elasticities

$$\text{Costs: } C = C^b + C^m + C^s$$

where:

C^i = industry costs of car type i ,

$$= B_0^i + (B_1^i + B_2^i E^i) Q^i$$

B_j^i = cost parameter for car type i

$$\text{Fuel Economy Fine: } F = T (M - E) Q$$

where:

T = fuel economy tax rate

M = fuel economy mandate

Q = total new car sales = $Q^b + Q^m + Q^s$

E = new car fuel economy,

$$= Q \left(\frac{Q^b}{E^b} + \frac{Q^m}{E^m} + \frac{Q^s}{E^s} \right)^{-1}$$

MODEL CONSTRUCTION

The model was constructed using 1976 values for the exogenous variables and parameters, which were gathered from these sources:

- 1) new car sales--Jan. 10, 1977, issue of Automotive News
- 2) fuel economy values--Environmental Protection Agency estimates
- 3) price and cost estimates--primarily derived from material released by the Council on Wage and Price Stability
- 4) demand elasticities--determined based on a review of the recent literature

DATA USED IN RUNNING MODEL

A tax rate associated with the fuel economy mandate and maximum feasible fuel economy levels for each type of car both need to be specified.

REFERENCE

Stucker, D.P.; Burright, B.K.; Mooz, W.E., Modeling the response of the domestic automobile industry to mandates for increased fuel economy: an industry model, Rand Corporation, P-5858. December 1977.

COMMUNITY NOISE COUNTERMEASURES COST EFFECTIVENESS
OPTIMIZATION COMPUTER PROGRAM (NOIZOP)

A model of Quantification of Transportation Noise was prepared in 1975 by Wyle Laboratories for the Motor Vehicle Manufacturers Association. Its purpose is to quantify community noise.

SPONSOR

Motor Vehicle Manufacturers Association
320 New Center Building
Detroit, Mich. 48202

AUTHOR

Robert Rackl, Louis Sutherland, and Jack Swing
Wyle Laboratories
El Segundo, Calif. 90245

KEYWORDS

Noise pollution

OBJECTIVE OF MODEL

The objective of the model was to quantify community noise in order to perform a trade-off study between noise abatement measures (not only motor vehicle noise sources, but also rail, aircraft and other sources) and abatement costs. This information may then be used in formulating motor vehicle and highway policies within an overall national policy of community noise abatement.

RELATIONSHIP TO OTHER MODELS

There is no relationship to other models.

ASSUMPTIONS

The model assumes that the adverse responses of human beings to noise can be quantified and that these quantifications are representative of the community. In running the model for cases in the future, various assumptions were made concerning the useful life of the auto fleet, the range of costs for noise countermeasures, the increased vehicle operating costs, etc.

VALIDATION

The model was evaluated for 1978 and refined on the basis of experiences in Spokane, Washington, whose level of noise was thought to be typical. The model authors feel, therefore, that the results of the analysis conducted for Spokane are applicable to many areas of the country, but caution that there are regional limitations to the applicability. The model has also been applied to Menlo Park, California, and to Allentown, Pennsylvania. Validation of the model, in the strict sense, would require noise and human annoyance measures before and after implementation of noise abatement policies recommended by the model. This would be quite costly, and has never been done.

STRUCTURE

The model process is as follows:

- 1) The city or area being analyzed is divided into acoustically homogeneous cells.
- 2) The noise sources are identified by cell.
- 3) The level of source activity (e.g., traffic flow) is quantified by time period.
- 4) The composite total noise exposure for each cell for each time period is quantified, based on noise levels from each source.
- 5) Transfer functions are applied to the noise exposure level in each cell to produce the percentage of people in the cell who will respond adversely to the noise exposure.
- 6) Based on the total population of the cell, the number of people who will respond adversely is estimated.

MODEL CONSTRUCTION

This is a physical systems model in which parameter values are based on actual noise measurements and other current relationships.

DATA USED IN RUNNING MODEL

Required for each class of vehicles (automobiles, trucks, etc.) are the number of vehicles per unit distance of roadway and a reference noise level measured at a standard distance. In addition, the perpendicular distance of the observer from the roadway must be known.

Other types of data are required and are listed in the model report. These include transfer functions relating noise levels to a human response, population distributions by day and night and land use, and strength of the noise sources.

REFERENCE

Rackl, R.; Sutherland, L.; Swing, J., Community noise countermeasures: cost-effectiveness analysis, prepared for the Motor Vehicle Manufacturers Association by Wyle Laboratories, Wyle Research Report WCR75-2, 2 Volumes, July 1975. Appendices A, B, and C, WCR-76-15, June 1977.

Burke, R.E.; Glenn, P.K., Community noise assessment manual-strategy guidelines, Wyle Research Report no. WR78-1, to be submitted to the U.S. Environmental Protection Agency, June 1979.

COMPUTER REQUIREMENTS

The model can be run in batch mode or at a remote terminal. It is written in ANSI FORTRAN IV for general compatibility with most computer systems.

ECONOMETRIC MODELS OF THE DEMAND FOR MOTOR FUEL

Econometric Models of the Demand for Motor Fuel was prepared in April 1975 by the Rand Corporation. The study was sponsored by the National Science Foundation and the Federal Energy Administration. It develops econometric measures of the short-run and long-run demand for highway motor fuel and gasoline.

SPONSOR

National Science Foundation
Washington, D.C. 20550

Federal Energy Administration
Washington, D.C. 20461

AUTHOR

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KEYWORDS

Fuel consumption, vehicle miles traveled, automobile demand, fuel economy

OBJECTIVE OF MODEL

The purpose of the study in which the models were prepared was to develop econometric measures of the short-run and long-run demand for highway motor fuel and gasoline.

RELATIONSHIP TO OTHER MODELS

This study is part of Rand's continuing research program on the evaluation of measures to conserve energy. Other models in the series include 74-001A - Generalized Automobile Design Model, 74-001B - Automobile Fleet Mix Model, and 74-001C - New Car Sales/Auto Ownership/Vehicle Miles Traveled (NAV) Model. This report expands on work appearing in 74-001B and 74-001C.

ASSUMPTIONS

The study estimates both the short-run and long-run demand for gasoline under a variety of assumptions as to functional form and relevant variables. The short-run model assumes that the bias of simultaneous equations is not a serious problem; therefore only ordinary

and generalized least squares estimation procedures are presented. The theoretical analysis assumes that vehicle miles traveled are produced for each household according to the short-run production function. The model also assumes that all automobiles are alike. The long-run model assumes that new and used cars have the same average fuel efficiency. Real prices of gasoline and new cars are exogenous to the model.

VALIDATION

The models' results are compared and contrasted with the results produced by other models.

LIMITATIONS AND BENEFITS

The study provides a good comparison of various estimates of the elasticity of demand for gasoline. However, the long-run model assumes a perfectly elastic supply of gasoline and new cars, so that market-clearing price-quantities combinations cannot be predicted.

STRUCTURE

The study estimates both the short-run and long-run demand for motor fuel. The short-run demand function is derived from a simple model of household decision-making which explains the demand for vehicle miles traveled. The function is estimated using two data bases: (1) a pooled time-series of state data from 1955 to 1970, and (2) national time-series data from 1950 to 1972. Estimates using the pooled data are obtained by generalized least squares and ordinary least squares (OLS). A representative equation estimated by generalized least squares is:

$$\begin{aligned} \log(F/POP) = & \quad -.66 - \quad .27 [\log(P_f)] + \quad .18 [\log(Y/POP)] \\ & \quad (-3.5) \quad (-11.5) \quad \quad (9.5) \\ & \quad + \quad .93 [\log(A/POP)] - \quad .09 (UPOP) \\ & \quad \quad (42.3) \quad \quad (1.8) \end{aligned}$$

$$\bar{R}^2 = .95 \quad \text{D.F.} = 763$$

where t-statistics are in parentheses, and

F = fuel consumption

P_f = average real price of regular gasoline

Y = disposable personal income

A = registered vehicles (millions)

UPOP = % of state population residing in urban areas

POP = population

Other equations included a miles-per-gallon variable. Short-run estimates are also obtained using national time-series data for fuel used in automobiles only. A short-run fuel demand function is estimated and combined with an equation explaining miles-per-gallon to obtain short-run fuel demand functions such as the following:

$$\log(F/POP) = 8.337 - .190 [\log(P_f)] - .810 [\log(M)] \\ + .190 [\log(w)] + .010 [\log(Z)] + .849 [\log(A/P)] + .42 (D)$$

where:

M = average auto fuel efficiency (miles per gallon)

Z = unemployment rate (%)

D = dummy variable for safety and emission standard years (1968-72)

The equations are estimated for 1950 to 1972.

The long-run fuel demand model focuses on changes in the total number of automobiles owned. New car sales, the used car stock, and used car price are estimated using both ordinary least squares and two stage least squares for a variety of functional forms. A representative equation, estimated by OLS for 1954 to 1972, appears below.

$$\log(N/DPOP) = \begin{matrix} -2.931 & - & 1.629 & [\log(P_n)] \\ (-51.466) & & (-5.902) & \end{matrix} \\ + \begin{matrix} .958 & [\log(P_u)] & + & 5.316 & [\log(Y/H)] & + & .131 & (ST) \\ (2.031) & & & (2.412) & & & (3.170) & \end{matrix}$$

$$\bar{R}^2 = .67$$

where t-statistics are in parentheses, and

N = U.S. new car unit sales

DPOP = driving age population

P_n = average real price of new cars

P_u = average real price of used cars

Y = permanent disposable personal income

H = households

ST = dummy auto strike variable (= -1, strike year; = 1, year following strike; = 0, otherwise)

MODEL CONSTRUCTION

Data sources for the short-run and long-run demand models are listed in the model report. Automobile gasoline use, automobile miles driven, automobile ownership, and average fleet efficiency were taken from Highway Statistics. Automobile registration and production data were obtained from the Federal Highway Administration. The actual data values for all variables are also listed in the report.

REFERENCE

Burright, B.K.; Enns, J.H., Econometric models of the demand for motor fuel, The Rand Corporation, R-1561 - NSF/FEA, April 1975.

ELASTICITIES OF DEMAND FOR NEW AUTOMOBILES

"The Elasticities of Demand for New Automobiles" was written at the General Motors Corporation Research Laboratories and is dated May 1976. The demand for new automobiles is examined by using single equation models and monthly registration data. The model estimates the impact of income, new car price, used car price, and fuel prices on auto demand. These estimates are selected on the basis of their statistical properties, their potential for forecasting, and the results of ridge regression analysis.

SPONSOR

General Motors Corporation

AUTHOR

H. F. Gallasch, Jr.
General Motors Research Laboratories
Warren, Mich. 48090

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of the model is to study and estimate the impact of new car price, income, used car price, and gasoline price on auto demand.

RELATIONSHIP TO OTHER MODELS

No relationship to other operating forecasting models is indicated in the model report.

HISTORICAL BACKGROUND

The author notes that the majority of automobile demand studies have been primarily concerned with testing various theories of durable goods demand. The Gallasch model was developed to pay more attention to structural parameter estimates such as income, new car price, used car price, and fuel price.

ASSUMPTIONS

The model assumes that demand depends on income, new car price, used car price, gasoline price, and unemployment. Seasonal dummies are

included as right hand variables. Ridge regression estimation was used to test the effect of multicollinearity in the explanatory variables.

VALIDATION

The parameter estimates are compared with other estimates that have appeared in the economics literature. The elasticities of the Gallasch model compare favorably with other historical elasticities (price and income). It is reported that one estimated equation has an average forecasting error of 14% which is equivalent to 100 thousand units on a monthly basis.

LIMITATIONS AND BENEFITS

A limitation of the model is that since the model is monthly, its use as a policy analysis tool is rather limited due to the extreme short-run nature of the model. Short-run cyclical factors dominate the model as expected. A benefit is that a fairly innovative estimation technique, ridge regression, is employed.

STRUCTURE

Single equation models are examined. Both static and dynamic equations are estimated. The equations are all of the form:

$$X = A (P_{nc}^{\alpha_1}) (P_{uc}^{\alpha_2}) (P_g^{\alpha_3}) (Y^{\alpha_4}) \\ \times \exp[B(U) + \sum_{i=1}^{12} G_i (D_i)]$$

where:

X = new car sales (domestic and imports)

A = constant term

P_{nc} = new car price with coefficient α_1

P_{uc} = used car price with coefficient α_2

P_g = gasoline price with coefficient α_3

Y = disposable income with coefficient α_4

U = unemployment rate with coefficient B

D_u = monthly dummy variables with coefficients G_i

MODEL CONSTRUCTION

The model is calibrated using monthly data for 1967-75, including:

- 1) New car registrations from the Survey of Current Business (Department of Commerce),
- 2) Consumer Price Index for new cars from the Department of Commerce,
- 3) Consumer Price Index for used cars from the Department of Commerce,
- 4) Gasoline price from the Petroleum Publishing Company,
- 5) Income from the Department of Commerce, and
- 6) Unemployment rate from the Department of Commerce.

DATA USED IN RUNNING MODEL

For future projections, forecasts of the independent variables are required. For within-sample validation, the historical data are required.

REFERENCE

Gallasch Jr., H.F., Elasticities of demand for new automobiles, Research Laboratories, General Motors Corporation, May 21, 1976.

DECISION ANALYSIS OF AUTO EMISSION CONTROL

A model of Auto Emission Control was prepared in 1976 at Stanford University, with the objective of providing a general analytical framework to examine automobile emissions as a social problem. Specifically, a driver behavior model is used to compare the effects of "direct regulation" policies and "market" policies in correcting the auto emission problem.

AUTHOR

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Stanford, Calif. 94305

KEYWORDS

Emissions, economic impact

OBJECTIVE OF MODEL

The objective of the model is to evaluate the social costs and benefits of alternative emissions control strategies.

RELATIONSHIP TO OTHER MODELS

There is no formal, direct relationship to other models. However, much of the data used in Judd's model comes from Dewees' work on automobile air pollution. See, for example, Donald W. Dewees, Economics and Public Policy: The Automobile Pollution Case. Cambridge, Mass., MIT Press, 1974.

HISTORICAL BACKGROUND

The study was prepared as the author's Ph.D. thesis in Engineering-Economic Systems at Stanford University. Dr. Judd is now at Applied Decision Analysis, Inc. in Menlo Park, California.

ASSUMPTIONS

Numerous assumptions are made concerning vehicle type, vehicle size, vehicle age, operating costs, emission control devices, vehicle depreciation, willingness to pay to reduce automotive emissions by 50%, emissions taxes, gasoline taxes, etc. These are outlined in Chapter 4 of the model report.

VALIDATION

Sensitivity analysis with respect to the parameters of the model was conducted. It is concluded that auto emissions standards are not the most socially beneficial of regulatory alternatives, as compared to gas taxes, emissions taxes, or to no controls.

LIMITATIONS AND BENEFITS

A limitation of the analysis is that the numbers generated by the model are illustrative and are intended only to produce insight into which factors are most important in choosing among emission control plans. Thus, the model is not meant to be used as a forecasting tool per se. A benefit of the model is that it explicitly deals with issues traditionally not quantified, such as values derived from motoring and the social willingness to pay for eliminating pollution.

STRUCTURE

There are two main models used in the analysis, a driver model and a breather model. These interact to yield a social profit indicator for each emissions control policy considered. The principal components of the driver model are: demand curve generator, supply curve generator, vehicle evaluation, market trading, new vehicle prices, and driver profit computation. The breather model does not have any submodels.

MODEL CONSTRUCTION

The model was constructed using data sources which are documented in Appendix A of the model report. The Los Angeles area was used as the subject area for study.

DATA USED IN RUNNING MODEL

To run the model, projections or assumptions about the data used in the construction of the model are required.

REFERENCE

Judd, B.R., Decision analysis of auto emission control, doctoral dissertation at Stanford University, Dept. of Engineering-Economic Systems, May 1976.

COMPUTER REQUIREMENTS

The computer model code, written in FORTRAN, is listed in Appendix C of the dissertation. Appendix D has computer output for years 1976-1980.

THE MOTOR VEHICLE/HIGHWAY NOISE MODEL

The Motor Vehicle/Highway Noise Model was reported in "A Study of the Magnitude of Transportation Noise Generation and Potential Abatement," a seven-volume report which includes an assessment of transportation-noise-abatement problems and their potential solutions. It was written in 1970 by Serendipity, Inc. under sponsorship of the U.S. Department of Transportation.

SPONSOR

U.S. Department of Transportation
Office of the Secretary
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AUTHOR

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KEYWORDS

Noise pollution

OBJECTIVE OF MODEL

The objective of the Motor Vehicle/Highway Noise Model is to estimate the noise generated as a result of alternative traffic flows and vehicle mixes and to evaluate the effectiveness of noise abatement alternatives.

RELATIONSHIP TO OTHER MODELS

There is no apparent relationship to other models.

HISTORICAL BACKGROUND

The model was developed under U.S. Department of Transportation sponsorship as a part of their program to assess noise problems stemming from all modes of transportation.

ASSUMPTIONS

The model is based on the following simplifying assumptions:

- 1) The sound source is omni-directional.
- 2) Sound rays travel in a straight line on the shortest path between predefined points.
- 3) The phase phenomenon of sound is omitted from consideration.
- 4) When the air absorption option is used, no extreme conditions of temperature or relative humidity will prevail.
- 5) Any excess attenuation will occur over a ground strip parallel to the road element.
- 6) The reflection surfaces are flat and rigid so that no resonance due to barrier vibration occurs.
- 7) The road element is straight.
- 8) The direction edge is a straight line.
- 9) Sufficient accuracy is maintained by separating a continuous sound spectrum into eight octave bands.
- 10) No sound distortions such as from shielding and focusing occur due to the presence of other highway vehicles.

VALIDATION

No validation of the model was reported in the model report.

STRUCTURE

The model is a generalization of the motor vehicle-highway system which contains the following three elements: noise source, noise paths, and receiver. Primary calculations in the model are performed in the main loop of the computer program which consists of a series of five hierarchical loops. The eight-octave band spectrum values at each of the receiver points from all source points through each designated path are calculated here.

MODEL CONSTRUCTION

The model is based on empirical noise relationships.

DATA USED IN RUNNING MODEL

Inputs to the model include descriptions of the roadbed and adjoining barriers in terms of widths, heights, and placement angles; absorption spectra for road surfaces (optional); noise source spacing (or vehicles per hour per lane); percentages of vehicle types (optional); receiver

points; sound ray behavior; sound path; and air absorption and excess attenuation values (optional).

REFERENCE

A study of the magnitude of transportation noise generation and potential abatement, Final Report, Vol. I--Summary, Serendipity, Inc., Report No. OST-ONA-71-1, November 1970. NTIS No. PB-206 067.

A study of the magnitude of transportation noise generation and potential abatement, Final Report, Vol. IV--Motor Vehicle/Highway System Noise, Serendipity, Inc., Report No. OST-ONA-71-1, November 1970. NTIS No. PB 203 185.

COMPUTER REQUIREMENTS

The computer program is written in FORTRAN IV for the Burroughs 5500 computer. The users' manual for the model program is Appendix A of Vol. IV of the report, cited above.

MODELING THE DEMAND FOR AUTOMOBILES IN THE UNITED STATES

A model of the Demand for Automobiles in the United States was written in 1977 as a dissertation at The University of Michigan. The general objective of the model is to improve upon the typical single-equation models of auto demand by increasing the number of endogenous variables considered (e.g., market segment new car demand, new car price, and used car price).

AUTHOR

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KEYWORDS

Auto demand, market share, vehicle miles traveled (VMT), pricing

OBJECTIVE OF MODEL

The objectives of developing this model are as follows:

- 1) To build an operational forecasting model of automobile demand, or, at the very least, to provide the foundation for a model that could be used in an ex-ante forecasting program.
- 2) To expand the single-equation models of auto demand typically found in the literature. This includes improving the specification of auto demand per se as well as increasing the number of endogenous variables in the model (e.g., market segment new car demand, new car price, and used car price).
- 3) To incorporate the following distinguishing features into an integrated demand model:
 - a) The change in the supply of unsold new cars is assumed to influence new car demand through its impact on new car price.
 - b) The used car market is assumed to affect new car demand through used car prices.
 - c) The model determines the composition of new car sales by three basic market segments: domestic small (wheel base under 112"), domestic large (wheel base 112" and over), and imports (foreign-type cars and captive imports; domestics produced in Canada are excluded).

RELATIONSHIP TO OTHER MODELS

There is no direct operating relationship to other models.

HISTORICAL BACKGROUND

The model was developed as the author's doctoral dissertation in Economics at The University of Michigan. The author is now with the Ford Motor Company.

VALIDATION

Two types of evaluation exercises are reported in the paper. First, the dynamic properties of the new car price equation are analyzed. In particular, it is shown that increases in the retail price of new cars are almost exactly proportional to increases in the wholesale price of new cars in the long run. Second, the forecasting behavior of the new car demand equation is analyzed. Both within-sample and post-sample predictions are considered. The equation performs quite well in the within-sample period (1969.1-1971.4) with a mean absolute percentage error of less than one percent. For the post-sample period (1972.1-1974.4) the predictions of the equations are not as accurate as those from within the sample. However, this is to be expected, based on the econometric methods employed. The root mean squared error for the post-sample period is 560,000 units, which is not completely out of line with the standard error of estimate of 330,000 units.

LIMITATIONS AND BENEFITS

The limitations of the model are:

- 1) Although not specifically mentioned in the paper, the inventory equation of the model has a definite tendency to underpredict domestic new car inventory levels. This may be caused by an unfortunate specification of the equation in which inventory levels were assumed to depend on the natural logarithm of domestic new car sales.
- 2) Most of the equations of the model were fitted with data only through the third quarter of 1973 (the new car price equation is an exception, being fitted through 1974.4). This was done intentionally to avoid having to take into account the disruptive effects of the Arab oil embargo in the specification and estimation of the model. However, it also limits the usefulness of the model for forecasting, since the model does not understand the large increases in automobile operating costs that have occurred since 1973. Thus the model needs to be refitted with more recent data.

The benefits of the model are:

- 1) The approach to the modeling of the market segments is unique in

terms of the public literature. The segments are viewed as an example of the problem of seemingly unrelated regressions and are specified in such a way that the adding-up problem is avoided. In addition, the market segments display some very interesting dynamic properties with respect to changes in income or the unemployment rate.

- 2) The model also explains and predicts a number of auto market variables that are generally neglected in models of auto demand (e.g., new car price, used car price, inventories).

STRUCTURE

The model contains nine endogenous variables that are explained in stochastic equations. They are: retail new car price, retail used car price, new car demand, market segment new car demand (domestic small, domestic large and imports), domestic new car inventories, used car stock, and vehicle miles traveled (VMT). In addition, there are two identities that explain total domestic new car demand and total small new car demand.

The change in the supply of unsold new cars is assumed to influence new car sales through its impact on new car price. New car price at the retail level is explained as a function of the wholesale price for new cars and the recent change in inventory levels. This establishes feedback from new car demand to retail price. A loop is created between new car demand, inventories, and retail price. Essentially what has been done is to endogenize new car price. Most auto demand models treat price as exogenous.

The used car market is assumed to affect new car demand through used car prices. An increase in used car prices, other things equal, will lower the net purchase price of a new car and stimulate demand. New car sales, in turn, impact on the stock of used cars held by franchised new car dealers. Finally, used car prices are negatively correlated with the level of the used car stock. Circularity has been established between new car demand, used car stock, and used car prices.

The model determines the composition of new car sales by market segments defined on the basis of length of wheelbase: domestic small (wheelbase under 112"), domestic large (wheelbase 112" and over), and imports (foreign-type cars and captive imports; domestics produced in Canada are excluded).

MODEL CONSTRUCTION

The model was built with quarterly data generally available from the following sources: Survey of Current Business, Wards Automotive Reports, Automotive News, Motor Vehicle Manufacturers Association Statistics Department.

77-064

DATA USED IN RUNNING MODEL

Values for all the exogenous variables are necessary to simulate the model over any time period.

REFERENCE

Luckey, M.M., Modeling the demand for automobiles in the United States, in An Overview of Simulation in Highway Transportation, Simulation Councils Proceedings Series, Vol. 7, Number 1, June 1977, pp19-25.

COMPUTER REQUIREMENTS

The model may be run using the MIST (Michigan Interactive Simulator of Time Series) simulation program at The University of Michigan.

MANUFACTURING ASSESSMENT SYSTEM

Automotive Data Base for Manufacturing Assessment System was prepared by Rath and Strong, Inc. in 1975 for the U.S. Department of Transportation, Transportation Systems Center. The purpose of the study was to develop a computer based methodology to evaluate the impact on manufacturing resources in the automotive and truck industry of various alternative vehicles and implementation plans. A basic concept employed in the report is to group products and their component resources according to how they are made rather than how they are sold or used.

SPONSOR

U.S. Department of Transportation
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AUTHOR

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Rath and Strong, Inc.
Boston, Mass.

KEYWORDS

Vehicle manufacturing resource utilization, automobile design, pricing

OBJECTIVE OF MODEL

The objective of the Manufacturing Assessment System is to develop a computer based methodology and data base capable of analyzing the impact on manufacturing resources of various alternative vehicle designs and configurations.

RELATIONSHIP TO OTHER MODELS

This model is a part of the DRI Motor Vehicle Assessment System.

HISTORICAL BACKGROUND

This report expands the National Academy of Sciences/Committee on Motor Vehicle Emissions II data base completed in December 1974. The added data elements include after-market usage and prices, reliability and life cycle maintenance costs and quality costs. Improved structural elements consist of a more detailed component definition of the body and drive system. The model was originally developed for use by the Transportation Systems Center in the Automotive Energy Efficiency

Program (AEEP).

ASSUMPTIONS

The basic assumption underlying the entire data base and model is that the auto industry can be analyzed by identifying the significant products, components, and supporting resources used in the manufacturing and assembly of vehicles. More specifically, the data base is structured around the concept of how a product is made rather than how it is sold or used. The data base and model attempt to describe and analyze the manufacturing process in the automobile industry.

LIMITATIONS AND BENEFITS

Much of the data used in the areas of cost and resource utilization are now out of date and subject to considerable change in the future as the auto companies develop new products and manufacturing technologies. This implies that the ability of the model to predict the cost and resource utilization of future vehicle configurations depends on a continual updating of the data.

STRUCTURE

The Manufacturing Assessment System is composed of the following data bases:

- 1) Product Data Base, the identification of the end item vehicles and the components.
- 2) Resource Data Base, the identification of the facilities and tooling required to manufacture the components and assemble the vehicles.
- 3) Product-Resource Master Data Base, the cross reference or chaining data base to establish the relationship of the products to the proper resource.
- 4) Configuration and Cost Data Base, the specific data base of the end item vehicle and all the components that comprise the vehicle configuration. The manufacturing costs are included in this data base for use in the development of vehicle sticker prices.
- 5) Retrieval Number Data Base, the significant part numbering or coding system used in the identification of specific vehicle configurations.
- 6) Fuel Economy, Emission, Maintenance, Mileage Patterns Data Base, the end item vehicle performance data that is used in the simulation programs for the determination of total operating costs.

MODEL CONSTRUCTION

The data sources used to build some of the data bases are documented in the model report; however, some are undocumented.

REFERENCE

Lindgren, L.H.; Fitzgibbons, R.G., Automotive data base for manufacturing assessment system, Rath and Strong, Inc. for DOT/TSC No. 803, June 1975.

URBAN TRAFFIC CONTROL SYSTEM--PROGRAM 1 SIMULATION MODEL (UTCS-1 MODEL)

The Urban Traffic Control System - Program 1 Simulation Model, dated February 1976, was prepared by Honeywell, Inc. for the Federal Energy Administration and the Federal Highway Administration (FHWA). The purpose of the model is computer simulation testing of traffic control scenarios to determine the effects of various traffic conditions, network configurations and traffic control policies on the consumption of fuel by vehicles in a network. The impact on fuel consumption of one-way streets, a pedestrian scramble system, fixed-time and actuated traffic signals, signal controller cycle lengths, traffic volume levels, and exclusive bus lanes was examined.

SPONSOR

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U.S. Department of Transportation
Federal Highway Administration
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AUTHOR

Honeywell, Inc.
Honeywell Traffic Management Center
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Hopkins, Minn. 55343

KEYWORDS

Fuel economy

OBJECTIVE OF MODEL

The basic objective of the model is to study the impact on vehicle fuel consumption of various traffic control strategies, including one-way streets, a pedestrian scramble system, fixed-time and actuated traffic signals, signal controller cycle lengths, traffic volume levels, and exclusive bus lanes.

The UTCS-1 model simulates traffic operations on street networks. This model was originally designed to assist in developing traffic control strategies for use on the TCS network in Washington, D.C. It is, however, a general-purpose model, and can be applied to a wide range of networks and traffic conditions.

RELATIONSHIP TO OTHER MODELS

There is no direct operating relationship to other models.

HISTORICAL BACKGROUND

The UTCS-1 simulation model reported here is an in-house FHWA model and was provided to Honeywell by the FHWA. The basic model was not developed by Honeywell, Inc., although they did make the following modifications to the model for use in their research.

- 1) Rather than storing vehicle trajectories on a mass storage device for later use, trajectories are used at each program time step to compute values for fuel consumption efficiency and emissions for each vehicle.
- 2) The capability of the program was expanded to permit simulation of up to 160 links, 85 nodes, and 20 actuated intersections.

ASSUMPTIONS

The following traffic control scenarios were run on the model

- 1) one-way/two-way streets
- 2) pedestrian scramble system
- 3) fully actuated versus pre-timed signal systems
- 4) comparisons of cycle lengths
- 5) variations in traffic demand
- 6) exclusive bus lanes

For each scenario, the specific input assumptions actually used in running the UTCS-1 Model are detailed in Section 3 of the model report.

VALIDATION

The principal results of the research with respect to each simulation experiment follow. The impact on fuel consumption of each traffic control strategy is stated:

- 1) One-Way/Two-Way Streets: On average, fuel consumption efficiency (FCE) in vehicle miles per gallon is estimated to increase by 12 percent as a result of changing some two-way streets to one-way streets in the UTCS network in Washington, D.C.
- 2) Pedestrian Scramble System: The use of a pedestrian scramble system implemented by an all-red interval is estimated to decrease

fuel consumption efficiency (FCE) by 35-48 percent, depending on the level of turning movements in the traffic flow.

- 3) Fully Actuated vs. Pre-Timed Signals: Fully actuated signals are estimated to increase FCE significantly, based on data for M Street in Washington, D.C. with a main-street/cross-street volume ratio of 7:1. The improvement in FCE was inversely related to the amount of cross-street traffic.
- 4) Cycle Lengths: FCE is estimated to increase as cycle length is increased.
- 5) Traffic Demand: The simulation results indicate that FCE in an urban network is inversely related to vehicle traffic demand, as expected.
- 6) Bus Traffic: The simulation results showed that the addition of bus traffic to an arterial caused a decrease in FCE. The results also indicated that auto traffic is penalized (longer delays, more fuel consumed) by the use of exclusive bus lanes.

STRUCTURE

The UTCS-1 model operates by generating vehicles at the input sources as specified by the input data. The position, speed, and acceleration of each vehicle generated is recorded in the simulation data base. Vehicles move throughout the network according to the rules that drivers observe when on a traffic network; for example, vehicles turn in proportion to the probabilities included for each intersection, and they switch lanes according to demands imposed by congestion and the need to execute turning movements. In addition, urban bus operation, pedestrian interference, and short-term, disruptive events such as taxicab pickups and stalled vehicles can be readily simulated. Regression analysis was performed with which it was determined that fuel consumption efficiency is most highly correlated with average network speed and can be predicted by the equation:

$$FCE = 0.142 (S) + 3.61$$

where:

FCE = fuel consumption efficiency in miles per gallon

S = average network speed in miles per hour

MODEL CONSTRUCTION

This is a network-based accounting model using traffic generation and directional data collected by the Federal Highway Administration.

DATA BASE USED IN RUNNING MODEL

Typical input data requirements include description of network geometry, network characteristics, and the signal control strategies. Data inputs must also describe the traffic stream itself, including the volumes of traffic entering or leaving at the periphery of the network and at midblock sources and sinks, and the percentage of turning movements at each intersection in the test network. While not required, the following types of inputs can be applied usefully: the percentage of truck and bus traffic in the network, bus route descriptions, and similar types of information.

REFERENCE

Fuel consumption study. urban traffic control system (utcs) software support project, Honeywell Inc., prepared for FHWA, Report No. FHWA-RD-76-81, February 1976. NTIS No. PB-259 003.

A summary description of UTCS-1 simulation model is available from: Dr. Guido Radelat, Office of Research HRS-31, Federal Highway Administration, Washington, D.C. 20590.

Preliminary documentation of additions to the utcs-1 model to provide estimates of vehicular fuel consumption emissions, KLD Associates, Inc., for FHWA under contract DOT-FH-11-8251, August 1975.

AUTOMOTIVE FLEET FUEL CONSUMPTION MODEL (FUEL)

The Automotive Fleet Fuel Consumption Model (FUEL) is an accounting model to evaluate the potential fuel conservation benefits attributable to the implementation of various hypothetical schedules of automotive fuel efficiency. The model was developed at the Transportation Systems Center and used by the National Highway Traffic Safety Administration in support of the 1981-84 passenger automobile average fuel economy standards, and reported in "Passenger Automobile Average Fuel Economy Standards," Federal Register, June 1977.

This model is an updated version of the Highway Fuel Consumption Model (74-006).

SPONSOR

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AUTHOR

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Transportation Systems Center
Energy Programs Division

KEYWORDS

Fuel Consumption

OBJECTIVE OF MODEL

The objective of the model is to evaluate potential fuel conservation benefits attributable to the implementation of various hypothetical schedules of automotive fuel economy. Benefits are reported in terms of (1) annual fuel savings (billions of gallons), (2) cumulative fuel savings (billions of barrels), and (3) discounted cumulative cash savings (billions of dollars).

RELATIONSHIP TO OTHER MODELS

This model has no direct relationship to other models.

HISTORICAL BACKGROUND

The model was constructed specifically to analyze the relative fuel conservation benefits of various schedules of automotive fuel economy for the NHTSA standards issued 6/30/77. It replaced the Fleet Accounting Model (76-007) in this function.

This model is an updated version of the Highway Fuel Consumption Model (74-006 and 74-037C)

STRUCTURE

The FUEL model is an accounting model. It calculates fuel consumption during year i by all vehicles of age j , FC_{ij} , with the following formula:

$$FC_{ij} = \frac{(REG_k) (VM_j) (SURV_j)}{(FE_k)}$$

where:

i = calendar year index

j = vehicle age index

$k = i - j + 1$ = model year index

FC_{ij} = fuel consumption by all vehicles of age j during year i

REG_k = new car registrations of model year k

VM_j = yearly travel of cars of age j

$SURV_j$ = likelihood of a new car surviving to age j

FE_k = average new car fuel economy of model year k .

Total fleet fuel consumption during year i , SFC_i , is obtained from:

$$SFC_i = \sum_{j=1}^{15} FC_{ij}$$

MODEL CONSTRUCTION

Five sets of data required to run the FUEL model are presented in the model report. They are:

- 1) New car registrations by model year
- 2) Miles traveled annually by car as a function of its age

77-067

- 3) Schedule of vehicle survivability as a function of age
- 4) Average new car fuel economy by model year for existing fleet
- 5) Hypothetical "baseline" new car fuel economy by model year

DATA USED IN RUNNING MODEL

The user must supply a schedule of hypothetical "improved" new car fuel economy by model year.

REFERENCE

Horton, J.R., Automotive fleet fuel consumption model: FUEL:FOR, Final Report, TSC, Report No. DOT-TSC-NHTSA-78-1, March 1978.

URBAN AREA AUTOMOBILE EMISSIONS ACCORDING TO TRIP TYPE

A model of Urban Area Automobile Emissions According to Trip Type was prepared in 1974 by staff at the Environmental Protection Agency and the University of Alaska under the sponsorship of the Transportation Research Board. It may be used with traffic survey data in a metropolitan area to predict the emissions generated according to trip purpose. This information can be used for planning transit improvements to reduce emissions.

SPONSOR

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Fairbanks, Alaska 99701

KEYWORDS

Emissions

OBJECTIVE OF MODEL

This model predicts the amount of pollutant emissions that are produced by motor vehicles according to trip purpose in a metropolitan area. This information can be used to identify the strategies for reducing vehicle trips and miles traveled that would most effectively reduce emissions.

RELATIONSHIP TO OTHER MODELS

There is no apparent relationship to other models.

HISTORICAL BACKGROUND

The model was applied to data from two metropolitan areas: Allegheny County, PA (Pittsburgh), (reported in 1974), and Washington, D.C., (reported in 1976).

ASSUMPTIONS

Data used were from large-scale traffic surveys done in Washington in 1968 and in Pittsburgh in 1967. It was assumed that the relative traffic patterns were the same in 1975 when the emissions estimates were made.

VALIDATION

No known effort was made to validate the model results.

LIMITATIONS AND BENEFITS

The model predicts only the total amount of emissions by trip type, not their distribution. The information can be used in planning transit improvements. For example, it was found that in Washington, D.C. improvements in long-range suburban bus service would reduce emissions, while in Allegheny County, Pa. demand-response bus service to the central area would be advised.

STRUCTURE

The model structure is as follows:

$$E_p = E_p(1) + E_p(2) + E_p(3)$$

$$E_p(1) = L \sum_{i=n-16}^n [e_{ip} d_{ip}(n-i) m(n-i) \\ \times S_{ip}(v) + K_{ip} m(n-i)]$$

$$E_p(2) = \alpha \sum_{i=n-16}^n C_{ip} d_{ip}(n-i) m(n-i)$$

$$E_p(3) = \sum_{i=n-16}^n h_{ip} m(n-i)$$

where:

E_p = emissions of pollutant p, kg

$E_p(1)$ = running emissions of pollutant p, kg

$E_p(2)$ = cold-start emissions of pollutant p, kg

$E_p(3)$ = hot-soak evaporative emissions of pollutant p, kg (non-zero for hydrocarbons only)

L = trip length, miles

n = calendar year 1975

e_{ip} = low-mileage running exhaust emissions of pollutant p by car of model year i, kg/mile

$d_{ip}(n-i)$ = deterioration factor for pollutant p by car of model year i when it is n-i years old

$m(n-i)$ = fraction of VMT attributable to cars of model year i in calendar year n

$S_{ip}(v)$ = speed adjustment factor for trip speed v

K_{ip} = crankcase emissions of pollutant p by car of model year i, kg/mile (non-zero only for hydrocarbons)

α = 1 if trip begins with a cold start, 0 otherwise

C_{ip} = low-mileage cold-start emissions for car of model year i, kg

h_{ip} = hot-soak evaporative emissions of pollutant p by car of model year i, kg (non-zero for hydrocarbons only)

MODEL CONSTRUCTION

This is an accounting model, for which the emissions rates used come from a variety of sources cited in the model documentation.

DATA USED IN RUNNING MODEL

To run the model, data on trip purpose, direction, and length are needed for the entire metropolitan area.

REFERENCE

Horowitz, J.L.; Pernela, L.M., Analysis of urban area automobile emissions according to trip type, Transportation Research Record 492, pp. 1-8, 1974.

Horowitz, J.L.; Pernela, L.M., Comparison of automobile emissions based on trip type in two metropolitan areas, Transportation Research Record 580, pp. 13-21, 1976.

NOISE ANNOYANCE IMPACT ALGORITHM

The Noise Annoyance Impact (NAI) Algorithm was developed at McMaster University and presented in an article in the Transportation Research Record 580, 1976, entitled, "Toward a Community Impact Measure for Assessment of Transportation Noise." The purpose of the algorithm is to provide procedures to assess the total impact on a community of transportation-produced noise. A sample application was presented to clarify the discussion and demonstrate the practicability of the noise annoyance impact measure.

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KEYWORDS

Noise pollution

OBJECTIVE OF MODEL

The objective of the algorithm was to provide procedures for identifying the total impact on a community of transportation-produced noise. The noise annoyance impact measure was developed for measuring the total impact in a variety of units, such as the total number of people annoyed, the total monetary cost of the noise annoyance, etc.

RELATIONSHIP TO OTHER MODELS

There is no direct relationship to other models.

HISTORICAL BACKGROUND

The authors state that concern about the noise produced by transportation facilities has led to better techniques for measuring and predicting noise, but procedures are needed to incorporate the information into an overall assessment of the noise impact on the community of a new transportation facility.

ASSUMPTIONS

The model assumes that the sensitivity to noise of the sample population is similar to that of the whole population. It further assumes that the population annoyed by a given noise at a given location can be represented by a single function.

VALIDATION

There is no validation of the algorithm. Rather a sample application of noise study data was used to clarify the discussion and demonstrate its practicability.

STRUCTURE

The noise annoyance impact measure (NAI) is calculated as a double integral function of an appropriate measure of noise at a particular location, the density of people at that location, and a function that describes the annoyance effect of a given level of noise on people and that will change according to the units chosen to express NAI (e.g., total number of people annoyed, total monetary cost of the noise annoyance, etc.).

MODEL CONSTRUCTION

This is a physical accounting model.

DATA USED IN RUNNING MODEL

Values of the following independent variables of the equation are necessary to calculate the noise annoyance impact measure: population density at point (x,y); measure of noise at point (x,y); and annoyance effect of the noise on the population expressed in total number of people annoyed, total monetary cost of the noise annoyance, or any other appropriate unit.

REFERENCE

Hall, F.L.; Allen, B.L., Toward a community impact measure for assessment of transportation noise, Transportation Research Record 580, pp. 22-35, 1976.

AIRPOL-4

AIRPOL-4 was designed by the Virginia Highway and Transportation Research Council and is presented in Transportation Research Record 580, 1976. The model report compares the predictive and cost performances of AIRPOL-4 with those of two other air pollution models: CALAIR (California Division of Highways) and HIWAY (U.S. Environmental Protection Agency). The results demonstrate that the predictive capability and reliability of AIRPOL-4 are generally superior to those of the other two models.

SPONSOR

Virginia Department of Highways and Transportation
Charlottesville, Va.

AUTHOR

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Virginia Highway and Transportation Research Council
Charlottesville, Va.

KEYWORDS

Air pollution/air quality

OBJECTIVE OF MODEL

The objective of AIRPOL-4 is to predict carbon monoxide (CO) concentrations in the vicinity of roadways.

RELATIONSHIP TO OTHER MODELS

There is no direct relationship to other models.

HISTORICAL BACKGROUND

AIRPOL-4 was developed as an improvement to two existing air pollution models. The existing models (CALAIR and HIWAY) were cumbersome and expensive to use. They were, furthermore, generally inaccurate and tended to severely overpredict pollution levels in the critical cases of low wind speeds and small road-wind angles.

ASSUMPTIONS

The basic assumption of the model is that of the Gaussian line-source formulation.

VALIDATION

The predictive performances of three models (AIRPOL-4, CALAIR, and HIWAY) were evaluated against measured data. The variables considered included wind speed, road-wind angle, atmospheric stability class, source height, and receptor location. Data from five sites in Virginia were used.

Three criteria were used in analyzing the predictive capabilities of the three models. First, mean squared errors were examined and compared among the three models. Second, regressions of actual values on predicted values were run and studied. Third, 100% confidence limits on the prediction errors were constructed.

The results demonstrated that the predictive capability and reliability of AIRPOL-4 are generally superior to those of the other two models.

LIMITATIONS AND BENEFITS

It is significantly more cost effective to use AIRPOL-4 than CALAIR or HIWAY; the Gaussian formulation, however, is not capable of analyzing highway sections that are elevated by earthen fill.

STRUCTURE

The basic structure is that of a Gaussian line-source air pollution model.

MODEL CONSTRUCTION

AIRPOL-4 is a physical system model.

DATA USED IN RUNNING MODEL

Data describing the site, traffic volumes, speeds, percentage of heavy duty vehicles, and wind direction and speed are collected to run the model.

REFERENCE

Carpenter, W.A.; Clemena, G.C., Evaluation and comparison of three air pollution prediction models, Transportation Research Record 580, pp. 76-89, 1976.

Carpenter, W.A.; Clemena, G.G., Analysis and comparative evaluation of AIRPOL-4, Virginia Highway and Transportation Research Council, Rept. VHTRC 75-R55, May 1975.

MANUAL MODEL TO PREDICT HIGHWAY RELATED CARBON MONOXIDE CONCENTRATIONS

A Manual Model to Predict Highway Related Carbon Monoxide Concentrations, dated April 1975, was prepared by the Southeast Michigan Council of Governments and the Michigan Department of State Highways and Transportation and sponsored by the U.S. Department of Transportation. The model, making use of information generally available to a highway planning agency, predicts whether a transportation facility could violate the National Ambient Air Quality Standards in southeast Michigan. Carbon monoxide concentrations are predicted and used as an indicator for other pollutants. The model is adapted from the computerized California model developed by Beaton, Skog, Ranzieri, which is now superseded by CALINE-2 (76-084).

SPONSOR

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Michigan Department of State Highways and Transportation
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KEYWORDS

Air pollution/air quality, emissions

OBJECTIVE OF MODEL

The model is intended to predict whether a transportation facility would violate the National Ambient Air Quality Standards. It is a manual model that uses information readily available to highway planners so that alternative facilities can be quickly evaluated for possible violations for carbon monoxide and other pollutant concentration standards. Carbon monoxide concentrations are predicted and used as an indicator for other pollutant violations, such as nitrogen dioxides and hydrocarbons.

RELATIONSHIP TO OTHER MODELS

This manual model is an adaption of the computerized California air pollution model developed by Beaton, Skog, and Ranzieri in a report entitled, Meteorology and Its Influence on the Dispersion of Pollutants from Highway Line Sources, Vol. I, 1972.

ASSUMPTIONS

The basic assumption of the model is twofold: pollutants are immediately expanded to cell size, based on the mechanical mixing cell theory; and pollutants are then diffused by Gaussian equations to predict concentrations away from the cell.

The model further assumes that ambient pollutant concentrations are proportional to total emissions. The model does not consider spatial and temporal characteristics of air pollutants.

VALIDATION

The model report does not discuss any validation procedures.

LIMITATIONS AND BENEFITS

The primary benefit of the model is its manual characteristics. The look-up tables for levels of pollutant concentrations can easily be used to indicate areas where more refined analysis is needed.

The major limitations of the model are that it is not a precise predictor of carbon monoxide concentrations and other pollutants and that it is a model apparently only valid for a specific region.

In addition, more complex methods are needed because the model calculates the pollutant concentrations based on the worst meteorological and use situations. Its intended use is as an early tool in transportation planning, not as a final analytical tool.

STRUCTURE

The model has two main equations. The first equation incorporates meteorological, traffic, mixing cell, and carbon monoxide emission variables to determine the carbon monoxide concentrations.

$$C_{mmc} = \frac{(1.06) (1.73 \times 10^{-7}) (VPH) (EF) (SAF)}{(4.24) (u) (\sin P)}$$

where:

C_{mmc} = the pollutant concentration within the mechanical mixing cell

75-071

VPH = vehicles per hour

EF = the appropriate emission factor

SAF = a speed factor to adjust emissions

u = wind speed in meters/second

SinP = the sine of the wind direction

The empirical factors represent the following adjustments:

(1.06) relates the concentration increase in the mechanical mixing cell due to vertical vehicular turbulence

(1.73×10^{-7}) accounts for all unit changes in the equation, modifying it so that the resultant unit is in grams per cubic meter

(4.24) relates the concentration decrease in the mechanical mixing due to horizontal vehicular turbulence

For concentrations away from the mixing cell the Gaussian diffusion equations for height and horizontal distance are used to adjust the calculated mixing cell concentration:

$\exp[-1/2 (\frac{H}{sz})^2]$ is used to adjust for elevated sections

$\exp[+1/2 (\frac{Z}{sz})^2]$ is used to adjust for depressed sections

$\exp[-1/2 (\frac{Y}{sy})^2]$ is used to adjust for horizontal distance

where:

H = height of elevated section above the receptor in meters

Z = depth of the depressed section below the receptor in meters

Y = normal distance from the receptor to the nearest edge of the highway in meters

sz = horizontal turbulent parameter in meters

sy = vertical turbulent parameter in meters

MODEL CONSTRUCTION

This is a physical systems model.

DATA USED IN RUNNING MODEL

The model requires the following input variables to predict concentration of carbon monoxide: the year of the prediction, the number of vehicles in the vehicle population on the highway section, the percentage of heavy-duty vehicles in the vehicle population, the average speed of the vehicles, and the vertical and horizontal distance of the receptor from the highway section.

REFERENCE

Doctor, D.A., A manual model to predict highway related carbon monoxide concentrations, Southeast Michigan Council of Governments, Transportation Working Paper No. 15, April 1975. NTIS No. PB-245 407/2.

COMPUTER REQUIREMENTS

There are no computer requirements since this is a manual model.

LIGHT-DUTY EMISSION AND CONTROL COST SIMULATION MODEL

The Light-Duty Emission and Control Cost Simulation Model was prepared by Mathematica, Inc. for the Motor Vehicle Manufacturers Association (MVMA) in 1975. In general terms, the model may be used to examine the cost and the likely consequences for air quality of alternative policies and strategies for the control of pollution from mobile sources.

SPONSOR

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AUTHOR

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KEYWORDS

Air pollution/air quality, emissions, vehicle user costs/vehicle operating costs

OBJECTIVE OF MODEL

The objective of the model is to estimate the costs and effectiveness of alternative policies for achieving cleaner air. Policy alternatives examined can be evaluated according to two principal criteria: (1) the direct and indirect costs, including capital outlay and operating expenditures, and (2) the effectiveness in improving ambient air quality.

RELATIONSHIP TO OTHER MODELS

There is no direct operating relationship to other models.

HISTORICAL BACKGROUND

MVMA's purpose in sponsoring the study was to have an independent and objective evaluation of alternative policies to abate pollution from motor vehicles. Unlike other studies of mobile-source pollution control, the effort was to focus on the question of how can the timely abatement of pollution be encouraged rather than on questions about justifying any particular set of pollution standards or timetables for compliance.

LIMITATIONS AND BENEFITS

Limitations of the model include the following. (1) The roll-back methodology used in the ambient air quality submodel neglects knowledge about the spatial and temporal diffusion of pollution. (2) No estimates are made of the costs and effectiveness of policies designed to reduce VMT. (3) Possible changes in emission control costs over time as learning and technical change occur are not considered. (4) Pollution problems related to mobile source emissions such as noise, lead emissions, and sulfates are not included.

Benefits of the model include: (1) the capability to qualitatively analyze the economic strengths and weaknesses of current air pollution control policy; and (2) the capability to analyze alternative policies for reducing ambient air pollution and estimate the cost-effectiveness of such policies.

STRUCTURE

The model is exercised as follows. A particular strategy or set of strategies is specified along with its impact on light-duty vehicle emission rates, emission control device costs, fuel costs, VMT growth factors, etc. Then, based on data on emissions per mile of travel by light-duty motor vehicles, emissions are computed. Stationary source emissions and emissions from other vehicles and from aircraft are specified exogenously. This yields total emissions. A roll-back model is used to convert emissions figures to an estimate of their effect on ambient air quality. Capital costs and the present value of operating costs of each strategy are also calculated. The aggregation of these costs along with the effect on ambient air quality provides the basis for an assessment of the cost-effectiveness of various strategies.

There are three basic submodels contained in the full model:

- 1) Emissions Model: The emissions model combines detailed calculations of emissions for light-duty vehicles with simple growth projections of emissions from heavy-duty vehicles, motorcycles, aircraft, and stationary sources.
- 2) Ambient Air Quality Model: The ambient air quality model uses the roll-back methodology. This approach is based on the assumption that ambient concentrations less any background concentrations are proportional to total emissions.
- 3) Cost Model: The cost model evaluates the present value of the capital, operating, and maintenance costs associated with control devices applied to new and used vehicles over the simulation period.

MODEL CONSTRUCTION

Data presented in the report used to construct the model include: vehicle miles of travel, light-duty vehicle emissions factors, speed correction factors, alternative engine emissions, retrofit device effectiveness, scrappage, new car registrations, speeds, emissions from other sources, costs of controls and alternative engines, etc.

DATA USED IN RUNNING MODEL

There are two types of input data to the model. The first set reflects the impact of a particular strategy or set of strategies. This type of data includes vehicle emission rates, emission control device costs, fuel costs, etc. These inputs are then combined with the second type of data, namely, those that do not vary with the strategies being simulated. These include stationary source emissions, travel growth factors, etc.

REFERENCE

Policies to abate pollution from motor vehicles: an evaluation of some alternatives, Mathematica, Inc., July 1, 1975, 2 volumes.

AUTOMOBILE AND GASOLINE DEMAND MODEL

The Automobile and Gasoline Demand Model was prepared in 1975 for the Motor Vehicle Manufacturers Association (MVMA) by Data Resources, Inc. and The University of Arizona. The model was designed to determine the impact of alternative fuel economy policies on new car sales, gasoline consumption, and new car prices.

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KEYWORDS

Fuel consumption, automobile demand, pricing, market share

OBJECTIVE OF MODEL

The objective of the model is to determine the impact of alternative fuel economy policies on new car sales, the composition of new car sales, gasoline consumption and used car prices.

RELATIONSHIP TO OTHER MODELS

There is no direct relationship to other models.

ASSUMPTIONS

The following basic assumptions are the foundation of the gasoline and auto demand model:

- 1) The demand for new cars is determined indirectly as a function of the desired number of car miles to be traveled.
- 2) The number of new cars sold is an input to a set of segment

equations which determines the composition of new car sales in terms of weight, horsepower, etc.

- 3) In the long run the ratio of used car prices to new car prices is determined by the gasoline efficiency of used cars relative to the gasoline efficiency of new cars and the cost of maintenance.
- 4) The demand for gasoline is derived from the demand for travel.

VALIDATION

There is no validation of the model since it had not been estimated with actual data in the report.

LIMITATIONS AND BENEFITS

The authors report that the model possesses the following benefits:

- 1) The demand for new cars and the demand for gasoline are approached in the framework of an integrated model that sees both demands as being derived from the demand for motor-car transportation.
- 2) The demand for an equilibrium car stock (which itself derives from the demand for a desired number of car-miles to be traveled) is formulated as a function of the level of income and the user-cost of motor-car travel.
- 3) A shortfall of actual car stocks from desired car stocks is assumed to affect the demand for new cars through the used car market rather than directly.
- 4) The short-run demand for gasoline is derived from the selection of a utilization rate of the existing car stock.

STRUCTURE

The model reported is an analytical model of gasoline and auto demand. As presented, it is ready to be estimated and tested, but this has not been done because of limited resources.

The model contains four main components:

- 1) Demand for new cars
- 2) Determination of used car prices
- 3) Composition of new car sales
- 4) Demand for gasoline

A typical equation specification is:

$$E_T = M_T \sum_i \frac{q_i e_i}{M_{Li}} + \frac{1}{M_T} \sum_j \sum_i s_i r_{ij} m_{ij} g_{ij}$$

where:

E_T = average total energy consumed per mile in period T

M_T = total demand for car miles in period T

q_i = number of vehicles of type i of all vintages on the road in period T

e_i = amount of energy input into construction of a vehicle of type i

M_{Li} = expected number of total miles of vehicle of type i over its lifetime

s_i = share of vehicles of type i in total sales

r_{ij} = percentage of cars of type i of vintage j remaining on the road in period T

m_{ij} = average miles per period driven by a vehicle of type i and vintage j

g_{ij} = average gallons per mile consumed by a vehicle of type i and vintage j

MODEL CONSTRUCTION

An estimation of the model was not done; therefore no data were used in building the model.

DATA USED IN RUNNING MODEL

It is not clear what data are necessary to run the model.

REFERENCE

Taylor, L.D.; Verleger, P.K.; Hirtzel, C.W., The welfare effects of fuel economy policies, July 1975. The report is available from MVMA or through NTIS.

AUTOMOBILE DEMAND EQUATIONS

Several automobile demand equations were estimated by Alan C. Hess of the University of Washington and published in Econometrica, April 1977. The models were built to investigate three main issues: the length of the household planning horizon; the range of substitution among assets; and the relative importance of substitution and wealth effects. The equations were estimated over the same set of data to reflect different assumptions about the planning horizon and range of substitutions among assets.

AUTHOR

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KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of the models is to answer the following questions concerning automobile stock demand: (1) whether the household is better viewed as planning over a single-period or a multi-period horizon; (2) whether the household is better viewed as planning in a single-asset or a multi-asset framework; and (3) what is the relative importance of substitution and wealth effects as sources of change in the stock demand for automobiles. It was not an objective to build an operational simulation model.

RELATIONSHIP TO OTHER MODELS

There is no direct relationship to other operating forecasting models.

ASSUMPTIONS

The basic assumption from which the alternative household automobile demand equations in this study are derived is that the goal of the household is to maximize the value of a lifetime utility function which is the sum of each period's utility discounted by a time preference parameter.

VALIDATION

There is no validation outside the sample period for the various equations. Within-sample summary statistics are presented. Elasticities for several alternative equation specifications are calculated.

STRUCTURE

Four basic single-equation specifications were examined. They were:

- 1) Multi-period, multi-asset model.
- 2) Multi-period, single-asset model.
- 3) Single-period, single-asset model.
- 4) Single-period, multi-asset model.

The multi-period, multi-asset model was judged to be superior to the other three specifications. The following additional conclusions were drawn: (1) the household is better viewed as planning over a multi-period as compared to a single-period horizon with respect to automobile stock demand; (2) the household is better viewed as substituting between consumption, autos, durable goods, and housing rather than just between consumption and autos; and (3) substitution effects have larger impacts on auto stock demand than do wealth effects. In comparison with the wealth effects, substitution effects account for approximately seven times more of the variation in auto stock demand.

MODEL CONSTRUCTION

The data base used to estimate the model includes implicit price deflators for autos, other goods, residences, and personal consumption, inflation rates, interest rates, disposable income, wealth, households, and real stock of autos.

DATA USED IN RUNNING MODEL

An operational forecasting model was not constructed.

REFERENCE

Hess, A.C., A comparison of automobile demand equations, Econometrica, April, 1977, pp. 683-701.

77-074

COMPUTER REQUIREMENTS

Not applicable.

ESTIMATING AUTO EMISSIONS OF ALTERNATIVE TRANSPORTATION SYSTEMS

Estimating Auto Emissions of Alternative Transportation Systems, dated April 1972, was written by the Metropolitan Washington Council of Governments under the sponsorship of the U.S. Department of Transportation. The objective of the model is to estimate the magnitude of carbon monoxide, hydrocarbons, and oxides of nitrogen from automobile emissions for alternative regional transportation systems. The estimates are made relative to the baseline of no improvements in the transportation system, i.e., zero-control strategy.

SPONSOR

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KEYWORDS

Emissions, air pollution/air quality, vehicle miles traveled, automobile demand

OBJECTIVE OF MODEL

The objective of the model is to estimate the magnitude of carbon monoxide, hydrocarbons, and oxides of nitrogen from automobile emissions for alternative regional transportation systems.

RELATIONSHIP TO OTHER MODELS

There is no direct relationship to other models. However, a portion of the program logic is based on model development by the Tri-State Transportation Commission for estimating highway facility requirements.

HISTORICAL BACKGROUND

The introduction to the model report states that the model was developed to bring social and environmental factors into the decision-making framework that engineering concerns enjoy.

ASSUMPTIONS

The major assumption is that air pollutant emissions rates are a function of the age distribution of automobiles, average emissions factors of autos of age t, vehicle miles traveled, and socio-economic characteristics of the population. Truck emissions rates were not considered to be a significant part of total emission rates, and therefore, are not part of the model. Various assumptions were made about the layout of different highway systems and transit alternatives.

VALIDATION

There are no validation procedures discussed in the model report.

LIMITATIONS AND BENEFITS

The primary benefit of the model is its simplicity. It is an analytical tool which can be used to rapidly evaluate the relative magnitude and location of auto emissions for alternative regional transportation systems.

A major limitation of the model results from the method of constructing traffic volumes. These volumes were determined from relationships between vehicle-miles of travel, the use of different types of facilities, vehicle trip origin density, and expressway capacity. This bypassed the traditional and expensive process of determining origins and destinations for all future trips, assigning them to links in the network, and estimating speeds on each link. Therefore, estimates of traffic volumes only represent average conditions across each sub-area. The full range of operating conditions found within a sub-area is not modeled.

STRUCTURE

The model consists of the following three sub-models:

- 1) The trip generation submodel computes vehicle trip origins by sub-area from socio-economic data and transit system characteristics.
- 2) The travel description submodel computes vehicle miles of travel (VMT) and speeds by the highway facility type from vehicle trip origin estimates and highway supply data.
- 3) The pollutant emissions submodel estimates the carbon monoxide, hydrocarbon, and nitrogen oxides emissions rates for each sub-area from average speed and VMT data.

DATA USED IN RUNNING MODEL

The following categories of data are required to run the model: vehicle trip origins, population, employment, automobile ownership, vehicle miles of travel, vehicle ages, highway system description, automobile emission rates, sub-area description, and transit system alternatives.

Descriptions of future highway facilities are required for alternative highway analysis and estimates of air pollutant emissions rates.

REFERENCE

Berwager, S.D.; Wickstrom, G.V., Estimating auto emissions of alternative transportation systems, Report No. DOT-05-20004, April 1972. NTIS No. PB-208 914.

COMPUTER REQUIREMENTS

The model programs are operational on an IBM 360 Model 50.

MATHAIR

MATHAIR was prepared in 1976 by MATHTECH, Inc. for the Corvallis Environmental Research Laboratory, U.S. Environmental Protection Agency. The model enables the user to perform experiments evaluating the impact of air pollution control strategies in different geographic regions. For each particular strategy, the model calculates both the effect on air quality and the dollar benefits and costs associated with that strategy for a user-specified geographic region. The calculations are made relative to a baseline of zero-control strategy.

SPONSOR

U.S. Environmental Protection Agency
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KEYWORDS

Air pollution/air quality, emissions, vehicle miles traveled, modal split.

OBJECTIVE OF MODEL

The objective of the MATHAIR Model is to estimate the impact of strategies for controlling mobile source air pollution for both the effect on air quality and the associated benefits and costs (in dollars).

RELATIONSHIP TO OTHER MODELS

There is no direct operating relationship to other models. However, parameters estimated by Charles River Associates of Cambridge, Mass., in a study of Pittsburgh (March 1972) were used to calibrate the Transportation Model of MATHAIR.

HISTORICAL BACKGROUND

MATHAIR was developed to be used as an analytical tool in the ever-present controversy over air pollution standards.

ASSUMPTIONS

One important assumption of the model is that the benefits of a particular air pollution control strategy are calculated in dollar terms. It is therefore possible to calculate the net benefits of any particular strategy since costs are also in dollars. Many models and analyses of air pollution control only estimate their benefits in physical terms, which then dictates a cost-effectiveness approach as opposed to a cost-benefit one.

VALIDATION

Sensitivity analysis was performed on MATHAIR to determine which inputs have a critical effect on strategy outcomes. The following three experiments were conducted:

- 1) The first experiment assumed an accelerated rate of removing automobiles from the stock. This was estimated to have a minimal effect on policy implications.
- 2) The second experiment simulated a set of "worst case" assumptions for Los Angeles: increased control device costs, low baseline dollar damages due to air pollution and low estimates of the pollutant reduction efficiencies of auto control devices. The combined impact of these assumptions resulted in a dramatic decrease in net benefits.
- 3) The last experiment simulated three versions of the strictest control strategy, each containing a different transportation control measure. The marginal cost of the strategy exceeded the marginal benefit in all cases.

Several of the output series of the transportation model were compared with an independent data series. It was shown that the percentage of trips predicted by the model originating in central city or suburb by mode is similar in four major metropolitan areas to figures from the 1974 Urban Transportation Factbook.

LIMITATIONS AND BENEFITS

A unique feature of MATHAIR is that it includes, on the cost side, the cost incurred when a traveler abandons his preferred mode of transportation and either switches to a less convenient mode or foregoes the trip altogether. Using the number and prices of different types of trips, the cost module of the model calculates the cost to travelers of reduced (or enhanced) mobility due to transportation control measures.

A limitation of MATHAIR is contained in the air quality module of the model. A simple linear rollback model is used for predicting air quality. This formulation is based on the assumption that ambient pollutant concentrations are proportional to total emissions. This approach fails to consider information on the spatial and temporal

diffusion of pollution. The estimated rollback coefficients may also be subject to considerable error since they are derived from data on pollution emissions and concentrations for a single base year.

STRUCTURE

MATHAIR consists of the following six modules (or sub-models):

- 1) Automobile Stock Module--computes the composition of the auto stock.
- 2) Transportation Model--forecasts vehicle miles of travel for each mode of transportation.
- 3) Emissions Module--calculates pollution emissions for mobile sources and stationary sources subject to the installation of control devices.
- 4) Air Quality Module--calculates ambient concentrations of the pollutants.
- 5) Benefits Module--calculates dollar losses due to pollution damage and the benefits (i.e., reduction in losses) with respect to a baseline case.
- 6) Cost Module--calculates the cost of implementing the control strategy.

The output of a MATHAIR simulation contains the following information:

- 1) Predicted emissions (tons/day) of carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides, and lead from automobiles, from all mobile sources, and from all stationary sources, respectively.
- 2) Predicted ambient concentrations (ppm) of carbon monoxide, nitrogen oxides, oxidants, and sulfur oxides and of lead (mean g/m^3).
- 3) Discounted costs and benefits for the strategy which has been simulated.

The outputs above are generated for each year of the simulation horizon. Additional output includes:

- 4) Discounted present value of benefits and costs over the complete forecast period.
- 5) Detailed output of the transportation module. This includes the number of passenger trips, passenger miles, and vehicle miles for each type of trip as well as mode-split and trip frequency probabilities.

MODEL CONSTRUCTION

MATHAIR is an accounting model.

DATA USED IN RUNNING MODEL

Six categories of data, corresponding to the six MATHAIR modules, are required for a MATHAIR simulation run. The data include: new auto registrations, scrappage, parking costs, trip length, speed, time and fare, modal split parameters, number of trips, vehicle occupancy, vehicle miles traveled, emissions factors and costs, control strategy costs, etc.

The input data required for the MATHAIR Model are described in detail in the model report.

REFERENCE

A computer simulation model for analyzing mobile source air pollution control, MATHTECH, Inc., Sept. 1976, EPA-600/5-76-100. NTIS No. PB-260 877.

COMPUTER REQUIREMENTS

All MATHAIR programs and data are stored as files on an IBM 371-68. The model can be accessed through the NCSS time-sharing computer network.

PRICING IN THE AUTOMOBILE INDUSTRY: A SIMPLE ECONOMETRIC MODEL

"Pricing in the Automobile Industry: A Simple Econometric Model" was written at Virginia Commonwealth University and Mary Washington College and published in the Southern Economic Journal, V. 43, No. 1, 1976. The purpose of the model is to test the importance of various cost factors and administered pricing in the determination of auto prices.

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KEYWORDS

Pricing

OBJECTIVE OF MODEL

The objective of the model is to test the relative importance of cost factors and anticipated market demand in the determination of auto prices.

RELATIONSHIP TO OTHER MODELS

There is no direct relationship to other models.

HISTORICAL BACKGROUND

The authors state the model was developed to contribute to the debate concerning the reasons for the increases in auto prices in 1974 and 1975 in spite of decreased sales volume.

ASSUMPTIONS

The model assumes that the wholesale price of new cars is a function of factor costs and anticipated growth in sales volume. It assumes also that pricing decisions for new car models are made in mid-summer, so the annual price index is constructed with July values.

VALIDATION

There is no validation of the model outside the sample period. The usual summary statistics (t-ratios and R^2) are presented with the estimated equation. Results of exercising the model are:

- 1) Factor costs and anticipated strength of domestic new car sales were found to be significant determinants of wholesale auto prices.
- 2) Factor costs were the most significant determinant of price changes.
- 3) Contrary to the administered pricing hypothesis, wholesale new car prices were estimated to be a direct function of anticipated market demand.
- 4) Market forces have become a stronger influence on new car prices more recently.

STRUCTURE

The single equation model is of the form:

$$P_t = A_0 + A_1 (V_t) + A_2 (C_{t-1})$$

where:

P_t = a wholesale price index for autos in year t

V_t = a variable indicating expected growth in sales volume in year t

C_{t-1} = a composite cost index for auto manufacturing

MODEL CONSTRUCTION

The model was estimated with annual data from 1953-1975.

Specific data are:

- 1) Bureau of Labor Statistics wholesale price index for new cars.
- 2) Published estimates of General Motors for approaching model year sales volume.
- 3) Bureau of Labor Statistics wholesale price index for materials in durable manufacturing.
- 4) Bureau of Labor Statistics series on gross hourly wage rates for the motor vehicle and parts industry.

76-080

DATA USED IN RUNNING MODEL

Historical data or assumed future values for the independent variables are necessary to generate predictions for the wholesale price index for new cars.

REFERENCE

Hoffer, G.; Marchand, J.; Albertine, J., Pricing in the automobile industry: a simple econometric model, Southern Economic Journal, Vol. 43, No. 1, 1976.

THE MOTOR VEHICLE EMISSION AND COST MODEL (MOVEC)

The Motor Vehicle Emission and Cost Model (MOVEC), published in December 1973, was developed by the Rand Corporation as part of the Clean Air Project of San Diego County's Environmental Development Agency under the sponsorship of the U.S. Environmental Protection Agency. The MOVEC model permits an evaluation of alternative light-duty motor vehicle retrofit and inspection/maintenance strategies. For specified strategies, the total annual costs (both purchase and operating) are calculated for the region.

SPONSOR

County of San Diego
Office of Environmental Management
Environmental Development Agency
(under a grant from the U.S. Environmental Protection Agency)

AUTHOR

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KEYWORDS

Air quality, emissions, economic impact, vehicle user costs/vehicle operating costs.

OBJECTIVE OF MODEL

The Motor Vehicle Emissions and Cost Model (MOVEC) was developed for use in analyzing the impact of motor vehicle emissions on an urban region. The main purpose of MOVEC is to analyze light-duty motor vehicle emissions for any specified calendar year between 1960 and 1999. Several attendant features of the model are that it:

- 1) applies user-specified additional emission control strategies to vehicles in selected 1955-1974 model years;
- 2) calculates the total annual costs that a region would incur by mandating a particular retrofit-inspection/maintenance control strategy;
- 3) calculates the distribution of costs among various income groups for three different payment schemes by which the cost of the control strategy might be funded;
- 4) plots four emission parameters for various pollutants versus annual cost of different strategies for a given calendar year; and

- 5) plots four emission parameters versus calendar year for a time history of the region with a given control strategy in force.

RELATIONSHIP TO OTHER MODELS

MOVEC is one of several models developed by the Rand Corporation to identify strategies for meeting of the National Air Quality Standards in San Diego as specified by the 1970 Amendment to the Clean Air Act. The models and methods were designed to emphasize breadth rather than depth of impact. Although the models were designed to San Diego's particular characteristics, they have been made purposely general enough for use in similar studies of other regions. The methodology and models used in the Clean Air Project include:

- 1) Fixed Source Analysis Techniques to evaluate the cost and effectiveness of controls on fixed sources;
- 2) MOVEC evaluates the cost and effectiveness of retrofit and inspection/maintenance strategies for in-use vehicles;
- 3) Transportation Model evaluates the costs and effects of transportation management strategies;
- 4) Bus System Cost Model evaluates the annualized costs of providing a particular quality and quantity of bus service for a region;
- 5) Tradeoff Model evaluates retrofit-inspection/maintenance control strategies and transportation management strategies for a given fixed source control strategy;
- 6) Air Quality Model determines the percentage reduction in base year (1970) emissions required to meet each air quality standard;
- 7) Larsen Model estimates how air quality varies between different parts of the region; and
- 8) Total Base Year Emissions compiles a 1970 emissions inventory estimating both fixed and mobile sources.

ASSUMPTIONS

The following explicit assumptions were noted in the model report:

- 1) The vehicle population and mileage distributions by age of vehicle are static;
- 2) The vehicle emissions for each model year are described by average emission factors for exhaust, evaporative, and blowby sources expressed in terms of grams per mile;
- 3) The full implication of a control strategy is assumed to occur wholly within one analysis year, and annualized costs are

calculated on that basis;

- 4) Deterioration and speed correction factors apply only to the exhaust emissions, while crankcase blowby and evaporative emissions remain at the level specified for a new vehicle;
- 5) 1975 and later model year vehicles are excluded from retrofit strategies because they are assumed to meet the federal emission standards for hydrocarbons, carbon monoxide, and the California standards for oxides of nitrogen with original equipment;
- 6) It is assumed that a linear relationship exists between ambient pollutants and total emissions; and
- 7) It is assumed that certain emission species serve as proxy for ambient concentrations of other species; reactive hydrocarbons for oxidant, nitrogen oxides for nitrogen dioxide, and sulfur oxides for sulfur dioxides.

VALIDATION

The model report does not discuss specific validation efforts for this model.

LIMITATIONS AND BENEFITS

A unique feature of the MOVEC model is the flexibility of its data base. MOVEC is structured to provide a computational framework that will readily permit new technical assumptions concerning emission factors, effectiveness of controls, costs, and other new data to be incorporated. Since the impacts of the control strategies are strongly dependent on the technical assumptions, it is important that MOVEC permits "latest" scientific information to be incorporated in analysis.

MOVEC is coupled to a computer graphics system which produces two kinds of plots: cost plots and time plots.

STRUCTURE

MOVEC consists of the following modules:

- 1) vehicle population distribution by age of vehicle;
- 2) vehicle mileage distribution by age of vehicle;
- 3) vehicle emissions without additional controls;
- 4) vehicle emissions under a control strategy;
- 5) incremental costs of a control strategy to the region; and

- 6) distributional impacts: costs to different income groups.

For a particular year and set of strategies, MOVEC reports the emissions by species (total and reactive hydrocarbons, carbon monoxide, nitrogen oxides, sulfur dioxide, lead and particulate matter) in the following way:

- 1) regional light-duty motor vehicle emissions;
- 2) regional reduction of light-duty motor vehicle emissions resulting from the control strategy;
- 3) total regional emissions from all sources;
- 4) total regional emissions in excess of the regional standards;
- 5) total regional annualized cost of the control strategies; and
- 6) distributional impacts by income group for financing the control strategies.

MODEL CONSTRUCTION

MOVEC is a physical accounting model.

DATA USED IN RUNNING MODEL

The data base necessary to run the model includes: effectiveness and cost of the light-duty motor vehicle retrofit and inspection/maintenance control tactics; vehicle population distribution by age of vehicle; vehicle mileage distribution by age of vehicle; new vehicle emission factors by model year; age-deterioration factors for exhaust emissions; speed correction functions for exhaust emissions; regional income distribution data; and vehicle ownership by income group.

REFERENCE

Mikilowsky, W.T., The motor vehicle emission and cost model (MOVEC): model description and illustrative applications, Rand Corporation, R-1364-SD/Appendix 2, December 1973.

Goeller, B.L., San Diego clean air project, Rand Corporation, R-1364-SD, December 1973.

COMPUTER REQUIREMENTS

MOVEC was developed on the IBM 370/158 computer and is designed to be coupled with an S-C 4060 computer graphics system. However, the graphics system is not required for most of the model output.

CALINE-2: CALIFORNIA LINE SOURCE DISPERSION MODEL

The California Line Source Dispersion Model, called CALINE-2, is designed to predict the level of carbon monoxide adjacent to, and dispersed from, a line source such as a highway. The latest version was developed in 1977 by the California Department of Transportation under the sponsorship of the Federal Highway Administration and may be used to assess the impact on air quality of proposed highway improvements.

SPONSOR

U.S. Department of Transportation
Federal Highway Administration
Offices of Research and Development
Washington, D.C. 20590

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KEYWORDS

Air pollution/air quality

OBJECTIVE OF MODEL

This model simulates the dispersion of carbon monoxide pollution from a line source, such as a highway, using the Gaussian dispersion theory. It is intended for use in assessing the impact on air quality of proposed transportation projects as a part of a required Environmental Impact Report.

RELATIONSHIP TO OTHER MODELS

There is no apparent relationship to other models.

HISTORICAL BACKGROUND

CALINE-2 is the second major version of the California Line Source Dispersion Model developed by the California Department of Transportation. It supersedes the earlier version, called CAL%DISP, developed in 1972.

ASSUMPTIONS

Gaussian dispersion equations are the basis of the model. The model assumes that winds are uniform, emissions are continuous, pollutants are dispersed from a region in the highway right-of-way called the "mixing cell," and predictions are only made above ambient levels.

VALIDATION

An air sampling study was done at four locations on the Los Angeles freeway system, and the observed dispersed pollution levels were compared with the predictions of the model using regression analysis. The model was found to predict best at sites with depressed roadways and parallel winds, but it generally came reasonably close to predicting actual conditions.

LIMITATIONS AND BENEFITS

This model as designed is suitable only for predicting the dispersion of carbon monoxide, but it represents the present state-of-the-art for this purpose. It predicts pollution levels only in the micro-scale area adjacent to the line source.

STRUCTURE

The general form of the Gaussian diffusion equation is:

$$C(x,y,z;H) = \frac{QF}{2\pi s_y s_z U} \left[\exp\left(-\frac{1}{2} \left[\frac{y}{s_y}\right]^2\right) \right] \\ \left[\exp\left(-\frac{1}{2} \left[\frac{Z+H}{s_z}\right]^2\right) + \exp\left(-\frac{1}{2} \left[\frac{Z-H}{s_z}\right]^2\right) \right]$$

where:

C = concentration, ppm or mean g/m³

x,y,z = receptor location in 3-dimensional space, meters

H = effective stack height, meters

Q = source strength, gms/sec

s_y,s_z = horizontal and vertical dispersion parameters, meters

U = mean wind speed, meters/sec

F = conversion factor to change input units to output units

The equation is varied depending on wind direction.

MODEL CONSTRUCTION

This is a physical model formulated on the basis of mathematical relationships.

DATA USED IN RUNNING MODEL

To run the model the following must be used for input: traffic volume, average emissions, wind speed and angle, surface atmospheric stability, pavement elevation and width, and receptor distance from the road and height from the ground.

REFERENCE

Ward, C.E., Jr.; Ranzieri, A.J.; Shirley, E.C., CALINE-2: an improved microscale model for the dispersion of air pollutants from a line source, California Department of Transportation, June 1977.

The report is reproduced in Assessing Transportation-Related Air Quality Impacts, Special Report 167, Transportation Research Board, p. 97, 1976.

COMPUTER REQUIREMENTS

The source program listing and sample runs are included in K.E. Jones and A. Wilbur, A User's Manual for the CALINE-2 Computer Program, Environmental Design and Control Division, Offices of Research and Development, Federal Highway Administration. A magnetic tape containing the program is available from NTIS. The program is written in FORTRAN IV.

DYNAMIC MODEL OF THE U.S. AUTOMOBILE FLEET

A Dynamic Model of the U.S. Automobile Fleet was prepared in 1977 by the Environmental Impact Center, Inc. for the Transportation Systems Center. Its purpose is to explain dynamically the properties of the overall U.S. automobile fleet.

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KEYWORDS

Fleet size

OBJECTIVE OF MODEL

The objective of the model is to simulate dynamically the properties of the automobile fleet, including new car sales, scrappage, and total fleet size. Equation specifications and estimates empirically developed in other studies were incorporated into this model.

RELATIONSHIP TO OTHER MODELS

Other work incorporated in the development of this model includes that of Rand (74-001A,B,C), Chase (74-002A,B), TSC, General Motors, etc.

HISTORICAL BACKGROUND

This model was developed under the Transportation Systems Center's Transportation Energy Efficiency Program.

ASSUMPTIONS

The automobile fleet was disaggregated by age only.

VALIDATION

Comparisons were made between the model's predictions and actual values for the years 1960, 1965, and 1970. The model did a poor job of predicting actual trends; this was judged by the model author to be due to the equation specifications by Rand. Sensitivity analyses were also performed.

LIMITATIONS AND BENEFITS

The relationships derived in previous studies lend empirical credence to the model. This was a test made to see if a group of independently estimated parametric relationships could be amalgamated. Most other models explicitly represent new car sales and fleet size with scrappage as the residual; this model tests the approaches of modeling scrappage and sales with fleet size as the residual and modeling scrappage and fleet size with sales as the residual. The model does not include a mechanism for limiting the growth of the fleet when a saturation point has been reached.

STRUCTURE

The fleet is disaggregated into the initial age group, which is dependent on new car sales, the intermediate age group, and the terminal age group. All three of these age groups feed into both the total fleet size and scrappage. Either fleet size, sales, and scrappage may be determined by varying econometric specifications, or one of them may be dynamically simulated as a result of the other two. For example, a typical equation is:

$$F_t = F_{t-1} + NCS_{\Delta t} - S_{\Delta t}$$

where:

F_t = fleet size at time t

F_{t-1} = fleet size at time t-1

$NCS_{\Delta t}$ = new car sales between t-1 and t

$S_{\Delta t}$ = scrappage between t-1 and t

MODEL CONSTRUCTION

Since this model is based on the estimates of other studies, no data were required to estimate it. The model is constructed using the System Dynamics approach to modeling, which was developed by the System Dynamics Group at the Massachusetts Institute of Technology.

DATA USED IN RUNNING MODEL

The following may be required input to the model: the price of new cars, the price of used cars, household income, the ten-year average of used-car prices, the effect of mileage on scrappage, the price of gasoline, the number of drivers per household, the average fleet fuel economy, and the initial stock of automobiles.

REFERENCE

Rabe, F.T., Dynamic models of the U.S. automobile fleet, Environmental Impact Center, Inc., prepared for U.S. Department of Transportation, under Contract No. TS-9961, August 1977.

COMPUTER REQUIREMENTS

This model is programed in the DYNAMO language, which is especially suited to the Systems Dynamics modeling approach. See A.L. Pugh III, DYNAMO Users Manual, 3rd Edition, MIT Press, 1967.

DETERMINANTS OF SCRAPPING RATES FOR POSTWAR VINTAGE AUTOMOBILES

A model of the Determinants of Scrapping Rates for Postwar Vintage Automobiles by Richard W. Parks was sponsored by the National Science Foundation and was published in Econometrica, July 1977. The model analyzes U.S. produced automobiles for the years 1947 through 1973. Probabilities that a car will be scrapped are dependent upon the car's age, make, relative cost of repairs, and durability characteristics.

SPONSOR

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AUTHOR

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KEYWORDS

Scrappage

OBJECTIVE OF MODEL

The objective of the model is to describe scrapping rates for U.S. produced automobiles as a function of the specific make, age, relative cost of repairs, and durability characteristics.

RELATIONSHIP TO OTHER MODELS

There is no direct relationship to other models.

HISTORICAL BACKGROUND

The responsiveness of scrappage rates to economic variables has important implications for attempts to regulate automobile characteristics, as cost changes brought about by regulations may have an effect on scrappage rates.

ASSUMPTIONS

The model is based on the following assumptions:

- 1) Durability characteristics are simplified into a single parameter called durability, represented by d , for all a -year old cars.
- 2) Cars of all ages provide the same level of transportation services.
- 3) Rental or service cost of a car is the interest rate multiplied by the present discounted value of the expected cost of providing a continual service plan.
- 4) Scrapping rate is described in terms of conditional probabilities, conditional on survival of the car to age a and increasing with age of car.

VALIDATION

The results of the study consist of regressions of the logit of postwar domestic automobile scrapping rates on economic and dummy variables. The ratio of new car prices to repair prices is the only significant observation-year variable. The regressions account for about 90 percent of the variation in the logit of scrapping rates for most makes. The age variables account for a major part of the variance in the dependent variables. The sets of vintage coefficients are significant for most of the makes. Registration data for 1973 were compared with predicted 1973 data for age and vintage variables. The predicted results were consistent with observed values at the 5 percent level of significance. The implications of the model are thus confirmed.

LIMITATIONS AND BENEFITS

The primary benefit of the model can be found in the scrappage function.

STRUCTURE

An econometric model is constructed which expresses the probability that a car will be scrapped as a function of the car's age, the relative cost of repairs, and the durability characteristics of the car. The durability characteristics are hypothesized to be influenced by economic variables anticipated at the time of manufacture. The scrappage rates are fitted to a logit function:

$$\ln\left(\frac{L_{mav}}{1 - L_{mav}}\right) = d_{mv} + age_{ma} + b_m + C_m \left(\frac{P_v}{q_t}\right)$$

L_{mav} = probability that a car of model type m , age a , and vintage v , will fail to survive to age $a + 1$.

d_{mv} = make-vintage dummy variable

age_{ma} = age dummy variable

b_m = constant term for model type m

C_m = coefficient

P_v = new car price index for vintage v cars

q_t = index of automobile repairs in year t

The age variable dominates the regressions, and the repair price variable enters significantly. The vintage variables also enter significantly in many of the regressions. However, the values of the vintage variables cannot be fully explained by movements in economic variables associated with the vintage year, as was hypothesized.

MODEL CONSTRUCTION

The following data were used to estimate the model: the number of automobiles registered in the U.S. cross-classified by make and model for years 1936-1967, from Automotive Industries Annual Statistical Issue and the R.L. Polk Company; the cost of new automobiles (Bureau of Labor Statistics Consumer Price Index, New Car Price, Series K-3); the index of the price of automobile repairs (Bureau of Labor Statistics, Consumer Price Index, Auto Repairs and Maintenance Index); the interest rate series for years 1924-1973; the index of price of scrap steel (constructed from the Pittsburgh price series for scrap steel reported in various issues of The Survey of Current Business).

REFERENCE

Parks, R.W., Determinants of scrapping rates for postwar vintage automobiles, Econometrica, Volume 45, No. 5, pp.1099-1115, July 1977.

CONSUMPTION OF GASOLINE BY HOUSEHOLDS

Two models are developed in the Rand study entitled "The Economic Impact of Automobile Travel Cost Increases on Households," to determine the effects of governmental policy options for conserving gasoline and improving air quality on families that own and operate automobiles in the United States. Specifically, the study is concerned with the income distribution effects of governmental policy options that may cause the costs of owning and operating a car to increase. These models were reported in 1977 and sponsored by the National Science Foundation and the Federal Energy Administration. The first model, Consumption of Gasoline by Households, which is described here, focuses on the initial impacts of an increased gasoline tax on households. The authors conclude that such a gasoline tax is regressive because the tax would be more of a burden to a poorer family than to more wealthy families.

The second model is described in 77-087B.

SPONSOR

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With additional Support from:
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KEYWORDS

Vehicle miles traveled, fuel consumption

OBJECTIVE OF MODEL

The purpose of this model is to examine the initial impact of gasoline price increases, specifically gasoline tax increases, on households of different incomes.

RELATIONSHIP TO OTHER MODELS

This model was developed in conjunction with the Household Expenditures on Automobile Ownership and Operation Model (77-087B).

HISTORICAL BACKGROUND

In the past the gasoline tax was commonly assumed to be extremely regressive. More recent studies conclude that a gasoline tax may not be regressive. However, most of these recent studies are limited because they use national or state aggregate data. The Rand study uses survey data disaggregated by household income levels. An analysis of these data provide better insight on whether a gasoline tax is regressive.

VALIDATION

To validate the model results, data from the National Personal Transportation Survey were used. The results of the validation effort indicated similar trends in the income elasticities by income group.

LIMITATIONS AND BENEFITS

The analysis assumes that all households within an income group have similar driving habits. This is certainly not true for lower income households since only one-half of these household have access to a car. Thus, half of these households would not share the burden of a gasoline tax and the other half would feel the tax more severely than indicated in the analysis.

STRUCTURE

Several small models are estimated. The model results are examined to determine the relationship between gasoline expenditures and household income.

Two results of the models are that (1) the income elasticity of household auto miles driven is near 1.0 for lower income families, and this elasticity decreases with income; and (2) the income elasticity of household gasoline consumption has a similar trend.

MODEL CONSTRUCTION

The data used to build the models were obtained from the 1973 Lifestyles and Energy Supply Survey collected by Response Analysis Corporation for the Washington Center for Metropolitan Studies.

Other data used in the analyses were Environmental Protection Agency estimates of automobile fuel economy, and 1969 and 1970 survey data from the Nationwide Personal Transportation Study of the U.S. Department of Transportation.

77-087A

REFERENCE

Stucker, J.P.; Kirkwood, T.F., The economic impact of automobile travel cost increases on households, R-1842-NSF/FEA, The Rand Corporation, July 1977.

HOUSEHOLD EXPENDITURES ON AUTOMOBILE OWNERSHIP AND OPERATION

Two models are developed in the Rand study entitled, "The Economic Impact of Automobile Travel Cost Increases on Households," to determine the effects of governmental policy options for conserving gasoline and improving air quality on families that own and operate cars in the United States. Specifically, the study is concerned with the effect on income distribution of governmental policy options that may cause the costs of owning and operating a car to increase. The models were reported in 1977 and were sponsored by the National Science Foundation and the Federal Energy Administration. The second model, Household Expenditures on Automobile Ownership and Operation, which is described here, was developed to evaluate possible tactics that car owners of different income groups may use to reduce their auto ownership costs in an attempt to offset an increase in fuel cost. The authors conclude that a powerful means of offsetting travel cost increases for all income groups is to purchase a new car with better-than-average fuel economy.

The first model is described in 77-087A.

SPONSOR

National Science Foundation
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With additional Support from:
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AUTHOR

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KEYWORDS

Vehicle user costs/vehicle operating costs

OBJECTIVE OF MODEL

The purposes of this model are to assess the effects of an increase in fuel price on households of different income groups and to evaluate possible tactics that owners may use to reduce their auto ownership costs in an attempt to offset a fuel cost increase. The tactics examined by the model are: (1) driving less, (2) using austere maintenance, (3) buying used cars, (4) eliminating second cars, and (5) buying new fuel-efficient cars.

RELATIONSHIP TO OTHER MODELS

This model was developed in conjunction with the Consumption of Gasoline by Households Model (77-087A).

HISTORICAL BACKGROUND

Past studies have arrived at estimates of auto ownership costs for all owners on the assumption of certain auto lifetimes and driving mileage. However, people in different income groups buy cars of different ages and drive them different amounts; and they may keep their cars in different states of repairs and carry different levels of insurance. This model addresses itself to these differences in ownership practices by different income groups.

ASSUMPTIONS

The estimates of the number of miles each car is driven assume that the average second-hand car is driven less as it gets older. However, once a car is purchased, it is assumed to be driven the same distance each year, as determined by the income groups and age of the vehicle, for as long as the car is kept.

STRUCTURE

The annual cost of ownership is given by:

$$A_t = P_t - P_{t+1} + r(P_t) + \frac{M}{y} + I + \frac{m(C)}{y(\text{mpg})} + 30.1$$

where:

A_t = annual ownership cost (dollars) of one auto in year t

P_t = value of car at beginning of year t

P_{t+1} = value of car at end of year t

M = total maintenance cost for y years

I = annual insurance cost

m = miles driven during the years the car is owned

C = cost of gasoline per gallon

r = interest rate = 7%

y = years car is owned

30.1 = national average annual cost of registration and license

mpg = car miles per gallon

The depreciation and maintenance costs are estimated for new and used car purchases for each income group. These two estimates are combined by weighting them in accordance with the fraction of new and used cars that each income group purchases.

MODEL CONSTRUCTION

New and used car prices were obtained from NADA Offices Used Car Guide, December 1970 and 1974.

Maintenance cost figures were based on Highway Research Board, Running Costs of Motor Vehicles Affected by Road Design and Traffic, National Cooperative Highway Research Program, Report III, Washington, D.C., 1971; also Consumer Reports, 1974.

Insurance costs are based on Consumer Reports, 1970.

DATA USED IN RUNNING MODEL

The right-hand-side variables of the equation for auto ownership cost must be specified for various income groups.

REFERENCE

Stucker, J.P.; Kirkwood, T.F., The economic impact of automobile travel cost increases on households, R-1842-NSF/FEA, The Rand Corporation, July 1977.

MODEL OF TRAFFIC NOISE

A Model of Traffic Noise was developed by Bolt, Baranek, and Newman under the sponsorship of the American Association of State Highway and Transportation Officials and the Federal Highway Administration in 1976. It is intended for use by highway planners in designing roads to meet noise level design standards in adjacent land use areas.

SPONSOR

American Association of State Highway and Transportation Officials
341 National Press Building
Washington, D.C. 20045

U.S. Department of Transportation
Federal Highway Administration
Washington, D.C. 20590

AUTHOR

B. Andrew Kugler, Daniel E. Commins, and William J. Galloway
Bolt, Beranek and Newman
Los Angeles, Calif.

KEYWORDS

Noise pollution

OBJECTIVE OF MODEL

This model predicts the noise level produced by highway traffic at selected observation points, given the volume and speed of traffic, the distance to the roadway from the observation point, and the physical configuration of the road and the surrounding landscape. A method is described by which highway planners can use the model to design roads and sound barriers or choose the alignment of new roads, so as to meet noise level standards for abutting land uses. The described method is intended to help highway planners comply with federal and state noise control legislation.

RELATIONSHIP TO OTHER MODELS

The user is advised to use first a "short method" involving hand calculations and nomographs to obtain gross approximations and identify potential problem areas. Then the "complete method" is used, involving the computer model and precise data input, to evaluate alternative road design features.

HISTORICAL BACKGROUND

This study is the fourth in a series of highway noise research studies carried out under the National Cooperative Highway Research Program.

ASSUMPTIONS

The noise emissions levels are assumed to be different for three classes of vehicles: automobiles, medium trucks, and heavy trucks. These values are derived from complex engineering studies of noise sources, including engines, exhaust systems, tires, etc.

VALIDATION

No validation efforts are presented in the report of the model.

LIMITATIONS AND BENEFITS

The model allows for a large variety of variables that may affect noise diffusion, and thus requires a complex set of input data to be prepared. The model deals primarily with changes to the physical environment rather than with changes to motor vehicles which may be made to minimize noise pollution. However, some discussion is devoted to changes in motor vehicles which may be made, but these potential alterations are not included in the model.

STRUCTURE

The model predicts L_{10} , the sound level in decibels that is exceeded 10% of the time, produced by an infinite line source. Adjustments are made for finite attenuated line sources, angle from source, road width variations, grades, curves, pavement type, imbalanced flow, differences in directional average speed, barriers, and differences in directional flow elevation. Those elements of the proposed roadway that are excessively noisy are identified, as are the shielding elements required at that point to reduce noise levels to the design goal.

MODEL CONSTRUCTION

This is a physical relationships model using a computational algorithm, with some adjustment to bring it in line with observed results.

DATA USED IN RUNNING MODEL

To run the model, the user must identify observer locations, roadway length and width, division into elements due to alignment, traffic

76-089

characteristics, ramps, shielding, and barriers.

REFERENCE

Highway noise-generation and control, Bolt, Beranek and Newman, National Cooperative Highway Research Program Report 173, Transportation Research Board, Washington, D.C., 1976.

Highway noise-a design guide for prediction and control, Bolt, Beranek and Newman, National Cooperative Highway Research Program Report 174, Transportation Research Board, Washington, D.C., 1976.

COMPUTER REQUIREMENTS

National Cooperative Highway Research Program Report 174 is a step by step guide to using the computer model and the "short method." The complete program, written in FORTRAN, is included.

DOT MODEL (VEHSIM)

A model of auto fuel economy, performance, and emissions, sometimes referred to as VEHSIM, was prepared at the U.S. Department of Transportation (DOT) in 1976. It simulates the performance of the automotive vehicle, and may be used to predict performance, fuel economy, and emissions, given changes in engine, vehicle, or driveline specifications. It was used by DOT in the Motor Vehicle Goals Beyond 1980 Study.

SPONSOR

U.S. Department of Transportation
Washington, D.C. 20590

AUTHOR

A.C. Malliaris, H. Gould, and E. Withjack
U.S. Department of Transportation
Transportation Systems Center
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KEYWORDS

Fuel economy, emissions, vehicle operating performance

OBJECTIVE OF MODEL

This model simulates the physical performance of an automotive vehicle, including its fuel economy, emissions, and acceleration rate, given its weight, engine type, type of transmission, and configuration.

RELATIONSHIP TO OTHER MODELS

This model has capabilities similar to those of GPSIM (72-017).

HISTORICAL BACKGROUND

An earlier version of this model was called VEHSIM.

ASSUMPTIONS

The performance fuel economy and emissions of a specified motor vehicle is simulated with steady state engine dynamometer-based data as it moves through a given driving cycle.

VALIDATION

Results of the simulation are compared with Environmental Protection Agency fuel-economy and emissions measurements. Fuel economy is predicted within five to ten percent of actual measurements, NO_x is within twenty-five percent, while there are substantial errors for CO and HC.

LIMITATIONS AND BENEFITS

The model is stronger in producing relative rather than absolute results. Fuel economy, acceleration performance and perhaps NO_x emissions can be adequately simulated. Because of engine transient effects, however, a larger uncertainty is attached to HC and CO absolute predictions.

STRUCTURE

This is an engineering model whose computations rely on analytically tractable aspects of auto operation and on extensive engineering test data of pivotal components. Equations involve force, acceleration, torque, engine speed, and vehicle load.

MODEL CONSTRUCTION

Detailed engineering test data regarding components and parameters of 1975 autos were used to build the model.

DATA USED IN RUNNING MODEL

Engine performance maps, including information on engine loads and speeds, specific fuel consumption, WOT performance, torque converter characteristics, gear and axle ratios, shift logics, rotating inertias, tire parameters and accessory loads are inputs to the simulation.

REFERENCE

Malliaris, A.C.; Withjack, E.; Gould, H., Simulated sensitivities of auto fuel economy performance and emissions, Society of Automotive Engineers Paper No. 760157.

DIFKIN PHOTOCHEMICAL POLLUTION DIFFUSION MODEL

The DIFKIN Photochemical Pollution Diffusion Model was developed by the General Research Corporation in 1976 under the sponsorship of the Environmental Protection Agency and the Department of Health, Education, and Welfare. It is intended for use by transportation planners in simulating the effects of a single segment of a transportation plan on the air quality of a metropolitan region.

SPONSOR

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National Air Pollution Control Administration
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Coordinating Research Council
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U.S. Environmental Protection Agency
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401 M Street SW
Washington, D.C. 20460

AUTHOR

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KEYWORDS

Air pollution/air quality

OBJECTIVE OF MODEL

This model simulates the transport, chemical reactions, and diffusion of pollutants in the region surrounding a highway. It is intended for use by transportation planners.

RELATIONSHIP TO OTHER MODELS

The DIFKIN Model is intended for use in project level comparisons--for testing the effects of a single segment of a local transportation plan. Other models would be used on a system level for simulating the effects of an entire transportation plan on the region.

HISTORICAL BACKGROUND

The authors began work on this subject in the late 1960s.

ASSUMPTIONS

This is a Lagrangian model that simulates a column of air travelling with the wind through a grid system in a metropolitan area.

VALIDATION

Sensitivity analysis of the model was done. It was found that the model was most sensitive to initial pollutant concentrations, reaction rate constants, and diffusivity coefficients.

LIMITATIONS AND BENEFITS

The model is not applicable for convergent or divergent wind flow fields, where vertical wind shear is involved, or for multi-day simulations.

STRUCTURE

A simplified mass continuity equation is solved for each vertical cell of the column of air as it moves along its trajectory. The mass concentration of the pollutant with respect to time, speed, and direction is calculated as a function of the vertical turbulent diffusion coefficient, the reaction (production/destruction) rate, and the source flux emission rate. The chemical module of the model contains sixteen chemical reaction equations.

MODEL CONSTRUCTION

Chemical reaction and kinetic diffusion equations were derived by the authors based on earlier work by themselves and others.

DATA USED IN RUNNING MODEL

Inversion base height, diffusivity coefficients, initial concentrations, and a trajectory must be input to the model.

REFERENCE

Allen, P.D.; Crews, W.B.; Ranzieri, A.J.; Shirley, E.C., Transportation systems and regional air quality--a DIFKIN sensitivity analysis, Office of Transportation Laboratory, California Department of Transportation, 1976.

Eschenroeder, A.Q.; Martinez, J.R., Concepts and applications of photochemical smog models, in Advances in Chemistry Series 113, 1972, pp. 101-168.

COMPUTER REQUIREMENTS

A run of the program on an IBM 370 costs about twenty dollars. A sample of data cards input to the program is provided in the Allen et al. report.

CONSUMER CREDIT AND CONSUMER DEMAND FOR AUTOMOBILES

A model of Consumer Credit and Consumer Demand for Automobiles was prepared at the University of Lowell, and the Environmental Law Institute and appeared in The Journal of Finance in March 1976. The objective of the model is to provide an alternative measure of consumer installment credit contract length and to test the explanatory power of the new variable as a determinant of automobile demand.

AUTHOR

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KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of the model is to develop an alternative estimation procedure for contract length of consumer installment credit and to test the explanatory power of the new series as a determinant of automobile demand.

RELATIONSHIP TO OTHER MODELS

There is no direct operating relationship to other models.

HISTORICAL BACKGROUND

Previous studies of the role of consumer installment credit have used the availability of credit as a determinant of consumer durable expenditure. The definition of average contract length used in these studies suffers from two deficiencies: contract length is biased when the volume of credit extended changes, and it is derived from an average of all outstanding credit rather than from a measure of current credit conditions. This model is designed to remedy these two deficiencies. Dr. Eastwood is now at the University of Tennessee in Knoxville.

VALIDATION

The statistical properties of the equation over the fit period are analyzed. No post-sample evaluations are conducted.

LIMITATIONS AND BENEFITS

The analysis is restricted to only one credit term, length of contract. No aggregate time series data are available for all three credit terms: the downpayment percent, the finance charge, and the length of contract. Since the authors must deal only with the length of contract, it is assumed that the average maturity is a measure of ease of credit in general.

A new method of estimating one of the terms of credit--length of contract--is developed. Theoretically it avoids the problem of the systematic bias contained in the average maturity for all outstanding debt. The new series is also desirable because it reflects current credit conditions, not a weighted average of current and existing loans.

STRUCTURE

The basic stock adjustment model of auto demand that was estimated is as follows:

$$S^* = a + b (Y) + c (Pd) + f (N^*)$$

where:

S^* = desired stock of autos

Y = real disposable income

Pd = relative price of autos

N^* = average maturity of new debt

The following relationships are used:

$$Cd = S - S_{-1} + D$$

$$S - S_{-1} = T(S^* - S_{-1})$$

$$D = e_1 (Cd) + e_2 (S_{-1})$$

where:

S = actual stock of cars

Cd = consumer durable expenditure for autos and parts

T = adjustment coefficient

D = replacement expenditure

e_1 = depreciation of current period expenditure

e_2 = depreciation of existing stock

The following basic stock adjustment equation is obtained:

$$Cd = T(S^* - S_{-1}) + e_1 (Cd) + e_2 (S_{-1})$$

The estimated results in the model report indicate that the new contract length series N^* , performs better in the model than the traditional contract length series which measures average maturity of all outstanding credit.

MODEL CONSTRUCTION

The model is not intended to be an operational simulation model to be used for ex-ante forecasting and policy analysis. The data sources used in building the model are the National Income and Product Accounts and the Federal Reserve Bulletin.

DATA USED IN RUNNING MODEL

Values for all the exogenous variables in the model are necessary to generate predictions for auto demand.

REFERENCE

Eastwood, D.B.; Anderson, R., Consumer credit and consumer demand for automobiles, The Journal of Finance, Vol. XXXI, No. 1, March 1976, pp. 113-123.

TSC HIGHWAY NOISE PREDICTION CODE: MOD-04

This report presents the latest version of the Transportation Systems Center prediction model of highway traffic noise, which was prepared by Science Applications, Inc. under the sponsorship of the Federal Highway Administration. The model estimates the acoustic intensity at a receiver location resulting from the noise on roadway segment.

SPONSOR

U.S. Department of Transportation
Federal Highway Administration
Office of Research, Environmental Design and Control
Washington, D.C. 20590

AUTHOR

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KEYWORDS

Noise pollution

OBJECTIVE OF MODEL

The objective of the model is to estimate the acoustic intensity at a receiver location resulting from the noise generated on a roadway segment.

HISTORICAL BACKGROUND

The computer code described is a documentation and revision of the 1974 version of the TSC Highway Noise Prediction Code. The 1974 version (MOD-03) is described in: Hinckley, R. and Steinberg, J., Manual for Highway Noise Prediction (Appendix B) Amendment, U.S. Department of Transportation, Federal Highway Administration, Report no. DOT-TSC-FHWA-72-1, October 1974.

VALIDATION

The results of the MOD-03 and MOD-04 versions are compared. The results indicate dramatic decreases in sound level estimates using the current MOD-04 version of the prediction code if the traffic flow comprises a significant mix of medium trucks to heavy trucks and if the

traffic flow speed is less than approximately 45 mph.

LIMITATIONS AND BENEFITS

In making a prediction with the MOD-04 version, the user should be aware of two limitations:

- (1) The noise emission levels contained within the program are based on cruise conditions and thus are not applicable to situations involving acceleration and grades. In these instances it is recommended that the 55 mph emission levels be used, that is, 82 dBA for medium trucks and 86 dBA for heavy trucks.
- (2) The model is capable of predicting noise levels for vehicle speeds as low as 20 miles per hour. It is recommended, however, that predictions not be made for speeds less than 30 mph. This limitation is recommended since the data base for determining levels in the 20-30 mph speed range is not complete.

STRUCTURE

The model predicts L_p , the sound level in decibels, for each receiver and each frequency band. The model also considers the variation of vehicle noise emission characteristics with vehicle speed. It considers four vehicle types: automobiles and light trucks, heavy trucks, medium trucks, and a user-defined vehicle.

MODEL CONSTRUCTION

This is a physical-relationships model based on acoustical science.

DATA USED IN RUNNING MODEL

To run the model the user must specify the following: (1) type of roadway; (2) vehicle type; (3) traffic flow conditions; and (4) the acoustic characteristics of the site.

REFERENCE

Rudder, F.F., Jr.; Lam, P., User's Manual, TSC highway noise prediction code: MOD-04, Federal Highway Administration Report no. FHWA-RD-77-18, 1977.

Rudder, F.F., Jr.; Lam, P., Update of TSC highway traffic noise prediction code, Federal Highway Administration, Report no. FHWA-RD-77-19, 1977.

COMPUTER REQUIREMENTS

The program is written in the FORTRAN IV language and is intended to be run in batch mode.

FUTURE AUTOMOBILE POPULATION STOCHASTIC MODEL (FAPS)

The Future Automobile Population (FAPS) Model is a stochastic model that can be used to investigate uncertainties involving future motor vehicle populations. It was developed in 1977 at the Highway Safety Research Institute of The University of Michigan and was sponsored by the Transportation Systems Center of the U.S. Department of Transportation. The model consists of the Wharton EFA Automobile Demand Model modified to use input from the authors' own scrappage model, which is based on both technological and behavioral information, and a procedure for incorporating uncertainty into the model by specifying future values of exogenous parameters of the model. A computer program of the FAPS Model was written and is documented in the author's report.

SPONSOR

U.S. Department of Transportation
Transportation Systems Center
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AUTHOR

D. Henry Golomb and Howard M. Bunch
University of Michigan
Highway Safety Research Institute
Ann Arbor, Mich. 48109

KEYWORDS

Automobile demand, scrappage, fleet size

OBJECTIVE OF MODEL

The objective of the model is to forecast the composition of future domestic vehicle populations by age and size-class for 1975 through 2000. A distribution of forecasts dependent upon subjective probabilities assigned to future planned and unplanned events is produced. A planned event is one which is controllable. An unplanned event is inherently non-controllable. This type of model facilitates the study of the uncertainties surrounding changes in the vehicle population when public policies and other strategies attempt to change the characteristics of future vehicle populations.

RELATIONSHIP TO OTHER MODELS

The FAPS model employs a revised version of the Wharton EFA Automobile Demand Model (77-046). The procedure for incorporating uncertainty into the model is based on an interview process developed at the Stanford Research Institute that is referenced in: Spetzler, C.,

Von Holstein, S., Probability encoding in decision analysis, Management Science, Vol. 22, 1975.

HISTORICAL BACKGROUND

The FAPS model was developed to overcome two problems with existing forecasting models of future vehicle populations. First, the authors considered existing scrappage models inadequate, and so constructed a different type of scrappage model. Second, existing vehicle population models did not consider the uncertainties in forecasting. The authors included in the FAPS model a procedure to incorporate the uncertainty of future values of exogenous parameters into the model.

ASSUMPTIONS

The parameters of the modified Weibull distribution, used to calculate the probability of scrappage by vintage and size-class, are assumed to be constant over time.

The authors acknowledge that behavioral hypotheses should be constructed for each type of vehicle. However, they formulated behavioral hypotheses which assumed that fluctuations in scrappage for all types of vehicles correspond to fluctuations in total scrappage.

VALIDATION

The accuracy of the new car sales and vehicle survival blocks of the model was tested by performing simulations over the historical period, 1960 to 1974, using each of the three forms of the behavioral equation for yearly scrappage. The historical values of total new car sales and scrappage were closely simulated. For market shares the results were less satisfactory, and the authors warn that the model's share predictions should be used carefully.

LIMITATIONS AND BENEFITS

The scrappage model and procedure for introducing uncertainty into the model represent the author's attempts to significantly improve the modeling of future vehicle populations. A limitation is that the procedure for incorporating the uncertainty of future events has not been tested. Furthermore, the procedure as formulated by the authors may be so complex that implementation of the procedure is not possible without considerable simplification.

STRUCTURE

The model is composed of three blocks: a revised version of the Wharton EFA Automobile Demand Model; the author's own model of vehicle survival; and a procedure for incorporating uncertainty into the model.

The Wharton EFA Automobile Demand Model is a complex econometric model involving about 600 variables. It is essentially a stock adjustment model. (For more detail see 77-046) The Wharton EFA Automobile Demand Model was revised by replacing all of its vehicle scrappage equations with the vehicle survival model. Its role in FAPS is to predict new car sales.

The model of vehicle survival combines two sets of hypotheses to generate estimates of total yearly scrappage, the number of vehicles by size class, and total number of vehicles. These estimates are then input to the Wharton EFA Automobile Demand Model. The two sets of hypotheses are: (1) technological, relating vehicle technology to scrappage, and (2) behavioral, relating public policies, economic conditions, travel patterns, and other variables to scrappage. Scrappage is calculated in two steps corresponding to these two sets. First, "expected scrappage" is calculated based on a modified Weibull distribution, representing the authors' technological hypotheses. Second, "expected scrappage" by vintage and size-class is modified such that the sum of the modified scrappage by vintage and size-class equals the total scrappage predicted by one of three behavioral equations. The computer program prompts the user to choose a behavioral equation.

The procedure for incorporating uncertainty into the model is two-part. First, future events, planned and unplanned, must be represented in terms of the exogenous variables of the FAPS model. Second, the unpredictable nature of unplanned events must be described. Scenario trees are used to model alternative futures. Probabilities can then be calculated for each possible sequence of planned and unplanned events, that is, for each alternative future. The forecast for each alternative future is assigned the probability associated with that particular sequence of events.

MODEL CONSTRUCTION

The scenario trees describing the subjective probabilities of the exogenous events must be constructed using data from a substantial interview process.

DATA USED IN RUNNING MODEL

The Wharton EFA Automobile Demand Model requires four major groups of input variables: economic variables, demographic variables, transportation mode assumptions, and auto characteristics assumptions. Forecasts of most of the economic variables are obtainable from Wharton EFA's Annual Long-Term Econometric Model. Forecasts of most of the demographic variables are available from the Bureau of the Census.

REFERENCE

Golomb, D.H.; Bunch, H.M., Stochastic analysis of future vehicle populations, The University of Michigan, Highway Safety Research

Institute, Report no. UM-HSRI-78-15, April 1978.

COMPUTER REQUIREMENTS

The computer program of the FAPS model is written in FORTRAN IV and implemented on The University of Michigan computer system. The program does not print the forecast results, but generates an output file which can be analyzed by a statistical analysis package.

ANL/HIWAY: AN AIR POLLUTION EVALUATION MODEL FOR ROADWAYS

The ANL/HIWAY model was developed in 1976 by Argonne National Laboratory and the University of Chicago with the objective of estimating the air quality levels of nonreactive pollutants originating from a roadway segment. The model can be used by planners in analyzing the effects of a proposed roadway on adjacent air quality. The ANL/HIWAY model expands the evaluation capabilities of the U.S. Environmental Protection Agency HIWAY dispersion model. The ANL/HIWAY model is reported to be a more comprehensive planning tool than the EPA/HIWAY model, and their differences are outlined in the report.

SPONSOR

National Science Foundation
Research Applied to National Needs

AUTHOR

George A. Concaildi, Alan S. Cohen, and Richard F. King

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The University of Chicago
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KEYWORDS

Air pollution/air quality

OBJECTIVE OF MODEL

The objective of the model is to estimate the air quality levels of nonreactive pollutants downwind of a roadway segment in relatively uncomplicated terrain. It may be used by planners to analyze the effects of a proposed roadway on adjacent air quality.

RELATIONSHIP TO OTHER MODELS

This model has no known relationship to other models.

HISTORICAL BACKGROUND

The ANL/HIWAY model is an updated version of the EPA/HIWAY model. The difference between the ANL/HIWAY and the EPA/HIWAY models lies in their usefulness for conducting policy evaluations or preparing environmental impact statements. The ANL/HIWAY model is generally a more comprehensive planning tool.

ASSUMPTIONS

Each lane of traffic is modeled as though it were a straight, continuous, finite line source with a uniform emission rate. Multi-lane roadway segments require multiple runs of the model. The emission rate, as calculated by the model, is intended to be representative of 1969 model automobiles, although it is also representative of the vehicle mix near the end of 1973.

VALIDATION

No validation efforts are indicated in the report.

LIMITATIONS AND BENEFITS

The model is limited by its design for use in uncomplicated terrain and for straight roadway segments. There is no internal provision for the modeling of cars idling at a traffic signal or waiting to turn at an intersection. Desirable future modifications include: the modeling of diesel vehicles; the modeling of vehicles during acceleration, deceleration, and idling, and at intersections; curve fitting of observed emission vs. computed emissions; and curve plotting and contour mapping of computed air quality concentrations. However, this model is more versatile and is more comprehensive than preceding models of its kind.

STRUCTURE

Air pollution concentrations are made by a numerical integration of the Gaussian plume point source expression over a finite length. A uniform emission rate may be specified as an input variable or can be computed by ANL/HIWAY from exogenously provided average vehicle speed, and hourly volume of traffic data. Dispersion functions indicate the amount the pollutant plume has spread after leaving its source. These functions are dependent on wind conditions (eg. angle and speed), heights of both the receptors and sources of pollution, and the downwind distance from the source to the receptor.

DATA USED IN RUNNING MODEL

The following inputs may be required for model simulation: descriptions of sources (length, width, height, etc.), volume of traffic, average speed of traffic, positions of receptors, wind speeds and directions, and conversion factors used to change emissions into parts-per-million units.

REFERENCE

Concaildi, G.A.; Cohen, A.S.; King, R.F., ANL/HiWAY: an air pollution evaluation model for roadways, ANL-76-XX-37, 1976.

Zimmerman, J.R.; Thomson, R.S., User's guide for HiWAY, a highway air pollution model, U.S. Environmental Protection Agency, Report no. EPA-650/4-74-008, 1975.

COMPUTER REQUIREMENTS

The program is written in FORTRAN IV for an IBM 360. It is designed to run in batch mode and is capable of responding to a wide variety of input commands, parameters, and data. A program listing, examples of runs and output, and a complete program description is included in the documentation.

THE IMPACT OF RESIDENTIAL CONSTRUCTION
ON THE DEMAND FOR AUTOMOBILE MODELS

MODEL

The Impact of Residential Construction on the Demand for Automobiles Model, developed in 1977 by personnel at Baker, Weeks and Company and Lehman Brothers, Inc., is an econometric model of the demand for automobiles formulated as a stock adjustment process. The model is innovative in that it includes new residential construction as a determining variable, thereby generating more reliable forecasts.

AUTHOR

Richard D. Rippe
Baker Weeks and Co., Inc.

Richard L. Feldman
Lehman Brothers, Inc.

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The authors' purpose is to improve the forecasting of consumption expenditures on automobiles by including a housing construction variable in a stock-adjustment model.

RELATIONSHIP TO OTHER MODELS

There is no relationship to other models.

ASSUMPTIONS

This model uses a stock adjustment process in which new car sales is a function of the difference between desired and actual stock of cars, as well as income and prices.

HISTORICAL BACKGROUND

Stock adjustment models of the demand for automobiles generally evince substantial autocorrelation, suggesting that the models may be misspecified. Moreover, these models do not predict well. The authors believe that the inclusion of a formerly omitted variable, housing construction, will rectify this situation.

VALIDATION

While it is not possible to perform a thorough ex-ante forecasting test with the model, one ex-post forecast was performed. Forecasts of demand were using the actual values of the exogenous variables (except the lagged stock of autos that was updated with the auto demand predicted by the model in each forecast period). The model without the housing variable substantially underestimated actual expenditures, while the model with housing approximated actual fluctuations in auto demand fairly well.

LIMITATIONS AND BENEFITS

The results of this model suggest that forecasts of automobile demand will benefit by considering prospects for residential construction over the forecast period. Forecasters must be aware, however, that a dramatic change in the location of housing construction from the pattern of the past fifteen years could alter the structural relationships represented in the model.

STRUCTURE

The authors sought to improve the results of other researchers using stock adjustment models by including consumption of residential housing as a determinant of automobile demand. The usual approach would be to include price of housing among the variables determining the desired stock of autos. The authors argue, however, that disequilibrium in the housing market and data problems with housing price make it preferable to include a quantity-of-new-housing-constructed variable among the determinants of desired stock. The model including the housing variable is:

$$\begin{aligned}
 y_t = & 8.100 + 0.0720 (I_t) - 7.000 \left(\frac{PA_t}{PC_t}\right) \\
 & (2.47) \quad (4.62) \quad (-2.73) \\
 & - 0.348 (U_t) + 0.404 (H_{t-1}) \\
 & (-8.87) \quad (9.92) \\
 & - 0.955 (DB) + 0.665 (DA) \\
 & (-5.54) \quad (3.60) \\
 & - 0.0638 (k_{t-1}) \\
 & (-3.46)
 \end{aligned}$$

$$\bar{R}^2 = .975 \quad \text{SEE} = 0.22 \quad \text{DW} = 1.64$$

where t-statistics are in parentheses, and

H_{t-1} = investment in residential structures, in 1958 dollars, in period t-1, seasonally adjusted at quarterly rates (mobile homes and trailers are not included)

y_t = expenditures for automobiles, in 1958 dollars

I_t = disposable income less transfer payments, in 1958 dollars

PA_t = implicit price deflator for automobiles

PC_t = implicit price deflator for all consumption

U_t = the rate of unemployment

DB = dummy variable for quarter of the General Motors strikes in 1964 and 1970

DA = dummy variable for quarter after General Motors strikes in 1964 and 1970

k_{t-1} = stock of automobiles in previous quarter

MODEL CONSTRUCTION

Consumption expenditures for mobile homes and trailers were removed from the auto data. These consumption data were obtained from the Survey of Current Business and unpublished estimates by the Bureau of Economic Analysis. Income, price and investment in residential structures data are from The National Income and Product Accounts of the United States, Survey of Current Business. Unemployment data are from the Monthly Labor Review. The coefficient in the existing stock equation is an estimate from Michael K. Evans, Macroeconomic Activity: Theory, Forecasting, and Control: An Econometric Approach, New York, 1969.

REFERENCE

Rippe, R.D.; Feldman, R.L., The impact of residential construction on the demand for automobiles: an omitted variable, Journal of Business, 49:389-401, 1976.

DYNAMIC EQUILIBRIUM MODEL OF THE U.K. AUTO MARKET

The Dynamic Equilibrium Model of the U.K. Auto Market was developed in 1978 at the Greater London Council with the objective of attempting to reproduce what happens in the auto market as the quantity of money input to the market varies from year to year. The model attempts to delineate the complex chain of reactions within the car market that was set off by the rapid rise in gasoline prices. The model can be used in policy applications to simulate the effects of increases in car and gasoline prices.

AUTHOR

M.J.H. Mogridge
Greater London Council
London, England

KEYWORDS

Automobile demand, pricing

OBJECTIVE OF MODEL

The objective of this model is to simulate what happens in the U.K. automobile market, in the short and long term, as the quantity of money input to the market varies from year to year. The report uses the model in an attempt to delineate the complex chain of reactions within the car market set off by the rapid rise in gasoline prices which began in 1973.

RELATIONSHIP TO OTHER MODELS

This model has no known relationship to other models.

HISTORICAL BACKGROUND

This study was developed to aid in evaluating the effects of various policy options related to the transportation system.

ASSUMPTIONS

In order to simplify the model, a gamma distribution was assumed to hold in several instances. The following were assumed to have gamma distributions: the price distribution of the total stock of cars, the amount of time that cars are kept before resale as distributed over time, the rate of expenditure on automobiles as distributed over income levels, the price distribution of cars scrapped, the probability distribution for assigning households to car ownership categories and distribution within each category, and the total gross household income

distribution. In addition, to develop a description of household car ownership by category of ownership and by age and price of car for each household gross income level, a bias function is used to define the distribution.

VALIDATION

The model results are compared over the historical period, 1966-76, and with other studies. The report concludes that an increase in the price of gasoline will cause a shift in the balance of expenditure from purchases to operating expenses. The effect on the car market is a large increase in the depreciation rates of larger cars while the rate for smaller cars remains constant. The purchase/operating expense tradeoff also has implications for taxes on cars: they will be absorbed by the market through shifting to smaller cars and decreasing operating expenses.

LIMITATIONS AND BENEFITS

An innovation in the model is that each block in the model (demand, supply and equilibrium) contains distributions concerning price, expenditure, and time. This is in contrast to previous work in this area that used only average prices for the supply side of the market. A limitation is that the model would probably require re-calibration for use in countries other than the U.K.

STRUCTURE

The model consists of three blocks: the supply side that determines price distribution of cars or the value of the existing stock of cars; the demand side that determines the amount of expenditure on cars, both purchase and operating expenses; and the equilibrium block where the flow of expenditures is converted to the value of the stock of cars. There are two fundamental inputs to the model, the growth in household incomes and new car prices. The outputs of the model are the price distribution of cars of all ages and the comparison of value of cars (price) and expenditure at each gross household income level.

MODEL CONSTRUCTION

The household expenditure in the car market are drawn from the Family Expenditure Survey of the U.K., published in 1971. The price distribution of the car stock are from the National Travel Survey (1972) and Motor Transactions Survey (1971).

DATA USED IN RUNNING MODEL

The inputs required to run the model are the growth in gross household incomes, and new car prices.

78-098

REFERENCE

Mogridge, M.J.H., The effect of the oil crisis on the growth in the ownership and use of cars, Transportation, Vol. 7 no. 1, March 1978.

DRIVING CYCLE RELATIVE ENERGY CONSUMPTION MODEL

The Driving Cycle Relative Energy Consumption Model was developed in 1978 at the National Highway Traffic Safety Administration of the U.S. Department of Transportation. The model facilitates comparison of the energy efficiencies of vehicles and provides a theoretical upper limit for fuel economy. The efficiencies are estimated for city and highway driving tests.

AUTHOR

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National Highway Traffic Safety Administration
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Washington, D.C. 20590

KEYWORDS

Fuel economy

OBJECTIVE OF MODEL

This model evaluates and compares the energy efficiency of vehicles for city and highway driving test cycles. A theoretical upper limit of fuel economy is determined and is compared with the relative actual energy consumption of vehicles.

RELATIONSHIP TO OTHER MODELS

This model evolved from the earlier work of Luchter and Daye which lacked the theoretical basis that the present model has.

HISTORICAL BACKGROUND

While fuel economy is a convenient parameter easily understood by policymakers and consumers, it is not a sufficient indicator of the energy efficiency of the vehicle. This work is an attempt to facilitate comparisons of energy efficiencies by considering factors not adequately represented in the fuel economy ratings.

ASSUMPTIONS

The specific fuel consumption value is assumed to be 0.44 lb/hp-hr for a vehicle. This represents an efficiency of 33% for a fuel with a 18,900 BTU/lb heating value. This is an optimistic assumption for automobile power plants. The other assumption made is a fuel specific weight of 6.1 lb/gal, which is typical of gasoline. These assumptions

would need to be changed if there was a dramatic shift to diesel powered automobiles. Since there is a lack of estimates of fuel consumption for both idling and deceleration, the model authors assumed those fuel consumptions were zero. While this assumption has limited practicality with today's automobiles, the fuel consumption in both deceleration and idle modes can be quite small.

VALIDATION

The model was used to calculate energy efficiencies from 1957 to 1977 and to forecast the energy efficiencies of 1981 to 1985 automobiles. The results show an increase in the energy efficiency of automobiles since 1974 as opposed to a decrease in efficiency over the period 1963 to 1974. These were the trends for an average weight vehicle with an average fuel economy. The model also determines a theoretical upper limit of fuel economy, which is compared to the forecasts of best fuel economies by two studies. The comparison shows the best predicted fuel efficiency may come within 10% of the theoretical limit.

LIMITATIONS AND BENEFITS

The power requirements of the theoretical test vehicles are those needed to accomplish the time-speed schedules of the urban and highway driving cycles on the chassis dynamometer. However, these dynamometer results tended to be biased at certain horsepower levels. The two driving cycles are those used by the U.S. Environmental Protection Agency and allow for different driving conditions.

STRUCTURE

The model utilizes data concerning time and speed requirements of cycles and the type of vehicle (i.e., weight) to determine the horsepower-seconds required for a vehicle to theoretically traverse the two driving cycles. This is determined by the following equation:

$$P = [.0142 + .000121 (W) (a)] (V) + .000440 (V^2) + .00266 (f_2) (V^3)$$

where:

P = horsepower

W = weight, lbm

a = acceleration, miles/hr/sec

V = velocity, miles/hr

f_2 = value based on inertia, weight, and horsepower setting for the dynamometer

This can be translated into gallons of fuel at the engine which will

produce an estimate of the fuel economy of the vehicle over the driving cycles.

MODEL CONSTRUCTION

The constants in the equation are based on engineering and physical relationships, and on dynamometer tests of actual vehicles.

DATA USED IN RUNNING MODEL

The following are exogenous to the model and are required to produce estimates of fuel economy: velocity, weight, acceleration, horsepower setting on dynamometer, specific fuel consumption, a fuel specific weight, and the distance traveled in the driving cycle. These variables are dependent on the driving cycle, vehicle characteristics, and the type of engine and fuel used.

REFERENCE

Luchter, S., Passenger car fuel economy and relative energy consumption, Society of Automotive Engineers Inc., Technical Paper no. 780615, presented at Passenger Car Meeting, Troy, Michigan, 1978.

VEHICLE COURSE FUEL ECONOMY PROJECTION METHOD

The Vehicle Course Fuel Economy Projection Method was developed at the Ford Motor Company in 1969. It is used to simulate the performance and fuel economy of various configurations of automobile designs.

AUTHOR

David N. Hwang
Ford Motor Company

KEYWORDS

Automobile design, fuel economy

OBJECTIVE OF MODEL

The model simulates the transient operation of a vehicle over a prescribed course to evaluate the effect of engine design parameter changes and parameter interactions on performance criteria including fuel economy and acceleration.

RELATIONSHIP TO OTHER MODELS

There is no known relationship to other models.

ASSUMPTIONS

Performance criteria are used to evaluate the design parameters of automobiles. These criteria must reflect the driving situations frequently encountered by the majority of drivers, must be sensitive to the performance characteristics which are highly regarded by drivers, and must be flexible enough to optimize the satisfaction of customers. The criteria include acceleration times and fuel economy ratings and may be revised as consumers' tastes change.

VALIDATION

The simulation results may be evaluated against the performance criteria, but can only be validated by assessment against the performance of actual vehicles.

LIMITATIONS AND BENEFITS

The method may be used to calculate the effects on fuel economy due to engine, vehicle, and transmission design parameters such as displacement, compression ratio, bore-stroke ratio, torque converter

size factor, speed ratio, torque ratio, gear ratio, gearbox efficiency, transmission shift pattern, axle efficiency, axle ratio, power train inertia, vehicle weight, rolling and aerodynamic resistance, central gravity, and length of wheelbase. The model can simulate part-throttle or full-throttle operation, automatic or manual-shift transmissions, and driving up or down grades.

STRUCTURE

The vehicle course fuel economy is expressed by:

$$\text{MPG} = \frac{S \times R_g}{5280 \times Q}$$

where:

MPG = vehicle course fuel economy

S = total prescribed course length in feet

R_g = fuel density in lb/gal

Q = fuel consumption in lb at the end of the prescribed course

The fuel consumption is expressed by:

$$Q = \Sigma \Delta F_{cid} + \Sigma \Delta F_{cdc} + \Sigma \Delta F_{cs} + \Delta F_{ca}$$

where:

ΔF_{cid} = idling fuel consumption in lb

ΔF_{cdc} = deceleration fuel consumption in lb

ΔF_{cs} = steady state fuel consumption in lb

ΔF_{ca} = acceleration fuel consumption in lb

Each of the components of total fuel consumption is developed in detail.

A driving course is described during which the acceleration of the vehicle is varied. The calculations are repeated for each increment of time until the prescribed simulated course is completed.

MODEL CONSTRUCTION

The components of fuel consumption are calculated according to pre-specified performance curves which describe the relationships between torque, speed, and pressure for various vehicle parts.

DATA USED IN RUNNING MODEL

Several different kinds of projections may be selected. There is a choice of four engine types, different accessories and transmissions, axle ratios, vehicle weights, and course specifications. Input parameters may be used which describe the geometry and configuration of the engine, idling speed, fuel flow and density, axles, wheel assemblies, tires, gear train, control system, torque converter, fluid coupling, etc.

REFERENCE

Hwang, D.N., Fundamental parameters of vehicle fuel economy and acceleration, SAE Transactions, Volume 78, section 3, paper 690541, 1969.

COMPUTER REQUIREMENTS

The computer program was developed at the Ford Motor Company.

DISTRIBUTIONAL IMPACTS OF AUTOMOTIVE POLLUTION CONTROL PROGRAMS MODEL

The Distributional Impacts of Automobile Pollution Control Programs Model was developed in 1975 at the University of California at Davis. The model can be used to compute the incidence of automotive pollution control costs according to the income class of vehicle owners.

SPONSOR

Rockefeller Foundation

AUTHOR

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University of California at Davis
Division of Environmental Studies
Davis, Calif. 95616

KEYWORDS

Air pollution/air quality, national economic impact

OBJECTIVE OF MODEL

The model computes the incidence of automotive pollution control costs according to the income class of vehicle owners.

RELATIONSHIP TO OTHER MODELS

There is no known relationship to other models.

HISTORICAL BACKGROUND

This is the first of a two-part study: (1) calculation of program costs and their distribution, and (2) analysis of benefit distribution. The latter is left for a future date.

ASSUMPTIONS

It is assumed that different income groups are assigned different weights when calculating the costs and benefits of a program, rather than assuming that equal marginal utility of benefits applies to all groups. Some assumptions are made during the illustrative calculations for inspection-maintenance programs in California. These are: (1) the costs recur annually, i.e., there are no capital costs; (2) the total cost is made up of the maintenance/repair cost, the cost of inspection, the cost of travel to and from the inspection station and service

station (for those who fail the test), and the cost of lost time; and (3) the national vehicle age distribution applies to the specific area (California) for which this analysis is undertaken.

VALIDATION

The results of the calculations illustrated for San Diego County data indicate that the lowest income group will experience a much larger ratio of inspection-maintenance program costs to income than the highest income group.

LIMITATIONS AND BENEFITS

The separation of the program costs according to the income class of vehicle owner will allow the affected interest groups to be better informed about the impacts. This will, thereby, enhance participation in the decision-making process as regards cost-increasing programs.

STRUCTURE

This model consists of three equations.

The cost equation is:

$$E_i(c) = \sum_K E(c/k) f_i(k)$$

where:

$E_i(c)$ = expected cost for vehicles owned by members of income group i

$E(c/k)$ = average program cost for vehicles in age group k

$f_i(k)$ = probability (frequency) function for age of vehicles owned by members of income group i

The total cost to members of income group i , TC_i , is calculated as follows:

$$TC_i = N_{iT} E_i(c) = N_{iT} \sum_K E(c/k) f_i(k)$$

where:

N_{iT} = total number of vehicles owned by members of income group i

The fraction of population exceeding a specified cost is calculated as:

$$\Pr[c > c_s] = 1 - \Pr[c \leq c_s] = 1 - \sum_K \left[\sum_{c=0}^{c_s} f(c/k) f_i(k) \right]$$

c_s = specified amount

$f(c/k)$ = conditional probability (frequency) function for program cost given vehicle age

DATA USED IN RUNNING MODEL

The model requires construction of the cost distribution function and the vehicle age distribution by income group.

MODEL CONSTRUCTION

The model is based on probability theory. Data used during the illustrative example (for San Diego County) were: the adjusted maintenance and repair cost by vehicle age for vehicles failing the inspection test; the probability frequency function of inspection maintenance program costs by vehicle age; the vehicle age distribution by income group; number of households; and number of vehicles.

REFERENCE

Schwartz, S.I., Distributional impacts of automotive pollution control programs: a model for evaluation, Journal of Environmental Systems, Vol. 5(3), 1975.

A CROSS-SECTION MODEL OF AUTOMOBILE CONSUMPTION

The Cross-Section Model of Automobile Consumption was developed in 1964 as a doctoral dissertation at the University of Rochester. The objective of the model is to determine how well automobile consumption can be explained by income and other social and demographic variables.

AUTHOR

W.B. Bennett
University of Rochester
Rochester, N.Y.

KEYWORDS

Automobile demand, vehicle user costs/vehicle operating costs

OBJECTIVE OF MODEL

The objective of the model is to determine how well automobile consumption can be explained by income and other social and demographic variables.

RELATIONSHIP TO OTHER MODELS

This model has no direct relationship to other models.

HISTORICAL BACKGROUND

This model was part of the author's doctoral dissertation at the University of Rochester in 1964, and was developed further while he was at Union College in Schenectady, N.Y.

ASSUMPTIONS

Automobile consumption has two components, depreciation and operating costs. The depreciation expenses are based on an average rate of depreciation and are dependent on the make and age of the car. Operating expenses are assumed to equal only the repair costs, which are a linear function of the age of the car. Costs other than depreciation and repair costs are omitted.

VALIDATION

The model author estimated the equation for each year from 1955 to 1957 using a least squares estimation technique on the full model. Some variables were then omitted and the model was re-estimated with a

maximum likelihood estimation technique. The conclusions derived from the study are: (1) household consumption rises with income but rises less sharply at higher than at lower incomes; (2) consumption decreases as the head of the household approaches retirement age; (3) consumption increases as the number of adults in the spending unit increases; (4) expenditure decreases as the number of children increases; (5) after adjustment for other factors, spending units living in New York and Chicago show lower than average, and those living in rural areas show higher than average consumption; (6) non-white spending units consume cars at a lower level than white units.

LIMITATIONS AND BENEFITS

The methodology of the study may be useful to current research. However, the cross-sectional relationships estimated may have changed dramatically since 1957. These changes would limit the value of the estimated coefficients in the model.

STRUCTURE

The equation was estimated for each year from 1955 to 1957. The estimated equation for 1955 is:

$$\begin{aligned}
 C = & -140 + \frac{0.0595}{(0.0030)} (Y) - \frac{0.00000049}{(0.000000083)} (Y^2) - \frac{17.8}{(24.4)} (A_1) + \frac{19.1}{(40.6)} (A_2) \\
 & - \frac{66.7}{(18.1)} (A_3) - \frac{80.8}{(19.6)} (A_4) - \frac{143.3}{(21.1)} (A_5) + \frac{64.2}{(10.7)} (N_a) - \frac{14.2}{(4.5)} (N_c) \\
 & + \frac{9.64}{(14.5)} (N_1) - \frac{175.6}{(24.5)} (L_1) + \frac{75.0}{(15.1)} (L_2) - \frac{128.1}{(22.6)} (R)
 \end{aligned}$$

where standard errors are in parentheses, and

C = expenditure on automobiles

Y = disposable income per spending unit in current dollars

A_1 = dummy variable which equals 1 when age of head of family is 18-24, otherwise zero

A_2 = 1 when age of head is 25-34, otherwise zero

A_3 = 1 when age of head is 45-54, otherwise zero

A_4 = 1 when age of head is 55-64, otherwise zero

A_5 = 1 when age of head is 65 or over, otherwise zero.

N_a = number of adults in the spending unit

N_c = number of children in spending unit

N_i = number of income earners in spending unit

L_1 = dummy variable which equals 1 when spending unit is located in a metropolitan area, otherwise zero.

L_2 = dummy variable which equals 1 when spending unit is located in rural area, otherwise zero

R = dummy dummy variable which equals 1 when spending unit is a non-white race

MODEL CONSTRUCTION

The model was estimated using data as follows: all data except for the automobile price and repair cost data originate from the Surveys of Consumer Finances collected by the Survey Research Center at The University of Michigan. Price data and repair cost data were developed from National Automobile Dealers Association, Official Used Car Guide, and Automobile Facts and Figures by the American Automobile Association.

REFERENCE

Bennett, W.B., Cross-section studies of the consumption of automobiles in the United States, The American Economic Review, Vol. LVII, No. 4, 1967.

ADL CONSUMER RESPONSE MODEL

The ADL Consumer Response Model, dated November 1976, was prepared for the Transportation Systems Center (TSC) of the U.S. Department of Transportation by Arthur D. Little (ADL) Inc. The model predicts the effects of various policy options on the number of automobiles sold, the distribution of sales among small, medium, and large cars, and between foreign and domestic cars, and the gross revenues resulting from these sales. The policy scenarios used are a gas tax, an excise tax, and a mandatory corporate average fuel economy.

SPONSOR

U.S. Department of Transportation
Office of the Secretary
Office of the Assistant Secretary for Systems Development and Technology
Office of Systems Engineering Center
Washington, D.C. 20590

AUTHOR

Arthur D. Little, Inc.
25 Acorn Park
Cambridge, Mass. 02139

KEYWORDS

Fuel consumption, automobile demand, market shares, industrial financial performance

OBJECTIVE OF MODEL

The objective of the model is to predict the effects of various policy options on the number of automobiles sold, the distribution of sales among small, medium, and large cars and between foreign and domestic automobiles, and the gross revenues resulting from these sales.

HISTORICAL BACKGROUND

This model is part of an ADL report Study of Automobile Market Dynamics. That study examines some options which the Federal Government might utilize in order to reduce gasoline consumption by passenger automobiles. This involved an examination of technological change and its cost, a formulation of policy options, and forecasting the effects of the various options.

ASSUMPTIONS

The characteristics of consumers regarding their intentions to purchase new cars as described by a survey done in 1976 are assumed to accurately forecast consumer's actions in the future. The prices of new cars are assumed to increase by 200 to 300 dollars in constant dollar terms, over the forecasting period.

VALIDATION

The model was used to forecast the effects of four policy scenarios over the period 1978 to 1980. It was found that sales of medium and small cars would increase at the expense of large cars under all of the policies and especially under the gas tax scenario. All of the policies would encourage the sales of foreign cars at the expense of domestic cars.

LIMITATIONS AND BENEFITS

While the methodology can be duplicated in future research, policy scenarios different from those presented cannot be readily evaluated since the model is dependent on survey results concerning consumer reactions to various policies.

STRUCTURE

The model is based on matrix multiplication theory. A matrix describing a forecast of new car sales is multiplied by a matrix of switching probabilities which describes consumer reaction to the selected policy option. The total new car sales forecast is thus distributed among small, medium, and large cars.

MODEL CONSTRUCTION

The matrices of switching probabilities which describe the policy options were derived from survey data. The survey, done in 1976, was of people who had recently purchased new cars and who intended to purchase another new car before 1981. Consumers' intended responses to various policies were questioned. The four policy options used are a base case (no policies), a gasoline tax, excise taxes, and a policy requiring that manufacturers meet a corporate average fuel economy rating.

DATA USED IN RUNNING MODEL

A baseline forecast of total new car sales is required to use the model, as well as a choice of policy option. The forecast used in the study was that of a Data Resources, Inc. model.

REFERENCE

Morton, A.S.; Strong, S.T.; Metcalf, E.I.; Marple, G.A.; Freedman, A., Study of automobile market dynamics - vol. 1: description, vol. 2: analysis, Arthur D. Little, Inc., under contract to Transportation Systems Center, Cambridge, Mass., Report no. DOT-TSC-OST-77-1. I and II, August 1977.

Study of automobile market dynamics: final test of consumer response (Task 5), Report no. 78542-06, Arthur D. Little, Inc., November 1976.

AGGREGATE AUTOMOBILE SCRAPPAGE MODEL

The Aggregate Automobile Scrappage model was developed in 1968 at the State University of New York at Albany. The objective of the model is to examine the trends and fluctuations in aggregate scrappage of passenger automobiles in the United States over most of the period since World War II.

AUTHOR

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Department of Economics
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KEYWORDS

Scrappage

OBJECTIVE OF MODEL

The objective of the paper is to analyze the trend and fluctuations in aggregate scrappage of passenger automobiles in the United States over most of the period since World War II.

RELATIONSHIP TO OTHER MODELS

There is no relationship to other models.

HISTORICAL BACKGROUND

Much of the work was done while the author was employed by the Board of Governors of the Federal Reserve System and an earlier report was published in the Board's internally circulated Staff Comments.

ASSUMPTIONS

No data are available for the rate of turnover of auto ownership or even for used car sales. Instead, the ratio of new car registrations to total car registrations is used as a surrogate variable on the assumption that new and used car sales fluctuate together from similar causes.

VALIDATION

Scrappage rates rise with age but level off at advanced ages. Two-thirds of the variation of the actual scrappage rate from its trend is

"explained" by changes in turnover and prices. The estimated trend and fluctuation components yield estimates of aggregate annual scrappage that "explain" 90 per cent of changes in observed scrappage over the years 1949 through 1964. The analysis suggests that the declining trend in scrappage of prewar models was somewhat more than offset by the rising trend of postwar models.

STRUCTURE

The econometric model consists of two interdependent stochastic equations:

$$S_t = a (R_t)^\alpha (P_t)^G M^*_t K_t u_t \quad (1)$$

$$M_s = 1/[L + B (e)^{ks}] + E_s \quad (2)$$

where:

S_t = aggregate scrappage in number of vehicles in year t

R_t = rate of turnover of car ownership, approximated by the ratio of new car registrations to total car registrations in year t

P_t = index of used car prices divided by an index of car maintenance and repair prices, in year t

M^*_t = expected scrappage rate in year t because of aging alone, a weighted mean of expected age-specific scrappage rates calculated from the regression estimate of equation (2)

K_t = total stock of operable cars at the beginning of year t , in number of vehicles

M_s = mean scrappage rate of vehicles aged s years, i.e., proportion of vehicles surviving s years that are scrapped, on the average, prior to their $(s + 1)$ st birthday.

u_t, E_s = random errors

a, α, G, L, B, k = parameters

s = age of a vehicle in years since purchased new

Equation (2) was estimated using logarithmic form for postwar and prewar models, while equation (1) was estimated using logarithmic form for postwar models.

MODEL CONSTRUCTION

All data and transformations of data used to build the model will be provided by the author on request.

68-155

DATA USED IN RUNNING MODEL

To run the model the following must be used for input: new car registrations, total car registrations, index of used car prices, and index of car maintenance and repair prices.

REFERENCE

Walker, F.V., Determinants of auto scrappage, Review of Economics and Statistics, Vol. L, no. 4, November 1968.

LIFESTYLE MODEL OF AUTOMOBILE USE

The Lifestyle Model of Automobile Use was developed in 1977 at the University of Pittsburg for Oak Ridge National Laboratory. The model attempts to relate vehicle miles traveled (VMT) to household characteristics which would reflect future social and economic change. A linear regression equation is estimated and used to project VMT for seven scenarios corresponding to different assumptions about socio-economic and demographic change. The model is used together with the Lifestyle Model of Automobile Ownership (77-200B) to analyze various scenarios.

SPONSOR

Oak Ridge National Laboratory

AUTHOR

Norman P. Hummon, Douglas P. Sharp, Linda M. Zemotel
University of Pittsburgh
Environmental Systems Engineering

KEYWORDS

Vehicle miles traveled

OBJECTIVE OF MODEL

The model relates vehicle miles traveled (VMT) to different household life cycle stages in order to project average daily VMT per household. This projection is then multiplied by 365 and by projected number of households to derive total yearly U.S. VMT.

RELATIONSHIP TO OTHER MODELS

The model was constructed together with the Lifestyle model of Automobile Ownership (77-200B). The two models are meant to be used together to examine the automobile-related impacts of possible socio-economic changes.

STRUCTURE

A linear regression model was used to relate total vehicle miles traveled per day by a household to life cycle stages and other household characteristics. The Use model uses three variable sets (Life Cycle Stage, Environmental Preference and Economic Attainment) also used in the Lifetime Model of Automobile Ownership. Five of the Environmental Preference variables were dropped, however, for lack of significance.

Eleven dummy variables, representing number of automobiles owned, day of the week, and month of the year for which travel was surveyed, were added. The adjusted R-squared was 0.14. The results of the estimation of the use equation were presented in Volume 2, Scenario analyses as shown in the table below.

MODEL CONSTRUCTION

Household population projections were based on U.S. Census Bureau Current population reports. Data used to estimate the use equation were taken from the U.S. Department of Transportation, Federal Highway Administration National personal transportation study, 1973, and other sources referenced in the model documentation.

REFERENCE

Hummon, N.P.; Sharp, D.P.; Zemotel, L.M., Projections of automobile use and ownership based on lifestyle factors: first pass analyses and scenarios, University of Pittsburgh, Report no. ORNL-sub-7356-1, July 1977.

Hummon, N.P.; Sharp, D.P.; Zemotel, L.M., Projections of automobile use and ownership based on lifestyle factors: scenario analyses, University of Pittsburgh, Report no. ORNL-sub-7356-2, October 1977.

Variable Names	Values of Coefficients	t-statistics
Life Cycle Stage (year)		
2	-1.885	0.48
3	-8.233	2.49
4	-10.347	2.02
5	-12.942	3.75
6	-14.577	3.74
7	-12.557	3.67
8	-11.244	2.99
9	-8.186	1.99
Environmental Preference		
MOUNTAIN	-6.826	2.00
SUBURBAN	-4.672	2.94
RURAL	3.782	2.43
Economic Attainment		
EMPLOYED	4.116	4.30
LOMIDINC(5-10K)	7.360	4.27
HIMIDINC(10-15K)	9.951	4.30
HIGHINC(15+K)	17.864	6.40
Autos		
AUTOS	21.094	20.56
Temporal		
SUN	-1.375	0.74
MON	-7.090	3.12
TUE	-7.720	3.38
WED	-8.586	3.82
THUR	-6.057	2.65
FRI	-4.070	1.77
APR	9.388	4.83
JUL	9.464	4.88
AUG	11.340	5.75
OCT	4.969	2.57

LIFESTYLE MODEL OF AUTOMOBILE OWNERSHIP

SUMMARY

The Lifestyle Model of Automobile Ownership was developed in 1977 at the University of Pittsburg for Oak Ridge National Laboratory. The model attempts to relate automobile ownership to household characteristics which would reflect future social and economic change. A linear regression is estimated and used to project ownership for seven scenarios corresponding to different assumptions about socio-economic and demographic change. The model is used together with the Lifestyle Model of Automobile Use (77-200A) to analyze various scenarios.

SPONSOR

Oak Ridge National Laboratory

AUTHOR

Norman P. Hummon, Douglas P. Sharp, Linda M. Zemotel
University of Pittsburgh
Environmental Systems Engineering

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The ownership model relates auto ownership patterns to different household life cycle stages in order to project average auto ownership per household. This projection is then multiplied by the projected number of households to derive total U.S. auto ownership.

RELATIONSHIP TO OTHER MODELS

The ownership model is used with the Lifestyle Model of Automobile Use (77-200A) to develop scenario analyses.

STRUCTURE

The model authors preferred a discrete multivariate model for ownership on theoretical grounds. Due to the lack of the software for this technique a linear regression model was used instead. Linear regression models ownership as a continuous variable when ownership should be modeled as a discrete or categorical variable. The ownership model is based on three variable sets: Life Cycle Stage, Environmental

Preference, and Economic Attainment. The Life Cycle Stage variables were composites of age of head of household, presence of a spouse, and presence of children, and distinguish nine life cycle stages. The Lifecycle stages were represented by dummy variables for eight of the nine stages. The Environmental Preference variables represent household decisions about housing location and density. Eight dummy variables are used to characterize geographical location, density, housing type, and housing ownership versus rental. The Economic Attainment variables are three dummy variables for income class and a dummy variable for number of employed persons in the household. The corrected R-squared for the regression was 0.40. The results of the estimation of the ownership equation were presented as shown in the table below:

Variable Name	Coefficients	t-statistics
Life Cycle Stage (year)		
2	.235	5.14
3	.201	5.06
4	.236	5.33
5	.183	4.32
6	-.169	3.82
7	.048	1.10
8	-.287	6.38
9	-.087	1.85
Environmental Preference		
ECENTRAL	.124	6.21
WCENTRAL	.176	7.15
MOUNTAIN	.226	5.38
PACIFIC	.271	10.46
SUBURBAN	.207	10.28
RURAL	.146	6.98
Single Family Dwelling Unit	.145	6.98
OWN	.185	9.41
Economic Attainment		
EMPLOYED	.172	15.62
LOMIDINC(5-10K)	.195	15.62
UPMIDINC(10-15K)	.328	12.67
HIGHINC(15+K)		

MODEL CONSTRUCTION

Household population projections were based on U.S. Census Bureau Current population reports. Data used to estimate the ownership equation were taken from the 1970 Public use sample of the U.S. Census Bureau, and other sources referenced in the model documentation.

REFERENCE

Hummon, N.P.; Sharp D.P.; Zemotel, L.M., Projections of automobile use and ownership based on lifestyle factors: first pass analyses and scenarios, University of Pittsburgh, Report no. ORNL-sub-7356-1, July 1977.

Hummon, N.P.; Sharp, D.P.; Zemotel, L.M., Projections of automobile use and ownership based on lifestyle factors: scenario analyses, University of Pittsburgh, Report no. ORNL-sub-7356-2, October 1977.

3.0 ABSTRACTS OF ASSOCIATED LITERATURE

REFERENCE

Grove H.W., Engineering model of future motor vehicles volume II: data book, Report no. DOT HS-803 446, Springfield, Virginia, January 1978.

CONCERNING MODEL:

Engineering Model of Future Motor Vehicles (77-030)

KEYWORDS

Automobile design, weight

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

PERFORMING ORGANIZATION

Volkswagenwerk AG
Research Division
3180 Wolfsburg
Germany

ABSTRACT

The Engineering Model of Future Motor Vehicles, previously reported in February 1977 in DOT-HS-802209 (77-030), provides the safety engineer with a computerized data base. The computer program provides passenger vehicle data to the user in a compressed form, for example as mean values, standard deviations, or regression functions. The program allows the user to retrieve, transform, and perform statistical analyses upon the data, and is designed for working on-line. The data include information on design, weight, performance, and fuel economy. This report gives a brief introduction to the program system and the contents of the data base as updated January 1978 (see also "Final Report"). This "Data Book" is intended to be a handy reference guide for the user to operate the program at the terminal. [Author's abstract modified]

S-78-102

REFERENCE

Lee, L.D., A comparison of econometric models, U.S. Congress, Joint Economic Committee, Committee Print, 95th Congress, 2d sess., July 1978.

KEYWORDS

Automobile demand

SPONSOR

U.S. Congress
Joint Economic Committee

PERFORMING ORGANIZATION

U.S. Congress
Joint Economic Committee
Committee Staff
G 133
Dirksen Senate Office Building
Washington, D.C. 20510

ABSTRACT

This Committee Print briefly explains the three large macroeconomic models developed by Chase Econometric Associates, Inc., Data Resources, Inc., and Wharton Econometric Forecasting Associates, Inc. There is also a short discussion of theoretical issues in the application of such models in policy analysis. These issues primarily revolve around criticisms by "rational expectations" theorists.

REFERENCE

Suits, D.B., Forecasting and analysis with an econometric model, American Economic Review, Vol. LII No. 1, March 1962.

KEYWORDS

Automobile demand, national economic impact

ABSTRACT

This paper is an introduction to the use of econometric models in forecasting. The author explains the role of judgment in modeling, and the interpretation of short- and long-run policy multipliers. He also reviews a 32-equation model of the U.S. economy, including an equation for automobile demand, developed by The University Of Michigan Research Seminar in Quantitative Economics.

S-77-105

REFERENCE

Plotkin, K.J.; Kunicki, R.G., Comparison of highway noise prediction models, U.S. Dept. of Commerce, May 1977. NTIS no. PB-276 710.

KEYWORDS

Noise pollution

SPONSOR

U.S. Environmental Protection Agency
Office of Noise Abatement and Control
1921 Jefferson Davis Highway
Arlington, Va.

PERFORMING ORGANIZATION

Wyle Laboratories/Wyle Research
2361 Jefferson Davis Highway, Suite 404
Arlington, Va. 22202

ABSTRACT

A review and comparison has been conducted of three highway noise prediction models: National Cooperative Highway Research Program (NCHRP) as in NCHRP reports 117 and 144, Transportation Systems Center (TSC) as in DOT-TSC-315-1, and Wyle Research as in Wyle Research reports WR74-5 and WR76-24 (U.S. EPA 550/9-77-356). The first two are those approved by the Federal Highway Administration. The third was developed for the Environmental Protection Agency. The elements comprising each model are analyzed in detail, including basic formulation, vehicle noise levels, propagation, treatment of various road geometries, and shielding by barriers. Significant differences among the models were found. A series of charts is presented whereby differences among the models may be estimated for particular input data. Comparisons between measured roadside levels and predictions from the three models are also presented. [Author's abstract modified]

REFERENCE

Automobile fuel economy: hearings, U.S. Congress, Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology, and Space, 95th Congress, 1st sess., July 1977.

CONCERNING MODEL:

Automobile Sector Forecasting Model (76-016)
Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Fuel economy, automobile demand, national economic impact

SPONSOR

U.S. Senate
Commerce, Science, and Transportation Committee
Science, Technology, and Space Subcommittee

PERFORMING ORGANIZATION

U.S. Senate
Commerce, Science, and Transportation Committee
Science, Technology, and Space Subcommittee

ABSTRACT

These hearings were held to receive testimony on the implementation of the automobile fuel economy standards mandated by the Energy Policy Conservation Act (EPCA), and on fuel-economy-related provisions of the Administration's energy program. Among the witnesses who appeared were Alice M. Rivlin and Damian J. Kulash for the Congressional Budget Office (CBO), and Joan Claybrook for the National Highway Traffic Safety Administration (NHTSA). Testimony for the CBO concerned impacts of fuel-economy-related legislation as projected by the Jack Faucett Associates' Automobile Sector Forecasting Model (76-016). Responses by the CBO to questions from the committee about the economic impacts of the EPCA are included, as well as some information about the assumptions underlying the CBO's projections.

Testimony for NHTSA projected significantly less severe declines in sales to result from fuel-economy-related legislation than did the CBO. The NHTSA projections appear to be derived from the Wharton Economic Forecasting Associates' Automobile Demand Model (77-046). Ms. Claybrook attributed differences between CBO and NHTSA projections to the use of more recent data by NHTSA, rather than to differences between the models. Testimony from the Center for Auto Safety also relied on

S-77-108

projections of the Faucett model. Among the other information presented was a study, Motor vehicle operating costs and fuel usage in the United States, by the Hertz Corporation.

REFERENCE

Dobson, R.; Larson, K.E., Psychological and socioeconomic correlates of car size, Presented at the 1979 Transportation Research Board Conference Session on "Consumer Behavior and Attitudes in Automobile Buying, DOT-HS-7-01779, November 1978.

KEYWORDS

Fuel economy, market share

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

PERFORMING ORGANIZATION

Chase Automotive Division

Charles River Associates, Inc.
1050 Massachusetts Ave.
Cambridge, Mass. 02138

ABSTRACT

This paper focuses on selected psychological and sociological correlates of vehicle size. The researchers conclude that while consumer awareness of U.S. Environmental Protection Agency fuel economy ratings are correlated with car size, the awareness level was a function of car size purchased, not vice versa. Factor analysis identifies four clusters of vehicle attributes: value/service, sportiness/performance, economy/size, and mechanical attributes. Economy/size was determined to be most significant in differentiating among vehicle size classes. Income and size of car replaced are found to be positively correlated with size of new car purchased. There is a negative correlation between average car size and number of autos per household. Education is also found to be inversely related to car size. Average car size is found to vary regionally.

S-78-110

REFERENCE

Sosslau, A.B.; Hassam, A.B.; Carter, M.M.; Wickstrom, G.V., Travel estimation procedures for quick response to urban policy issues, NCHRP Report 186, Transportation Research Board, 1978.

KEYWORDS

Vehicle miles traveled, air pollution/air quality

SPONSOR

Transportation Research Board
National Cooperative Highway Research Program
2101 Constitution Ave. N.W.
Washington, D.C. 20418

PERFORMING ORGANIZATION

Washington Metropolitan Council of Governments (Phase I)
1225 Connecticut Ave. N.W.
Washington, D.C. 20036

COMSIS Corporation
Wheaton, Md.

ABSTRACT

This report presents the result of an effort to provide operational travel estimation techniques with quick response times for use by state and local planners. Policy issues and the demands these place on travel estimating procedures were identified. Descriptions and evaluations of 40 models and procedures were compiled. A User's Guide was developed (NCHRP Report 187) to enable users to carry out a simplified analysis using manual techniques without the need to refer to other sources.

REFERENCE

The effects of the auto fuel economy provisions of the Energy Policy and Conservation Act, Jack Faucett Associates, Inc., April 1977.

CONCERNING MODEL:

Jack Faucett Associates Automobile Sector Forecasting Model (76-016)

KEYWORDS

Fuel economy, market share, automobile demand

SPONSOR

Center for Auto Safety
1223 Dupont Circle Bldg.
Washington, D.C. 20036

PERFORMING ORGANIZATION

Jack Faucett Associates, Inc.
5454 Wisconsin Ave.
Chevy Chase, Md. 20015

ABSTRACT

The Jack Faucett Associates Inc. (JFA) Automobile Sector Forecasting Model is used to project the impacts of the fuel economy provisions of the Energy Policy and Conservation Act on fuel consumption, vehicle ownership and sales, vehicle miles traveled, new car fuel economy, vehicle price, and composition of new car sales. (Marketing and Mobility, report of the Interagency Task Force on Motor Vehicle Goals Beyond 1980, March 1976; and Damian Kulash, "Forecasting Long-Run Automobile Demand", Transportation Research Special Report 169, 1975, pp. 14-19.) These projections are based on a set of assumptions different from those which were the basis for the JFA report to the Federal Energy Administration. The new assumptions are that diesels are not precluded on environmental grounds, and that ten percent engine replacement reductions are acceptable to consumers. In addition fuel economy measures are revised to better conform with current U.S. Environmental Protection Agency measurement practice.

S-76-112

REFERENCE

Comments of the Motor Vehicle Manufacturers Association of the United States, Inc. on the draft report by the Federal Task Force on Motor Vehicle Goals Beyond 1980, Motor Vehicle Manufacturers Association of the U.S., Inc., December 9, 1976.

CONCERNING MODEL:

Jack Faucett Associates Automobile Sector Forecasting Model (76-016)

KEYWORDS

Automobile demand, emissions, fuel economy, fuel consumption, automobile design

SPONSOR

Motor Vehicle Manufacturers Association
300 New Center Building
Detroit, Mich. 48202

PERFORMING ORGANIZATION

Motor Vehicle Manufacturers Association
320 New Center Building
Detroit, Mich. 48202

ABSTRACT

The comments suggest possible improvements to the report of the Federal Task Force on Motor Vehicle Goals (MVG) Beyond 1980. The dangers and uncertainties of government intervention in automobile design, specifically fuel economy requirements, are discussed. The trade-offs among emissions, fuel economy, damageability, and safety are highlighted. Attention is called to non-automobile influences on the environment, highway safety, and energy conservation. Other issues specifically considered are: marketing, mobility, study approach, manufacturing and ancillary industries, design, safety, air quality and health, fuels and materials resources, R and D requirements, and federal policy implications. An appendix deals with the MVG Beyond 1980 Marketing and Mobility Panel Reports' new car sales forecasts.

REFERENCE

Air quality and automobile emission control. The relationship of emissions to ambient air quality, Committee on the Relationship of Emissions to Ambient Air Quality, National Academy of Sciences/National Academy of Engineering, prepared for Senate Committee on Public Works, Committee Print, September 1974. NTIS no. N74-35073.

KEYWORDS

Emissions, air pollution/air quality

SPONSOR

U.S. Senate
Committee on Public Works
Washington, D.C.

PERFORMING ORGANIZATION

National Academy of Engineering
Coordinating Committee on Air Quality Studies
2101 Constitution Ave. N.W.
Washington, D.C. 20418

ABSTRACT

This report focuses on limitations of current knowledge about the links between emissions and ambient air quality, and of attempts to forecast the impacts of emissions control strategies on air quality. Data and trends for emissions and air quality are presented, as is the theory of emissions transformation and dispersion. Air quality monitoring systems are discussed. The report also describes various types of air quality models, and evaluates the applications, limitations, and state of development of these models. One section is specifically devoted to the modeling of control strategies for chemically reactive pollutants.

REFERENCE

Whitney, G.; Deyman, G.; Dean, W.; McElroy, J.; Bainbridge, H., The Fuel Efficiency Incentive Tax Proposal: its impact upon the future of the U.S. passenger automobile industry, A Report to the Senate Committee on Finance, 95th Congress, 1st sess. by the Office of Industries of the International Trade Commission, Washington, D.C., July 1977.

CONCERNING MODEL:

Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Fuel economy, automobile demand

SPONSOR

U.S. Senate
Committee on Finance
Washington, D.C.

PERFORMING ORGANIZATION

U.S. International Trade Commission
Office of Industries
Washington, D.C. 20436

ABSTRACT

The Wharton EFA Automobile Demand Model is used to project impacts of the Fuel Efficiency Incentive Tax Proposal. This proposal's purpose was to promote demand for more fuel-efficient autos. Separate projections are made for a base case, the Fuel Inefficiency Tax (FIT) and Fuel Efficiency Rebate (FER) provisions together, and the FIT alone. The projections assume equal treatment for imports and U.S./Canadian autos under the proposal. The FIT/FER and FIT alone are projected to decrease sales of U.S. automobile manufacturers, primarily of full sized passenger autos. Some U.S. consumers will switch to new imports, mostly from Japan, but U.S. sales of imported and U.S./Canadian passenger autos combined are expected to decline under the FIT/FER or FIT as compared with the base case. FIT/FER and FIT are projected to decrease employment. For U.S./Canadian autos prices of new mid-size, full-size, and luxury models rise under the proposal, while prices of smaller cars fall under the FIT/FER and remain at the base level under the FIT alone. Similar price impacts are projected for subcompact and compact imports. The FER/FIT is projected to make no meaningful contribution to the domestic industry's ability to meet the fuel economy standards required by law.

REFERENCE

Braden, P.L., Consumer acceptance of down-sized automobiles, Society of Automotive Engineers Inc., Technical Paper no. 780090 presented at Congress and Exposition, Detroit, Michigan, February 1978.

KEYWORDS

Market share

PERFORMING ORGANIZATION

University of Michigan
Graduate School of Business Administration
Ann Arbor, Mich. 48109

ABSTRACT

This paper discusses the effects of down-sizing automobiles on consumer behavior and the marketing strategies and product positioning of the automakers. The average fuel economy standards enacted under the Energy Policy and Conservation Act of 1975 have stimulated domestic producers to down-size new passenger vehicles. As a result, the strategies employed by manufacturers to maintain their competitive positions and the corresponding consumer response to down-sized vehicles created visible shifts in the market place. The resulting disappearance of the traditional size-class distinctions is discussed in the framework of the theory of consumer behavior and corporate marketing strategy. [Author's abstract modified]

S-75-119

REFERENCE

Tradeoffs associated with possible auto emission standards, A report to the Administrator of the Environmental Protection Agency, 1975. NTIS no. PB-267 571.

KEYWORDS

Air pollution/air quality

PERFORMING ORGANIZATION

U.S. Environmental Protection Agency
Mobile Source Pollution Control Program
Emission Control Technology Division
Ann Arbor, Mich. 48105

ABSTRACT

The report evaluates the impacts of various auto emissions standards. The impacts considered are those which are direct results of changes in emission control technology: vehicle cost changes, vehicle fuel economy changes, and unregulated pollutant level changes. Impacts not dealt with include: changes in vehicle miles traveled, ambient air quality, and market demand.

The report presents five scenarios of emission standards. For each scenario, the authors estimate the type of emission control systems that would be used to meet the standards, the initial cost of these control systems, the fuel economy of a typical car using these control systems, and the sulfate emission levels the typical car would produce. Estimates are shown for the model years 1974-1980. Projections presented are based on industry estimates; on experimental work done by the EPA, Exxon Research and Engineering, and the M.W. Kellogg Co.; and on industry data on prototype cars and analysis of EPA certification data.

REFERENCE

Potential for motor vehicle fuel economy improvement, U.S. Department of Transportation and U.S. Environmental Protection Agency, 1974. Report to the Congress, Washington, D.C.

KEYWORDS

Fuel economy, emissions, air pollution/air quality

PERFORMING ORGANIZATION

U.S. Environmental Protection Agency
Washington, D.C.

U.S. Department of Transportation
Washington, D.C.

ABSTRACT

This report is a study of the practicability of a fuel economy improvement standard of 20 percent for new motor vehicles in the 1980 time frame. It evaluates the effect of fuel economy improvement on price of new cars, safety standards, emissions, air quality, gas consumption, and economic costs and benefits. It also presents the 1980 fuel economy potential for buses and trucks. Consideration is given to the various means of enforcing an improvement in fuel economy, the impact of these means, and the improvement achieved, as compared with reliance on market forces.

S-78-122

REFERENCE

Automotive fuel economy contractors' coordination meeting: summary report, U.S. Department of Transportation, Report no. DOT HS-803 706, 11-13 December 1978.

CONCERNING MODEL:

CRA Hedonic Market Share Model (76-025)
Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Fuel economy, automobile demand, emissions, automobile design, industrial financial performance, weight

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Passenger Vehicle Research
Technology Assessment Division
Washington, D.C. 20590

ABSTRACT

This report summarizes the presentations at the second Automotive Fuel Economy Research and Analysis Program Contractors' Coordination Meeting held in Washington, D.C. in December, 1978. The Research and Analysis Program's objective is to develop the data bases and analytic tools needed to evaluate policy and rulemaking regarding automobile energy conservation. The general topics explored in the report are fuel economy and emissions considerations, automobile demand forecasting, consumer behavior towards fuel efficient vehicles, engines, weight reduction, and corporate strategies of auto manufacturers as these relate impacts of government fuel economy standards. Automobile demand reports deal with demand models by Wharton Economic Forecasting Associates (77-046), Charles River Associates (76-025), and A.T. Kearney, Inc.

Specific model applications are discussed, as well as general methodologies and planned modifications of the models. Cambridge Systematics, Inc. and the Survey Research Center of the Institute for Social Research at The University of Michigan report on survey data and

on an aggregate forecasting model, incorporating disaggregate models of vehicle-type choice, developed to forecast consumer response to autos meeting fuel economy standards. Specifically, the model is supposed to predict the time path of scrappage and new and used vehicle transactions through 1985. The model is to be responsive to alternative fuel prices and availabilities, manufacturer strategies, and demographic changes. The methodology is described in the report.

S-78-123

REFERENCE

McNutt, B.; Pirkey, D.; Dulla, R.; Miller, C., A comparison of fuel economy results from EPA tests and actual in-use experience, 1974-1977 model year cars, Society of Automotive Engineers Paper no. 780037, Detroit, Michigan, 1978.

KEYWORDS

Fuel economy

SPONSOR

U.S. Department of Energy
Washington, D.C.

PERFORMING ORGANIZATION

Energy and Environmental Analysis, Inc.
Arlington, Va.

U.S. Department of Energy
Washington, D.C.

ABSTRACT

This report covers the development of the data base for a Department of Energy study that compares actual on-road fuel economy with Environmental Protection Agency (EPA) fuel economy numbers. Data on over 5000 vehicles were collected for model years 1974-1977 for vehicles in fleet and typical consumer use, from on-road tests, and from in-use dynamometer tests. Comparisons using linear regressions were made between these mpg values and the EPA certification results for the same models. Differences are described as a function of vehicle mpg and model year. Other more specific comparisons are also made. A measurable difference is found in the composite fuel economy of cars when tested in use employing EPA test procedures, as compared to the certification values. [Author's abstract modified]

REFERENCE

Siegel, H.M.; Burrows, T.M.; LaCivita, C.J., Automobile marketing strategies, pricing, and product planning, ASL Engineering, Inc. for Department of Transportation, Transportation Systems Center, Report no. DOT-TSC-13632, September 1977.

KEYWORDS

Fuel economy, pricing, market share

SPONSOR

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

PERFORMING ORGANIZATION

ASL Engineering, Inc.
495 South Fairview Avenue
Goleta, Calif. 93017

ABSTRACT

This study examines the problems and practices of the U.S. automobile industry in three areas -- product planning, pricing, and marketing. Each of these areas is analyzed from the viewpoint of how current procedures inhibit or prevent the increased manufacture and sales of U.S. cars that are more fuel efficient. The conclusions and the recommendations are expected to be useful to regulatory personnel in forming policies which are appropriate to given industry practices. The analysis includes the independent dealer organizations as well as the manufacturers and buyers in recommending policies to increase the fuel economy of the automobile fleet. [Author's abstract modified]

REFERENCE

Mauri, G.; Fetterman, G.P., Jr.; Ricci, R.L., Economic comparison of future automotive power systems, Society of Automotive Engineers Inc., Technical Paper no. 780035, February 1978.

KEYWORDS

Energy consumption, vehicle user costs/vehicle operating costs, automobile design, weight

PERFORMING ORGANIZATION

Exxon Enterprises Inc.
1251 Avenue of the Americas
New York, New York 10020

ABSTRACT

This paper presents Exxon Enterprises Inc.'s approach to the economic evaluation of advanced automotive power systems. The paper derives and compares projected initial costs and operating costs for a subcompact car and a full size car powered by four different advanced power systems, i.e. an advanced spark ignition engine, a lightweight diesel, a battery powered motor, and a diesel electric hybrid system. The operating economics are based on a detailed analysis of the power system energy consumption. The initial and operating costs of the vehicles reflect the different size and weight of the power systems as well as weight propagation effects on the rest of the vehicle. For a meaningful comparison basis, each vehicle power system is sized to achieve an equivalent performance level. The analysis concludes that while the advanced electric hybrid power system does not have the lowest initial cost, it does have low operating costs. This advantage is most evident in the larger, more powerful cars. [Author's abstract modified]

REFERENCE

Coulter, H.T., The usefulness of two multi-regional economic models in evaluating transportation policies: a comparison of the multi-regional input-output model by Karen R. Polenske and the multi-regional multi-industry forecasting model by Curtis C. Harris, Jr., Paper presented at the 56th annual meeting of the Transportation Research Board, Washington, D.C., 1977.

KEYWORDS

National economic impact

PERFORMING ORGANIZATION

U.S. Department of Transportation
Federal Highway Administration
Office of Program and Policy Planning
Socio-Economic Studies Division
Washington, D.C.

ABSTRACT

This report describes and compares the Multi-Regional Input-Output Model (MRIO) and the Multi-Regional Multi-Industry Forecasting Model (MRMI) and also examines their usefulness to transportation planning at the national, state, and local levels. The models are fundamentally different methods of economic forecasting, and thus have different appropriate applications in transportation planning. A basic difference is that the Polenske model is used mainly for analyzing the effects of changes in inter-industry trade flows between regions, whereas the Harris model is used mainly in forecasting regional growth and evaluating effects of alternative highway and other transportation systems. [Author's abstract modified]

REFERENCE

Intercity travel data search, Phase IV, automobile demand models: state of the art, Northwestern Univ., unpublished paper.

KEYWORDS

Automobile demand

PERFORMING ORGANIZATION

Northwestern University
Evanston, Ill. 60201

ABSTRACT

This is a review of automobile demand models used to estimate point-to-point intercity automobile passenger volumes, including multi-modal models that could be used to model demand for auto travel. Model assumptions, the mathematical expression of independent variables, and limitations upon the accuracy and comprehensiveness of estimations are sub-topics. Application of abstract mode models is discussed. The state-of-the-art in auto demand modeling is summarized and the demand estimates of various models are compared.

REFERENCE

Beachley, N.; Frank, A., Improving vehicle fuel economy with hybrid power systems, Society of Automotive Engineers Inc., Milwaukee Section, Paper no. 780667 South Milwaukee, April 1977.

KEYWORDS

Fuel economy, automobile design, emissions

PERFORMING ORGANIZATION

University of Wisconsin
College of Engineering
Madison, Wisc.

ABSTRACT

Hybrid vehicles, i.e., those containing two or more sources of power, have the potential of increased fuel economy under certain types of driving conditions. Systems currently being investigated include combinations of heat engines, electric drives, flywheels, and accumulators. In order to obtain fuel economy improvement over conventional vehicles, efficient components are required as well as a good system design. Hybrid power plants appear more promising for heavier vehicles. [Author's abstract]

REFERENCE

Curry, D.; Carlson, R.; Henderson, C.; Mandel, T; Mitchell, A.; Pozdena, R.; and Schwartz, P., Transportation in America's future: potentials for the next half century...part 1: societal context, and part 2: transportation forecasts, Department of Transportation, Report no. DOT-TPI-20-77-21, June 1977.

KEYWORDS

Automobile demand, vehicle miles traveled, fuel consumption, air pollution

SPONSOR

U.S. Department of Transportation
Office of the Secretary
Office of Planning
400 7th St., S.W.
Washington, D.C. 20590

PERFORMING ORGANIZATION

Stanford Research Institute
Menlo Park, Calif. 94025

ABSTRACT

This report describes four potential socio-economic futures for the United States and the implications of these futures for transportation through the year 2025. The futures are designated: success, foul weather, disciplined institutional structure, and popular values. There is extensive discussion of automobiles, trucking, urban and intercity transport, alternative travel modes, and improved and innovative vehicles and transportation systems. Part one provides narrative scenarios and separate analyses of the energy, demographic, economic, and urban implications of each scenario. Part two provides demand forecasts for most modes; technology forecasts for twelve modes and seven systems; and analyses of six critical transportation problems. Most of the analysis is not qualitative. Some quantitative models are used to provide reference points for the rest of the analysis. In particular, simple equations are used to give aggregate forecasts of vehicle miles traveled per household and of automobile ownership.

REFERENCE

Rickley, E.J.; Ford, D.W.; Quinn, R.W., Highway noise measurements for verification of prediction models, Transportation Systems Center, January 1978.

CONCERNING MODEL:

Model of Traffic Noise (76-089)

KEYWORDS

Noise Pollution

SPONSOR

U.S. Department of Transportation
Office of the Secretary
Office of the Assistant Secretary for Systems Development and Technology
Office of Noise Abatement
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

ABSTRACT

Noise level data were obtained along highways and arteries in North Carolina, Florida, Washington, and Colorado for the purpose of evaluating the predictions of noise models. Differences between the measured field data and the predictions of three models are presented. These models are the Transportation Systems Center model, the Michigan Version of the National Cooperative Highway Research Program (NCHRP) 117/144 report, and the Bolt Beranek and Newman Revised Design Guide or NCHRP 174 report (76-089). The authors conclude that the differences between field data and predictions indicate the need for a closer look at these models, as the models are used to determine future noise levels around proposed highways for Environmental Impact Statements.

S-77-139

REFERENCE

Automotive fuel economy program: first annual report to the Congress,
National Highway Traffic Safety Administration, January 1977.

KEYWORDS

Automobile demand, fuel economy

SPONSOR

U.S. Department of Transportation
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Automotive Fuel Economy
Washington, D.C. 20590

ABSTRACT

In accordance with responsibilities under the Energy Policy Conservation Act, as delegated by the Secretary of Transportation, the National Highway Traffic Safety Administration (NHTSA) reported to Congress on the progress of the NHTSA Office of Automotive Fuel Economy in developing fuel economy standards for automotive vehicles. NHTSA established an Automotive Fuel Economy Research and Development support program. The two objectives of the support program are developing data bases and analytical tools needed to evaluate the impacts of fuel economy levels. This involves estimating the effects of standards on consumer choices and manufacturers; the macroeconomic, air quality, and safety impacts of standards; and the fuel price effects of the standards.

REFERENCE

Automotive fuel economy program: second annual report to the Congress,
National Highway Traffic Safety Administration, January 1978.

CONCERNING MODEL:

Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Fuel economy, automobile demand

SPONSOR

U.S. Department of Transportation
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Automotive Fuel Economy
Washington, D.C. 20590

ABSTRACT

It is reported that the Research and Development support program has assembled the analytical tools, data bases, and models needed to develop 1984-86 passenger automobile fuel economy standards. This was done in large part through the Transportation Systems Center. The report details the passenger and non-passenger automobile standards, fuel economy regulations, predicted impacts of the passenger auto standards, and interaction with the Environmental Protection Agency. The Wharton Econometric Forecasting Associates Demand Model (77-046) was used to evaluate the impact of retail price increases on auto sales.

S-79-141

REFERENCE

Automotive fuel economy program: third annual report to the congress,
National Highway Traffic Safety Administration, January 1979.

KEYWORDS

Fuel economy, automobile demand

SPONSOR

U.S. Department of Transportation
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Automotive Fuel Economy
Washington, D.C. 20590

ABSTRACT

This report presents a comprehensive analysis of the National Highway Traffic Safety Administration's automotive fuel economy regulatory program. The ability of motor vehicle manufacturers to meet the average fuel economy standard of 27.5 mpg for model year 1985 passenger automobiles set by Congress, is specifically assessed. Also examined are the program's impacts on fuel conservation, dependence on foreign petroleum sources, consumers, the auto industry, and the economy. Recommendations are made for modifications to the program.

REFERENCE

The automobile as a component of community noise: task 1B interim report-MVMA model evaluation, Battelle Memorial Institute, Columbus Laboratories, January 1978.

CONCERNING MODEL:

Community Noise Countermeasures Cost Effectiveness Optimization Computer Program (NOIZOP) (75-057)

KEYWORDS

Noise pollution

SPONSOR

Motor Vehicle Manufacturers Association
300 New Center Building
Detroit, Mich. 48202

PERFORMING ORGANIZATION

Battelle Memorial Institute
Columbus Laboratories
505 King Ave.
Columbus, Oh. 43201

ABSTRACT

This report evaluates The Community Noise Countermeasures Cost Effectiveness Optimization Computer Program developed by Wyle Laboratories in 1975. A sensitivity analysis is done using hypothetical test data. The program is found to be extremely flexible for analyzing alternative approaches to reducing the noise impact index. The program requires voluminous data. Some method of data construction, such as a community noise model, and economic cost models are also required.

S-78-143

REFERENCE

Cermak, G.W.; Von Buseck, C.R., Quantitative studies of traffic noise annoyance, Society of Automotive Engineers Inc., Technical Paper 780390, presented at Congress and Exposition, Detroit, Michigan, February 1978.

KEYWORDS

Noise pollution

SPONSOR

General Motors Corporation

PERFORMING ORGANIZATION

General Motors Corporation
General Motors Technical Center
General Motors Research Laboratories
Societal Analysis Department
12 Mile and Mound Rd.
Warren, Mich. 48090

ABSTRACT

The research program on traffic noise annoyance conducted by the Societal Analysis Department of General Motors Research Laboratories is described in this paper. The Societal Analysis Department community noise model is composed of one program that calculates traffic noise levels for particular roads in a neighborhood, and another program that collates the traffic noise and population distributions for the neighborhood to produce a population noise exposure forecast. The acoustical part of the model is adapted from a traffic noise simulation program developed by Galloway, Clark, and Kerrick in 1969. The model is meant to be used in estimating the effectiveness of traffic noise abatement schemes.

REFERENCE

Review of analytic tools, accounting models and data bases applicable to TSC support of the AFE R&D program, Transportation Systems Center, July 1977.

KEYWORDS

Automobile design, automobile demand, industrial financial performance, fuel consumption, market share, vehicle operating performance, vehicle manufacturing resource utilization, scrappage, air pollution/air quality

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
400 7th St. S.W.
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

ABSTRACT

In support of the activities of the Automobile Fuel Economy Research and Development program, computer programs, procedures, and data file processors have been collected to provide quantitative information relating to technology assessment, industry assessment, economics and marketing assessment, and assessment of other impacts of fuel economy standards. This volume summarizes the objectives, capabilities, outputs, and special requirements of the collected computer procedures. It is neither a user's manual nor a software documentation for the various tools. Ten of the procedures are contained in Richardson, B.C., et al., An inventory of selected mathematical models relating to the motor vehicle transportation system, The University of Michigan, Highway Safety Research Institute, Sept. 1978. Of the fourteen other procedures, most relate to technology assessment and industry assessment.

S-77-146

REFERENCE

Disaggregated financial data and analysis for the domestic motor vehicle manufacturers, U.S. Department of Transportation, Transportation Systems Center, July 1977.

KEYWORDS

Industrial financial performance

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
400 7th Street, S.W.
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

ABSTRACT

Financial data for the four principal U.S. automobile manufacturers are abstracted from annual stockholder reports and reports to the Securities Exchange Commission. The data are analyzed to provide estimates of capital available for product improvement and to evaluate possible financial impacts of automobile fuel economy regulation. [Author's abstract]

REFERENCE

Automobile fuel economy contractors' coordination meeting summary report, National Highway Traffic Safety Administration, Washington D.C., 24-26 April 1978.

CONCERNING MODEL:

CRA Hedonic Demand Model (76-025)
Wharton EFA Automobile Demand Model (77-046)
New Passenger Car Sales & Market Shares Model (Chase) (74-002)

KEYWORDS

Fuel economy, market shares, scrappage, automobile demand, automobile design, industrial financial performance

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Passenger Vehicle Research
Technology Assessment Division
Washington, D.C. 20590

ABSTRACT

The presentations at the U.S. Department of Transportation National Highway Traffic Safety Administration Automotive Fuel Economy Research and Analysis Program Contractors' Coordination Meeting held in Washington, D.C. on April 24-26, 1978 are summarized in this report. Presentations dealt with progress reports on studies currently (1978) being funded by NHTSA and focused on the following major areas: integrated test vehicles; vehicle weight reduction; auto transmissions; manufacturing, maintenance, and costs; spark ignition engines; diesel engines; fuel economy reviews; industrial analysis; manufacturer impacts and alternatives; fuel conservation on the road; the consumer; and auto demand. At least one automotive manufacturing cost analysis uses a model, and several industrial analyses develop models. The Wharton Economic Associates Automobile Demand Forecasting Model, the Charles River Associates Hedonic Demand Model, and models developed by The Futures Group are used to estimate the impacts of government regulations on the auto manufacturers. There are statistical analyses and models of consumer behavior towards fuel efficient vehicles presented. Also included are automobile demand forecasts from Wharton Economic Forecasting Associates Inc., Data Resources Inc., and Chase Econometrics.

S-76-151

REFERENCE

Cheslow, M.D., Industrial and economic impacts of improving automobile fuel efficiency: an input-output analysis, The Urban Institute, Washington, D.C., April 1976.

KEYWORDS

National economic impact, energy consumption, fuel economy, weight

SPONSOR

National Science Foundation
Research Applied to National Needs
Office of Systems Integration and Analysis
1800 G Street N.W.
Washington, D.C. 20550

PERFORMING ORGANIZATION

The Urban Institute
2100 M Street N.W.
Washington, D.C. 20037

ABSTRACT

Three alternatives for improving automobile fuel economy are examined. Two involve reducing iron and steel with lighter weight aluminum or plastic. The other is changing the sales mix in favor of smaller cars. The 1967 Department of Commerce Input/Output Table is used to study these three policy alternatives. The estimated national economic impacts of all three alternatives are relatively small.

REFERENCE

Darling, E.M.; Prerau, D.S.; Downey, P.I.; Mengert, P.H., Highway air pollution dispersion modeling: preliminary evaluation of thirteen models, Transportation Systems Center Report no. DOT-TSC-OST-77-33, June 1977.

CONCERNING MODEL:

Caline-2 (76-084)

KEYWORDS

Air pollution/air quality

SPONSOR

U.S. Department of Transportation
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Office of Systems Engineering
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

ABSTRACT

Thirteen highway air pollution dispersion models were compared to determine how closely the model predictions agree with one another. The models were obtained from Aero-Vironment Inc., the California Division of Highways, the Transportation Systems Center/Environmental Protection Agency, Environmental Research and Technology Inc., Walden Research, Inc., Environmental Systems Laboratory, General Electric, Intera, Kaman Sciences Corporation, Lockheed Missiles and Space Company, Inc., Systems Control, Inc., Systems Science, and the Center for the Environment and Man. The models from the first five sources listed above emerged as consensus models; that is, the model predictions closely agree. This conclusion is considered to be preliminary due to the limited range of the sample data. However, this conclusion says nothing about the accuracy of the various model predictions.

S-72-153

REFERENCE

Darling, E.M., Jr., Computer modeling of transportation-generated air pollution - a state-of-the-art survey, Transportation Systems Center, DOT-TSC-OST-72-20, June 1972. NTIS no. PB-213 013.

KEYWORDS

Air pollution/air quality

SPONSOR

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Office of the Assistant Secretary for Systems Development and Technology
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

ABSTRACT

The emphasis of this report is on the modeling of dispersion of air pollutants from transportation sources. Those models which have been implemented are stressed, and the computational aspects of these models are treated in detail. Applications are discussed and validations are critically assessed. Primarily due to the only recent existence of instrumented transportation test sites, the performances of widely used models have not been adequately tested. [Author's abstract modified]

REFERENCE

Downey, P.J.; Garlitz, J.D.; Murphy, K.H., A comparison of six highway air pollution dispersion models using synthetic data, U.S. Department of Transportation, Report no. DOT-TSC-OST-76-58, September 1977.

KEYWORDS

Air pollution/air quality

SPONSOR

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Office of the Secretary
Office of the Assistant Secretary for Systems Development and Technology
Office of Systems Engineering
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
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Cambridge, Mass. 02142

ABSTRACT

This is the second of two studies conducted by the Transportation Systems Center (TSC) to test the performance of highway air pollution dispersion models, using synthetic data (i.e., either measured or artificially constructed input data for models, consisting of traffic and meteorological parameters). In the first study (DOT-TSC-OST-77-33, dated June 1977), thirteen models were tested with a portion of the Airedale air quality data base. In the present study, six models (including five of the original thirteen) were tested with a new synthetic data base. A group of three models which were found to generate very similar predictions in the first study also generated very similar predictions in the second study. [Author's abstract modified]

S-77-158

REFERENCE

Air pollution pilot study assessment of methodology and modeling: bibliography of grey literature on air quality modeling (Gaussian plume models), Modeling Panel, Committee on the Challenges of Modern Society, North Atlantic Treaty Organization, October 1977.

KEYWORDS

Air pollution/air quality

SPONSOR

North Atlantic Treaty Organization

PERFORMING ORGANIZATION

North Atlantic Treaty Organization
Committee on the Challenges of Modern Society
Modeling Panel

ABSTRACT

This bibliography is the first part of a registration and documentation of papers on the art of air quality modeling that have not yet been published in generally available journals. This first part concentrates on the applied air quality model literature (particularly Gaussian plume models). A second part will concentrate on new modeling techniques. In Part One over 300 papers and reports are abstracted, and cataloged by 12 categories of descriptors (including model type, compound, application, and model input and output), as well as by author's name and date of publication.

REFERENCE

Rabe, F.T., Study design for a method of projecting vehicle miles of travel, Environmental Impact Center, Report no. DOT-TSC-OST-77-25, August 1977.

CONCERNING MODEL:

NAV Model (74-001C)
Aggregate Auto Miles Traveled (75-011)
Gasoline Consumption Model (74-002)

KEYWORDS

Vehicle miles traveled

SPONSOR

U.S. Department of Transportation
Office of the Secretary
Office of the Assistant Secretary for Systems Development and Technology
Office of Systems Engineering
Washington, D.C. 20590

PERFORMING ORGANIZATION

Environmental Impact Center, Inc.
55 Chapel St.
Newton, Mass. 02158

ABSTRACT

The purpose of this report is to assess the state of the art of vehicle-miles-traveled (VMT) forecasting. The report begins with an inventory of data sources and problems. Three models representing the state of the art (developed by the Transportation Systems Center, the Rand Corporation, and Chase Econometrics Associates, Inc.) are evaluated. The conclusion of the evaluation is that all three models suffer because: (1) interactions between auto stock and VMT have not been adequately explored; (2) parameter estimates are likely to be biased because of omitted simultaneous relationships; and (3) cross elasticities of VMT with respect to the price and availability of competing modes of travel remain unknown. Recommendations for further research and the labor requirements for pursuing that research are reported as well.

S-61-160

REFERENCE

Suits, D.B., Exploring alternative formulations of automobile demand, The Review of Economics and Statistics, Vol. XLIII No. 1, February 1961.

CONCERNING MODEL:

Demand for New Automobiles in the United States 1929-1956 (58-033)

KEYWORDS

Automobile demand

PERFORMING ORGANIZATION

University of Michigan
Research Seminar in Quantitative Economics
Ann Arbor, Mich. 48109

ABSTRACT

The basis for this article is Dr. Suit's demand model developed earlier in "The demand for new automobiles in the United States 1929-1956," published in the same journal (November 1958).

The statistical implications of four alternative formulations of that model are examined. The first is that demand for autos is responsive to "supernumerary" income, rather than to disposable income. By supernumerary is meant some excess of income over a "subsistence" level. This alternative formulation improves the fit of the regression. The second distinguishes between pre- and post-war periods. It is suggested that there has been an upward shift in the desire to own autos, regardless of income. The stock effect and interest elasticity differ significantly between the two periods. The third introduces the age composition of the used car stock as an explanatory factor, but the results are not found to be statistically significant. The fourth is a reformulation of the price term. Demand is found to be more elastic with respect to wholesale price than to retail price.

REFERENCE

Murell, J.D., Light duty automotive fuel economy...trends through 1978, U.S. Environmental Protection Agency, Society of Automotive Engineers Technical Paper 780036, 1978.

KEYWORDS

Fuel economy

PERFORMING ORGANIZATION

U.S. Environmental Protection Agency

ABSTRACT

This is an analysis of fuel economy data compiled by the U.S. Environmental Protection Agency on passenger cars for model years 1958-1978, and light-duty trucks for 1975-1978. The paper includes new fuel economy data on pre-1975 cars, which indicate that fleet average MPG for the older models is slightly higher than had been previously estimated.

Analysis of 1977-78 passenger cars' and light trucks' economy characteristics in terms of the new Environmental Protection Agency/Department of Energy "Vehicle Size" classes provides new insight into fleet miles per gallon characteristics as related to model changes. The methodology for isolating fleet and individual manufacturer fuel economy changes due to specific factors such as system optimization and weight mix shifts has been refined. [Author's abstract modified]

S-77-162

REFERENCE

Rulemaking support paper concerning the 1981-1984 passenger auto average fuel economy standards, National Highway Traffic Safety Administration, July 1977.

CONCERNING MODEL:

Faucett Automobile Sector Forecasting Model (76-016)
Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Fuel economy, national economic impact, industrial financial performance, automobile demand

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Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

ABSTRACT

This rulemaking support paper focuses on the development and evaluation of three passenger automobile fuel economy schedules designated as Low-Range, Medium-Range, and High-Range, and the schedule selected for this rule. The selected schedule is between the Low- and Medium-Range reference schedules in early years and is identical to the Medium-Range schedule in later years. The schedules are evaluated in the context of: (1) the manufacturer's ability to make technological and manufacturing changes required to comply with the schedules, (2) the manufacturer's ability to finance the above changes, and (3) the consumer's acceptance of new automobile products and fleets with potential impacts on industry economics, employment, air quality, and fuel economy. Both the Wharton EFA Automobile Demand Model and the Faucett Associates Automobile Sector Forecasting Model are used to estimate economic impacts on the auto industry.

REFERENCE

Barksdale, H.C.; Guffey, H.J., Jr., A cross-spectral analysis of motor vehicle sales and registration, Swedish Journal of Economics, Vol. 75 no. 3 pp. 266-277, 1973.

KEYWORDS

Automobile demand

PERFORMING ORGANIZATION

University of Georgia (Hiram C. Barksdale)
Athens, Georgia

Auburn University (Hugh J. Guffey Jr.)
Auburn, Alabama

ABSTRACT

The purposes of this paper are to illustrate the application of cross-spectral analysis and to develop estimates of the lag structure between factory sales of motor vehicles and auto registrations in the United States for the period 1947-1971. Spectral analysis is used to determine the rhythmic patterns of behavior in time series, thus providing more detailed information than the traditional analytic method, covariance analysis. There are two major advantages of cross-spectral analysis. First, it provides for the decomposition of two time-series in terms of frequencies, thus allowing the investigation of the interaction between the series frequency-by-frequency. Second, it provides information about the lead-lag relationship between the series. Cross-spectral analysis could be a useful method for investigating the cyclic behavior so evident in the field of economics.

S-73-165

REFERENCE

Lamb, D.V.; Badgley, F.I.; Rossano, A.T., Jr., A critical review of mathematical diffusion modeling techniques for predicting air quality with relation to motor vehicle transportation, Washington State Department of Highways, June 1973.

KEYWORDS

Air pollution/air quality

SPONSOR

State of Washington
Department of Highways
Olympia, Wash. 98504

PERFORMING ORGANIZATION

University of Washington
Atmospheric Sciences and Civil Engineering
Seattle, Wash. 98195

ABSTRACT

This literature review is an attempt to assess the state of the art in air quality modeling relating to motor vehicle transportation. Government agencies, private companies, and individuals with models were contacted. The models reviewed are described and examined to identify the latest state-of-the art characteristics, model applicability, and model limitations. Recommendations are offered on the use of air quality diffusion models. [Author's abstract modified]

REFERENCE

Lehmann, E.J., Urban air pollution (a bibliography with abstracts), July 1976. NTIS no. PS-76/0584/36I.

KEYWORDS

Air pollution/air quality

PERFORMING ORGANIZATION

U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, Va. 22161

ABSTRACT

This is a bibliography (with abstracts) of reports on urban air pollution, including atmospheric models used for planning. The studies cited are of general interest to urban planners who wish to become aware of new abatement strategies and techniques. Most of the studies deal with transportation emissions. This update of a 1975 bibliography contains 241 abstracts, 69 of which were not in the earlier edition. There is a similar bibliography by Lehmann for urban noise pollution, NTIS no. PS-76/0585/0GA.

S-75-173

REFERENCE

Study of potential for motor vehicle fuel economy improvement: air quality and emissions panel report, Task Force under Department of Transportation and Environmental Protection Agency, January 10, 1975.

KEYWORDS

Air pollution/air quality, emissions

SPONSOR

U.S. Senate
Committee on Commerce
Washington, D.C. 20510

PERFORMING ORGANIZATION

U.S. Department of Transportation
Washington, D.C. 20590

U.S. Environmental Protection Agency
Washington, D.C. 20460

ABSTRACT

The Air Quality Panel Report is the third of seven reports prepared by a joint DOT-EPA Task Force to study the feasibility of a 20% fuel economy improvement standard for new motor vehicles produced through 1980. The authors project the impact of fuel economy improvements on air quality using simple air quality models. They conclude that such improvements are unlikely to have much impact on air quality, unless emissions standards are altered for fuel economy purposes. Air quality might be adversely affected if "large quantities" of autos and light trucks are converted to state-of-the-art diesel engines. Relaxation or delay of the .4 gpm NO_x standard's application could increase fuel economy, yet would have little effect on air quality.

REFERENCE

Study of potential for motor vehicle fuel economy improvement: economics panel report, Task Force under Department of Transportation and Environmental Protection Agency, January 10, 1975.

KEYWORDS

Fuel economy

SPONSOR

U.S. Senate
Committee on Commerce
Washington, D.C. 20510

PERFORMING ORGANIZATION

U.S. Department of Transportation
Washington, D.C. 20590

U.S. Environmental Protection Agency
Washington, D.C. 20460

ABSTRACT

The Economics Panel Report is the fifth of seven reports prepared by a joint DOT-EPA Task Force to study the practicability of a 20% fuel economy improvement standard for new motor vehicles produced through 1980. It covers four scenarios of fuel economy improvements. Estimates for improvement impacts are given for: operating costs of automobiles (five classes); automobile industry sales and capital requirements; major supplier industries, including petroleum refineries; oil imports; and (briefly) macroeconomic factors, specifically car prices and sales, employment, investment, and foreign trade. Conclusions are: (1) Consumer fuel and maintenance expenditure savings will generally exceed car price increases resulting from fuel economy improvements. (2) Effect of fuel economy improvements is likely to be an increased, or at least unchanged, level of sales. (3) Fuel economy improvements are likely to encourage a shift in sales towards full size cars. (4) Impacts on supplier industries and on auto industry capital requirements, as well as macroeconomic impacts, are small. (5) Petroleum savings of 0.9 to 1.5 million barrels/day by 1980 and 1.9 to 4.0 by 1990 are possible. Either balance-of-trade or domestic investment pictures could be improved as a result.

S-77-177

REFERENCE

Data and analysis for 1981-1984 passenger automobile fuel economy standards: summary report, National Highway Traffic Safety Administration, February 1977.

KEYWORDS

Fuel economy, automobile demand, industrial performance, automobile design

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Automotive Fuel Economy
Washington, D.C.

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Research and Development
Energy Research Division
Washington, D.C.

ABSTRACT

Data and Analysis for the 1981-1984 passenger auto fuel economy standards is presented as five separate support documents--a summary report and four numbered (1-4) documents. These documents supply a data base together with analyses and judgments relating to the establishment of average fuel economy standards for 1981-1984 passenger automobile model years, as mandated in Section 502 of the Motor Vehicle Information and Cost Savings Act, as amended by the Energy Policy and Conservation Act, 15VSC 2002(a)(3) of 1975. As required by that Act the support documents discuss the following four factors in determining maximum feasible fuel economy: technological feasibility, economic practicality, effects of other federal motor vehicle standards on fuel economy, and the nation's need to conserve energy. The Summary report summarizes the information on these four factors contained in the other four support documents. Department of Transportation projections are compared with manufacturers' projections. The summary is divided into two major sections. The first evaluates the impacts of, and potential for, improved auto fuel economy. The second evaluates the impact of the introduction of fuel-economical autos on the domestic auto industry.

REFERENCE

Data and analysis for 1981-1984 passenger automobile fuel economy standards: document 1, automobile demand and marketing, Transportation Systems Center, February 1977.

CONCERNING MODEL:

Wharton EFA Automobile Demand Model

KEYWORDS

Automobile demand, fuel economy

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Automobile Fuel Economy
Washington, D.C.

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Research and Development
Energy Research Division
Washington, D.C.

ABSTRACT

The automobile demand and marketing document examines demand and supply issues relating to the economic practicability of fuel economy standards. The auto base and auto demand model of Wharton EFA, Inc. are employed in the analysis of demand, and Wharton forecasts are compared with those from Chase Econometrics Associates, Inc., and Data Resources Inc. Industry marketing and pricing strategies are analyzed on the basis of manufacturer information and sales projections. There are four appendices. The first reviews automobile demand models with emphasis on the structure of the Wharton EFA model used by the Transportation Systems Center. The second appendix lists new car registration information for 1947-1974. The third contains sample Wharton EFA model forecasts for auto demand (apparently not the ones used in the analysis of fuel economy standards). The fourth appendix presents sales and revenues of the auto industry for 1975 and 1976 by size class and model.

S-77-179

REFERENCE

Data and analyses for 1981-1984 passenger automobile fuel economy standards: document 2, automotive design and technology, (volumes I and II), Transportation Systems Center, February 1977.

KEYWORDS

Automobile design, fuel economy

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Automotive Fuel Economy
Washington, D.C.

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

ABSTRACT

Document 2 supplies auto design and technology analyses relevant to the technical feasibility of 1981-1984 passenger automobile fuel economy standards. This document presents projected changes in passenger auto components and computations of the resulting fuel economies for each domestic manufacturer by year. Projected changes are organized in three alternatives intended to represent varying technological risks. These alternatives are: weight reduction by redesign only, weight reduction by redesign and major material substitution, and same as the second but with the addition of diesel engine penetration in the heavier models. A simple computational model is used to simulate the effects of design changes on fuel economy. An extensive data base and simulation results are presented. [Author's summary modified]

REFERENCE

Data and analysis for 1981-1984 passenger automobile fuel economy standards: document 3, automobile manufacturing processes and costs, National Highway Traffic Safety Administration, February 1977.

KEYWORDS

Fuel economy, automobile design

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Washington, D.C.

PERFORMING ORGANIZATION

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Transportation Systems Center
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Cambridge, Mass. 02142

ABSTRACT

Document 3 examines the manufacturing processes and costs which will affect the manufacturers' responses to fuel economy standards. Manufacturing facilities, capital expenditures and lead time required to build and modify manufacturing facilities, and production rates and volumes for vehicle engines, transmissions and other components are described. Changes in the variable cost of vehicles and the cost of components which manufacturers may add or delete to increase fuel economy are estimated. Appendices provide detailed engineering and cost analyses of various design changes including: the use of lightweight body materials, diesel engines, dual catalytic converter systems, fuel injections, and types of automatic transmissions.

S-77-181

REFERENCE

Data and analysis for 1981-1984 passenger automobile fuel economy standards: document 4, financial analysis of the U.S. automobile manufacturers, Transportation Systems Center, February 1977.

KEYWORDS

Industrial financial performance, fuel economy

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Automotive Fuel Economy
Washington, D.C.

PERFORMING ORGANIZATION

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Transportation Systems Center
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ABSTRACT

Document 4 analyzes the potential impacts of automotive fuel economy standards on the financial positions of the four large U.S. automakers: General Motors Corporation, Ford Motor Company, Chrysler Corporation, and American Motors Corporation. The document begins by setting out a conceptual framework for financial analysis, and then analyzes the historical patterns of financial structure and capital financing. These patterns are compared with trends in other U.S. industries. Capital needs implied by projections of the impacts of fuel economy standards and alternatives for meeting these capital needs are discussed, as are the effects of the penalty charges for failing to meet the standards. The document concludes that fuel economy standard related expenditures alone would not ordinarily present "major difficulties" for the automakers. However, the current (latest financial data used, 1975) financial positions of Chrysler and American Motors Corporation are such as to make it difficult to raise new capital. The report suggests that these two companies could turn to several strategies for reducing and avoiding extraordinary expenditures. [Author's introduction and summary modified]

REFERENCE

Five year plan for motor vehicle safety and fuel economy rulemaking and invitation for applications for financial assistance, National Highway Traffic Safety Administration, March 1978.

KEYWORDS

Fuel economy

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C.

ABSTRACT

Public comments and applications for financial aid in preparing comments are solicited concerning the Five Year Plan. The objectives of the plan are (1) to provide an internal working document for developing and issuing motor vehicle safety and fuel economy standards, and (2) to provide information to the public future activities, encourage comments, and permit industry to anticipate potential requirements in long-range planning. Rulemaking priorities and a tentative time schedule for rulemaking for passenger autos, light trucks, and low volume manufacturers are presented. The president has directed the Secretary of Transportation to "begin the analytic work necessary to examine how his authority should be used to raise mileage standards above 27.5 mpg beyond 1985." A notice of proposed rulemaking for model year 1985 and 1986 passenger autos is expected to be issued in January 1979, with a final rule to follow in July 1979.

REFERENCE

Rulemaking support paper for the 1980 and 1981 non-passenger automobile fuel economy standards, National Highway Safety Administration, December 1977.

KEYWORDS

Trucks, fuel economy

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C.

ABSTRACT

This paper supports the proposed fuel economy standards for non-passenger autos (NPA's) authorized by Title V of the Motor Vehicle Information and Cost Savings Act (amended). Standards are proposed for all NPA's of 8500 pounds gross vehicle weight rating or less. Separate ratings are proposed for two- and four-wheel drive vehicles. In addition, two separate fuel economy standards are proposed, one excluding, and one including, vehicles manufactured in a foreign country, but imported and sold by domestic manufacturers (captive imports). Underlying the development of the standards are assumptions regarding the effects of changes in emission standards, other federal motor vehicle standards, and Environmental Protection Agency test procedures on measured fuel economy. The substance of the report includes a consideration of the NPA market and the classification of NPA vehicles. The necessity for energy conservation is addressed, and the voluntary efforts of manufacturers are outlined. The proposed fuel economy standards are developed by a consideration of technology, weight reduction, and performance reduction. The options considered in fuel economy level selection, and the economic and environmental impacts of the proposed standards are also discussed at length. [Author's introduction modified]

REFERENCE

Machey, J.M., Final environmental impact statement: proposed rulemaking concerning passenger automotive average fuel economy, National Highway Traffic Safety Administration, June 1977.

CONCERNING MODEL:

Wharton EFA Automobile Demand Model (77-046)
Automobile Simulation Model of PIES (75-004A)

KEYWORDS

Air pollution/air quality, fuel economy, noise pollution

SPONSOR

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PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Automotive Fuel Economy
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ABSTRACT

This Environmental Impact Statement reviews the environmental impact of auto fuel economy standards for 1981-1984 and beyond model years. The environmental impacts of the standards on material substitution, diesel engines, noise, water usage, air quality, and solid waste are examined. The statement relies upon data from the 1976 National energy outlook (which uses the PIES model 75-004A) produced by the Federal Energy Administration, the Data and analysis for 1981-1984 passenger fuel economy standards, volumes 1 through 4, (which makes use of the Wharton EFA model 77-046) produced by the National Highway Traffic Safety Administration, the auto manufacturers, and other sources.

REFERENCE

Kulash, D.J.; Difiglio, C., The impact of mandatory fuel economy standards on future automobile sales and fuel use, presented at the Fifty-sixth annual Meeting of the Transportation Research Board, Washington, D.C., 24-28 January 1977.

CONCERNING MODEL:

Jack Faucett Associates Automobile Sector Forecasting Model (76-016)

KEYWORDS

Fuel economy, fuel consumption, automobile demand, scrappage, vehicle miles traveled, market share

PERFORMING ORGANIZATION

Jack Faucett Associates, Inc. (Kulash)
5454 Wisconsin Ave.
Chevy Chase, Md. 20015

U.S. Department of Energy (Difiglio)
Office of Conservation and Advanced Energy Systems Policy
Room 5311
1200 Perry, N.W.
Washington, D.C. 20461

ABSTRACT

The authors use the Jack Faucett Associates Automobile Sector Forecasting Model, as presented in Marketing and Mobility, report of a panel of the Interagency Task Force on Motor Vehicle Goals Beyond 1980, March 1976, by C. Difiglio and D. Kulash, to develop a basis for projecting and evaluating the impact of mandatory fuel economy standards and gasoline taxes on automobile sales and fuel use. The analytical procedures are based on explicit estimates of the cost to improve new car fuel efficiency and a behavioral model of consumer choice of auto by market class. Policy alternatives are evaluated in terms of impacts on fuel consumption, fuel economy, auto sales, scrappage, fleet composition, and vehicle miles traveled. The authors conclude that gasoline price increases have considerable potential to reduce auto fuel consumption, but simultaneously reduce vehicle miles traveled and auto sales substantially. Fuel economy standards, however, apparently can reduce fuel consumption significantly with relatively slight impact on travel and auto sales. It is suggested that standards set in existing (as of January 1977) legislation may be unattainable. [Author's abstract modified]

REFERENCE

Menchen, W.R., A study of industry response to policy measures designed to improve automobile fuel economy, Hittman Associates, Inc., Report no. PB 234625, February 1974.

KEYWORDS

Automobile design, weight, fuel economy, emissions

SPONSOR

Council on Environmental Quality

U.S. Department of Interior

U.S. Department of Transportation

U.S. Environmental Protection Agency

PERFORMING ORGANIZATION

Hittman Associates, Inc.
Columbia, Md.

ABSTRACT

The objective of the study was to provide insight on how auto manufacturers may respond to government policies designed to minimize passenger auto fuel consumption. The first task regarded near-term modifications in autos that would increase fuel economy; the second regarded the composite nature of each class of passenger auto that would be produced under a variety of tax and regulatory schemes. A simple cost model is formulated. [Author's abstract modified]

S-76-190

REFERENCE

Mellman, R.E., Aggregate auto travel forecasting: state of the art and suggestions for future research, Transportation Systems Center, Report no. DOT-TSC-OST-76-51, December 1976.

CONCERNING MODEL:

Chase 74-002B, EEA 75-003B, JFA 76-016, FEA 75-004A, Rand 74-001C, TSC 75-011, EIC 76-022A

KEYWORDS

Vehicle miles traveled

SPONSOR

U.S. Department of Transportation
Office of the Secretary
Office of the Assistant Secretary for Systems Development and Technology

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

ABSTRACT

The report critically reviews seven existing forecasting models of vehicle miles of travel (VMT) for the United States, most of which emphasize demographic, income, and fuel price explanatory variables. The report presents evidence that explanatory variables not included in existing models are also primary determinants of VMT in the United States. These other variables are the adequacy of highway and transit facilities and the effect of this existing transport infrastructure on spatial form. It is argued that these variables are critical to VMT analysis because they influence the relative time cost of highway travel. It is the time cost of travel, rather than the money cost of travel or perhaps even available income, that is the most important determinant of the number of miles people choose to travel per year. Models critiqued are those by Chase Econometrics, Jack Faucett Associates, Energy and Environmental Analysis, Federal Energy Administration, RAND, Transportation Systems Center, and EIC. [Author's introduction modified]

REFERENCE

Department of Transportation and related agencies appropriations, fiscal year 1978, part 2-justifications, related agencies, U.S. Congress, Senate, Committee on Appropriations, 95th Congress, 1st sess., pp. 187-8, 1977.

KEYWORDS

Vehicle miles traveled

SPONSOR

U.S. Senate
Committee on Appropriations
Washington, D.C.

PERFORMING ORGANIZATION

Interstate Commerce Commission
Bureau of Economics

ABSTRACT

This report is a justification of the fiscal year budget request for the Bureau of Economics of the Interstate Commerce Commission. In the past the Bureau has used economic models obtained from Data Resources, Inc. (DRI) and Chase Econometrics. The Bureau proposed to utilize a DRI model and long-term projections together with a data bank, statistical routines, and model-building features to study the transportation industry and to forecast traffic flows, financial position, and rate requirements for railroads and motor carriers. The Bureau proposed use of Chase Econometrics regional model and long-term regional projections in conjunction with a data bank, projections for 50 states and 150 SMSA's, and statistical routines to evaluate the regional performance of the transportation industry.

S-75-193

REFERENCE

Ryan, P., The elasticity of demand for gasoline, Energy Resources Co., Inc., Federal Energy Administration under contract number C-04-50081-00, March 1975.

CONCERNING MODEL:

New Car Sales/Auto Ownership/Vehicle Miles Traveled (NAV) Submodel of the Rand model (74-001C)

KEYWORDS

Fuel consumption, vehicle user costs/vehicle operating costs

SPONSOR

U.S. Federal Energy Administration
Office of Transportation
Washington, D.C.

PERFORMING ORGANIZATION

Energy Resources Co., Inc.
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ABSTRACT

One of the most important parameters for policy makers considering a gasoline tax increase to encourage conservation is the price elasticity of demand. This elasticity is the percentage decline in gasoline consumption which would result from a one percent increase in gasoline price. This paper examines several studies of the price elasticity, all of which fail to include supply behavior in the models used to estimate the elasticity. This probably leads to less elastic estimates than would otherwise result. All the models also suffer from misspecification biases with impacts on the estimates which are more difficult to determine. Another problem is that the variation in prices before 1973 is too limited and often too closely associated with trend to identify price elasticity of demand consistently and reliably, or to provide good information about the effects of 1973-1974 prices. The various studies produce elasticity estimates scattered from 0 to unity, the range one could set a priori on a theoretical basis. Of these estimates, Ryan judges values of around -0.08 for the first quarter and -0.25 in the longer run to be most plausible. Based on 1973-1975 data Ryan estimates the one-year price elasticity to be -0.18.

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Greene, D.L.; O'Connor, T.P.; Patterson, P.D.; Rose, A.B.; Shonka, D.B., Conservation book: edition 1, Oak Ridge National Laboratory, ORNL-5435 Special, September 1978.

KEYWORDS

Energy consumption, fleet size, fuel consumption, modal split

SPONSOR

Department of Energy
Office of Conservation
Transportation Energy Conservation Division
Non-highway Transport Systems and Special Projects
Data Analysis Branch

PERFORMING ORGANIZATION

Department of Energy
Oak Ridge National Laboratory
Energy Division
Regional and Urban Studies Section
Oak Ridge, Tenn. 37830

ABSTRACT

This document seeks to highlight regional differences in characteristics affecting transportation energy conservation in the U.S. The basic energy use data are presented in five modal chapters: highway, air, rail, marine, and pipeline. Each chapter contains information on stock of vehicles, transport networks, vehicle use, fuel use, and related data. Within modal chapters, data are presented at three levels of spatial disaggregation: selected metropolitan areas, states, and the ten federal regions. A sixth chapter considers socioeconomic factors relevant to transportation demand, focusing on the household as the basic consuming unit. Chapter seven considers energy supply and aggregate energy use for states. In the final chapter (Chapter Eight), United States energy use in transportation is placed in a world regional perspective. The Regional Data Book is a companion to the Transportation Energy Conservation Data Book which provides data at the national level. [Author's abstract]

S-78-199

REFERENCE

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KEYWORDS

Automobile demand, fleet size

SPONSOR

U.S. Department of Energy
Office of Conservation
Transportation Energy Conservation Division
Non-highway Transport Systems and Special Projects
Data Analysis Branch

PERFORMING ORGANIZATION

Oak Ridge National Laboratory
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ABSTRACT

Information on fleet automobiles is important to analysts of the automobile industry, since cars sold for fleet use represent 13 percent of total new car retail sales, and cars in fleet service represent over 6 percent of total U.S. car stock. This report increases the availability of such information. The report covers several major areas relating to fleet operations in the U.S. All known available sources of statistics on fleet vehicles are described. Fleet operations are characterized by stock composition and operational characteristics. Properties of fleet cars are compared with those of the total car population, and a comparison is made among fleets used by different sectors. Finally, the significance of fleet operations for transportation energy conservation is discussed. [Author's abstract modified]

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Fromm, G.; Hamilton, W.L.; Hamilton, D.E., Federally supported mathematical models: survey and analysis, National Science Foundation, contract no. NSF-C-804, PB-243-095, June 1974.

KEYWORDS

Model assessment

SPONSOR

National Science Foundation
Research Applied to National Needs
Washington, D.C. 20550

PERFORMING ORGANIZATION

Data Resources Inc.

Abt Associates, Inc.

ABSTRACT

This study examines the extent to which and the manner in which federal agencies use mathematical models. Part I analyzes the results of an extensive survey of federal agencies. The report recommends that for the potential of modeling to be realized, improvements must be made in the availability of data, in the funding and monitoring of research, and in information flows between model builders and policy makers. Part II lists projects alphabetically by project director, institution, sponsor, and subject area. Part III contains the appendices: project director questionnaire, agency monitor questionnaire, and tables.

REFERENCE

Whitney, G.; Deyman, G.; Dean, W., The Gas Guzzler Tax proposal: comparison of its impact with that of the Fuel Efficiency Incentive Tax proposal upon the future of the U.S. passenger automobile industry, U.S. Congress Senate, Committee on Finance, 95th Congress, 1st sess., Committee print, September 1977.

CONCERNING MODEL:

Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Fuel consumption, fuel economy, automobile demand

SPONSOR

U.S. Senate
Committee on Finance
Washington, D.C.

PERFORMING ORGANIZATION

U.S. International Trade Commission
Office of Industries
Machinery and Equipment Division
Washington, D.C.

ABSTRACT

This report compares the impact on U.S. sales of U.S./Canadian and imported passenger autos, employment in the U.S. auto industry, and U.S. consumers of passenger autos of the Gas Guzzler Tax (H.R. 6831 sec. 2021-2022) with the impact of the Administration's Fuel Efficiency Incentive Tax proposal. The Wharton Econometric Forecasting Associates Automobile Demand Model (77-046) is employed as an analytical tool to project auto sales, product mix, industrial employment, and retail prices. The report acknowledges that the error in the model estimates of the two proposals' impacts may be so substantial that in some cases the margin of error may be as great as the projected differences in proposal impacts. The major conclusions of the report are that the 'domestic' share of new car sales is greater, employment in the production of new autos in the U.S. is higher, and prices of subcompact and compact domestic autos are higher, while other size class prices are lower, under the House proposal than under the Administration proposal. The House proposal, however, is generally less effective in reducing consumer demand for fuel-inefficient autos than is the Administration proposal.

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ABSTRACT

This volume presents (1) descriptions of selected mathematical models (econometric, physical, accounting, etc.) relating to the motor vehicle transportation system, and (2) abstracts of associated documents that relate to models and the policies analyzed by the models. The models included describe some impact on society and/or the environment and may have the potential for use in policy-related analyses. Complete references and summaries are given for the models and associated literature. The models are further described, indicating their objectives, limitations and benefits, structure, data and computer requirements, and other relevant information. Indexes included may be used to identify models and documents according to model name, report title, keywords, personal and organizational authors, and sponsors. Subject areas covered include: automobile demand, fuel consumption and economy, air pollution, market share, and vehicle miles traveled.