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

FIRST SUPPLEMENT

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

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Barbara C. Richardson
Lawrence D. Segel
Kent B. Joscelyn

Policy Analysis Division
Highway Safety Research Institute
The University of Michigan

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Kent B. Joscelyn
Principal Investigator

Barbara C. Richardson
Principal Investigator

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1.0 INTRODUCTION

This volume continues 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 a supplement to an earlier volume[1] that contains descriptions of 90 models and abstracts of 62 associated documents. This volume contains descriptions of 52 models added to the inventory, and a revised report on one of those from the earlier volume. There are also 54 abstracts of associated documents added to the collection.

Each model predicts some variable(s) related to the motor vehicle transportation system as functions of policy-related variables. Most models have the potential for use in public policy analyses. Other models 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 associated literature that is summarized contains data that may be used in running or building models, describes uses of models, or reports on evaluations of 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 the Highway Safety Research Institute (HSRI) at The University of Michigan.

The work for this volume was done during the period June 1979 through June 1980. The project is a continuing one, and more supplements to the inventory 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 related model literature. 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 "long-form" reports on individual models collected through May 1980. Section 3.0 contains less-detailed "short-form" abstracts on the model-related documents. Section 4.0 is a set of indexes that may be used to locate particular

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[1]Richardson, B.C.; Segel, L.D.; Barnett, W.S.; Joscelyn, K.B., <u>An inventory of selected mathematical models relating to the motor vehicle transportation system and associated literature</u>, Ann Arbor, Michigan: UMI Press, an imprint of University Microfilms International, 1979.

models or documents according to six different categories: personal authors, organizational authors, sponsors, keywords, model names, and report titles. This section indexes reports and abstracts contained in both this supplement and the previous volume.

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 associated model literature,

3) provide the capability for exercising selected models via computer,

4) analyze selected models, and

5) investigate the use of models in policy formulation.

This volume reports on the progress made during the period June 1979 through May 1980 on the first two of these objectives. As more literature is collected, additional supplements will be issued. In accordance with the other objectives of the project, several other reports have been prepared. Three of these are: a report on the analysis of the Wharton Econometric Forecasting Associates' Automobile Demand Model[2]; a report on the use of that model in federal policy studies[3], and a report on the limitations on the use of mathematical models in transportation policy analysis[4]. A report on an analysis of the Faucett Automobile Sector Forecasting Model is forthcoming.

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[2]Golomb, 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.

[3]Saalberg, 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.

[4]Richardson, B.C.; Joscelyn, K.B.; Saalberg, J.H., Limitations on the use of mathematical models in transportation policy analysis, Ann Arbor, Michigan: UMI Research Press, an imprint of University Microfilms International, 1979.

1.3 Technical Approach

Literature for this inventory was found and collected in four ways: searching library catalogs, searching computerized literature data bases, reviewing references cited in other reports, and personally contacting model authors, sponsors, and other knowledgeable people in the field.

Models and related documents were considered appropriate for the inventory if a check of titles and abstracts indicated that they were related to the motor vehicle transportation system and (1) were judged to be usable in policy analyses, or (2) advanced the development of models.

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 as well as 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 transportation system.

In general, the project 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. or if certain aspects of them might be useful in building U.S. models.

In addition to the models and documents described above, this supplement volume exhibits the results of a search for national-level energy policy models. A report has been drafted[5] that briefly describes and compares twenty-one operational computer models and submodels of forecasting

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[5]Richardson, B.C.; Dahl, C.A.; Barnett, W.S.; Roberts, D.C.; Joscelyn, K.B, An overview of selected national-level energy/transportation mathematical models, Ann Arbor, Michigan: The University of Michigan Highway Safety Research Institute, Report no. UM-HSRI-80-47, 1980, Review Draft.

systems that are used to analyze energy resource supply, consumption, and price. Descriptions of these models will be found in this volume under these accession numbers: 76-016, 79-020, 77-242, 78-243, 79-254, 73-261, 79-263, 77-283, 77-286, 78-361, 79-368, 79-383, 79-384, 78-398, and 78-462.

This volume also contains abstracts of some documents that relate to a large number of models or to major forecasting efforts. These are described under: S-79-221, S-78-275, S-79-396, S-78-419, and S-79-468.

A comparison of this supplement with the original inventory volume will show that two model descriptions are repeated here. 76-016 has minor changes, and 79-254 is a major revision of 75-004A.

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

Every effort was made to be as comprehensive as possible, but the authors recognize that any effort of this nature is bound to be incomplete and somewhat outdated at the time of publication. They would, therefore, 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.

1.4 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. It has not been possible to provide information for every category for every model and document. This is because the required information was either unavailable or inappropriate for the subject model or report. 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 inventory was extracted.

1.4.1 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 that occurs prior to final inclusion in the inventory. These documents were deleted from the inventory, but only after the accession numbers had been assigned.

Sponsor: Included in this item are the name and address or 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, report or paper title, organizational author or publication data, report number, date, and National Technical Information Service (NTIS) number, if there is one.

1.4.2 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 other imposed conditions.

Validation: This includes any information relating to the forecasting behavior and dynamic properties of the model that has been reported by model authors or others. Forecastinq 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. When no model validation has been done, but the authors report results from their research with the model, that information is described.

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. Generally the limitations and benefits listed are those reported by the model authors.

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

Model Construction: This section discusses, for econometric models, 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.

1.4.3 Information on Supporting Literature

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.

1.4.4 Indexes

In the fourth section of this volume, all of the models and documents are indexed. There are six separate indexes in which personal authors, organizational authors, sponsors, keywords, model names, and report titles are all listed alphabetically, followed by 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.

Most models and documents have more than one keyword, so they appear under several keywords in the index.

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 (for accession numbers without the "S-" prefix) or an abstract in Section 3.0 (for accession numbers preceded by "S-"). 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 outside corner of each page.

The indexes are cumulative, in that they list models and documents contained in both this supplement and in the oriainal (1979) report. Accession numbers followed by (79) refer to abstracts or reports that are to be found in the earlier volume of the Inventory.

2.0 MODEL INVENTORY REPORTS

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 in policy analysis by the Federal Energy Administration (FEA), the Energy Research and Development Administration, the Energy Information Administration, the White House, The Transportation Systems Center, the Congressional Budget Office and the National Highway Traffic Safety Administration (NHTSA).

SPONSOR

Federal Energy Administration
Washington, D.C. 20461

AUTHOR

Jack Faucett Associates, Inc.
5454 Wisconsin Avenue
Chevy Chase, Md. 20015

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

All or part of this model has been used or may be used as the automobile transportation component or the automobile industry simulation component of these models: Transportation Energy Conservation Model (TEC) (S-78-385), Mid-term Energy Forecasting System (MEFS) (S-78-419), and Light Duty Vehicle Fleet Fuel Consumption Model (LDVFFCM) (78-368). There are five versions of the Faucett model, each being a modification of the previous version. The one reported here is the August 1977 version.

HISTORICAL BACKGROUND

There are two major parts of the model: an econometric automobile demand block and an automobile industry simulation block. 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 and the existing 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 are 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 by the model authors 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 at the Highway Safety Research Institute of The University of Michigan. A report on this study is forthcoming.

LIMITATIONS AND BENEFITS

The model authors report that this model is an improvement over previous models, in that alternative fuel economy policies can be tested by the model. This includes 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:

$$\log(N_t) = \underset{(1.4240)}{5.45746} + \underset{(0.21001)}{0.21779}\,[\log(O^*_t - \text{Autos}_t - D_t)] - \underset{(0.44124)}{1.7039}\,[\log(X^*_t)]$$

where standard errors are in parentheses, and

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

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

$$O^*_t = (\sum_I H_I P_{It})\, \text{HHLD}_t$$

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

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

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

$$\log(H_I) = -1.7481 + 0.4743\,[\log(I)]$$

I = midpoint of income bracket for income group I

$$\ln\left(\frac{S^C_t}{1-S^C_t}\right) = \underset{(1.3983)}{-4.1749} - \underset{(1.0526)}{1.8660}\,(B_1)\,Y^S_t - \underset{(3.4071)}{2.0765}\,(B_2)\,Y^M_t$$

$$- \underset{(1.6215)}{0.4299}\,(B_3)\,Y^L_t + \underset{(1.4913)}{3.5450}\,(B_2)\,Y^S_t + \underset{(1.6586)}{3.5093}\,(B_1)\,Y^M_t$$

$$+ \underset{(2.0077)}{1.8117}\,(B_3)\,Y^M_t + \underset{(2.3472)}{0.2589}\,(B_2)\,Y^L_t + \underset{(1.0249)}{5.6428}\,S^C_{t-1}$$

S^C_t = market share of size class C (small, medium, and large cars) in year t

B_1, B_2, B_3 = dummy variables with a value of one for small, medium, and large car observations, respectively; zero otherwise

Y^S_t, Y^M_t, Y^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

$$SPG_t = \underset{(0.04127)}{0.40675} - \underset{(0.04104)}{0.078433}\,(P_n)_t - \underset{(0.005085)}{0.015519}\,(U_t)$$

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

$$\frac{VMT}{HHLD_t} = \underset{(14492.1)}{-52979.8} + \underset{(4281)}{15087}\,\left[\log\left(\frac{DI_t}{HHLD_t}\right)\right]$$

$$+ \underset{(2307.1)}{6337.7}\,(\text{Autos}/HHLD_t) - \underset{(958.59)}{2204.24}\,[\log(100 \times CPM_t)]$$

VMT_t = total vehicle miles traveled in year t

DI_t = total real disposable income in year t

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

$$AMT_M = 17.9729 - 9.57841\ [\log(M)]$$

AMT_M = annual miles traveled per automobile at age M

M = vehicle age in years

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

1) new car sales,
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). Data for these variables are built into the program: income, population, historical stock of cars and fuel economies, unemployment rate, target auto ownership, technological costs of achieving future fuel economy ratings, and projected fuel economy.

REFERENCE

Impact of the Energy Policy and Conservation Act on automobile sales, ownership and usage, Jack Faucett Associates, Inc., March 1976.

Automobile sector forecasting model documentation, Jack Faucett Associates, Inc., Report no. JACKFAU-76-137-7, August 1976.

Fuel economy/cost relationships for future automobiles, Hittman Associates, Inc., Report no. JACKFAU-76-137-5, January 1976.

Fuel economy policies and their effects on automobile ownership, use, and fuel consumption, Jack Faucett Associates, Inc., submitted to the Federal Energy Administration, Report no. JACKFAU-76-137-8, August 1976.

Kulash, D.J.; Difiglio, C., Impact of mandatory fuel economy standards on future automobile sales and fuel use, Jack Faucett Associates, Inc. Presented at the Transportation Research Board, 56th annual meeting, Jan. 24-28, 1977, Washington, D.C., Jan. 1977.

Difiglio, C.; Kulash, D.J., Marketing and mobility, Report of the Panel on Marketing and Mobility of the Interagency Task Force on Motor Vehicle Goals Beyond 1980, interim report, March 1976.

Automobile sector forecasting model user's guide, Jack Faucett Associates, Inc., Report no. JACKFAU-76-137-6, August 1976.

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Difiglio, C.; Kulash, D.J., Methodology and analysis of ways of increasing the effectiveness of the use of fuel energy resources:: increasing automobile fuel economy via government policy, Presented to the U.S.-U.S.S.R. Joint Energy Committee: Information and Forecasting, Oct. 1977.

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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.

Duncombe, H.L., Jr., Motor vehicle goals beyond 1980: an economist's view, General Motors Corporation, 1977.

Kulash, D.J., Comparison of policies for improving automotive fuel economy, Congressional Budget Office, 1978.

Report by the Federal Task Force on motor vehicle goals beyond 1980: Volume 3, Appendices--preliminary draft, U.S. Department of Transportation, Oct. 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.

TRANSPORTATION ENERGY CONSERVATION NETWORK (TECNET)

The Transportation Energy Conservation Network was developed in 1976 and has been under revision by International Research and Technology Corporation. Major revisions by the MITRE and CONSAD corporations are underway. Sponsored by the Energy Research and Development Administration and the U.S. Department of Energy, it is designed to project the total energy requirements, direct and indirect, that occur as a result of transportation activity. The model has been used to study the effects of alternative economic and technological scenarios.

SPONSOR

U.S. Department of Energy
Office of Transportation Programs
Assistant Secretary for Conservation and Solar Applications
Washington, D.C. 20545

AUTHOR

Richard Meyer, Ralph M. Doggett, Robert U. Ayres, Adele Shapanka, Robert Strieter, and Mark Heller
International Research and Technology Corp.
McLean, Va.

KEYWORDS

Energy consumption, fuel consumption

OBJECTIVE OF MODEL

The purpose of TECNET is to measure the total energy consumption of alternative transportation strategies, out to the year 2025.

RELATIONSHIP TO OTHER MODELS

Estimates of the economic impacts of alternative policies affecting energy use by the transportation sector are provided through the Interindustry Forecasting Model (INFORUM). It provides aggregate economic statistics such as Gross National Product. TECNET operates as a module of the U.S. Environmental Protection Agency's Strategic Environmental Assessment System (SEAS), in conjunction with INFORUM, and using as input forecasts from the Chase Econometrics Associates Macroeconomic Model.

HISTORICAL BACKGROUND

TECNET has been adapted from an extension of SEAS, with additional detail to explicitly analyze the transportation sector. Major revisions to the model, by the MITRE Corporation and the CONSAD Research Corporation, are underway.

ASSUMPTIONS

The total energy consumption of the transportation sector is defined as the fuels used directly by vehicles, plus the potential fuel values lost during the conversion of crude energy resources into fuel products, and the energy embodied in vehicles and in infrastructure like highways, parking garages, etc.

VALIDATION

The model reports contain assumptions for, and projections from, several alternative scenario simulations: a base case (business as usual scenario), a high conservation scenario, an assessment of alternative engine (Brayton or Stirling) automobiles, and a gas rationing scenario. Sensitivity analyses of modal shares and energy intensity changes are also done.

LIMITATIONS AND BENEFITS

TECNET explicitly relates energy use to final demand and displays connections between intermediate uses; it is dynamic and is driven by long-range economic forecasts; it permits exploration of technological substitution; and it allows simulation of alternative scenarios, and sensitivity analysis. Passenger and freight transportation activities are modeled.

STRUCTURE

Energy use is viewed as a service, so that consumer demand can be satisfied by substitution. The major transportation service provided is passenger miles traveled, thus energy can be conserved without reducing the service, by increasing average vehicle occupancy or by increasing vehicle fuel efficiency.

Indirect energy use is estimated for these modes: auto, truck, bus, air, water, rail, and pipeline. It is further disaggregated for each mode into three basic categories: (1) transportation equipment manufacture, including energy consumed in the process of producing finished vehicles from raw materials; (2) transportation services, including energy used by support activities such as insurance, repair, warehousing, and baggage handling; and (3) transportation infrastructure, such as construction and maintenance of highways, railroads, ports, and pipelines.

TECNET consists of six interdependent modules. INFORUM makes dollar output projections of 185 industries. The TRANS module uses these to estimate the direct energy requirements of the transportation sector; RESGEN estimates the generation of pollution emissions, and ENERGY predicts energy use by the nontransportation sectors of the economy. The EMBODEN module estimates the indirect energy requirements of the transportation sector. The TECSET module feeds user-specified scenario parameters, such as material substitution trends, to other parts of the model.

Passenger miles traveled is a function of GNP, and is broken down into urban and rural, by mode. It is combined with vehicle occupancy ratios and energy intensity to estimate total energy use by mode.

MODEL CONSTRUCTION

TECNET is primarily an input-output model.

DATA USED IN RUNNING MODEL

The model user may specify exogenous scenario data for demographic projections, government expenditures, disposable income, timing and stringency of federal pollution abatement standards, materials used in manufacturing, rate of penetration for technological innovations, etc. The TECNET system initially provides the user with a base case scenario that can be modified by changing assumptions of economic growth, transportation activity, conservation initiatives, and environmental policy. A user may specify the shares of car sizes in the model, the market penetration rates for alternative automobile engines, and the average life of autos, which affects scrappage and automobile stock.

REFERENCE

Doggett, R.M.; Shapanka, A.; Meyer, R.; Strieter, R., Further development and use of the Transportation Energy Conservation Network (TECNET), International Research and Technology Corp., Report no. HCP/M2101-2, March 1979.

Meyer, R.; Doggett, R.M.; Ayres, R.U., Transportation Energy Conservation Network (TECNET): a summary description, draft report, International Research and Technology Corp., Report no. IRT-432-R, May 1976.

Doggett, R.M.; Meyer, R.; Heller, M., Ten scenarios of transportation energy conservation using TECNET: final report, International Research and Technology Corp., Report no. HCP/M2101-1, March 1979.

THRESHOLD REGRESSION MODEL OF HOUSEHOLD AUTOMOBILE PURCHASES

The Threshold Regression Model of Household Automobile Purchases was contained in a paper presented at the meetings of the "Societe Canadienne de Science Economique" held in Montreal in May of 1973. The research and development of this model was financed in major part by the Canadian Council of Arts. The objective of this model is to predict household purchases of automobiles, given the independent variables: permanent income, education of head of household, and number of children. A threshold regression approach is used. The model was originally developed in 1969.

SPONSOR

Canadian Council of Arts
255 Albert St.
Ottawa, Ont.

AUTHOR

Marcel G. Dagenais

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The objective of this model is to apply a threshold regression approach to the prediction of household purchases of automobiles, given the independent variables: permanent income, education of head of household, and number of children. The threshold regression model assumes that the value of the dependent variable remains fixed until the joint action of the independent variables and the error term causes it to overcome its reaction threshold. Thus, while the ownership of the first car would depend on the household's income, the household would purchase more cars only when the education of the head and the number of children reach a certain threshold. This characteristic makes the threshold regression model a theoretically pleasing model for the purchase of expensive durables such as automobiles.

RELATIONSHIP TO OTHER MODELS

This model does not interact with any other models.

HISTORICAL BACKGROUND

This model is a modified version of a general threshold regression model developed previously by the author. (See Dagenais, M.G., A threshold regression model, Econometrica, vol. 37, pp. 193-203, April 1969.) The paper containing the model was presented at the 1973 meetings of the "Societe Canadienne de Science Economique".

ASSUMPTIONS

The threshold regression model is based on the idea that the purchase of an automobile deals with a substantial sum of money, and that as a result, a threshold value does exist, at which point the household considering an automobile purchase will decide to commit funds toward that purchase.

Values for the "number of children" variable are constrained between zero and seven. The author assumes that the effect of any additional children on the value of new car purchases is zero. The author also constrains the correlation coefficient and variance of error terms in order to alleviate the problem of endless iterations. The study sample is limited to only those households owning one car in 1960 and 1961.

VALIDATION

The author compares the final results of the model estimation to those of other threshold regression studies and finds promising similarities and improvement in his model over past studies. The author also compares the performance of the threshold regression model as a statistical model to the probit-truncated regression model, and finds that when using the mean square error as a criterion of performance, the probit-truncated regression model is superior. However, under other criteria, the threshold regression model seems to be superior. The author suggests that more testing must be done.

LIMITATIONS AND BENEFITS

Most models that employ cross sections from survey data consider the consumption of flows of automobile services. Few focus on automobile purchases as this model does. The model is designed to deal only with households having one car, and thus the value of additional cars cannot be considered.

STRUCTURE

The model calculates both the dependent variable in the automobile purchase equation (which is defined as the difference between the real value of the car previously owned by the household and the real value of the new car purchased) and a threshold value that depends on household anticipations of car purchases as indicated during the previous year.

These are calculated as follows:

$$Y_h = \underset{(1.02)}{-7.22} + \underset{(0.37)}{3.04} [\ln(N_h + 1)] - \underset{(0.1809)}{0.0849} (H_h) + \underset{(0.5738)}{0.00550} (E_h)$$

$$S_h = \underset{(0.81)}{5.62} - \underset{(1.39)}{3.49} (A_h) - \underset{(0.81)}{5.62} [6/(N_h + 6)]$$

where asymptotic standard errors are in parentheses, and

Y_h = value of automobiles purchased in year t by household h

$Y_h = [C(t)_h]/[C(t-1)_h] - 1$

$C(t)_h$ = value of the cars owned by household h at the end of period t

$C(t-1)_h$ = value of the cars owned by household h at the end of period t-1

E_h = 0 if the head of household h has a high school education or less, = 1 otherwise

H_h = number of children living with household h

N_h = income normalized by stock of cars previously owned

$N_h = (I_h)/[C(t-1)_h]$

I_h = permanent income of household h

h = household

S_h = threshold value

A_h = 0 if the household did not anticipate changing its car in 1961, = 1 if the household did anticipate changing its car in 1961

The threshold value enters the automobile purchases equation as a cutoff value, below which the independent variables of the automobile purchases equation as a group have no effect on the dependent variable.

MODEL CONSTRUCTION

Most of the data come from a three-year survey panel conducted by The University of Michigan Survey Research Center (1961, 1962, 1963). The data period is over the years 1959-1961. The sample contains 318 spending units, of which 68 replaced their car and 250 did not. The values of cars held by households in years 1961 and 1960 were determined by referring to the Official Used Car Guide. Automotive Industry was consulted to check which special equipment was more generally found on the different kinds of cars, for each year.

REFERENCE

Dagenais, M.G., Application of a threshold regression model to household purchases of automobiles, Review of Economics and Statistics, vol. 57, no. 3, pp. 275-85, August 1975.

TRAFFIC NOISE MODEL

The Traffic Noise Model was developed in 1974 at the University of Maryland. It predicts the fluctuations in noise due to the variations in highway traffic.

AUTHOR

Allan H. Marcus
University of Maryland
Department of Mathematics
Baltimore, Maryland 21228

KEYWORDS

Noise pollution

OBJECTIVE OF MODEL

The objective of the model is to predict fluctuations in traffic noise due to statistical variation in properties of highway traffic, including differences in vehicle types, variation in individual vehicle emissions, clustering of vehicles by vehicle type, and variation in vehicle spacings within and between clusters.

RELATIONSHIP TO OTHER MODELS

The model has no direct relationship to other models.

ASSUMPTIONS

Variability in noise levels from a long stretch of moving traffic arises from several sources: (a) different vehicle types emit different amounts of noise; (b) different vehicles of the same type emit different amounts of noise; (c) vehicles tend to cluster, forming "platoons," and different type vehicles have different clustering properties; (d) vehicle spacings, within and between platoons, are not equal. A factor not taken into account is that vehicles in adjacent lanes of a highway do not act independently of each other. Each vehicle can be described by its state, i.e., slow versus fast, platoon leader or follower, high or low noise-emitting vehicle type.

The following assumptions were made in the construction of the traffic flow model: (1) The state of the following vehicle depends only on that of the leading vehicle. (2) The spacing distribution depends only on the state of the leading and following vehicle. (3) Sound is instantaneously transmitted.

VALIDATION

The theory developed in this paper is untested, but the author reports that it is readily amenable to observational testing.

STRUCTURE

The model involves three steps: a traffic flow model, a model of individual noise emissions, and a traffic noise model. Traffic flow is described by a Markov renewal process (MRP), and the noise heard by an off-highway observer as a filtered MRP. The average noise power at the observer due to a vehicle is specified to be an integral function of the average noise contributions of vehicles and the clustering of vehicles.

MODEL CONSTRUCTION

The noise emissions of individual vehicles are derived from analysis of extensive observations. The mean, variance, and covariance functions of noise intensity can be explicitly derived.

DATA USED IN RUNNING MODEL

The author uses observations from the southbound curb lane of U.S. 40 in Berkeley, California in the traffic flow model to illustrate vehicle type clustering tendencies.

REFERENCE

Marcus, A.H., Theoretical production of hiqhway noise fluctuations, _Journal of the Acoustic Society of America_, vol. 56, no. 1, pp. 132-137, July 1974.

AGGREGATE DEMAND MODEL FOR NEW AND USED AUTOMOBILES

The Aggregate Demand Model for New and Used Automobiles was developed in 1978 at Stanford Research Institute. The objective of the model is to improve on earlier empirical work examining the demand for automobile services, to explain the determination of used car rental prices, and to test the hypothesis that new car services are superior goods relative to used car services.

AUTHOR

Terry R. Johnson
Stanford Research Institute
Stanford, Calif. 94305

KEYWORDS

Automobile demand, pricing, model assessment

OBJECTIVE OF MODEL

The model explains demand for new car services, used car rental price, and the total quantity of automobile services. The model is used to explain the determination of used car rental prices and to test the hypothesis that new car services are a superior good with respect to used car services.

RELATIONSHIP TO OTHER MODELS

The new car service demand equation uses the same specification as that of Wykoff (73-010).

Another model by the same author is described under 78-307.

HISTORICAL BACKGROUND

Most previous studies ignored the heterogeneity of automobile stock; a single aggregate measure of stock was used. This study attempts to find satisfactory empirical results to explain used car prices.

ASSUMPTIONS

Relative rental price ratios are interpreted as weights that translate the services of automobiles of different makes and ages into a common numeraire unit in order to obtain various aggregate measures of automobile services.

VALIDATION

Used car rental prices are shown to depend on income and on the quantity of used car services. The income elasticity for new car services is considerably larger than that for used car services.

LIMITATIONS AND BENEFITS

The reliability of demand elasticities is limited by the quality of the aggregate measures of the variables. The model author's results indicate that care must be taken in constructing meaningful aggregates.

STRUCTURE

There are three market demand equations: the demand for new car services, the determination of used car rental prices, and the demand for the services of total auto stock. These three equations are estimated with each of the fourteen makes of cars alternately as the numeraire, for the periods 1954 to 1972. As an illustration, the third equation is shown here:

$$\log[A_M(t)] = b_{0M} + b_{1M}\,[\log(c_a[M,0,t])] + b_{2M}\,[\log(Y[t])] + v_M(t)$$

where:

$A_M(t)$ = total quantity of automobile services in period t, measured in new make-M service equivalents

$c_a(M,0,t)$ = actual rental price of a make-M, new automobile in period t

$Y(t)$ = consumer income in period t

$v_M(t)$ = random error term

MODEL CONSTRUCTION

The model is based on the user-cost of capital theory. The implicit rental prices, derived from new and used purchase prices and the market rate of interest, are representative of the real user-cost of the services provided by durable goods. Two alternative definitions of the implicit rental prices are constructed, depending on assumptions regarding the value of the rent period's expected price. Relative rental price ratios are employed as weights that translate the services of automobiles of different makes and ages into a common numeraire unit. This common rating is used to obtain various aggregate measures of automobile services.

REFERENCE

Johnson, T.R., Aggregation and the demand for new and used automobiles, Review of Economic Studies, vol. 45, no. 2 pp. 311-327, June 1978.

72-205

AUTOMOBILE DEMAND MODEL COMBINING ANTICIPATORY AND OBJECTIVE VARIABLES

The Automobile Demand Model Combining Anticipatory and Objective Variables was prepared as a part of a larger study being carried out by the National Bureau of Economic Research in cooperation with the U.S. Bureau of Census and was published in September 1972. It was funded in part by the National Science Foundation. It shows how consumer survey data can be incorporated into forecasting automobile demand.

SPONSOR

National Science Foundation
1800 G St. N.W.
Washington, D.C.

AUTHOR

F. Thomas Juster and Paul Wachtel
National Bureau of Economic Research
261 Madison Ave.
New York, N.Y. 10016

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

An optimum balance is sought between using survey data on consumer sentiment and more objective variables for forecasting automobile demand. Three models are developed, one using only objective variables, one relying on consumer survey data, and a third optimally combining aspects of both techniques.

HISTORICAL BACKGROUND

The study examines the introduction of data on consumer anticipation into the more traditional type of model that tends to emphasize information on capital stocks and income flows. Examples of these earlier models are by G.C. Chow (57-413) and D.B. Suits (58-033).

ASSUMPTIONS

In the objective variables model, consumers are viewed to have a target or desired stock of automobiles to which they adjust gradually. Net investment in automobiles is viewed to have a planned, permanent component, dependent on long-run income expectations and an unforeseen, transitory component representing the immediate reaction to unexpected income flows.

The consumer survey data model views consumer sentiment and expectations variables as a substitute for the desired automobile stock variables and for all lag and adjustment mechanisms. The optimal model views consumer anticipation variables as additional determinants of desired stock.

VALIDATION

Results of the three models are compared with actual data for automobile demand using standard errors. According to the authors, the anticipatory model is a close substitute for the objective model as long as consumer sentiment and expectations can be measured with relatively small sampling errors, but the objective model is markedly superior in the longer period. Incorporating survey data into the objective model improves its forecasting accuracy.

STRUCTURE

The following econometric equation is used to predict automobile demand with solely objective data:

$$\Delta S = \rho\ \beta\ Z - \rho\ \beta\ S_{-1}$$
$$+ (1-\rho)\ (1-\beta)\ \Delta S_{-1}$$
$$+ T - (1-\rho)\ T_{-1}$$

where:

ΔS = net durables investment

ρ = coefficient of income expectations

β = coefficient of stock adjustment speed

Z = desired stock

S_{-1} = actual durables stock, last period

T = transitory investment, current period

T_{-1} = transitory investment, last period

The following econometric equation uses consumer survey data to predict automobile demand:

$$X = a_0 + a_1\ (p) + a_2\ (A) + a_3\ (U)$$

where:

X = purchase rate

p = consumer intentions

A = consumer attitudes

U = working hours of labor force unemployed

MODEL CONSTRUCTION

This model uses U.S. quarterly economic data for measures of income, consumer durable investment, and the working hours of the labor force that are employed. The attitude variable is constructed from the Index of Consumer Sentiment. The intentions data are a spliced series. From 1953 to 1959 the source is the Survey Research Center (SRC); from 1959 to 1966, the Census Bureau's Quarterly Survey of Intentions. After 1966 the U.S. Census Consumer Buying Expectations (CBE) is used.

REFERENCE

Juster, F.T.; Wachtel, P., Anticipatory and objective models of durable aoods demand, American Economic Review, vol. 62, no. 4, pp. 364-579, September 1972.

ILLIQUIDITY OF CONSUMER DURABLES AND MONETARY POLICY MODEL

A model analyzing the illiquidity aspect of consumer durable assets and the effects of monetary policy on expenditures for durable assets (automobiles) was developed at the Massachusetts Institute of Technology in 1976. The work was supported by a National Science Foundation Graduate Fellowship and by the Federal Reserve Bank of Boston.

SPONSOR

National Science Foundation
1800 G St. N.W.
Washington, D.C.

Federal Reserve Bank of Boston

AUTHOR

Frederic S. Mishkin
Massachusetts Institute of Technology
Department of Economics
Cambridge, Mass. 02139

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

A model is developed that incorporates the effects of consumer durable illiquidity on the desirability of the asset. It is shown that the nature of markets for consumer durables forces the consumer to take account of his balance sheet status, i.e., his debt and financial asset position, as well as the riskiness of his input stream, in determining the desired level of his consumer durable stock. The theoretical model is specified for consumer durable expenditures in general; it is estimated with automobiles and parts expenditures as the dependent variable, for non-auto consumer durables, and for all consumer durables.

RELATIONSHIP TO OTHER MODELS

There is no relation to other models.

HISTORICAL BACKGROUND

In previous studies on consumer durable expenditure, monetary policy was thought to have a major impact through interest rate or liquid asset effects, but empirical work rarely found these effects to be substantial. This paper explores new channels through which monetary policy may affect consumer durable expenditures by affecting consumer financial asset holdings, and by affecting the cost and availability of credit, and thus the size of consumers' debt.

ASSUMPTIONS

A consumer durable is viewed as an asset in one's portfolio that yields a return of consumption services. The consumer derives benefits from the services of the stock, not from the purchases of durable goods. The consumer desires a certain stock of durables that is a function of permanent income and the user rental cost of capital. Consumer durable expenditure is modeled with the stock adjustment or so-called flexible accelerator model, which views consumers as adjusting only slowly to their desired stock. Net investment is viewed as a function of transitory income.

VALIDATION

The estimated coefficients have the correct signs, are significant, and have reasonable magnitudes.

LIMITATIONS AND BENEFITS

This study develops new channels through which monetary policy is shown to affect consumer durable expenditures. The illiquidity aspect of these assets is analyzed. The model author states that the hypothesis is supported that monetary policy has a strong impact on consumer durable expenditure through two channels: the price of assets, which affects consumer financial asset holdings; and the cost and availability of credit, influencing the size of consumers' debt holdings.

STRUCTURE

This econometric model is estimated with auto, nonauto, and all consumer durable expenditures as the dependent variable, and with different estimation techniques. One of the specifications of the model, with autos and parts expenditures as the dependent variable, is presented here:

$$EXP_A = \underset{(-2.89)}{-.1920} + \underset{(1.42)}{.1002}\,(Y_T) + \underset{(2.74)}{.2142}\,(Y_P)$$

$$- \underset{(-1.16)}{.1834}\,(CAPC_A\,Y_P) - \underset{(-.08)}{.0194}\,[K_A(-1)]$$

$$- \underset{(-4.24)}{.1731}\,(DEBT) + \underset{(4.09)}{.0398}\,(FIN) + .5163\,(r)$$

$R^2 = .9703$ DW = 1.84 SE = .007138

where asymptotic t-statistics are in parentheses, and

EXP_A = real per capita consumer expenditures on autos and parts at an annual rate

Y_T = real transitory income per capita

Y_P = real per capita expected average (permanent) income

$CAPC_A$ = user rental cost of consumer durable capital for autos and parts = (RCB + D) (PCD/PCON)

RCB = Moody's AAA corporate bond rate

D = annual depreciation rate = .25

PCD = consumer durables implicit price deflator

PCON = consumption implicit price deflator

K_A = real per capita stock of durables at the end of the quarter for autos and parts

DEBT = real per capita debt holdings of households--beginning of quarter

FIN = real per capita gross financial asset holdings of households--beginning of quarter

r = first-order serial correlation coefficient

MODEL CONSTRUCTION

A stock adjustment model is estimated based on quarterly aggregate time-series data for consumer durables and the two components of consumer durables: (1) autos and parts expenditure, and (2) nonauto consumer durable expenditures. Various specifications are used with data from the periods 1954-I through 1972-IV, excluding quarters when there were auto strikes. All quantities are in thousands of 1958 dollars per capita with flows as seasonally adjusted annual rates.

REFERENCE

Mishkin, F.S., Illiquidity, consumer durable expenditure, and monetary policy, American Economic Review, vol. 66, no. 4, pp. 642-654, September 1976.

HIGHWAY NOISE POLICY MODEL

The Highway Noise Policy Model was developed at Wyle Research Laboratories for the Environmental Protection Agency's Office of Noise Abatement and Control and published in September 1974. Its purpose is to evaluate regulatory strategies of highway noise control.

SPONSOR

U.S. Environmental Protection Agency
Office of Noise Abatement and Control
1921 Jefferson Davis Highway
Arlington, Va. 22210

AUTHOR

Kenneth J. Plotkin
Wyle Laboratories
Wyle Research
El Segundo, Calif.

KEYWORDS

Noise pollution

OBJECTIVE OF MODEL

The model was developed to evaluate government regulation strategies in controlling highway noise. Two types of regulation are evaluated: (1) operational regulations, where trucks operating on the highway may not produce noise levels above a specified value, and (2) new vehicle standards, where the maximum level produced by new vehicles is regulated. It also can be used to predict noise up to 400 feet away from a multi-lane highway.

HISTORICAL BACKGROUND

This model can evaluate individual vehicle noise regulation policies for effectiveness in reducing highway noise. Previously developed less aggregated models that employ empirical techniques are not able to evaluate such policies. The model is essentially a simplification of earlier models, drawing mainly from a method developed by Nelson in 1973 of combining statistics from two independent noise sources.

ASSUMPTIONS

Vehicle noise is assumed to be the only contribution to noise measured from a given distance from a highway.

VALIDATION

For a comparison of predictions of this model to those of other models, see S-77-105 in the 1979 volume of this inventory.

Measurements were made on freeways and arterials in southern California between Los Angeles and San Diego during the summer and fall of 1973. At 50 feet from the highway, noise is predicted with an accuracy of $\pm$ 3 dB. Predictions of noise levels from 400 feet of the highway are 6 to 10 dB higher than actual measurements.

LIMITATIONS AND BENEFITS

The model is valid only for freely flowing traffic where vehicles do not interact and spacing is random. At higher traffic flows with congested or rush-hour traffic jams, the model is not applicable.

STRUCTURE

$I_k(0) = I_{ref}$ integral$_L$[(P_k) (L) $(10^{L/10})$ dL]

where:

$I_k(0)$ = average sound intensity of vehicles in speed class k

I_{ref} = reference intensity corresponding to the standard sound pressure level reference of $2x10^{-5}$ Newton/Meters^2

P_k = fraction of vehicles at speed class K

$$\bar{I}_j = \left(\frac{d^2}{d_j}\pi\right) \sum_k \left[\frac{A_k}{V_k} I_k(0)\right]$$

where:

$\bar{I}_j$ = sound intensity from one lane

d = fixed reference distance

d_j = distance from the lane

A_k = vehicles per unit time

V_k = speed

k = class defined by speed

REFERENCE

Plotkin, K.J.; Kunicki, R.G., Comparison of highway noise prediction models, Wyle Labs/Wyle Research, Report no. 55019-77-355, May 1977. NTIS no. PB 276710

Plotkin, K.J., Model for the prediction of highway noise and assessment of strategies for its abatement through vehicle noise control, Wyle Research Report WR 74-5, Sept. 1974.

COMPUTER REQUIREMENTS

Two computer programs are presented in this report. The HIGHWAY program computes highway noise, using Tymshare Super Basic. The HINSCAM program applies noise regulation scenarios to the existing vehicle noise situation, and is written as a batch Tymshare Super FORTRAN program.

70-209

DEPRECIATION OF CAPITAL MODEL

Depreciation rates for automobiles are calculated using a model that defines depreciation in terms of the price of autos. It was developed in 1970 at Pomona College.

AUTHOR

Frank C. Wykoff
Pomona College
Claremont, Calif.

KEYWORDS

Fleet size, scrappage

OBJECTIVE OF MODEL

Actual depreciation rates for new and used automobiles are constructed, using a model that defines depreciation in terms of the price of automobiles.

RELATIONSHIP TO OTHER MODELS

Another model by this author is described under 73-010.

ASSUMPTIONS

It is assumed that owners of machines act as if they were renting to themselves, and that the cost of rental can be measured closely by using market interest rates and market purchase prices. It is also assumed that perfect capital markets exist, that transportation costs of the machines are relatively small, and that there are well-developed used-machine markets. The automobile market generally fits these assumptions.

LIMITATIONS AND BENEFITS

The general model presented here could be applied to other capital equipment such as appliances or furniture.

One conclusion of the model is that the hypothesis that depreciation is independent of time cannot be rejected, but there are subtle increases in depreciation, perhaps because increasing incomes have resulted in higher turnover of automobiles. Other conclusions of the study are that different size-classes of autos have different depreciation rates, and depreciation rates are not exponential.

STRUCTURE

The methodology for calculating depreciation rates is as follows. Implicit rental prices are used as estimates of, or proxies for, user costs (since true rental markets don't exist), and are derived from new and used purchase prices:

$$C(s,t) = r(t)\ p(s,t) + p(s,t) - p(s+1,t+1)$$

where:

$C(s,t)$ = implicit rental cost of holding a 5-year old machine throughout year t

$r(t)$ = market interest rate

$p(s,t)$ = purchase price of the machine of vintage s in year t

$R(s,t) = c(s,t)/c(0,t)$

where $R(s,t)$ is the ratio of the user-cost of a s-year old machine to that of a new machine, or the depreciated value of an s-year old machine in year t. If it is assumed that there is no technological change, then $R(s,t) = R(s)$; i.e., depreciation is independent of time. If depreciation rates are constant, then R is exponential:

$$R(s) = e^{-ds}$$

where d is the constant rate of depreciation.

If R is independent of time then the aggregate capital stock can be found as:

$$K(t) = \sum_{s=0}^{n} M(s)\ R(s)$$

where:

$K(t)$ = the stock of machines in period t

$M(s)$ = the quantity of machines built s years ago

n = the age of the oldest machine still in existence in year t

Depreciation rates are constructed for a variety of automobile makes and ages.

MODEL CONSTRUCTION

New and used passenger car retail prices from 1950 through 1969 of nineteen car models, taken from The Kelley Blue Book, are used to construct depreciation rates.

70-209

REFERENCE

Wykoff, F.C., Capital depreciation in the postwar period: automobiles, Review of Economics and Statistics, pp. 168-172, May 1970.

HIGHWAY POLLUTION TREND MODEL

The Highway Pollution Trend Model was sponsored by the National Academy of Engineering, developed at the Massachusetts Institute of Technology, and published in 1973. It extrapolates current trends of transportation resource use and pollution productions with various modal split scenarios.

SPONSOR

National Academy of Engineering
Committee on Motor-Vehicle Emissions
Washington, D.C. 20418

AUTHOR

D.G. Wilson
Massachusetts Institute of Technology
Cambridge, Mass. 02139

KEYWORDS

Air pollution/air quality, emissions, modal split

OBJECTIVE OF MODEL

The model's objective is to evaluate the approximate pollution levels and resource (gasoline, steel, cement, asphalt) use resulting from different proportions of automobile and bus transportation. An attempt is also made to put costs on congestion and pollution for three regions of a typical urban area: city center, inner suburbs, and outer suburbs.

ASSUMPTIONS

It is assumed that average fuel consumption of automobiles will remain steady through the year 2000. Automobile emission controls were assumed not to affect the output of particulates. Numerous other assumptions were made to make exploratory calculations of the future.

VALIDATION

The model shows that a substantial diversion of automobile commuters to public transportation would not result in a marked reduction in overall pollution. However, local pollution and congestion costs would be markedly reduced in central cities where pollution costs are the highest.

STRUCTURE

This accounting model extrapolates current trends and recent developments on transportation resource use and pollution levels up to the year 2000. A series of graphs with low and high probable ranges is used.

DATA USED IN RUNNING MODEL

This model used data from the 1970 Automobile Facts and Figures, Highway Statistics 1966 (U.S.DOT), The World Almanac and Book of Facts, and the Bureau of the Census' Statistical Abstract of the U.S.

REFERENCE

Wilson, D.G., Estimates of pollution from U.S. nonfreight highway transportation, International Journal of Environmental Studies, vol. 6, pp. 35-50, 1974.

TEMPORAL CROSS-SECTION SPECIFICATION OF THE REGIONAL DEMAND FOR GASOLINE

A temporal cross-section specification of the regional demand for gasoline, allowing for differences across states, and based on the lagged stock of automobiles, income, and gasoline price, was developed in 1978 by staff members of the National Science Foundation and the U.S. Department of Energy.

AUTHOR

John Kraft
National Science Foundation
Division of Advanced Productivity Research and Technology
Washington, D.C.

Mark Rodekohr
U.S. Department of Energy

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

A temporal cross-section specification is used to estimate the regional demand for gasoline, based on gasoline price, income, and the lagged stock of automobiles.

RELATIONSHIP TO OTHER MODELS

There is no relationship to other models.

HISTORICAL BACKGROUND

Previous studies of the demand for gasoline use either a flow adjustment model or a stock adjustment model. The flow adjustment model expresses gasoline consumption as a function of real gas price, disposable income and gas consumption in the previous period. It does not capture changes in the average efficiency of the stock of automobiles. The flow adjustment model pools data into an aggregate national equation and provides no regional implications. The stock adjustment model is felt to be superior and is used in this study.

ASSUMPTIONS

It is hypothesized that the regional demand for gasoline is best estimated by a stock adjustment model. The demand for gasoline is derived from the demand for gasoline-consuming goods, and the stock of automobiles serves as a proxy for this.

LIMITATIONS AND BENEFITS

Separate coefficients that determine gas consumption as a function of gas price, income, and auto stock were estimated for each region. This allows for the illustration of regional differences over time in gas consumption behavior. The Aitken-Zellner generalized least squares estimate was used in this model. This resulted in the rejection of the hypothesis that the estimated slope and intercept coefficients are the same for all of the states in each region. Thus, the estimation of the regional random coefficient specification model is an improvement over the aggregate gasoline demand specification that ignores variation in behavior across states and regions. The stock variable may reflect various omitted factors, which are not captured in the other variables, that describe the influence on demand of automobile stocks in the different regions.

STRUCTURE

The general equation specification is applied to nine regions, resulting in nine sets of coefficient estimations. The model specification, with the estimated coefficients for the Northeast Region as an example, is:

$$Q = \underset{(1.63)}{1.63} - \underset{(-1.98)}{.18}\,(PGAS_t) + \underset{(2.86)}{.51}\,(YD_t) + \underset{(1.32)}{.32}\,(STK_{t-1})$$

where t-statistics are in parentheses, and

Q = demand for gasoline: total gasoline consumption by all motor vehicles per capita

PGAS = retail price of gasoline divided by consumer price index

YD = disposable income per capita

STK = stock of automobiles: total automobile registrations per capita

The coefficients for all nine regions are presented in the paper. They were found to be significant at the one percent confidence level. Since the variables are in logarithmic form, the coefficients are elasticities. These vary considerably from region to region and are different from earlier studies. Price and allocation would thus have strong regional implications in the market for gasoline.

MODEL CONSTRUCTION

This econometric model is estimated with state-level annual data from 1954 through 1972 aggregated into nine census regions. A random coefficient model was estimated with heteroskedastic disturbances and variable intercept and slope coefficients across states within any region.

Gasoline consumption and price data came from the American Petroleum Institute's Petroleum Facts and Figures; auto registration data came from the U.S. Department of Transportation's Highway Statistics; income data were from the Bureau of Labor Statistics' Handbook of Labor Statistics; and population data came from the Bureau of the Census' Census of Population.

REFERENCE

Kraft, J.; Rodekohr, M., Regional demand for gasoline: a temporal cross-section specification, Journal of Regional Science, vol. 18, no. 1, April 1978.

GENERAL LEAST-COST AIR-QUALITY MODEL

A general linear programming model was developed in 1974 at the California Institute of Technology that finds the minimum cost of applying controls to emissions so that certain air quality standards are met.

AUTHOR

John C. Trijonis
California Institute of Technology
Environmental Quality Lab
Pasadena, Calif. 91109

KEYWORDS

Air pollution/air quality, emissions

OBJECTIVE OF MODEL

This mathematical linear programming model is designed to determine the least control cost associated with reaching specified air quality levels. Air pollution control policy should be based on a systematic comparison of all control costs associated with pollution abatement, and on all damage costs associated with atmospheric pollution levels. Control strategies and resulting air quality levels should be chosen so as to minimize total social cost, the sum of pollution control and damage costs. Transportation impacts are one component of this general model.

ASSUMPTIONS

To make the problem solvable, it is assumed that there is no space and time pattern of emissions; that emission control programs do not alter the pattern so that emission level changes occur in the same proportion at all points in space and time. Emissions are measured by total emission levels in the air basin for each primary contaminant.

VALIDATION

The model was applied and results were obtained for the specific situation of photochemical smog in Los Angeles County in 1975. Air quality models are developed for eye irritation, plant damage, visibility reduction, and high concentrations of oxidizing gases that determine how the levels of these irritants depend on reactive hydrocarbon and nitrogen oxide emissions. The least cost of reaching various emissions levels is found by applying linear programming to 23 major source types and 31 potential "add-on" controls.

LIMITATIONS AND BENEFITS

It may be possible to formulate a dynamic model that examines the cost of various air quality paths over time, but the solution would be very complex. This is a static, long-term model that calculates the cost of reaching various air quality levels in the future.

STRUCTURE

This linear programming model chooses the emission level that has the minimum control cost, subject to the constraint that the emission level will at least reach the air quality goals. The model does the following:

Choose E_i , i=1 ... n

that minimizes $C = G(E_i) = G(E_i \ldots E_n)$

subject to $P_j^0 \geq F_j(E_1 \ldots E_n)$, j = 1 ... M

where:

E_i = emissions level of contaminant i

C = total control cost

$G(E_i)$ = minimum control cost of achieving E_i, a techno-economic relationship

P_j^0 = air quality goal

$F_j(E_1 \ldots E_n)$ = expected air quality levels as a function of emissions levels, a physiochemical relationship

n = number of primary contaminants

The first step required before solving the above equation is to find the control cost-emission relationship, $G(E_i)$. Find the level of control activities (e.g., the number of certain devices added to 1970 vehicles) such that the total cost of all the various control device costs is minimized. This is done subject to the constraints: that emissions are reduced to some level for each contaminant; that no more than the total number of sources for each contaminant can be controlled; that the supply limits of fixed inputs are not exceeded (e.g., no more natural gas is substituted for coal than is available); and that there can be no fewer than zero control activities.

To find the emission level-air quality relationship, $F(E_i)$, a statistical-empirical approach is used. Two models are developed for primary and secondary contaminants that use management-type air quality indices; these measure the expected number of days per year violating state standards. This expected number of days for each contaminant is a function of the standard, the emission level, and the distribution function measured at one emission level. The distribution functions are determined from atmospheric monitoring data and a set of physical assumptions about air mass and weather behavior.

Once G and F have been determined, the complete model is solved, using nonlinear mathematical programming techniques. Given the various levels of costs required to produce various combinations of emissions levels for the set of contaminants, and the feasible set of air quality levels depending on the standards for the set of contaminants, the combination of emission levels is found where the feasible air quality region intersects the lowest possible control cost level.

REFERENCE

Trijonis, J.C., Economic air pollution control model for Los Angeles county in 1975--general least-cost air-quality model, Environmental Science and Technology, vol. 8, no. 9, pp. 811-827, Sept. 1974.

MINNESOTA GASOLINE DEMAND MODEL

The Minnesota Gasoline Demand Model was developed by the Minnesota Energy Agency and published in May 1977. Its purpose is to describe gasoline demand and show major determinants of consumption that policy makers can influence.

AUTHOR

Edwin Wong, Ernesto C. Venegas, and Donato B. Antiporta
Minnesota Energy Agency
740 American Center Building
150 East Kellogg Boulevard
St. Paul, Minn. 55101

KEYWORDS

Fuel consumption, vehicle miles traveled, fleet size

OBJECTIVE OF MODEL

There are two models described in this report. Model 1 generates estimates of price and income elasticity of gasoline demand. Model 2 relates gasoline consumption to income and gasoline price. The model estimates gasoline use through changes in average vehicle miles traveled, vehicle registration, the mix between small and large cars, and fuel economies of each type of car. The main objective of the two models is to describe and forecast gasoline demand in the state of Minnesota.

ASSUMPTIONS

In Model 1, gasoline consumption is postulated to respond with a lag to changes in real price and income. Model 2 calculates gasoline consumption from average vehicle miles traveled, automobile registration counts, and average miles per gallon. Automobiles are split into two categories, small and large.

VALIDATION

Estimated and actual values from 1960 to 1974 are compared for gasoline consumption for Model 1 and for car registration for Model 2. The model results prove to vary at most 4% from the actual figures.

LIMITATIONS AND BENEFITS

Both models allow for behavioral changes over time so that long-term response in gasoline consumption to changes in economic variables is larger than for the short-term response. Although the models are fitted to data from the state of Minnesota, the methodology is more broadly applicable.

STRUCTURE

Model 1:

Real gasoline price and elasticities and real income elasticities for gasoline consumption are empirically determined for Minnesota in Model 1.

$$C(t) = B_0 + B_1 P(t) + B_2 Y(t) + B_3 C(t-1) + e(t)$$

where:

C(t) = Minnesota's gasoline consumption per capita at time t

B = estimated coefficients

e(t) = error term

Y(t) = per-capita income divided by consumer price index at time t

P(t) = the Twin Cities retail price of gasoline divided by the consumer price index at time t

For Model 1, price elasticities for gasoline demand in the short run using ordinary and generalized least squares are, respectively, -0.34440 and -0.39054. Price elasticities for gasoline demand in the long run using ordinary and generalized least squares are, respectively, -0.55321 and -0.46743.

Model 2:

The following equation determines gasoline consumption:

$$C(t) = V(t) \left[\sum_{i=1}^{2} \left(\frac{R_i(t)}{MPG_i(t)} \right) \right]$$

where:

C(t) = fuel consumption by automobiles during the year (t)

V(t) = average vehicle miles traveled

Ri = total automobile registration of type i at the end of the year (t)

$MPG_i(t)$ = average miles per gallon for type i during the year (t)

i = 1 for small cars

i = 2 for large cars

Results from the following two equations are used as independent variables in the first equation of Model 2:

$$\ln[R(t)] = a_0 + a_1 (\ln[Y(t)]) + a_2 (\ln[P(t)]) + a_3 (\ln[V(t)]) + a_4 (\ln[R(t-1)])$$

$$\ln[V(t)] = S_0 + S_1 (\ln[Y(t)]) + S_2 (\ln[P(t)]) + S_3 (\ln[U(t)]) + S_4 (\ln[V(t-1)]$$

where:

$a_0 \ldots a_4$, $S_0 \ldots S_4$ = estimated coefficients

Y(t) = income in year t

P(t) = gasoline price

U(t) = average unemployment rate in year t

R(t-1) = automobile registration in the previous year

V(t-1) = vehicle miles traveled in the previous year

The predicted auto registration values from the following equation may be input to the first equation to make predictions of gasoline consumption.

$$R_i(t+1) = (1 - D_i) R_i(t) + d_i(t) [\sum_{i=1}^{2} D_i R_i(t) + G(t)]$$

where:

D_i = proportion of Ri(t) due for replacement at time t

$d_i(t)$ = allocation constant of the total of replacement demand for type i automobiles

G(t) = demand for new automobiles above the replacement demand

Income, price, and unemployment elasticities are determined for gasoline consumption, vehicle registration, small versus large cars, and vehicle miles traveled.

MODEL CONSTRUCTION

The model was estimated over the period of 1960 to 1974. Two estimation techniques are used, generalized least squares and ordinary least squares.

Price of gasoline is the average retail price in the Twin Cities (Minneapolis and St. Paul, Minnesota) for 1953-74. Prices and incomes are indexed to 1967 dollars by the CPI in the Twin Cities. Although other data are for only passenger cars, vehicle miles traveled was used for both cars and trucks, since no further separation was available. The categories of small and large cars are largely based on price of the cars.

REFERENCE

Wong, E.; Venegas, E.C.; Antiporta, D.B., Simulating the consumption of gasoline, Simulation, vol. 28, no. 5, pp. 145-152, May 1977.

COMPONENTS OF SHORT-RUN DEMAND FOR GASOLINE MODEL

This model was built in 1979 at Wayne State University. The basic findings of the model were that in the short-run half the total price elasticity of demand for gasoline of -.442 or half the adjustment from a gasoline tax comes from changing miles traveled and half comes from changing miles per gallon. In the long run over 90% of the long run elasticity (greater than -.78) came from changes in miles per gallon. The Council of Economic Advisors has referred to this model. These results were used to predict the effect of a 25-cent gasoline tax.

AUTHOR

Carol A. Dahl
Wayne State University
Department of Economics
Detroit, Mich. 48202

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The purpose of this model is to break the price elasticity of demand for gasoline into its component parts: an elasticity of miles traveled, and an elasticity of miles per gallon.

RELATIONSHIP TO OTHER MODELS

The calculation of long-run elasticity of demand is based on a study by the Office of Energy Systems at the Federal Energy Administration.

HISTORICAL BACKGROUND

The model was based on earlier work by the same author in a Ph.D. thesis, "Demand for Gasoline," under the name of Carol Dahl Norling.

ASSUMPTIONS

The model assumes elasticities of demand and supply are constant over income, price, and time.

LIMITATIONS AND BENEFITS

The model is estimated on a period of generally falling real gasoline prices and may be of questionable usefulness in a period of increasing real prices.

STRUCTURE

The complete model is a six-equation simultaneous system model estimated using two stage least squares with a correction for first-order serial correlation. The results for the three equations of interest are:

$$QD = \underset{(-1.946)}{-4.109} - \underset{(-1.702)}{.442}\,(PGAS) + \underset{(2.213)}{.322}\,(Y) + \underset{(2.842)}{.716}\,(SA) \qquad (1)$$

$R^2 = .999$

$$AMT = \underset{(-2.540)}{-4.540} - \underset{(-1.169)}{.101}\,(PGAS/MPG) + \underset{(1.205)}{.147}\,(Y) + \underset{(6.582)}{1.071}\,(SA) \qquad (2)$$

$R^2 = .998$

$$MPG = \underset{(9.019)}{2.714} + \underset{(2.977)}{.212}\,(PGAS) - \underset{(-.751)}{.028}\,(Y) - \underset{(-1.616)}{.013}\,(D) \qquad (3)$$

$R^2 = .953$

where t-statistics are in parentheses, and

QD = log of per capita consumption of gasoline in autos. Consumption per capita is measured in thousands of gallons.

PGAS = log of the price of regular gasoline. For the time-series estimates it is measured in dollars per gallon and deflated by the consumer price index with 1958 as the base year.

Y = log of income per capita. For U.S. data, disposable income per capita in thousands of 1958 dollars was used.

SA = log of the stock of autos per capita for the U.S. The stock of autos per capita is measured in thousands.

AMT = log of auto miles traveled per capita for the U.S.

MPG = log of average miles per gallon in passenger autos for the U.S.

D = pollution dummy which is 1 for 1968-1972 and zero for other years

MODEL CONSTRUCTION

The model was estimated on U.S. time-series data for 1937-1941 and 1946-1972.

The exogenous variables used in estimating the system were PRES, PDIST, Y, D, TAX, and PA.

PRES = log of the relative wholesale price of a barrel of residual fuel oil with respect to the wholesale price of a gallon of gasoline for the U.S.

PDIST = log of the relative wholesale price of a gallon of distillate fuel oil with respect to the wholesale price of a gallon of gasoline for the U.S.

TAX = log of the tax measured in 1958 prices for the U.S.

PA = log of the price index of new autos and parts with base year 1958

Data sources are:

Highway Statistics is the source of road mileages, and miles per gallon.

The Economic Report of the President is the source of U.S. statistics for disposable income, population, and the consumer price index.

Business Statistics updated by _The Survey of Current Business_ is the source of the U.S. wholesale prices for distillate fuel oil, residual fuel oil, and gasoline.

Petroleum Facts and Figures updated by _The Basic Petroleum Data Book_ is the source for U.S. gasoline price, and gasoline tax.

Auto Facts and Figures is the source for the stock of autos for the U.S. and for the states.

Petroleum Facts and Figures updated by _Highway Statistics_ is the source of gasoline consumption in autos and auto miles traveled.

Survey of Current Business, National Income Accounts, is the source of the auto price index.

REFERENCE

Dahl, C.A., Consumer adjustment to a gasoline tax, _Review of Economics and Statistics_, August 1979.

Norling, C. D., 1977. Demand for Gasoline, Ph.D. Thesis, University of Minnesota, 1977. Available from University Microfilms, Ann Arbor, Michigan.

Office of Energy Systems, "Passenger Car Use of Gasoline: An analysis of Policy Options," Washington, D.C., Federal Energy Administration, 1975.

COMPUTER REQUIREMENTS

The model was estimated using the TSP program on an Amdahl 470V4.

ELECTRIC PASSENGER VEHICLE MARKET IMPACT AND UTILITY LOAD MODEL

The Electric Passenger Vehicle Market Impact and Utility Load Model was prepared by MATHTECH in 1977 under the sponsorship of the Electric Power Research Institute. Its objective is to predict the market impact of electric vehicles and their effect on electric utility loads. An additional study using this model was performed by MATHTECH and sponsored by the U.S. Department of Transportation to evaluate several possible federal incentive policies intended to stimulate electrical vehicle demand.

SPONSOR

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, Calif. 94304

AUTHOR

E. Patrick Marfisi, Charles W. Upton, and Carson E. Agnew
Mathmatica, Inc.
MATHTECH Division
P.O. Box 2392
Princeton, New Jersey 08540

KEYWORDS

Automobile demand, national economic impact, automobile design, energy consumption, vehicle user costs/vehicle operating costs

OBJECTIVE OF MODEL

This model simulates the market impact of electric passenger vehicles in the future as well as the impact of these vehicles on electric utility loads over the period of 1985-2000.

RELATIONSHIP TO OTHER MODELS

The demand module of the model is based on the Wharton E.F.A. Automobile Demand Model (77-046).

ASSUMPTIONS

The probability of an individual's choosing a particular type of automobile is assumed to be based on vehicle operating cost, passenger capacity, percent of population in SMSA's, and kilometers of roads per square kilometer of land area.

VALIDATION

The Electric Vehicle Design Model component was tested by comparing its predictions to the known values of an actual vehicle, the Sebring-Vanguard Citicar. The results were fairly accurate. Though some weight components were highly inaccurate, the total weight predictions were off by only 1 kg.

LIMITATIONS AND BENEFITS

Since the model consistently underpredicted demand for small cars in western states and consistently overpredicted small car demand in southern states, and no variables were found to account for the poor predictions, dummy variables had to be used for these regions.

STRUCTURE

The model is divided into three components: a Supply Module, an Econometric Demand Module, and an Electricity Consumption Module. The supply module is in turn divided into an Electric Vehicle Design Model (EVDM) and a Cost Model.

The EVDM is a self-contained computer model that combines user-provided performance standards and battery technology to design a model vehicle and estimate its weight. The cost model uses EVDM input to determine component costs, vehicle purchase price, and annual operating costs. These parameters are integrated into an overall measure of full costs.

The Demand module is a modification of the Wharton EFA Automobile Demand model (77-046). The desired stock equations in the Wharton auto model for each type of automobile are replaced by an equation based on hedonic demand theory.

The Econometric Hedonic Demand Equation is:

$$V = (a_0 + a_1U + a_2R + a_3W)\ A + (a_4 + a_5U + a_6R + a_7W + a_8S)\ P$$
$$+ (a_9 + a_{10}U + a_{11}R + a_{12}W + a_{13}S)\ N^2$$
$$+ (a_{14} + a_{15}U + a_{16}R + a_{17}W + a_{18}S)\ L$$

where:

A = fraction with automatic transmission

p = price (cents/km)

N = passenger capacity

1 = luxury dummy

U = percent of population in SMSA's

R = kilometers of roads/km^2 of land area

W = dummy for western states

S = dummy for southern states

V = the probability that an individual will choose an electric car

Electric vehicle stock is predicted, using the least expensive currently-available technology for electric vehicles and reconciling supply and demand.

Estimates of electric utility loads resulting from the predicted electric vehicle stock are made for time periods during the day in the Electricity Consumption Module. These time periods are based on the times that commuters will most likely be recharging their vehicle batteries. Projections indicate that the impact of electric vehicles on electric utility loads will be negligible, amounting to less than 1% of total peak demand by 2000.

DATA USED IN RUNNING MODEL

The following are sources of data for the demand model: The U.S. Department of Transportation's Transportation Systems Center provided data on estimates of future electricity cost, nonelectric vehicle operating cost, fuel economy, operating cost, and gasoline prices. Projections of aggregate economic variables are obtained from the Wharton EFA Automobile Demand Model (77-046) data base.

Data on the performance and initial cost for electric vehicles are input.

REFERENCE

Marfisi, E.P.; Upton, C.W.; Agnew, C.E., Impact of electric passenger automobiles on utility system loads, 1985-2000, MATHTECH, Inc., November 1977.

Upton, C.W.; Agnew, C.E., Analysis of federal incentives to stimulate consumer acceptance of electric vehicles, MATHTECH, Inc., September 1977.

COMPUTER REQUIREMENTS

The programs for the EVDM, the cost model, and the demand model are written in batch FORTRAN language.

AMERICAN, CANADIAN, AND EUROPEAN GASOLINE CONSUMPTION MODEL

An international comparison of gasoline consumption was developed at the Department of Economics at Wayne State University in 1978. The conclusions suggest: (1) that there is a higher long-run price elasticity for gasoline in the U.S. than in Europe or Canada; and (2) if the U.S. were faced with European incomes, population densities, and gasoline prices, it would have a similar per capita gasoline consumption.

AUTHOR

Carol A. Dahl
Wayne State University
Department of Economics
Detroit, Mich. 48202

KEYWORDS

Fuel consumption, fuel price

OBJECTIVE OF MODEL

The objective of these models is to compare the demand for gasoline for the U.S., Canada, and The European Economic Community (EEC) to determine whether the U.S. would have the same per capita gasoline consumption as the EEC does if it were faced with the EEC's economic situation.

RELATIONSHIP TO OTHER MODELS

The gasoline demand estimates in the Components of Short-Run Demand for Gasoline Model (79-214) are used in this paper to predict the change in short-run gasoline demand for 1975 from 1974.

HISTORICAL BACKGROUND

The models estimated were based on those in a Ph.D. thesis by the same author under the name of Carol Dahl Norling.

ASSUMPTIONS

Constant elasticities of demand are assumed. Pooled cross-section time-series are used which assume that U.S. states all have the same demand schedule, that Canadian provinces all have the same demand schedules, and that five members of the EEC all have the same demand schedule.

VALIDATION

The short-run gasoline demand estimate reported above in 79-214 was predicted gasoline consumption for the U.S. in 1975, to increase by less than 1% from 1974. Actual consumption in 1975 increased onlv slightly from the previous year.

LIMITATIONS AND BENEFITS

The use of cross-section time-series data has the advantage of increasing sample size, income variation, and price variation.

STRUCTURE

Five gasoline demand equations were estimated using two-stage least squares with a correction for first-order serial correlation on five data sets. The first equation was on a U.S. time series and is reported above in Components of Short-run Demand for Gasoline Model (79-214). The second was a Canadian time series. These results are not reported but are similar to those for the U.S. time-series except that the price elasticity of demand was insignificant; this insignificance is likely the result of a small data set. Both of these results were considered to be short-run. The other three data sets for which results were reported were cross-section time-series data for: (1) U.S. states; (2) five Canadian provinces, and (3) five European Economic Community countries. The results on these three cross-section time-series, all considered long-run, are presented in the table below.

Elasticities

Demand Equation	Variables				Statistics	
	PG	Y	SA	AREA/POP	R^2	DW
U.S. States 1953-1972	-1.048 (-7.293)	0.322 (6.855)	0.545[a] (7.735)	0.134 (2.626)	0.877	1.98
Canadian Provinces 1954-1973	-0.460 (-1.424)	0.334 (8.142)	0.662 (8.403)	b	0.991	1.89
EEC 1960-1970	-0.358 (-5.404)	0.480 (7.419)	0.188 (2.556)	b	0.877	1.88

a. Total vehicles per capita were used.
b. These were insignificant so the equation was re-estimated eliminating them.
The numbers in parentheses below the coefficients are t-statistics.

The variables used in this table are as follows:

PG = real price of gasoline

Y = disposable real income per capita for U.S. and EEC, real personal income per capita for Canada

SA = the stock of automobiles per capita for Canada and the EEC, and stock of vehicles per capita for the U.S.

AREA/POP = population density

The dependent variable is the quantity of total highway fuel consumption per capita for the U.S., and the gasoline demanded for highway transport per capita for Canada and the EEC.

U.S. state data were differenced from the mean to allow for different state intercepts, and Canadian provincial dummy variables were used to allow for different provincial intercepts.

The instrumental variable for gasoline price was gasoline tax in U.S. states and Canadian provinces. In the E.E.C. the price of distillate fuel, the price of residual fuel, and the gasoline tax were all used as instruments for the price of gasoline.

MODEL CONSTRUCTION

The five different data sets used were:

U.S. time series for 1936-1941 and 1946-1972, Canadian time series for 1956-1971, U.S. state data for 1953-1972, Canadian provincial data for 1954-1973, and European Economic Community, except for Luxembourg, for 1960-1970.

DATA USED IN RUNNING MODEL

The demand estimate on U.S. cross-section time-series data was used to predict U.S. consumption in 1972 if faced with European gasoline prices, incomes, population density, and stock of vehicles.

COMPUTER REQUIREMENTS

The estimates were made using TSP on an Amdahl 470V4.

REFERENCE

Dahl, C.A., American energy consumption--extravagant or economical? A study of gasoline demand, Resources and Energy, vol. 1, pp. 359-373, 1978.

Norling, C. D., 1977. Demand for Gasoline, Ph.D. dissertation, University of Minnesota, 1977. Available from University Microfilms, Ann Arbor, Mich.

AUTOMOBILE EXHAUST EMISSION MODAL ANALYSIS MODEL

The Automobile Exhaust Emission Modal Analysis Model was developed in 1974 by Calspan Corporation for the U.S. Environmental Protection Agency (EPA). It calculates the emissions produced by one or a group of automobiles under varying speed and acceleration conditions. It could be used to evaluate the pollution impact of alternative highway routes or designs.

SPONSOR

U.S. Environmental Protection Agency
Office of Air and Water Programs
Office of Mobile Source Air Pollution Control
Certification and Surveillance Division
Ann Arbor, Mich. 48105

AUTHOR

H.T. McAdams, Paul Kunselman, Charles J. Domke, and Marcia Williams
Calspan Corporation
P.O. Box 235
4455 Genesee Street
Buffalo, N.Y. 14221

KEYWORDS

Emissions, fuel economy

OBJECTIVE OF MODEL

The model calculates the amounts of emissions of hydrocarbons, carbon monoxide, and nitrogen oxides that are emitted by individual vehicles or groups of vehicles over any of various driving sequences. The objective of the model is to determine emissions under varying speed and acceleration conditions.

RELATIONSHIP TO OTHER MODELS

There is no apparent relationship to other models.

HISTORICAL BACKGROUND

The model was developed in two phases. In the second phase the original model was refined and extended to increase its computational efficiency, to reduce testing requirements, to assess the accuracy and precision with which group emission predictions can be made, and to add on the method of predicting fuel economy.

ASSUMPTIONS

Driving sequences are broken down into segments having specified lengths, speeds, and acceleration and that are weighted by their time duration. The segments are referred to as "modes" (thus "modal analysis"). Different combinations of speed and acceleration result in 37 modes that are part of the EPA's Surveillance Driving Sequence.

VALIDATION

Considerable discussion is presented in the model reports of the theoretical precision and accuracy of the predictions for groups of vehicles and for arbitrary driving sequences. Comparisons are made between the mean amount of emissions from a sample of a group of vehicles, and the predictions of the model. For one particular driving cycle the absolute error was less than 33%, and the predicted values usually were within the 95% confidence interval around the sample mean, for hydrocarbons and carbon monoxide. The predictions of oxides of nitrogen are not so good.

LIMITATIONS AND BENEFITS

The model should be used only within the region of the speed and acceleration space that is spanned by the input data. It is most effective as a predictor of emissions of a group of warmed-up vehicles.

By postulating an anticipated mix of vehicles and the anticipated driving sequences, the relative desirability of alternative routes or highway designs can be ranked according to their pollution impact.

STRUCTURE

Emissions from the 37 discrete modes are expanded into a continuous function of time. The instantaneous emissions rate is a function of speed and acceleration at a point in time. This function characterizes a particular vehicle or a group of vehicles. Two accounting programs were developed. One computes emissions from individual vehicles over any specified continuous driving sequence, given the emissions for each mode for each vehicle. The other computes emissions from a group of vehicles over any sequence, given the emissions from each vehicle for each mode.

The emissions rate function is expressed as coefficients determined by regression. During times of non-zero acceleration:

$$e(v,a) = b_1 + b_2\,(v) + b_3\,(a) + b_4\,(a\,v) + b_5\,(v^2) + b_6\,(a^2) + b_7\,(v^2\,a) + b_8\,(a^2\,v) + b_9\,(a^2\,v^2)$$

where:

e(v,a) = instantaneous emission rate at speed v and acceleration a

v = speed

a = acceleration rate

b_1-b_9 = coefficients

The emissions rate function for a group of vehicles is the average of the rates of the vehicles in the group.

The model was extended to predict fuel economy by the carbon balance method: Miles per gallon is a function of the amount of carbon in the emissions produced per mile and the amount of carbon per gallon of fuel.

MODEL CONSTRUCTION

Emission data were given for 1020 individual light duty vehicles built through 1971 that represented variations in model year, manufacturer, engine and drive train equipment, accumulated mileage, state of maintenance, attached pollution abatement devices, and geographic location.

DATA USED IN RUNNING MODEL

The following may be specified by the user: length of driving sequence, number of cars in group, speed vs. time intervals, pollutant coefficients, description of vehicle group composition.

REFERENCE

Kunselman, P.; McAdams, H.T., Automobile exhaust emission modal analysis model, Calspan Corporation, Technical Report no. NA-5194-D3, EPA-460/3-74-005, July 1973.

Kunselman, P.; McAdams, H.T.; Domke, C.J.; Williams, M., Automobile exhaust emission modal analysis model, U.S. Environmental Protection Agency, Report no. EPA-460/3-74-005, January 1974.

McAdams, H.T., Automobile exhaust emission modal analysis model extension and refinement, Calspan Corporation, EPA-460/3-74-024, October 1974. NTIS no. PB-284 948/7.

COMPUTER REQUIREMENTS

The computer programs are written in FORTRAN. Program listings and a sample of input data and output results are included in the model reports.

LONG-TERM INTERINDUSTRY TRANSACTIONS MODEL (LITM)

The Long-Term Interindustry Transactions Model (LITM) was prepared by Data Resources, Inc. in 1977. Consisting of a macroeconometric model and a ten-sector flexible-coefficient interindustry model, it was designed for the General Services Administration to aid analysis of interdependence within the energy sector and between the energy sector and the rest of the economy. Further, it can be used for long-term forecasting and analysis of economic growth and structural change.

SPONSOR

U.S. General Services Administration
Federal Preparedness Agency
Applied Economics Division
Washington, D.C.

AUTHOR

Edward A. Hudson and Dale W. Jorgenson
Data Resources, Inc.
1750 Cambridge Street
Cambridge, Mass. 02138

KEYWORDS

Energy consumption, national economic impact

OBJECTIVE OF MODEL

LITM is a dynamic econometric model of the economy that can be used for long-term economic projection and structural analysis. Since it is a sectoral model it can be used to analyze the interdependence between energy and the rest of the economy and between transportation and the rest of the economy.

RELATIONSHIP TO OTHER MODELS

The model is used in conjunction with the Brookhaven I-O Model (78-361), the Brookhaven Linear Programming Models, (e.g., Time-Stepped Energy Systems Optimization Model TESOM (79-383).)

HISTORICAL BACKGROUND

LITM is based on the Hudson-Jorgenson growth and economic models. The Dynamic Generalized Equilibrium Model (DGEM, 78-243) is a second-generation LITM.

The model was originally built at Data Resources, Inc., but is currently under development by Dale W. Jorgenson Associates.

LIMITATIONS AND BENEFITS

The model allows analysis of the interaction of the energy system with the rest of the economy. It improves on standard I-O models by making input-output coefficients a function of prices. Limitations include a high degree of aggregation and the assumption that imports and exports are exogenous.

STRUCTURE

The model consists of two fully integrated components: a macroeconomic growth model and a ten-sector flexible coefficient input-output model. The macroeconomic model takes government activity, time, population, unemployment, and exports as exogenous and predicts aggregate demand for goods and services in the U.S. by components along with the price of labor and the price of capital. It consists of equations for investment supply, labor demand, a production possibility frontier, consumption demand, leisure demand, capital market balance, and linkages to the National Income Accounts. These linkage equations include inputed services for consumer durables, purchases of consumer durables, aggregate consumption, aggregate investment, aggregate government purchases, net exports, and gross national product aggregates.

The ten sectors in the interindustry model are: (1) agriculture, nonfuel mining and construction, (2) manufacturing, excluding petroleum refining, (3) transportation, (4) communications, trade, and services, (5) coal mining, (6) crude petroleum extraction, (7) petroleum refining, (8) electric utilities, (9) natural gas utilities, and (10) natural gas extraction. Price frontiers for each of the ten sectors are estimated econometrically and express an output price as a function of other output prices, technical efficiency, primary input prices (i.e., capital labor, and competitive imports), and producer markups. These ten price frontiers are solved simultaneously for output prices in all ten sectors. From the price possibility frontiers can be derived the share of each input in the production of a given input. These shares are used as input-output coefficients, along with final demand, by sector to determine the gross outputs and inputs for each sector.

Aggregate transportation is one sector of the model. The model predicts aggregate end-use transportation demand, total quantity of transportation, the price of transportation, and the resource inputs into transportation.

MODEL CONSTRUCTION

The producer submodels were estimated on a time series of input-output transactions data from 1947 to 1971 developed by Jack Faucett

Associates. The behavioral equations in the macroeconomic model were estimated on U.S. time-series data from 1929-1971.

DATA USED IN RUNNING MODEL

Inputs to the macro model include: aggregation variables relating capital stock and capital price to investment and investment price, and to asset and investment price; government purchases, production, taxes and transfer payments; imports; population; total time available to consumers; and implicit price deflators for various components of aggregate demand. Inputs to the interindustry model from the macro model include aggregate consumption, government spending on goods, services, investment and labor, gross private domestic investment, the price of capital services, the price of labor services and price deflators for various components of aggregate demand. Other exogenous variables are markups for goods sold to various sectors, productivity, and a price index of imported goods and services.

REFERENCE

Hudson, E.A.; Jorgenson, D.W., Long term Interindustry Transactions Model: a simulation model for energy and economic analysis, Data Resources, Inc., September 27, 1977.

Hoffman, K.C.; Jorgenson, D.W., Economic and technological models for evaluation of energy policy, Bell Journal of Economics, Vol. 8, pp. 444-466, 1977.

Hudson, E.A.; Jorgenson, D.W., U.S. energy policy and economic growth, 1975-2000, Bell Journal of Economics and Management Science, Vol. 5, no. 2, pp. 461-514, 1974.

Hoffman, K.C.; Wood, D.O., Energy system modeling and forecasting, Annual Review of Energy, vol. 1, pp. 423-453, 1976.

Groncki, P.J.; Marcuse, W., Brookhaven integrated energy/economy modeling system and its use in conservation policy analysis, preliminary copy, Brookhaven National Laboratory, Report no. BNL 51056, July 1979.

COMPUTER REQUIREMENTS

The model program is proprietary to Dale W. Jorgenson Associates.

PASSENGER CAR GASOLINE DEMAND MODEL

The Passenger Car Gasoline Demand Model was developed at Stanford University, and was documented in 1979.

It is sponsored by the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE), but is not yet considered an officially accepted EIA model, since it is still under development and has not undergone thorough testing. The model is also known by other names. It is a revised version of the Automobile Simulation Model of PIES (75-004A). Its purpose is to forecast gasoline consumption using a vintage capital approach to modeling the size and composition of automobile stock. The model is a submodel of the National Highway Transportation Fuel Demand Model and it is expected that the model will be incorporated into the Mid-term Energy Forecasting System of DOE.

SPONSOR

U.S. Department of Energy
Energy Information Administration
Office of Energy Use Analysis
12th and Pennsylvania Ave., N.W.
Washington, D.C. 20461

AUTHOR

James L. Sweeney
Stanford University
Energy Modeling Forum
Terman Engineering Center
Stanford, Calif. 94305

KEYWORDS

Fuel consumption, automobile demand, vehicles miles traveled, fleet size, scrappage

OBJECTIVE OF MODEL

The fundamental purpose of the model is to forecast demand for gasoline by passenger cars (including motorcycles). Forecasts are made of new car sales, total registrations, and related variables. The model is intended to be sufficient to examine policies acting through traditional economic variables or directed specifically at characteristics of the capital equipment (vehicles).

RELATIONSHIP TO OTHER MODELS

This is a submodel of the EIA's National Highway Transportation Fuel Demand Model. The other sectors in that model are trucks, buses, and non-highway fuels.

HISTORICAL BACKGROUND

This model is a revision of 75-004A, the Automobile Simulation Model of the Project Independence Evaluation System (PIES). PIES is now known as the Mid-term Energy Forecasting System (MEFS) (S-78-419). That first version of the model was developed by Dr. Sweeney at the Federal Energy Administration. It was subsequently re-estimated with more recent data. The second version was known as the Vintage Capital Model of the Automobile Demand for Gasoline; it was developed by Dr. Sweeney at the Department of Engineering-Economics Systems of Stanford University. This report describes the third generation of the model. It is known variously as the National Highway Transportation Fuel Demand Model, the National Auto Fuel Demand Model, the Passenger Car Gasoline Demand Model, the Sweeney Automobile Gasoline Demand Model, or simply the Sweeney Model. This version will eventually supersede the earlier versions used until now in MEFS as a part of its RDFOR Transportation Sector Model.

ASSUMPTIONS

The following assumptions remain unchanged from the previous version:

1) average MPG for each vintage is constant over time;

2) consumers adjust the existing vehicle stock to equal the desired stock by purchasing new vehicles;

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 reduced gasoline demand;

5) the EPCA fuel efficiency standards will be met on schedule.

The following assumptions represent modifications to the previous version:

6) the 55 mph speed limit is rigorously enforced; and

7) an exponential function represents the scrappage rate for vehicles over 15 years old.

The supply of gasoline is assumed to be perfectly elastic. The supply side of the auto market only enters the model implicitly, through a "technical efficiency" term and a "price effect" term used to compute fuel economy.

VALIDATION

Sample runs of the new version are provided in the 1979 documentation for 1978-1990. A gasoline tax reduces gasoline consumption, through decreased VMT and increased fuel economy, and vehicle sales decline. The old version produced similar results in response to a gas tax. An increase in the rate of growth of income raises sales, VMT, gas consumption, and fuel economy.

STRUCTURE

A vintage capital framework has been employed to model the stock of automobiles and the use of that stock. This model departs from the conventional stock-adjustment formulation of simple distributed laas by explicitly representing capital stock adjustments. The new version uses substantially different structural forms for some of the equations, including the vehicle miles traveled equation. The model's key equations are:

$$GAS = VM/AMPG \qquad (1)$$

where:

GAS = the aggregate gasoline consumption by passenger cars

VM = the total vehicle miles obtained by the fleet of automobiles

AMPG = the mean efficiency of the fleet

$$\begin{aligned} \log(VM/Pop) = {} & \underset{(1.2)}{2.381} - \underset{(-5.1)}{0.295}\,[\log(NCGCPM)] \\ & + \underset{(1.7)}{0.299}\,[\log(YD/Pop)] - \underset{(-4.9)}{1.540}\,[\log(HPEA)] \\ & + \underset{(2.6)}{0.519}\,[\log(PCR/Pop)] - \underset{(-0.5)}{0.006}\,[\log(DUMAH)] \\ & - \underset{(-0.3)}{0.004}\,[\log(DUM74)] \end{aligned} \qquad (2)$$

$R^2 = .997$ D.W. = 1.9

where t-statistics are in parentheses, and

VM/Pop = the total vehicle miles obtained by the fleet of automobiles, expressed per capita

NCGCPM = the gasoline costs per mile of driving

YD/Pop = disposable income per capita

HPEA = the average weekly hours of production on private nonagricultural payrolls

PCR/Pop = total number of passenger car registrations per year expressed per capita

DUMAH = a dummy variable included to account for changes in the historical data series

DUM74 = a dummy variable for the year 1974 to account for gasoline shortages and *ad hoc* rationing plans in that year

$$AMPG_t = ES_t/[\sum_{i=t-15}^{t} NPCR_i\ (SU_{it})\ GAMMA^{(t-1)}\ (1/MPG_i) + ESAMOC_t] \qquad (3)$$

where:

$AMPG_t$ = the mean efficiency of the fleet in year t

ES_t = the effective stock of automobiles in year t

$NPCR_i$ = the number of new passenger car registrations of vintage i

SU_{it} = the surviving fraction of the stock of automobiles of vintage i during year t

$GAMMA^{(t-i)}$ = the intensity of usage of automobiles from the i^{th} vintage in year t

MPG_i = fuel efficiency for automobiles of vintage i

$ESAMOC_t$ = the ratio of $ES_t/AMPG_t$ calculated only for cars older than 15 years of age

$$\log(NPCR/POP) = \underset{(4.5)}{16.993} - \underset{(-3.8)}{3.002}\,[\log(ESLO/POP)] + \underset{(3.5)}{2.325}\,[\log(YD/POP)] \qquad (4)$$

$$- \underset{(-1.4)}{0.479}\,[\log(PG)] - \underset{(-1.4)}{0.786}\,[\log(PCAR)] - \underset{(-4.0)}{0.049}\,(RU)$$

$\bar{R}^2 = 0.82$ DW = 1.8

where t-statistics are in parentheses, and

NPCR/POP = new passenger car registrations per capita

ESLO/POP = effective stock available in a given year from earlier vintages, per capita

YD/POP = real disposable income per capita

PG = real price of gasoline

PCR = total passenger cars registered

RU = unemployment rate

MODEL CONSTRUCTION

The econometric equations were estimated by ordinary least squares. Some of the equations had been estimated for the earlier version of the model in 1974, and again in 1976. This new version used data through 1977.

DATA USED IN RUNNING MODEL

Exogenous input variables needed to run the model are: (1) consumer price index, (2) population, (3) disposable income, (4) unemployment rate, (5) average weekly hours of work, (6) average hourly earnings, (7) average driving speed, (8) gasoline and diesel fuel prices, (9) technical fuel economy, (10) mean fuel economy of imports, (11) import sales share, and (12) fraction of vehicles using leaded and unleaded gas and diesel fuel.

REFERENCE

Sweeney, J.L., Passenger car gasoline demand model, November 1979.

Morlan, T.H.; Gantzer, D.J.; Emerson, F., Forecasting auto fuel demand: latest developments at the Energy Information Administration, U.S. Department of Energy, Presented at the 5th International Automotive Propulsion Systems Symposium, April 15, 1980.

These references are for the first (75-004A) version of the Sweeney model:

Sweeney, J.L., 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.

Sweeney, J.L., Vintage capital stock approach: The demand for gasoline, Draft.

These references are for the second generation of the model:

Sweeney, J.L., Demand for gasoline: A vintage capital model, Draft, Dept. of Engineering-Economic Systems, Stanford University.

Sweeney, J.L., EPCA new car efficiency standard: An economic analysis, July 1977.

Sweeney, J.L., Energy policies and automobile use of gasoline, Stanford University, Energy Modeling Forum, Occasional paper no. EMF OP 2.0, May

1979.

Sweeney, J.L., Effects of federal policies on gasoline consumption, Stanford University, Energy Modeling Forum, Occasional paper no. EMF OP 2.1, July 1979.

Sweeney, J.L., Impact of the President's proposed gasoline tax and gas-guzzler tax on gasoline consumption, May 1977.

COMPUTER REQUIREMENTS

The program of the model is written in WATFIV FORTRAN. The input data are attached to the program, which is 1350 lines long, including the data. The program costs at least one dollar to run.

SRI-GULF ENERGY MODEL

The SRI-Gulf Energy Model is a generalized equilibrium model of the supply and demand for energy in the U.S. It was originally developed in 1973 at the Stanford Research Institute under the sponsorship of the Gulf Oil Corporation. It has been under continued development since then at Decision Focus, Inc. It has been used to analyze synthetic fuels strategy and policy and commercialization, and prioritization of research and development on energy supply technologies.

SPONSOR

Gulf Oil Corporation
Pittsburgh, Pa.

AUTHOR

Edward G. Cazalet
Stanford Research Institute
Menlo Park, Calif.

KEYWORDS

Energy consumption, fuel price

OBJECTIVE OF MODEL

The model dynamically simulates the supply and demand for energy in the U.S. in a highly detailed manner. It can be used for analyzing policy and industrial strategy. It uses the coordinated decomposition of complex decision or optimization problems involving many resources, time, uncertainty, and multi-attribute preferences, where there is no single overall objective function. The synthesis of modeling techniques is called generalizeββββium modeling. Transportation is included as a sector that demands end-use energy services.

HISTORICAL BACKGROUND

The model was originally developed in 1973 to analyze synthetic fuels strategy for the Gulf Oil Corporation. The methodology has been extended over the years with financial support from Stanford Research Institute, the Council on Environmental Quality, the National Science Foundation, the Energy Research and Development Administration, Lawrence Livermore Laboratory, and the Electric Power Research Institute. The initial work was stimulated by the limitations of both mathematical programming and simulation. The methodology has been extended and developed into the DFI Generalized Equilibrium Modeling System (77-283), the Long-term Energy Analysis Program (77-286), and the Livermore Energy Policy Model (78-462).

ASSUMPTIONS

The methodology of generalized equilibrium modeling is based on decisior analysis and coordinated decomposition. Distinction is made between (a) the exogenous decisions made by decisionmakers with the aid of the endogenous decisions made within the rest of the world and (b) the crucial decision processes and physical systems in the model.

Markets are assumed to be perfectly competitive. Rent is allowed for in resource markets. New technology or products are restricted to allow gradual market penetration. The own-price elasticity of demand for automobile VMT is assumed to be a constant -0.38.

LIMITATIONS AND BENEFITS

Generalized equilibrium modeling combines the basic concepts of several modeling methodologies into an integrated framework or language.

This general equilibrium model decomposes complex decision processes into a number of simple submodels. These submodels represent market decision problems and are thought to better characterize reality and market interactions than models that optimize an overall objective function.

The model is modified to enhance or eliminate detail as required to evaluate the decision alternatives of each problem. End-use energy demand (such as for space heat) is distinguished from fuel demand (the input to a furnace). The high degree of decomposition means that the process submodels can be at a level of detail appropriate to the expertise and data available.

Limitations include: a wide variety of market structures all characterized in the same way; a quite decentralized framework that requires a large amount of exogenous information, much of which is subjective and overly simplified; the end-use demand side modeling is weak; and international interactions are inadequately captured.

STRUCTURE

This generalized equilibrium model has these basic elements: (1) processes describing the fundamental submodels; (2) a network describing the interactions or links among the processes; and (3) an algorithm for determining the numerical values of all of the variables in the model. A process is a set of economic and/or subjective relations or equations that may represent an entire national economic or natural system or a fundamental technological or decisionmaking process. Processes generally contain physical and/or behavioral relations. The algorithm finds the set of prices and quantities that satisfies the relations embodied in the processes and their linkages in the network. Prices and quantities are successively adjusted in a series of iterations in each time period to produce an equilibrium solution. The algorithm does not impose arbitrary restrictions on the solution to ensure convergence.

Instead, a relaxation methodology is used to dampen oscillations.

A number of end-use demands and geographic regions are modeled. Supply of resources by regions and their depletion over time is modeled. Estimates of future prices of primary resources are used to determine economic rent on resources in earlier time periods.

The types of basic processes in the model are: (1) simple conversion processes, e.g., synthetic gas from coal; (2) allocation processes, e.g., space heat demand among alternative furnaces and fuels; (3) primary resource processes--depletion and pricing of resources; (4) end-use demand processes--growth in demand and effects of prices; (5) transportation processes--technology and economics of moving energy; (6) complex conversion processes, e.g., refineries and electricity generation; and (7) secondary industrial processes--impact on prices of demand for materials such as pressure vessels and surface mining equipment.

In the simple conversion process, equations are included for material flow and quantity, capacity additions and replacement, initial conditions, net present value, operating cost, product price under slow and rapid growth, growth rate, inflation and secondary materials cost adjustments, and technological change and present value of capital cost. In the allocation process, equations are included for physical flow, total quantity, new and existing quantity demanded, market share, and static and dynamic allocation of demand. In the primary resource process, equations are included for production, capacity, initial conditions, long-run marginal cost and price, inflation and technological change factors, secondary material requirements, and adjusted primary resource price. In the end-use demand process there are reference demand and price sensitive demand equations. The transportation process includes capital cost, operating cost, and thermal efficiency adjustment equations. The complex conversion process has sets of equations for electric power generation, refineries, auxiliary inputs, and joint products. The price and quantity regulation process has quantity and price regulation equalities and inequalities, and relations for allocation process market share and the regulated or unregulated conversion process. The secondary material process has equations for prices, demand to capacity ratio, and industry capacity and half-life response time.

About 2700 processes were contained in the model at one time.

The output from the model includes input and output prices and quantities for each node over the time period in question. Calculations in the model are performed by moving either "up" the network, to calculate prices, or "down" to allocate quantities. Each node in the process is thus connected with two algorithms. The algorithm associated with a downward iteration is a physical relation (e.g., q_0 output requires i_0 input). The algorithm associated with an upward iteration is a behavioral relation (given costs, this is the price that will be charged for an output).

At the bottom of the network is a resource node. Given an initial resource output vector q, the algorithm, on an upward iteration in each time period, calculates an output price vector p. To do so it needs as input a marginal cost curve of resource supply, a rate of discount. and other technical parameters.

Moving from a resource node, the energy resource must be transported via a transport node or converted by a process. For a transportation process, the operating and capital costs will be a function of distance. Allowance can also be made for growth, excess capacity, secondary materials, technological change, and inflation.

From a transport node the resource can go to a conversion node. This node may take up to five inputs and up to five secondary inputs and converts them into one output. The basic formula for price out of a conversion node is the same as that for a transport node, where one of the costs is the cost of the inputs from the node below.

Once through a conversion node, the output could be transported to another conversion node or converted to an end-use demand or market node. End-use demand schedules, which are exogenous, can be either elastic or totally inelastic. From the price of an end-use demand and the end-use demand schedule, a quantity of end-use service is computed.

If more than one energy product is competing to supply an end-use service or any node, an allocation node is necessary (e.g., when urban vehicle miles can come from gasoline, diesel fuel or electricity). Then the share for each fuel may be a function of share last period, relative costs of the competing fuels, a parameter designating how rapidly market shares can change, and a price sensitivity parameter. The price of the end-use service in this case is a weighted average of the prices of the fuels used. The weighted average fuel price is used to calculate quantity demanded on each iteration.

Once an end-use quantity is computed, the model iterates back down the networks, using physical relations to calculate quantities at every conversion node.

Similar provisions are made for secondary material flows, and changes in capital stock. Working back down the system, input quantities are calculated at each node. Once at the resource node, the process starts again and prices are calculated going up the network. This whole process continues for every end-use demand, intermediate demand, and energy resource demand until prices and quantities converge for all periods.

Special processes are included to model: oil refineries, electricity generation, and capital equipment supplier industries.

The transportation component includes an end-use service demand (e.g., vehicle miles traveled), and the fuels needed to produce this service. Output includes price and quantity of different kinds of fuel needed to produce this end-use service.

MODEL CONSTRUCTION

The methodology involves the iterative solution of nonlinear, simultaneous equations in a dynamic fashion, i.e., over several time periods. The methodologies that are combined in generalized equilibrium modeling include econometric methods, optimization or programming methods, general competitive equilibrium models, and simulation methods.

DATA USED IN RUNNING MODEL

The data used to run the model were developed internally by SRI.

The basic inputs to the model are: (1) An energy network which sets up resource nodes, process nodes, demand nodes, market nodes, refinery locations or nodes, and transportation linkages; and (2) A parameter file that contains (a) Data for variables such as corporate tax rates, number of iterations, length of time period, rate of inflation, etc.; (b) Parameters for all intermediate calculations; (c) Information on each process--its type and parameters necessary for price-quantity calculations; (d) End-use demand schedules; (e) Resource supply curves, tracking depletion over time; (f) Distances on regional versions; (g) The initial market quantities for the entire network.

REFERENCE

Cazalet, E.G., Generalized equilibrium modeling: The methodology of the SRI-Gulf Energy Model, Decision Focus, Inc., May 1977.

COMPUTER REQUIREMENTS

An iteration of the model takes 1.3 minutes of IBM 370/168 computer time and uses 600,000 bytes of core storage. Thirty to sixty iterations are needed for a base case with poor initial estimates of prices and quantities. Ten to thirty iterations give satisfactory convergence for a sensitivity test.

STATE-LEVEL GASOLINE DEMAND MODEL

The State-Level Gasoline Demand Model has been under development since 1978 at Oak Ridge National Laboratory, under the sponsorship of the U.S. Department of Energy's Office of Conservation. Its purpose is to evaluate policies targeted to alter the fuel efficiency and composition of the stock of vehicles, using econometric techniques and data disaggregated to the level of individual states.

SPONSOR

U.S. Department of Energy
Office of Conservation
Transportation Energy Conservation Division
Nonhighway Transport Systems and Special Projects
Data Analysis Branch
Washington, D.C.

AUTHOR

David L. Greene
Oak Ridge National Laboratory
Regional and Urban Studies Section
Energy Division
Oak Ridge, Tenn. 37830

KEYWORDS

Fuel consumption, automobile demand, fleet size, fuel economy, market share, scrappage, vehicle miles traveled

OBJECTIVE OF MODEL

The model is a forecasting tool designed for use in evaluating policies targeted to alter the fuel efficiency and composition of the vehicle stock, including those policies directly affecting gasoline prices. Vehicle purchase and ownership for five classes of cars and light trucks are modeled along with fuel demand. Model output includes new vehicle sales, fleet (stock) composition by class and state, fuel efficiency of the fleet by state, and gasoline demand.

Demand forecasts are a function of exogenous demographic and economic variables. Geographic and other regionally varying factors also affect vehicle and fuel demand. The model combines econometric relationships with engineering relationships to deal with changes in vehicle technology.

RELATIONSHIP TO OTHER MODELS

This model may potentially be used as the transportation sector submodel of the Midterm Energy Forecasting System (MEFS) (S-78-419), which is used by the Energy Information Administration of the Department of Energy.

HISTORICAL BACKGROUND

This report reflects the model as described in the documentation listed below. Draft documentation on further revisions to the model is available, but is not reported here, since it is currently still under development.

ASSUMPTIONS

The model is based on household production theory, which represents the consumer as constrained by technology as well as by a budget and seeks to separate the effects of household production technology from those of preferences on consumer behavior. Thus, the model explicitly considers the impacts of transportation technology on energy use, as well as more traditional economic factors such as price and income. The long-run focus of the model is on changes in the stock of vehicles that alter fuel economy, and thus gasoline demand. In the short run, the aggregate stock of vehicles is fixed, but the model attempts to allow for consumer substitution among inputs in producing travel.

STRUCTURE

The model, as originally designed can be decomposed into five major submodels: (1) used vehicle fleet supply and demand, (2) new vehicle supply and demand, (3) vehicle fleet mix, (4) fleet fuel efficiency, and (5) gasoline demand. In operation the model was to proceed sequentially from submodel 1 to submodel 5 for each year, with a recursive feedback from submodel (3) to submodel (1). Thus, the fleet composition of the previous year influences used vehicle demand in the current year, which in turn influences current-year new vehicle demand. Each of these five submodels is discussed below.

Output is produced for 1977-1995. Printed output includes the exogenous input data, new vehicle demand by class, used vehicle stock by class, fleet fuel economy, and gasoline demand (leaded, unleaded, and total). All output data are presented at state, federal region, and national levels of aggregation.

Used and New Vehicle Demand Submodels

The model's stock system approach to capturing the dynamics of the vehicle population differs from the usual stock adjustment model in that new vehicles are not simply additions to the stock, but are considered to be distinct, superior goods that are close substitutes for used cars. As is explained below, the model's approach had to be altered somewhat because of data limitations.

Cars were classified by applying cluster analysis to 1965-1977 data using five characteristics: exterior and interior size, price, performance, and fuel economy. Pickup trucks and vans constitute separate classes. Classes are treated as close substitutes, and new vehicle demand equations are estimated for each class. New vehicle supply is assumed to be perfectly elastic. Simultaneous used vehicle supply and demand equations were originally planned to be estimated for each state, under the simplifying assumption that state vehicle markets are independent. Unfortunately, the lack of adequate data for such estimation led the model authors to instead estimate used car price simply as a function of new car price. The used car stock is then calculated in the Fleetmix Submodel based on previous new car sales and on scrappage. At the present stage of model development new vehicle prices must be entered exogenously. State new vehicle demand and used vehicle prices by class are passed on to the fleetmix submodel.

Fleetmix Submodel

The Fleetmix Submodel makes the transition from the limits of the behavioral vehicle demand submodel to the requirements of the fleet fuel efficiency submodel. It forecasts scrappage and migration rates by state, class, and vintage in order to track the fleet composition.

In the model, scrappage rates depend on age and on used vehicle price relative to repair costs. Thus, scrappage indirectly depends on new vehicle price. Fuel economy affects scrappage rates through "fuel economy rent" which is capitalized in a vehicle's market price. The historical pattern of interstate migration for two-, three-, and four-year-old vehicles is imposed in calculating state vehicle stock.

New vehicle demand and used vehicle prices are inputs to the Fleetmix Submodel.

The number of vehicles by state, class, and vintage are provided as inputs for the Fleet Fuel Efficiency Submodel. Vehicle ownership by class is supplied as an input for the Gasoline Demand Submodel.

Vehicle Efficiency Submodel

This submodel contains the engineering relationships necessary to develop state, fleet-weighted, harmonic mean fuel efficiencies for the total stock. U.S. Environmental Protection Agency (EPA) test results provide the basic data. These data are adjusted for variations in operating conditions such as ambient temperature, trip lengths, and urban vs. rural travel. An on-the-road efficiency correction is also made to the EPA data. Changes in technology to improve fuel economy are incorporated by class and vintage.

Gasoline Demand Submodel

This submodel uses vehicle ownership by class. vehicle fleet fuel efficiency, gasoline price and other predetermined variables to forecast gasoline demand by state. State vehicle miles traveled by light trucks, vans, and cars is estimated by multiplying gasoline demand by fuel efficiency.

Vehicle Cost Module and Fuels and Technology Assumption Module

While perhaps not fully submodels, two modules that are not currently part of the model may be added in the long-run. One, the Vehicle Cost Module, brings into the model the relationship between (future) fuel economy improvements and manufacturing costs, making new vehicle fuel efficiency endogenous to the model. This is accomplished by adopting the model of vehicle manufacturer behavior contained in the Jack Faucett Associates, Inc. Automobile Sector Forecasting Model (76-016). The Faucett model assumes that automakers attempt to minimize total costs (including fuel costs) to the consumer. Currently, the ORNL model is strictly a demand-side model; fuel economy and vehicle price are exogenous variables.

The model documentation suggests that the Fuels and Technology Assumptions module is also not currently a part of the model. This module could provide for the inclusion in the model of vehicles that have essentially the same characteristics as an existing class, but which are more fuel efficient. The method proposed is similar to that used by the model to account for leaded and unleaded gasoline consumption. Examples are the use of fuels such as gasohol, syncrudes, and diesel, or of alternative engines such as the Rankine and Stirling. Vehicles with very different technological characteristics, such as electric vehicles, could not be adequately handled by the model, however, at this time.

MODEL CONSTRUCTION

Neither the econometric techniques being used to estimate the equations nor the exact equation specifications are presented in the documentation relied upon for this report.

DATA USED IN RUNNING MODEL

A relatively large input data base is required. All numeric data, including coefficients of the model equations, are input data for the model but need not be supplied by the user. There are three types of input data. (1) Some data are unlikely to be altered from one computer run to the next, for example, coefficient values and some base year data. These are stored in a binary input file. (2) The time series of thirteen state-level exogenous variables is required to run a forecast. These data drive the computer program and must be supplied by the user. The table below lists the exogenous variables. (3) Other model parameters considered to be input data are the automobile finance rate and depreciation rates for used cars by class. However, those need not be specified by the user for each future year or each model run.

EXOGENOUS VARIABLES

1) population (10^3 persons)

2) number of households (10^3 households)

3) population inside Standard Metropolitan Statistical Areas (10^3)

4) population under 18 years of age (10^3)

5) population between 18 and 44 years of age (10^3)

6) per capita disposable income (1967 dollars)

7) unemployment rate (%)

8) farm earnings (1967 dollars)

9) new car prices by class (national level only, 1967 dollars)

10) state gasoline prices (1967 dollars)

11) state cost of living index (an index for 1977 in terms of 1967 dollars is supplied so that it is not necessary to supply these data for each year)

12) the decimal fraction of new cars, by class, using unleaded gasoline (national level)

13) city and highway miles per gallon of new cars by class in terms of 1977 EPA fuel economy test procedure (national level)

Source: Greene, Rose, and Thomas 1979.

REFERENCE

Greene, D.L., Econometric analysis of the demand for gasoline at the state level, Oak Ridge National Laboratory, Report no. ORNL/TM-6326, July 1978.

Greene, D.L., Investigation of the variability of gasoline consumption among states, Oak Ridge National Laboratory, Report no. ORNL-5391, July 1978.

Greene, D.L., Stock systems model of regional gasoline demand, draft, Oak Ridge National Laboratory, April 1979.

Greene, D.L.; Rose, A.B.; Thomas, B., User's introduction to the ORNL Highway Gasoline Demand Model preliminary version, Oak Ridge National Laboratory, October 8, 1979.

COMPUTER REQUIREMENTS

An interactive program facilitates the manipulation of input data for policy analysis. The user can create an entirely new data base, or modify all or part of an existing data base. Values of variables can be changed for a specific state and year, or for a time interval, or for all states. As a safeguard, the demand model program checks the input data for gross errors before execution.

Instructions on the use of the program are given in one of the reports.

AUTO OWNERSHIP AND MODE CHOICE MODEL

A model of auto ownership and mode choices based on household and urban structure characteristics was developed in 1977 by the Department of City and Regional Planning at Harvard University. It was sponsored by the U.S. Department of Transportation. Projections for the year 1990 are made which indicate a continuing long-term trend toward greater auto ownership and use.

SPONSOR

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

AUTHOR

John F. Kain, Gary R. Fauth, and Jeffrey Zax
Harvard University
Department of City and Regional Planning
Cambridge, Mass.

KEYWORDS

Automobile demand, modal split

OBJECTIVE OF MODEL

Two stages of the model are defined. One predicts the probabilities that a household will own zero, one, or two or more automobiles; the other predicts the probabilities that employed household members will commute to work as auto drivers, auto passengers, bus passengers, or rail passengers, or by walking. Probabilities are based on a variety of household, transit availability, and urban structure characteristics.

RELATIONSHIP TO OTHER MODELS

There is no relation to other models.

VALIDATION

A projection for the year 1990 was done. It was predicted that there would be a shift towards more auto ownership by households, more commuting by auto driving, and a lower percentage of commuting for each of the other modes. This latter finding disagrees dramatically with the _1974 National Transportation Report: Urban Data Supplement_ by the U.S. Department of Transportation.

With regard to the urban structure explanatory variables, a comparison is made with the model's predictions and the actual data for Boston and Phoenix. The model predicts well. An interesting comparison is also made between these two strikingly different cities.

LIMITATIONS AND BENEFITS

By looking at different cities rather than a single metropolitan area, it can be shown how different urban spatial structures and the levels of highway and transit investment affect household decisions. Also the distinction between the races illustrates how housing discrimination causes blacks and whites to respond differently to changes in land use patterns and transit supply.

STRUCTURE

Linear, recursive equations are estimated, consisting of disaggregated probabilities that, when added, result in the probability that a particular household will choose a level of auto ownership or a travel-to-work mode.

The number of cars owned is based on family type and composition, income, residential location, employment location of workers, density and age of housing stock in the region, and the levels of available highway and transit service. These variables and the number of cars owned are used to explain the mode choice. There are actually 30 auto ownership and 120 mode choice equations, since the total sample of households is stratified by race, the number of employed members (0, 1, 2 or more), work place location (CBD, central city, suburban ring), household type (husband-wife, single head, primary individual), age of head of household (older or younger than 65 years), number of drivers (persons 18-65 years old), number of children, and annual household income. Dwelling types are stratified by type of structure (single family, 1-4 units, 5-19 units, 20+ units, mobile homes), and by age (built 1960 or later, 1940-60, 1940 or earlier). Urban structure variables include road route miles per capita, annual bus seat-miles per capita, annual rail seat-miles per capita, fraction of housing in region built before 1920, and the fraction of housing that is single family.

Mean values for the variables are used in making projections for aggregate regions.

MODEL CONSTRUCTION

A two-stage linear probability model is calibrated using a special least squares procedure that produces conventional ordinary least squares estimators but permits the use of large numbers of variables and observations while saving on computations. Samples of data on 346,893 households and 407,731 workers in the largest 125 SMSA's in the U.S. from the 1970 Census were used.

DATA USED IN RUNNING MODEL

In making predictions, the general long-term trends, as defined by the census data, were assumed for the explanatory variables. For instance, it was assumed that real household income would rise, households would become more single-person oriented, more work places would be in the suburban ring, bus and rail supply would decrease, and housing density would decrease.

REFERENCE

Kain, J.F.; Fauth, G.; Zax, J., Forecasting auto ownership and mode choice for U.S. metropolitan areas, Urban Planning Policy Analysis and Administration, Harvard University, Report R77-4, December 1977. NTIS no. PB-292-873/7.

78-277

EMISSION AND FUEL USE MODEL FOR TRUCKS AND BUSES

An emission and fuel use computer model for truck and bus populations was developed in 1978 at Michigan Technological University. It was sponsored by the Environmental Protection Agency. The model can be applied to the entire U.S. or an urban area, and has truck population, mileage, fuel use, and emissions submodels.

SPONSOR

U.S. Environmental Protection Agency
Washington, D.C. 20460

AUTHOR

Anil B. Jambekar and John H. Johnson
Michigan Technological University
Houghton, Mich.

KEYWORDS

Emissions, fuel consumption, trucks, fleet size, vehicle miles traveled

OBJECTIVE OF MODEL

The operational model can be used to analyze the truck and bus populations for the entire U.S. or a selected urban area, by estimating the urban and rural inventories of up to eight emission sources, classified by engine type, age, and gross vehicle weight. The model is based on the model year sales and scrappage process of vehicle populations.

RELATIONSHIP TO OTHER MODELS

There is no relation to other models.

HISTORICAL BACKGROUND

Impetus for this more up-to-date and general approach grew out of initial modeling work by Tingley and Johnson (73-043).

ASSUMPTIONS

Model years are assumed to be calendar years; calculations are done on an annual basis; and trucks are assumed to last up to 30 years.

VALIDATION

Several application experiments with the model are discussed by the authors. The effects are investigated of increased rates of diesel engine use on vehicle sales. The sensitivity of the model to particulate emissions rates is shown. A case study is done of the New York metropolitan area to illustrate the capabilities of the model and point out the data collection requirements of the model, but actual and predicted values are not compared.

LIMITATIONS AND BENEFITS

The model can be used for sensitivity and scenario analysis. It is general enough to be applied to individual regions, or to be generalized to include automobile as well as truck and bus classes, if the necessary input data bases were developed. The model can also express outputs by a bus/axle classification of vehicles, and test the effect of fuel availability constraints on truck population distribution.

STRUCTURE

Vehicles are classified into nine classes of gross vehicle weight, two of engine type (gasoline and diesel), and by model year or age. The model has several component equations. Prior-year vehicle population, current-year sales, and scrappage determine current year population. These estimates of miles traveled, and the urban/rural mileage split, determine total miles traveled. Total miles traveled, along with payload estimates, determines total ton miles. It also determines, along with emission rate estimates, total emission contributions for the current year. Miles per gallon estimates and total miles traveled determine total fuel usage. A constraint on fuel availability effects total vehicle population and miles traveled. The following submodels feed into this structure: truck population, consisting of vehicle sales and scrappage processes, mileage, fuel usage, and emissions. Some additional outputs of the model include: average urban and rural miles, miles by engine type and weight class, total and average payload, payload by type and class, ton-miles per gallon, emissions by type and class, emissions per ton miles and per gallon. Fuel usage is a function of engine type and class, model year, speed correction factors, emissions standards, and technological upgrading. Emissions are a function of model year, deterioration due to aging, and speed correction.

MODEL CONSTRUCTION

Least squares analysis was used to find the relationship between new vehicle sales and scrappage (i.e., replacement sales). Historical data on scrappage, sales, payloads, miles traveled, and emissions came from several sources: Motor Truck Facts, MVMA, 1972 Census of Transportation, Federal Highway Administration, U.S. Environmental Protection Agency, and U.S. Department of Energy.

DATA USED IN RUNNING MODEL

For the model authors' scenario analyses, three sets of assumptions about the volume of truck sales were made: low, medium and high. To apply the model to an urban area, an input data base must be developed that (1) defines the geographical boundary of the study region, (2) estimates trucking activities, including (a) past and future vehicle populations, (b) miles traveled, (c) load carried, and (d) baseline fuel consumption rates, each differentiated by weight class and fuel type, and has (3) emission factors, (4) age deterioration correction curve parameters, and (5) speed correction factors that are consistent with the study area.

REFERENCE

Jambekar, A.B.; Johnson, J.H., Emission and fuel usage computer model for trucks and buses, Society of Automotive Engineers, Inc., Paper no. 780630, June 1978.

COMPUTER REQUIREMENTS

The computer program of the model has been written in FORTRAN and is implemented on the UNIVAC 1110 computer at Michigan Technological University. Total run times vary from one to two minutes, depending on output requirements.

URBAN VEHICULAR CARBON MONOXIDE POLLUTION MODEL (APRAC-1A)

The APRAC-1A model was developed in 1973 by Stanford Research Institute for the Coordinating Research Council and the U.S. Environmental Protection Agency. It predicts the impact of motor vehicles on air quality in urban areas by modeling concentrations of emissions, taking into account atmospheric conditions.

SPONSOR

Coordinating Research Council
Rockefeller Plaza, New York

Environmental Protection Agency
Research Triangle Park, N.C.

AUTHOR

Walter F. Dabberdt, F.L. Ludwig, and Warren B. Johnson, Jr.
Stanford Research Institute
Menlo Park, Calif. 94025

KEYWORDS

Air pollution/air quality

OBJECTIVE OF MODEL

This model was developed to predict concentrations of inert, vehicle-generated pollutants. It can be used to simulate current and future impact of motor vehicles on the air quality in an urban core region.

HISTORICAL BACKGROUND

APRAC-1A is a modified form of a receptor-oriented Gaussian plume formulation developed in 1964. Atmospheric stability parameters in the model are based on analysis of urban tracer tests done in 1972 by the model authors.

ASSUMPTIONS

Since nearly all urban carbon monoxide emissions are from internal combustion engines, no other carbon monoxide sources are considered, and zero emission height is the assumed source height. Emissions within each sector are assumed to be uniformly distributed. Wind speed is taken to be uniform in speed and direction over the entire urban area, made necessary by the fact that many cities have only one wind measurement site.

VALIDATION

Predictions using the basic model alone were compared with measured data from the Continuous Air Monitoring Program (CAMP) stations in the U.S. Observed and calculated values often differed significantly in magnitude, though with fair correlation. Carbon monoxide concentrations were monitored in urban core regions of San Jose, California and St. Louis, Missouri. Wind, temperature, and traffic data were also collected to evaluate the results and general applicability of the model. Predicted and observed concentrations of carbon monoxide in St. Louis differ by root mean square values of approximately 3 ppm while frequency distributions of hourly concentrations are given within 2-3 ppm.

LIMITATIONS AND BENEFITS

The model development and evaluation programs have only focused on the pollutant carbon monoxide, though the basic methodology is applicable for other pollutants. The model is practical in that it requires only routinely available meteorological and traffic data. Traffic engineers and city planners can use it in their efforts to develop transportation and land use policies with minimum pollution effects.

STRUCTURE

Four models are presented, the Basic Model, APRAC-1A, the Box, and the Street Canyon Model. The latter two models account for the barriers that buildings impose upon the mixina of pollutants with the upper atmosphere. In the basic model, pollution concentration at a receptor is determined by the emissions between logarithmically spaced angular segments emanating from the receptor point. The wind direction bisects the angle.

Basic Model

$$C_i = \frac{0.8\, Q_i}{\bar{u}\, a} \, \frac{X_{i+1}^{1-b} - X_i^{1-b}}{1 - b}$$

where:

C_i = concentration from sources in segment i (gm^{-3})

$\bar{u}$ = wind speed (m/sec.)

a,b = atmospheric stability parameters

Q_i = average segment pollution source strength (gm^{-2}/sec.)

X = downwind distance from the source

APRAC-1A

APRAC-1A uses an inventory of average daily traffic volume for major roads, based on historical or forecast data rather than an inventory of segment pollution source strength.

$$E = \alpha S^{-\rho}$$

where:

E = emission rate (grams carbon monoxide/vehicle-miles)

α, ρ = constants depending on characteristics of emission control devices installed in the fleet (α = 700, ρ = 0.75. These values are appropriate to a mixture of about half pre-1968 and half newer cars.)

S = speed (miles/hr.)

Box Model

The basic model changes to the Box Model when there are restrictions to the upward mixing of pollutants from the roadway.

$$C_i = Q_i \frac{X_{i+1} - X_i}{\bar{u}\, h}$$

where:

Ci, Qi, X = same as basic model

h = height above which there is no restriction to upward mixing of the pollutant

Street Canyon Model

The Street Canyon Model is an improved version of the Box Model.

$$\Delta C = K \frac{Q_L}{r\ (u+0.5)}$$

where:

ΔC = amount of carbon monoxide added at the receptor point located on the side of an upwind building

K = empirical constant (for San Jose and St. Louis, the constant is about 7)

r = slant distance between the receptor and the nearest traffic lane

u = roof-top wind speed (m/sec.)

Q_L = local street emissions (g/m-sec.)

MODEL CONSTRUCTION

This is an accounting model of a physical-chemical system. Data collected in San Jose and St. Louis were used in calibrating the empirical constant in the Street Canyon Model.

DATA USED IN RUNNING MODEL

The input variables required for application of the basic model are: traffic emissions, mixing height, atmospheric stability type, and transport wind speed. Mixing heights and stability type are estimated from available airport observations and emissions from the daily traffic volume on major city streets.

REFERENCE

Dabberdt, W.F.; Ludwig, F.L.; Johnson, W.B., Jr., Validation and applications of an urban diffusion model for vehicular pollutants, Atmospheric Environment, vol. 7, pp. 603-618, June 1973.

GENERAL EQUILIBRIUM MODELING SYSTEM (GEMS)

General Equilibrium Modeling System (GEMS), a nonregional general equilibrium modeling procedure, was developed by Decision Focus, Inc. in 1977 for analysis of the national energy system by the Federal Energy Administration. The specific analysis conducted with the system depends on the particular sponsor for whom an analysis is made. Transportation analyses done with the model have included simulation of end-use service demands for urban and rural vehicle miles, and of penetration of electric cars into the automobile market. Client users of the system have included the Chase Manhattan Bank, the Electric Power Research Institute, and the Tennessee Valley Authority.

SPONSOR

Federal Energy Administration
Washington, D.C.

AUTHOR

Ronald J. Adler, Edward G. Cazalet, Stephen M. Haas, Robert A. Marshalla, Dale M. Nesbitt, Robert L. Phillips
Decision Focus, Inc.
1801 Page Mill Road
Palo Alto, Calif. 94304

KEYWORDS

Energy consumption, fuel price

OBJECTIVE OF MODEL

The system is designed to aid analysts in constructing models of regional, national, and international economic markets and their linkages to the rest of the economy. These models could be used to evaluate the impact of specific public policy or private sector investment alternatives. GEMS has generally been applied to energy-economy modeling, but it could be applied to other problems and markets.

HISTORICAL BACKGROUND

GEMS developed out of the SRI-Gulf Model (73-261) methodology. The Long-term Energy Analysis Program (LEAP) (77-286) is a version of GEMS that was sold to the U.S. Department of Energy.

ASSUMPTIONS

The methodology employed is that of generalized equilibrium modeling, based on decision-focused analysis and coordinated decomposition of complex decision models. The forecasting approach is a combination of myopic extrapolation, in which future values of variables depend on the past and present values, and clairvoyance, in which actual future values are used to compute present profits.

LIMITATIONS AND BENEFITS

The provision of modeling conventions, off-the-shelf process models, and software relieves the modeler of routine tasks and provides a general and highly flexible structure within which a wide range of economic models can be constructed that are tailored to specific decision problems, thus avoiding the need to rely on one large all-purpose model or the construction of a new model for every problem.

STRUCTURE

GEMS consists of three components: (1) a system of modeling conventions that facilitates the definition of network models of economic systems that link together either macro- and micro-level process models of sectors of the economy, or specific economic activities such as crude oil refining or coal mining; (2) a basic library of generic process models that describe the physical and behavioral characteristics of basic economic activities; and (3) the DFI Model Data Management System (MDMS), which facilitates the definition of modeling conventions in the construction of process models, and in the management of data required in an actual model.

The basic elements of a model are: (1) process models of economic or natural systems, technologies, or decisionmaking processes, containing physical and/or behavioral relations; (2) a network defining the link between the processes, with end-use demand for energy processes at the top of the network, primary resource supply processes at the bottom, and market behavior, conversion, and transportation between; and (3) an algorithm that uses iterative techniques to successively adjust prices and quantities until a solution is found.

Models are constructed using a set of processes from a basic library of GEMS modules, with minor modifications. These modules simulate basic allocation, basic conversion, electric power conversion, electric power load, electric power allocation, depleteable resources, transportation, distribution, end-use conversion, end-use demand, financial, and governmental processes.

Constraints on the solution of a model, in the form of price regulation of resources, may be applied.

Some changes from the SRI-Gulf Model include data base revision; software that increases flexibility and reduces data management costs; a more hierarchical structure that allows feedback from the rest of the economy; new assumptions in the process logic that keep track of additions to energy plant capacity, new investment in resources and resource production; and altered assumptions about producer learning processes.

DATA USED IN RUNNING MODEL

Data can be organized along eleven dimensions: global region, local region, sector, activity, output link, input link, sub-link, generic process, specific process, time, and attribute. Network data are the pointers needed to construct a network, and process data are the actual input parameters and variables.

COMPUTER REQUIREMENTS

Data management is performed by the Model Data Management System, consisting of an EXECUTIVE program that allows the user to create, edit, store, and display data, and a TRANSFER system which transfers data to the model and results from it.

The software for GEMS and the Model Data Management System can be purchased from Decision Focus, Incorporated.

REFERENCE

Cazalet, E.G., Generalized equilibrium modeling: The methodology of the SRI-GULF Energy Model, Decision Focus, Inc., May 1977.

Adler, R.J.; Cazalet, E.G.; Haas, S.M.; Marshalla, R.A.; Nesbitt, D.M.; Phillips, R.L., DFI generalized equilibrium modeling system, Decision Focus Incorporated, Dec. 1979.

DEMAND MODEL FOR GASOLINE AND RESIDENTIAL ELECTRICITY

A model of energy consumption is applied to gasoline and electricity demand by individuals, in which demand is related to income and price in a flow-adjustment model estimated by the error components technique. The model was developed in 1974 by staff members at Data Resources, Inc. and Harvard University. The work was sponsored by the Ford Foundation and the Council on Environmental Quality.

SPONSOR

Ford Foundation
320 East 43rd St.
New York, N.Y. 10017

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

AUTHOR

H.S. Houthakker
Harvard University
Economics Department
Cambridge, Mass.

Philip K. Verleger, Jr. and Dennis P. Sheehan
Data Resources, Inc.
Lexington, Mass.

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The objective of the model is to forecast energy (gasoline and electricity) consumption of individuals as a function of price, income, and the quantity demanded in the prior period.

VALIDATION

It is shown that the growth in energy demand is due to rising incomes and falling prices; consequently, increases in prices should bring about adjustments in demand, without the use of rationing.

ASSUMPTIONS

A flow-adjustment model of demand is used, in which the stock of energy-using capital is assumed to be fixed over the short run, and the utilization of it is assumed to be a function of normal economic influences.

LIMITATIONS AND BENEFITS

The model assumes that the utilization rates of all energy-using equipment are the same, regardless of vintage. It would have been better to separate the utilization and capital equipment investment process into two equations.

STRUCTURE

The demand for energy resources is examined at a regional level because there should be variation in prices and consumption between states, due to climactic and population characteristics. The same model specification is used for gasoline and electricity, but they are priced in contrasting ways. The estimation for gasoline consumption is as follows:

$$\ln(q_{it}) = \underset{(.032)}{.593} - \underset{(.013)}{.075}\,[\ln(p_{it})] + \underset{(.017)}{.303}\,[\ln(y_{it})] + \underset{(.019)}{.696}\,[\ln(q_{i,t-1})]$$

$R^2 = .92$

where standard errors are in parentheses, and

q_{it} = quantity of gasoline demanded by individuals in state i at time t

p_{it} = price of gasoline in state i at time t

y_{it} = disposable income in state i at time t, found by deflating personal income per capita by the ratio of aggregate national personal income to national disposable personal income

MODEL CONSTRUCTION

The error components or variance component technique was used to estimate the model, to avoid biased estimates that would be caused by the lagged dependent variable in the flow-adjustment model. The error components technique also accounts for between-state fluctuations and provides the best estimate of the adjustment parameter. Quarterly data from 1963-1972 from 48 states and Washington, D.C. were used to fit the gasoline consumption model.

Gasoline consumption data came from the American Petroleum Institute, gas price from Platt's survey, personal income from the Bureau of Economic Analyses (BEA), population from the Census Bureau, and the total personal consumption expenditures deflator from the BEA.

REFERENCE

Houthakker, H.S.; Verleger, P.K., Jr.; Sheehan, D.P., Dynamic demand analyses for gasoline and residential electricity, American Journal of Agricultural Economics, vol. 56, pp. 412-418, May 1974.

LONG-TERM ENERGY ANALYSIS PROGRAM (LEAP)

The Long-term Energy Analysis Program (LEAP) is a national version of a dynamic generalized equilibrium model of energy supply and demand, developed by Decision Focus, Inc. (DFI) in 1977. It was designed to be a flexible tool for long-term energy projection for the Energy Information Administration (EIA) of the U.S. Department of Energy. Parts of the model were developed, and are continually updated, by the Long-Term Analysis Division of EIA. The model was used for the long-term projections presented in both the 1978 and 1979 EIA Annual Report to Congress.

SPONSOR

U.S. Department of Energy
Energy Information Administration
Washington, D.C.

AUTHOR

Decision Focus, Inc.
1801 Page Mill Road
Palo Alto, Calif. 94304

KEYWORDS

Energy consumption, fuel price

OBJECTIVE OF MODEL

The objective of the Long-term Energy Analysis Program is to provide long-term economic projections of energy product use and energy product prices. Transportation is included as end-use energy service demands for urban and rural auto miles as well as transport service demands for modes.

RELATIONSHIP TO OTHER MODELS

LEAP is calibrated to equal the Mid-term Economic Forecasting Svstem (MEFS) (S-78-419) model through 1995. LEAP is operational on EMS, a computer program developed by DFI, which makes it possible to define large network models. EMS employs data bases stored on MRI 2000, a proprietary DFI data management system. EMS and MRI 2000 have been superseded by a more flexible and efficient software system, the DFI Generalized Equilibrium Modeling System (GEMS) (77-283).

HISTORICAL BACKGROUND

LEAP is derived from the SRI-Gulf Energy Model (77-261), developed at Stanford Research Institute and Decision Focus, Inc. Other derivatives of the SRI-Gulf model are the GEMS (77-283) and the Livermore Energy Policy Model (EPM) (78-462). It is currently undergoing in-house (Decision Focus, Inc.) and subcontractor refinements.

ASSUMPTIONS

The model is a regional dynamic model of supply and demand for energy with assumptions similar to those of the SRI-Gulf model (73-261). LEAP combines an econometric measure of service demands with engineering/economic representations of the full range of processes in the national energy system. Its network structure models the market penetration of new conversion and renewable resource technologies, such as synthetic fuels, solar, and renewable energy, within the context of conventional supply and conversion technologies.

VALIDATION

The version of LEAP used in the EIA 1978 Annual Report to Congress and its forecasts were assessed and validated by the Office of Energy Information Validation of the Energy Information Administration, in conjunction with Oak Ridge National Laboratory. A draft report on the LEAP assessment has been written by DOE Office of Energy Information Validation and is dated March 1980.

LIMITATIONS AND BENEFITS

Limitations and benefits are similar to those of the SRI-Gulf Model, except that LEAP is a more flexible nonregional version. Possible applications of the model are a long-term comparative analysis of alternative energy technologies, programs and development scenarios; the effects of these on domestic economics; forecasting supply and demand for the EIA's Annual Report to Congress. The final transport service demands that have been analyzed include intercity and intracity vehicle miles traveled, light and heavy truck vehicle miles, air passenger, rail ton, marine ton, and bus vehicle miles. An analysis of electric vehicle demand has been done. LEAP can also be used to analyze the effects of various automobile efficiency assumptions and of higher oil prices.

STRUCTURE

This is a national-level model similar to the SRI-Gulf Model (described under 73-261 above). The version used for the 1979 EIA Annual Report to Contress has 225 nodes. LEAP describes the overall energy system of the U.S. from 1975 to 2020 by 5-year intervals. The various processes of energy production, conversion, transportation, and end-use are individually represented.

LEAP is similar to the SRI-Gulf and related models, in that its basic components are the energy-economy network, process submodels, and a solution algorithm. The sectors represented are utilities, residential, commercial, transportation, industry, distribution, uranium, coal/synthetics, and oil/gas. Within the transportation sector the materials and processes represented are light oil and marine fuel allocation, aircraft, oil-driven and electric automobiles, light trucks, buses, heavy trucks, rail, marine, all vehicle miles allocation, urban vehicle miles, and finally, personal transportation demand.

The process submodels included are for basic conversion, basic allocation, end-use demand, basic resource, coal process, allocation process, electric-power conversion, electric power loading, transportation, import/export, and a null process.

MODEL CONSTRUCTION

The model was based on the data base and methodology of the SRI-Gulf Model. The current data base was developed by the EIA Long-Term Analysis Division. It includes data on prices and quantities, and parameters on demand elasticities, technological parameters, future GNP, and future imported oil prices.

DATA USED IN RUNNING MODEL

Data used in running the model come from a variety of sources such as MEFS, U.S. Department of Transportation, National Coal Model, Oak Ridge National Laboratory, Brookhaven National Laboratory, and in-house data generation. Data can be grouped into the following types: conversion, resource, demand, allocation, and transportation. Within each of the fifteen process models, there are requirements for physical data such as quantities and technological parameters, and economic values such as cost, tax, and regulatory data.

REFERENCE

Cazalet, E.G., Generalized equilibrium modeling: The methodology of the SRI-GULF Energy Model, Decision Focus, Inc., May 1977.

Kydes, A.S.; Pearson, J.D.; eds., Comparative assessment of calibrated long-run energy projections, Brookhaven National Laboratory, Report no. BNL 51085, September 1979.

Analysis quality report: The 1978 ARC long-term forecast, draft, U.S. Department of Energy, Office of Energy Information Validation, March 1980.

Annual report to Congress 1979, vol. 3, U.S. Department of Energy, Energy Information Administration, Report no. DOE/EIA-0173(79)/3, 1980.

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Phillips, R.L., DFI generalized equilibrium modeling system, Decision Focus, Inc., December 1979.

Cazalet, E.G.; Deziel, L.B., Jr.; Haas, S.M.; Martin, T.M.; Nesbitt, D.M.; Phillips, R.L., DFI computer modeling software (CMS), U.S. Department of Energy, Long-term Energy Analysis Division, Report no. DOE/EIA-7013-1, October 1979.

Clark, C.E., Jr.; Cook, T.A.; Haas, S.M.; Nesbitt, D.M.; Oman, D.B.; Phillips, R.L., Modelers guide to bulding generalized equilibrium models, Decision Focus, Inc., July 1979.

Cohen, S., LEAP users manual, to be published by DOE.

McCormick; Falk; Soland, Research into the methodology of the LEAP model, Washington, D.C.: George Washington University, December 1979.

COMPUTER REQUIREMENTS

The program runs on an IBM 370/168 machine. It requires 1500 tracks of disk storage and 2000K bytes of core storage for a 50 year simulation. It is written in FORTRAN. The average turnaround is 30-35 seconds per iteration.

PARTIAL RECURSIVE MODEL OF AUTOMOBILE DEMAND

A simple econometric model of automobile demand was estimated in 1973 at the Ford Motor Company. The objective is to demonstrate that a simple approach is as good as that of large-scale models. This approach is meant to be illustrative of the model that Ford actually uses in forecasting automobile demand.

AUTHOR

A. John Steigmann
Ford Motor Company
Economic Research Division
Dearborn, Mich.

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

A simple partial recursive model is specified for the period 1961-1971 that describes automobile demand as a function of economic and monetary activity, and seasonal and strike effects. The model author's objective is to show that a simple model can be as good as larger econometric models.

RELATIONSHIP TO OTHER MODELS

The actual model used by Ford to forecast auto demand is proprietary and is not shown here. The model discussed here is an illustration of an approach and application that was tested by Ford economists.

ASSUMPTIONS

An endogenous predictor of car demand is used in the model. The money supply variable is not assumed to be exogenous. The error term on the economic activity equation is not independent of the money supply variable.

VALIDATION

A comparison is shown between the predicted and actual values for the twelve months of 1972 for the two dependent variables (monthly car sales and industrial production index); the values appear to be close. No statistics are given, but the author feels that the large-scale models do not seem to have shown results superior to the econometrically simpler approach.

LIMITATIONS AND BENEFITS

The author shows that the variance of a dependent variable about the conditional expectation of the independent variable, given an endogenous variable, is smaller than its variance about the conditional expectation of the dependent variable, given the exogenous variable on which the endogenous variable is dependent. Thus, the methodology based on the conditional expectation of endogenous variables, given exogenous variables, while yielding unbiased multiplier estimates, does not, therefore, yield efficient forecasts. The size and complexity of the standard large-scale econometric model is due largely to the use of this methodology. The efficiency of the simpler procedure is preferred by the model author. The particular large-scale models in question are not indicated.

STRUCTURE

The general form of this econometric model is:

For j = 1, 2:

$$\log(Y_{jt}) = \sum_{i=1}^{12} [\log(B_{ij})\ X_{ijt}]$$

$$+ \sum_{i=13}^{18} [\log(X_{13,j,t+13-i})\ B_{ij}]$$

$$+ \sum_{i=19}^{20} [\log(B_{ij})\ X_{ijt}] + \log(e_{jt})$$

where:

Y_1 = monthly car sales on a U.S. delivery, daily selling rate basis

$X_{1,1}$ through $X_{12,1}$ = 0,1 seasonal dummies

$X_{13,1}$ = Federal Reserve Board Index of Industrial Production

$X_{19,1}$ = 0,-1,+1 car strike dummy

$X_{20,1}$ = Nixon effect dummy, = 0 before August 1971, .5 in August, 1 in September through December 1971. This effect represents the impulsion of the public, under price controls, to purchase cars in anticipation of extensive price increases following the end of controls.

Y_2 = FRB Index of Industrial Production, = $X_{13,1}$

$X_{1,2}$ through $X_{12,2}$ = 0,1 seasonal dummies

$X_{13,2}$ = money supply (M_1 seasonally adjusted)

$X_{19,2}$ = car strike dummy differing from $X_{19,1}$ with respect to phase

$X_{20,2}$ = a steel contract renegotiation dummy, = 1 in the final four months of 1962, 1965, 1968, and 1971, = 0 otherwise.

The coefficients (B), i = 13 to 18, are not unconstrained by the estimation procedure but result from use of the Almon lag technique with a third-order polynomial and five-month lag.

Y_1 and Y_2 are fit separately to the X's, and Y_2 is substituted for $X_{13,1}$ to obtain the solved reduced form for Y_1.

The values of the estimated coefficients are shown in the paper.

MODEL CONSTRUCTION

The model was estimated with data from the 132 months from January 1961 through December 1971.

REFERENCE

Steigmann, A.J., Partial recursive model of automobile demand, Business Economics, vol. 8, no. 4, pp. 28-30, September 1973.

AUTOMOTIVE FLEET FUEL CONSUMPTION MODEL (FUEL4)

This generation of the Automotive Fleet Fuel Consumption Model was developed in 1977 by Automated Sciences Group, Inc. for the National Highway Traffic Safety Administration. It is used to predict fuel consumption for five different classes of automobiles using alternative fuel economy rating scenarios.

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Energy Research Division
400 7th Street S.W.
Washington, D.C. 20590

AUTHOR

Automated Sciences Group, Inc.
8555 16th Street
Silver Spring, Md. 20910

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The model projects fuel consumption so as to allow the evaluation of potential fuel conservation benefits resulting from the implementation of various hypothetical schedules of automotive fuel economy. Projected fuel conservation benefits are described in terms of annual fuel savings, cumulative fuel savings, and discounted cash savings for several sectors of the U.S. fleet of autos.

RELATIONSHIP TO OTHER MODELS

The model may be used in conjunction with the Fuel Economy Projection Program--FUEL6 (77-295B).

HISTORICAL BACKGROUND

The model was originally developed at the Transportation Systems Center. Earlier generations of this model are described in this inventory as 74-006 and 77-067.

LIMITATIONS AND BENEFITS

The primary application of the model is to compare two fuel economy scenarios, a hypothetical baseline and a hypothetical improved scenario. The model can be used interactively to change input data scenarios.

STRUCTURE

The major outputs of this accounting model are percentage baseline versus improved fuel savings, yearly and cumulative fuel consumption and vehicle miles traveled (VMT), discounted accumulated cash savings, average fleet fuel economy and age, fleet size, and total new registrations and scrappage. Input data are new car registrations (past and future), vehicle miles traveled, vehicle survivability by age of vehicle, fuel economies in miles per gallon for the baseline and improved scenarios (past and future), and discounted savings rate parameters. The total fleet of vehicles is divided into five sectors; the model can be run for any combination of sectors: domestic passenger automobiles, imported passenger, domestic nonpassenger less than 6,000 lbs., imported nonpassenger less than 6,000 lbs., and domestic and imported nonpassenger automobiles from 6,000 to 10,000 lbs. Each sector has its own input data for registrations, fuel economy, survivability, and vehicle miles traveled.

For each sector, these calculations are done: the baseline and improved fleet fuel consumption, discounted accumulated cash savings, total active registrations, vehicle scrappage, VMT, percentage fuel savings, average fuel economy and age, and average miles traveled and fuel consumed per vehicle. The values for the sectors are then combined for the total fleet.

MODEL CONSTRUCTION

This is an accounting model.

DATA USED IN RUNNING MODEL

The data necessary to run the model are fixed: historical registrations and fuel economy. These items may have alternate sets of data specified by the user: projected registrations and fuel economy, VMT, survival probabilities, fractional discount rate, year difference for discounting, and fuel economy correction factor.

REFERENCE

Fuel economy models, Automated Sciences Group, Inc., December 1977.

COMPUTER REQUIREMENTS

The interactive computer model is written in FORTRAN 10 and is operational on the PDP-10 timesharing system of First Data Corporation. The model documentation provides a user's guide, a programmer's guide, a data element dictionary, and a program listing.

FUEL ECONOMY PROJECTION PROGRAM (FUEL6)

The Fuel Economy Projection Program--FUEL6 was developed in 1977 at the Transportation Systems Center for the National Highway Traffic Safety Administration. It is used to calculate the fuel economy of fleets of automobiles, given the engine characteristics and sales of various auto models.

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Fuel Economy
400 7th Street, S.W.
Washington, D.C. 20590

AUTHOR

Automated Sciences Group, Inc.
8555 16th Street
Silver Spring, Md. 20910

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

KEYWORDS

Fuel economy

OBJECTIVE OF MODEL

The model is used to calculate the sales-weighted fuel economy for fleets of future passenger and nonpassenger automobiles, by model year.

RELATIONSHIP TO OTHER MODELS

This model may be used in conjunction with the Automotive Fleet Fuel Consumption Model--FUEL4 (77-295A).

STRUCTURE

In this accounting-estimation model each model of automobile in the fleet is described by its market concept, name, engine displacement, transmission type, inertia weiqht, rear axle ratio, engine power, vehicle fuel economy, and sales. Fuel economy projections are found by applying percentage changes and equations, developed from regression techniques, to the fuel economy of equivalent car models in a base fleet.

The model program produces the following output by market concept, model, actual displacement, transmission, and rear axle ratio: fuel economy performance, inertia weight, sales fraction, sales weighted average displacement, and average horsepower per inertia weight. Other output includes: the sales percentage and cars produced by engine and transmission combination, and fuel economy and sales percentage by inertia weight and engine type. All sales fractions are normalized to sum to 100%. Each average of fuel economy is a sales-weighted harmonic mean fuel economy, constructed by summing the ratio of a sales fraction and the corresponding fuel economy in miles per gallon, and dividing the resulting sum into the sum of sales fractions. This is equivalent to taking a sales-weighted average of gallons per mile driven, assuming each car sold will be driven the same distance.

DATA USED IN RUNNING MODEL

The following are input to the program: market concept of the car model, engine displacement, transmission type, inertia weight, rear axle ratio, engine power, vehicle fuel economy, sales, projected percentage improvements due to technology, and penalties due to regulatory constraints.

REFERENCE

Fuel economy models, Automated Sciences Group, Inc., December 1977.

COMPUTER REQUIREMENTS

The interactive computer program is written primarily in FORTRAN 10, with portions in assembly language, and is operational on the DEC PDP-10 of First Data Corporation in Waltham, Massachusetts. The model report includes a user's guide, programmer's guide, data element dictionary, and program listing.

FUEL-12 CAFE PROCESSING SYSTEM

The FUEL-12 CAFE Processing System was developed in 1979 by Automated Sciences Group, Inc. for the National Highway Traffic Safety Administration (NHTSA). It allows NHTSA to calculate automobile manufacturer's fleet fuel economies (CAFE) using vehicle test data provided by the Environmental Protection Agency (EPA).

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
400 7th Street, S.W.
Washington, D.C. 20590

AUTHOR

Automated Sciences Group, Inc.
Summit Office Building, Suite 713
8555 16th Street
Silver Spring, Md. 20910

KEYWORDS

Fuel economy

OBJECTIVE OF MODEL

The corporate average fuel economy (CAFE) for the automobile manufacturers is calculated by the EPA using their test data. The FUEL-12 program system is designed for NHTSA to allow them to duplicate the calculation and evaluation of the CAFE, using test data provided by EPA.

RELATIONSHIP TO OTHER MODELS

The EPA Manufacturers Average Program, used to calculate the official measures of CAFE, also produces output that is sent via magnetic tape to NHTSA. This data undergoes translation and implementation on a data base analysis system before it is input to the FUEL-12 system.

LIMITATIONS AND BENEFITS

The procedures developed ensure that the same data is used by EPA and NHTSA and that there is no duplication of clerical functions. Sensitivity analysis may be performed at the model type level. Direct access is allowed to the model users at NHTSA to test results and vehicle information. Report and data file generation is possible at the level of individual tests, vehicle configurations, base level, model type, and manufacturer.

STRUCTURE

CAFE values are computed in this accounting model from sample EPA city/highway fuel economy/emission test results in three stages. (1) Manufacturer's vehicle configurations are grouped into base levels that have common transmission class (manual/automatic), basic engine type, and inertia weight. Base level values of highway, city, and combined fuel economy are computed as sales-weighted harmonic means of the corresponding tested configuration fuel economies. Sales are partitioned among the various car lines and base levels. (2) Sales-weighted harmonic mean fuel economies are then computed from the base level fuel economies for each model type. (3) Finally, the manufacturer's CAFE is computed as the sales-weighted mean of the model type fuel economies. For some manufacturers the CAFE may include imported vehicle configurations. When city and highway test fuel economies are found the city/highway mileage split is assumed to be 55%/45%.

MODEL CONSTRUCTION

This is an accounting and data base management program.

DATA USED IN RUNNING MODEL

EPA tests samples of the vehicle configurations produced by each manufacturer for emissions and fuel economy. The data are generated, edited, and validated at the EPA laboratory in Ann Arbor, Michigan, and a copy is transferred to NHTSA.

REFERENCE

FUEL-12 system CAFE processing documentation, Automated Sciences Group, Inc., May 1979.

COMPUTER REQUIREMENTS

The computer program is written in FORTRAN, calls SYSTEM 1022 DPL subprograms, and uses SYSTEM 1022 data bases. It is operational on the ADP/First DEC System 10 computer operated by a time-sharing vendor for NHTSA. The data are created on The University of Michigan computer system.

MOTOR VEHICLE HOUSEHOLD CHOICE MODEL

The Motor Vehicle Household Choice Model was developed by Cambridge Systematics, Inc. and published in November 1978. The purpose of the model is to predict motor vehicle demand by analyzing household choice for new and used automobiles. It was used under sponsorship of the U.S. Department of Transportation and the National Science Foundation to forecast household vehicle type purchases and holdings over the 1978-1985 period.

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration

National Science Foundation

AUTHOR

Charles F. Manski, Leonard Sherman, and J. Royce Ginn
Cambridge Systematics, Inc.
238 Main Street
Cambridge, Mass. 02142

KEYWORDS

Automobile demand, market share

OBJECTIVE OF MODEL

This model's objective is to predict motor vehicle demand by analyzing household choice for new and used automobiles.

HISTORICAL BACKGROUND

The stock adjustment approach first applied by Chow (57-413) and others was the prevailing method until recently. Some models using this approach view the motor vehicle as a homogeneous good while others at least crudely recoanize product differentiation. Charles River Associates (76-025) and Lave and Train (77-055) examined choice of auto-type but only conditional on a decision that a new vehicle is to be purchased.

ASSUMPTIONS

The model assumes that each year a household evaluates its current vehicle holdings and determines whether any changes should be made. A household's decisions in year y are assumed to depend on its holdings at that time, and hence, on its decisions at year y-1.

Vehicles of all makes, models, and years are assumed to be available for purchase by all households. Since college-educated household heads were assumed to be more aware of an auto's depreciation rate and savings resulting from fuel efficiency, price and fuel cost variables interact in the model with an indicator of education level.

LIMITATIONS AND BENEFITS

The model authors indicate that this model constitutes the first effort to develop an econometric model explaining the make, model and vintage composition of individual household vehicle holdings.

The data used did not identify the engine type, transmission and amenity options that differentiate cars with a single make/model/vintage designation. The way this data problem was resolved was to characterize each make/model/vintage of vehicle by the highest-selling type of characteristics.

The model explains household vehicle holdings separately for households with one and two vehicles, but it does not explain why households own varying numbers of vehicles.

STRUCTURE

A household's choice of a motor vehicle is modeled as a function of passenger carrying characteristics, luggage space, performance characteristics, capital and operating costs, and transaction costs.

The one vehicle-household hedonic econometric model is:

$$U = (Z \times a) + (X \times b) + E$$

where:

U = maximized utility by motor vehicle choice

Z = vector of functions and household attributes associated with motor vehicle choice

X = transaction/search cost dummy variable

(a,b) = parameter vector to be estimated

E = Weibull disturbance

In the two-vehicle household model, the utility of a vehicle pair is assumed to be a sum of sub-utilities for each vehicle in the pair plus a fictitious composite vehicle containing the best attributes of both.

The effect of the number of seats in addition to the driver's seat on two-vehicle-household utility is:

$$U_s = \underset{(-1.51)}{-.268}\left(\frac{S_{ti} + S_{tj}}{2}\right) - \underset{(-1.63)}{.0722}\left(S_{ti}^{2} + S_{tj}^{2}\right) + \Big[\underset{(1.52)}{.120}$$

$$+ \underset{(3.50)}{.0293}\,(d_t)\Big]\,[\max(S_{ti}, S_{tj})]$$

where t-statistics are in parentheses, and

U_s = utility attributed to the number of seats excluding the driver's seat

(i,j) = a vehicle pair

t = a household

s = the number of seats excluding the driver's seat

d_t = dummy variable indicating households with four or more members

The effect of cost per mile of two vehicles on a household's utility is:

$$U_c = \underset{(-1.35)}{-.346}\left(\frac{C_i + C_j}{2}\right) + \underset{(1.27)}{.145}\,[\min(C_i, C_j)]$$

where:

U_c = utility attributed to vehicle cost per mile

(i,j) = a vehicle pair

C = cost per mile of the vehicle

MODEL CONSTRUCTION

The basic data source for this model is The University of Michigan's Survey Research Center's (SRC) winter 1976 survey of approximately 1,200 households drawn from its rotating consumer panel. This edition of the SRC survey obtained from each household typical socioeconomic and demographic data plus information regarding up to three vehicles currently held by the household. In addition to the SRC data, a file of vehicle characteristics for some 2,000 vintage vehicles was developed from the Automotive News Almanac and the Consumer Union Reports. Used car prices are obtained from the Red Book.

REFERENCE

Manski, C.F.; Sherman, L.; Ginn, J.R., Empirical analysis of household choice among motor vehicles, draft, Cambridge Systematics, Inc., Nov. 1978.

Sherman, L.; Manski, C.F., Analysis of the effects of gasoline prices and vehicle design attributes on consumer choice of vehicle type, Cambridge Systematics, Inc., 1979.

DEMAND FOR NEW AND USED AUTOMOBILES CROSS-SECTION MODEL

A cross-section analysis of the demand for new and used automobiles by households employing the construction of a multinomial logit probability model was performed in 1978 at Stanford Research Institute. The age and number of automobiles owned is shown to be related to family income, size, and age of household head.

AUTHOR

Terry R. Johnson
Stanford Research Institute
Stanford, Calif. 94305

KEYWORDS

Automobile demand

OBJECTIVE OF MODEL

The demand for new and used automobiles is explained as a result of household characteristics. The purpose of the study is to present more convincing evidence supporting the superiority of new over used cars. A multinomial logit probability model is developed that describes the probability of owning a certain number of cars, given the household characteristics. These probabilities can then be combined with variables describing households to calculate the stock of cars owned.

ASSUMPTIONS

The probability that a family will own a certain number and age of automobiles is assumed to be a function of the family size, income, and the age of the head of the household.

VALIDATION

The models appear to be stable over the two time periods for which the model was estimated, and the coefficients have the expected signs. Two methods of calculating total automobile stock using the results of the household ownership model were employed to further validate the model. These produced results less than 10% under the actual value. The model does not account for business- and government-owned cars.

LIMITATIONS AND BENEFITS

Data taken from separate time periods allow for a more reasonable test for differences in the coefficients.

STRUCTURE

An individual family can own only an integral number of automobiles. The statistical model used to describe this situation is the multinomial logit probability model. The variables used are:

$A_t(i)$ = age of car, i = 0 ... m, during year t. $A_t(0)$ includes vintages t and t+1. $A_t(m)$ includes all cars greater than or equal to age m=6.

Y(t) = logarithm of disposable income in year t

FAM = log of family size

AGEHEAD = log of age of household head

Several sets of model coefficients are estimated, with the following dependent variables: household owns one used car, one new car, two used cars, two new cars, two cars--new and used, car of age one through six, and no car.

Two alternative measures of the total stock of automobiles are used:

$$N(\bar{a}) = \sum_y \sum_f \sum_i g(y,f)\ P_i(y,f;\bar{a})\ i$$

$$N(\bar{f}) = \sum_y \sum_a \sum_i h(y,a)\ P_i(y,a;\bar{f})\ i$$

where:

$N(\bar{a})$ = total stock of automobiles owned by households, using mean age of household head

$N(\bar{f})$ = total stock of autos owned by households, using mean family size

g(y,f) = number of households of income level y and family size f

h(y,a) = number of households of income level y and age of household head a

P_i = probability of owning i cars using the coefficients of income (y), family size (f), and age of household head (a), or the means across i

MODEL CONSTRUCTION

Cross-section data on families were used to estimate the model coefficients from the 1959 and 1970 Surveys of Consumer Finances conducted by the Survey Research Center.

REFERENCE

Johnson, T.R., Cross-section analysis of the demand for new and used automobiles in the United States, Economic Inquiry, vol. 16, no. 4, pp.531-548, Oct. 1978.

78-312

S.U.R.E. DEMAND MODEL OF AUTOMOBILE SIZE CHOICE

The S.U.R.E. Demand Model of Automobile Size Choice was prepared at Louisiana State University in Shreveport, and published in April 1978. Its purpose is to explain the demand for automobiles of different sizes.

AUTHOR

Rodney L. Carlson
Louisiana State University
Shreveport, La.

KEYWORDS

Automobile demand, market share

OBJECTIVE OF MODEL

The objectives of this model are to explain automobile demand by size class and estimate automobile price elasticities.

HISTORICAL BACKGROUND

Chow (57-413) first used the desired stock adjustment approach. Suits (58-033) was the first to consider credit in his demand model. In 1970, Houthakker and Taylor used a first-order differential equation to derive the demand relationship. In 1950, Atkinson fitted a log-linear model, while in 1964, Huang used probit analysis and multiple regression. Smith (75-029) investigated the effects of changes in income distribution on auto sales. These previous studies noted by the author all use highly aggregative techniques, while this one breaks down demand into five separate markets by size class.

ASSUMPTIONS

In determining the price of autos, it is assumed that the dealer will lose half his markup in negotiations with customers. A depreciation rate of 6.25% per quarter is assumed for car prices. Replacement demand depends on the gap between desired and existing stock levels.

LIMITATIONS AND BENEFITS

The author indicates that since car size is a reasonably good proxy for gas consumption, the disaggregation of automobile demand into five size classes is useful for examining sales trends in the light of the energy crisis.

STRUCTURE

This five-equation linear econometric model employs a generalized least squares technique of Seemingly Unrelated Regression Estimation (SURE) for all parameters.

The regression coefficients in the following equations were transformed into beta-coefficients which make the dependent variable change one standard deviation for every one standard deviation change in any independent variable. This makes the coefficients comparable from equation to equation for the same variable and reflects the importance of the variables in each equation.

$$D^S = -.267\ (P^S) + .755\ (Y^D) + .154\ (G) - .044\ (Z^E)$$

$$D^C = -.677\ (P^C) + .881\ (Y^D) + .669\ (G) - .671\ (S^C) - .137\ (Z^E)$$

$$D^I = -.377\ (P^I) + .502\ (Y^D) - .551\ (G) - .318\ (Z^E) - .213\ (Z)$$

$$D^F = -.422\ (P^F) + .410\ (C) - .418\ (G) - .120\ (Z^E) - .101\ (Z)$$

$$D^L = -.307\ (P^L) + .741\ (Y^D) - .360\ (RG) + .405\ (S^L) - .177\ (Z^E)$$

where:

Superscripts S,C,I,F,L stand for subcompact, compact, intermediate, full-sized, and luxury car classes respectively.

D^X = demand per capita for car size X

P^X = average of car prices for size X, adjusted to constant dollars

C = index of consumer sentiment

Y^D = disposable income per capita adjusted to constant dollars

G = gasoline price

RG = gasoline price adjusted to constant dollars

Z^E = gasoline shortage dummy variable for the 1st and 2nd quarter of 1974

S^X = stock per capita for car size X

Z = dummy variable accounting for the effects of a United Auto Workers strike in the fall of 1970

The following table presents the model's estimated price elasticities of automobile demand for each size class:

Subcompact	.817
Compact	1.21
Intermediate	1.30
Full	1.54
Luxury	2.07

MODEL CONSTRUCTION

The model was estimated with data ranging from the first quarter of 1965 to the second quarter of 1975. Size classification was accomplished using Consumer Reports magazine to establish guidelines.

The Index of Consumer Sentiment, published by the Survey Research Center of The University of Michigan, is used to indicate consumer attitudes. Retail mark-up above dealer cost was estimated with the help of information obtained from Consumer Reports.

REFERENCE

Carlson, R.L., Seemingly unrelated regression and the demand for automobiles of different sizes, 1965-75: A disaggregate approach, Journal of Business, vol. 51, no. 2, pp. 243-262, April 1978.

HEAVY GOODS VEHICLE FUEL CONSUMPTION MODEL

An engineering-accounting model to predict the fuel consumption of heavy vehicles on a specified roadway and take into consideration both vehicle characteristics and driver behavior was developed in 1979 at the Transportation and Road Research Laboratory in England. The model was validated with controlled roadway test runs.

AUTHOR

M.A. Renouf
U.K. Department of the Environment
Transport and Road Research Laboratory
Transport Systems Department
Transport Engineering Division
Crowthorne, Berkshire
England

KEYWORDS

Trucks, fuel consumption, automobile design

OBJECTIVE OF MODEL

This engineering-accounting computer simulation model predicts the fuel consumption of heavy vehicles. It can simulate different vehicle shapes, power plants, and transmission systems. Interaction of the vehicle and the driver, representing varying road routes, can be simulated. The methodology could be applied, with proper calibration, to various vehicles and situations.

RELATIONSHIP TO OTHER MODELS

There is no apparent relationship to other models.

HISTORICAL BACKGROUND

Earlier similar models used simplified simulation routes consisting of a sequence of accelerations, cruises, braking, and idling.

VALIDATION

The model was validated by comparison with experimental measurements: on a test track, on a rural route, a motorway route, and urban routes. The test vehicle used had the same vehicle characteristics as those in the model. The vehicle was instrumented to measure time, distance, fuel used, accelerator angle, and gear selection, in order to make overall and small-section comparisons with the model. Comparison of simulation and measured results indicates good overall agreement. The largest errors occurred when only small amounts of fuel were used. Findings indicate that cornering forces make a small contribution to overall fuel consumption; that the number of stops and slows had a major effect; and that the unladen vehicle in the central urban section had higher fuel consumption than the fully laden vehicle on the motorway.

LIMITATIONS AND BENEFITS

The model simulates truck characteristics, road characteristics, and driver behavior. Insufficient data were available to individually define the variation of back axle efficiency with respect to variation in speed and for each gear with speed and torque.

STRUCTURE

The energy flow through the components of the accelerating engine is defined in this sequence: fuel tank (fuel equivalent energy), engine (thermal conversion and efficiency losses), energy consumed by auxiliaries (e.g., fan), transmission (gearbox, back axle), resistance forces (gradients, aerodynamics, rolling resistance, cornering), vehicle mass and inertia. The engine characteristics are contained in an engine map used by the model to determine engine torque and fuel consumption for a given engine speed and load, or to calculate the required load and consumption to give a required output torque. Then the changes in torque through the auxiliaries, transmission and drive line are found. Aerodynamic drag is affected by vehicle shape, speed and wind, both vehicle and route parameters. Rolling resistance depends on the road surface. If the force applied to the wheels exceeds the road loads, then the vehicle will accelerate.

A road is represented in the model as a sequence of distance-defined points, between which certain speeds are required or certain gradients or curvatures exist. Average wind speed and direction are used.

The driver is represented by the use of the accelerator and gear selection. When the maximum engine speed for a gear is reached, the gear is changed. Deceleration, downshifting, braking, and cruising are also simulated. The driver decisionmaking procedure when encountering hills is modeled.

One of eleven major equations is shown below:

$$WF = (GT - FT) \times GRAT \times AXL \times EA/WHLRAD$$

where:

WF = the force delivered to the road at the wheels

GT = gross engine output torque

FT = torque required by the fan at the engine

GRAT = gear ratio for given gear (7.25-0.77:1)

AXL = axle ratio (5.34:1)

EA = full load driveline efficiency (0.90)

WHLRAD = rolling radius of wheel tire combination (0.514m)

Values in parentheses were used in the validation exercise

MODEL CONSTRUCTION

This is an accounting model of physical and engineering systems. Aerodynamic drag coefficients are derived from wind tunnel tests on scale models. Other parameter values are dependent on the characteristics of the particular vehicle.

DATA USED IN RUNNING MODEL

Parameters relating to the various vehicle characteristics must be specified, as well as the description of the roadway route.

REFERENCE

Renouf, M.A., Prediction of the fuel consumption of heavy goods vehicles by computer simulation, Transport and Road Research Laboratory Supplementary Report no. 453, 1979.

72-329

DYNAMIC LINEAR EXPENDITURE MODEL

The Dynamic Linear Expenditure Model was applied by Louis Phlips in 1972 at the University Catholic de Louvain in Belgium. He estimated a complete system of demand equations that allowed for habit formation, stock adjustment, depreciation, and subsistence consumption of goods. Three of the eleven demand categories considered are involved with transportation. They are: automobiles and parts, gasoline and oil, and transportation.

AUTHOR

Louis Phlips
University Catholic de Louvain
Louvain, Belgium

KEYWORDS

Automobile demand, fuel consumption

OBJECTIVE OF MODEL

Phlips estimates a complete system of demand equations for all consumer expenditures by estimating dynamic demand equations for eleven categories of goods. These equations give short- and long-run income and price elasticities. They indicate whether consumption is habit forming or the result of a stock adjustment process and whether subsistence income changes over time for each category. Automobiles and parts, gasoline and oil, and transportation are the three expenditure categories that relate to transportation.

HISTORICAL BACKGROUND

The linear expenditure model was introduced by Klein and Rubin in 1947, clarified by Samuelson in 1947 and Geary in 1950, applied by Stone in 1954, 1964, and 1965, and Pollak in 1970. The purpose of this model is to provide a complete system of demand equations such that the normal economic assumptions about market behavior is consistent with the normal economic assumptions about individual behavior. For a reference to these works see Phlips 1972.

ASSUMPTIONS

Consumers consume a certain minimum or subsistence quantity of each good and they allocate the rest of income over all goods.

LIMITATIONS AND BENEFITS

The sample data ends in 1967. Thus the properties of these demand equations may not be applicable to the recent period characterized by large fuel price increases.

STRUCTURE

The structural model is:

$$Q_i(t) = K_{i0} + K_{i1}\, Q_i(t-1) + K_{i2}\, [U(t)\, P_i(t)]^{-1} + K_{i3}\, [U(t-1)\, P_i(t-1)]^{-1}$$

where:

$Q_i(t)$ = the quantity of the good i purchased in time period t

K_{ij} = coefficient j for the good i, for j = 0 ... 3

t = time period t

U = the marginal utility of income

$P_i(t)$ = the price of the good i in time period t

The model was estimated using an iterative maximum likelihood estimation with a correction for serial correlation. The estimates were constrained so that the estimated expenditures on individual commodities add up to total expenditures for all time periods.

The regression coefficients for the three equations of interest, with standard errors in parentheses, are shown in the table following.

COMMODITY	COEFFICIENTS				R^2
	K_{i0}	K_{i1}	K_{i2}	K_{i3}	
Automobiles and Parts	-18.4291 (7.9785)	.2646 (.1374)	47.3496 (6.2407)	-17.0363 (8.1697)	.950
Gasoline and Oil	.6573 (2.544)	.8871 (.0170)	4.4649 (.6075)	1.9077 (5.870)	.999
Transportation	2.5303 (.4355)	.7914 (.0267)	6.2486 (.6919)	-3.4220 (.9100)	.993

From these coefficients can be calculated: rates of depreciation; whether purchase of a good is habit forming or responds to inventory adjustment; and short-and long-run income and compensated price elasticities of demand.

Inventory adjustment seems to be the response in the automobile and parts sector, while habit formation seems to dominate in the purchase of gasoline and oil. The transportation sector does not show the dynamic behavior of either of the above two sectors.

The calculated elasticities for the sectors of interest are shown below.

COMMODITY	RUN	INCOME ELASTICITY	COMPENSATED PRICE ELASTICITY
Automobiles	short	5.48	-.73
and Parts	long	1.75	-.74
Gasoline	short	.58	-.11
and Oil	long	1.54	-.68
Transportation	short	.96	-.17
	long	.95	-.43

MODEL CONSTRUCTION

The data are the eleven United States consumption series published in the Survey of Current Business for 1929-1967 omitting, 1942-1945.

REFERENCE

Phlips, L., Dynamic version of the linear expenditure model, Review of Economics and Statistics, Vol. 54, no. 4, pp. 450-458, Nov. 1972.

SHORT-TERM PETROLEUM PRODUCT DEMAND FORECASTING MODEL (STPPDFM)

The Energy Information Administration (EIA) did a study in 1978 at the request of the Economic Regulatory Administration (ERA) of the U.S. Department of Energy. This study is a part of the EIA's continuing analysis of the short-term trends in petroleum product supply and demand, and it supplements an earlier report to Congress on the subject of motor gasoline decontrol. In the study for the ERA, a regional econometric model was used to estimate future motor gasoline demand, for the 1978-80 period, based on alternative assumptions about economic growth; this is the Short-term Petroleum Product Demand Forecasting Model described here. A refinery model, the Refinery and Petrochemical Modeling System (RPMS), was then used to estimate the refining capacity required to meet the projected demand levels. Projected refining capacity requirements are compared with projected available refinery capacity to determine whether motor gasoline supply will meet demand.

AUTHOR

Ercan Tukenmez, Richard Farmer, Hilda McDaniel, Charles Everett, Howard Walton, and Stephen Flanagan
U.S. Department of Energy
Energy Information Administration
Office of Energy Source Analysis
Division of Oil and Gas Analysis
Washington, D.C.

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The model estimates demands for eight refined petroleum products quarterly for a three-year horizon in each of five regions. Demand for each product is related to economic and weather variables. The model was used to project the demand for motor gasoline through the years 1978-80.

RELATIONSHIP TO OTHER MODELS

The model was estimated over a period in which automobile fleet efficiency remained constant and so it cannot capture structural changes in demand that would result from significantly increasing efficiency due to the new car fuel economy standards. Therefore, its demand forecasts are adjusted downward by estimates of conservation obtained from the Light Duty Vehicle Fleet Fuel Consumption Model (LDVFFCM) (78-368).

ASSUMPTIONS

Demand forecasts were adjusted by simulating the model under two scenarios: with a total fleet efficiency of 13.6 MPG, and with new vehicle fuel efficiency standards being met. The difference in total fuel consumption is the conservation savings subtracted from the demand forecasts. Increased diesel fuel use is also accounted for. Corrections are made for on-the-road versus EPA-tested fuel economy ratings.

VALIDATION

Assumed for the analysis were optimistic, pessimistic, and control economic growth rates, and low- and high-conservation scenarios. Also, retail motor gasoline prices were assumed to remain constant.

STRUCTURE

Gasoline demand is modeled as a function of U.S. population (a proxy for the number of potential drivers), real national income, and price of regular leaded gasoline at full-service outlets.

MODEL CONSTRUCTION

The equations are statistically estimated, based on historical data from 1970 through 1976.

DATA USED IN RUNNING MODEL

For the study, projections of future economic activity were obtained from Data Resources, Inc., for these variables: real national income, GNP price deflator, product prices, indexes of national electric power generation and chemical industry output, and federal national defense purchases.

REFERENCE

Tukenmez, E.; Farmer, R.; Flanagan, S., Motor gasoline supply and demand through 1980, U.S. Department of Energy, Report no. DOE/EIA-0102/11, August 1978.

Tukenmez, E.; Farmer, R.; McDaniel, H.; Everett, C.; Walton, H., 1980 motor gasoline supply and demand, U.S. Department of Energy, Report no. DOE/EIA-0102/32, December 1978.

GASOLINE PRICE ELASTICITY ESTIMATION

The price elasticity of gasoline was found by forecasting the sales of gasoline, using a trend model fit to California data from before the oil embargo of 1973, and comparing it to actual gasoline sales after that time. This was done at the University of California at San Diego in 1977.

AUTHOR

Alan M. Schneider
University of California
Department of Applied Mechanics and Engineering Sciences
La Jolla, Calif. 92093

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

The price elasticity of gasoline is found by comparing gasoline sales before and after the oil embargo of 1973.

HISTORICAL BACKGROUND

This study improves upon an earlier estimation by the author.

ASSUMPTIONS

The estimation assumes that the change in sales of gasoline is entirely due to the change in price. Two other factors may have contributed: the unemployment resulting from the recession of the mid-1970s, which would cause people to buy less gas, and voluntary conservation. It is believed that the effect of voluntary conservation of gas, prompted by government warnings, had little impact.

STRUCTURE

The derivation of the estimation of gas price elasticity is explained below under Model Construction. The estimated value is as follows:

$$E = 0.2054\ (1 - S/4.78) \pm 0.0378$$

where:

E = estimated price elasticity of gasoline

S = savings in gasoline consumption due to unemployment and voluntary conservation (per cent)

4.78 = percent of total forecast gasoline sales saved after oil embargo price increase

0.0378 = error within 95% confidence limit

If the savings due to unemployment and voluntary conservation, as a percentage of forecast sales, were 0, the elasticity would be 0.2054 $\pm$ 0.0378. If the savings were 4%, price elasticity would be 0.0335 $\pm$ 0.0378.

MODEL CONSTRUCTION

A Box-Jenkins time-series model of monthly gasoline sales was fit to data from January 1960 to October 1973 inclusive, using parameters obtained from a seasonal/nonseasonal moving average model fit to data from January 1960 through June 1972. The regular monthly seasonal variation in gasoline sales was then forecasted for November 1973 through March 1976. The forecasts represent the sales to be expected if there were no significant change in the mechanism underlying consumers' purchase decisions. The difference between the actual sales and the forecast, caused by the gasoline price increase, is used with the change in price to find the elasticity. The data used were for gasoline sales in California.

3.09% of the decrease in total gasoline sales was attributed to reduction of the speed limit to 55 mph. The remaining savings (4.78%) is attributed to higher prices, including the effect of buying smaller cars, voluntary conservation, and unemployment.

REFERENCE

Schneider, A.M., Elasticity of demand for gasoline since the 1973 oil embargo, Energy, Vol. 2, pp. 45-52, 1977.

CENTER FOR ADVANCED COMPUTATION/BROOKHAVEN INPUT-OUTPUT MODEL

The C.A.C/Brookhaven Input Output (I-O) Model was originally designed by the Center for Advanced Computation at the University of Illinois and by Brookhaven National Laboratory in 1975 under the sponsorship of the U.S. Department of Energy. It has been revised and improved since then. The model was designed to provide accounting information on total goods required for each of 110 sectors to produce a given set of end-use quantity demands for each sector. It was later modified to connect with linear programming models to allow analysis of energy sector response to changes in prices and new technologies. The I-O Model has been used in conjunction with the linear programming models (e.g., Brookhaven Energy System Optimization Model (78-378)) in studies of interfuel substitution, oil stockpiling, and a nuclear moratorium. It has been used in conjunction with the Long-term Interindustry Transaction Model (77-242) and the Dynamic Energy System Optimization Model (79-384) for analysis of energy-economy interaction, conservation, and solar energy.

SPONSOR

U.S. Department of Energy
Energy Information Administration
Washington, D.C.

AUTHOR

Brookhaven National Laboratory
Department of Energy and Environment
Economic Analysis Division
Upton, N.Y. 11973

University of Illinois
Center for Advanced Computation

KEYWORDS

Energy consumption, national economic impact

OBJECTIVE OF MODEL

The C.A.C/Brookhaven I-O Model was designed to provide a disaggregated accounting framework for estimating total energy, capital, and material requirements needed to produce end-use energy service, end-use auto, transport equipment, transport service, and other end-use product demands.

RELATIONSHIP TO OTHER MODELS

The model when used interactively provides an interface between the Time-Stepped Energy Optimization Model (TESOM) (79-383) and the Long Term Interindustry Model (LITM) (77-242).

HISTORICAL BACKGROUND

The present 110 sector I-O Model currently employed at Brookhaven National Laboratory was expanded from the original 101 sector CAC/Brookhaven Model to include more sectors and new energy technologies. These models were designed to calculate total quantities supplied in each of the 110 sectors that are necessary to satisfy exogenous end-use total quantities demand in each of the 110 sectors. The quantities supplied include total end-use quantities demanded plus quantities demanded as intermediate goods (e.g., the model calculates the quantity supplied of autos necessary to satisfy an end-use quantity demanded of autos or consumer demand plus the total quantity demanded of autos for use in the production of goods in all other sectors.)

ASSUMPTIONS

The model is divided into 20 energy sectors, with outputs measured in BTUs, and 90 nonenergy sectors with output measured in constant dollars. It is assumed that long-run equilibrium prevails and that factor inputs are perfectly mobile (e.g., steel can be immediately switched from making autos to making aircraft). The input-output coefficients, which indicate the input requirements of one good such as steel that is necessary to produce a unit of output of another good such as autos, or the A matrix below, are allowed to gradually change to allow for technological improvement.

LIMITATIONS AND BENEFITS

The static I-O Model with fixed coefficients does not allow interfuel substitution or differences in thermal efficiencies among fuels. This limitation can be corrected by connecting the I-O Model to the Brookhaven Linear Programming (LP) Models. Energy coefficients derived from the LP Models can be used to allow the energy I-O coefficients to vary with price and technology changes.

STRUCTURE

The current version of the CAC/Brookhaven Input-Output Model is a 110 sector model that can be represented by the following matrices:

$$\begin{bmatrix} \underset{[12\text{x}12]}{A_{SS}} & \underset{[12\text{x}8]}{A_{SP}} & \underset{[12\text{x}90]}{0} \\ \underset{[8\text{x}12]}{A_{PS}} & \underset{[8\text{x}8]}{0} & \underset{[8\text{x}90]}{A_{PI}} \\ \underset{[90\text{x}12]}{A_{IS}} & \underset{[90\text{x}8]}{0} & \underset{[90\text{x}90]}{A_{II}} \end{bmatrix} \begin{bmatrix} \underset{[12\text{x}1]}{X_S} \\ \underset{[8\text{x}1]}{X_P} \\ \underset{[90\text{x}1]}{X_I} \end{bmatrix} + \begin{bmatrix} \underset{[12\text{x}1]}{Y_S} \\ \underset{[8\text{x}1]}{Y_P} \\ \underset{[90\text{x}1]}{Y_I} \end{bmatrix} = \begin{bmatrix} \underset{[12\text{x}1]}{X_S} \\ \underset{[8\text{x}1]}{X_P} \\ \underset{[90\text{x}1]}{X_I} \end{bmatrix}$$

where:

X_S, X_P, X_I = the total production of basic energy products (e.g., crude oil), energy services (e.g., motive power), and nonenergy products (e.g., motor vehicles and equipment), respectively

Y_S, Y_P, Y_I = final end-use demands or consumer demand for basic energy products, energy services, and nonenergy products respectively

A_{SS} = input-output coefficients describing input of one energy/supply conversion sector to another energy conversion sector including production and distribution losses (e.g., sale of crude oil to refineries).

A_{SP} = input-output coefficients describing input of basic energy products to produce energy services. (e.g., refined oil products required to produce motive power)

A_{SI} = 0 implying that basic energy products are not used by nonenergy-producing sectors; energy services are used by the nonenergy-producing sectors

A_{PS} = input-output coefficients describing the input of energy services used by the basic energy-supplying industries. Included here would be electricity used for lighting a refinery.

A_{PP} = 0 implying that energy services are not used to produce energy services.

A_{PI} = input-output coefficients describing how energy services are used by nonenergy producing sectors. (e.g., refined petroleum products necessary to produce automobiles)

A_{IS} = input-output coefficients describing the uses of nonenergy materials and services by the energy industry (e.g., vehicles used in production of crude oil)

A_{IP} = 0 implying the energy services sectors require no material or service inputs. This is because they are pseudosectors rather than real producing sectors.

A_{II} = input-output coefficients describing how nonenergy products are used in the nonenergy producing sector. (e.g., glass used to produce motor vehicles and equipment).

When the above model is used in conjunction with LITM (77-242) and TESOM (79-383), Y_S, Y_P, and Y_I are disaggregated from LITM and A_{SS} and A_{SP} are derived from TESOM.

Of the 110 sectors in the model, 11 deal with transportation, and of these, 4 deal with the motor vehicle system.

The basic structure of the model can be explained more intuitively in terms of one of the transportation sectors. Given end-use demand for motor vehicles and equipment contained in Y, the model calculates all the inputs required for production of Y. Total demand contained in the X vector and calculated by the model includes the demand for motor vehicles and equipment as an input to produce other goods, plus final consumer demand for motor vehicles and equipment.

MODEL CONSTRUCTION

The earlier 101 sector model used 1967 Bureau of Economic Analysis input-output coefficients. The current 110 sector model uses input-output coefficients estimated by the Bureau of Labor Statistics for 1985. New energy technology supply coefficients were supplied by MITRE Corp. The model uses final demands disaggregated from LITM (77-242).

REFERENCE

Fraser, J.T., Documentation of the Brookhaven Energy I-O and I-O BESOM linkage, Brookhaven National Laboratory, Report no. BNL 50856, August 1978.

Groncki, P.J.; Marcuse, W., Brookhaven integrated energy/economy modeling system and its use in conservation policy analysis, preliminary copy, Brookhaven National Laboratory, Report no. BNL 51056, July 1979.

Griffin, J.M., Energy input-output modelling: problems and prospects, Electric Power Research Institute, Report no. EPRI EA-298, November 1976.

Lukachinski, J.; Groncki, P.J.; Tessmer, R.G., Jr.; Goettle, R.D., IV; Hudson, E.A., An integrated methodology for assessing energy-economy interactions, Brookhaven National Laboratory, Report no. BNL 26452, October 1979.

COMPUTER REQUIREMENTS

The model is operational on Control Data Corporation equipment.

DISAGGREGATE BEHAVIORAL MODEL OF AUTO OWNERSHIP AND MODE OF TRAVEL

Two sets of models describing the probability of automobile ownership and choice of mode for traveling to work were developed in 1976 by Cambridge Systematics, Inc. for the U.S. Department of Transportation. Both models use the same data base. The primary model, described here under 76-364A, allows for two modes, car and transit.

SPONSOR

U.S. Department of Transportation
Office of Transportation Systems Analysis and Information
Washington, D.C.

U.S. Department of Transportation
Federal Highway Administration
Office of Highway Planning
Washington, D.C.

AUTHOR

Moshe E. Ben-Akiva and Steven R. Lerman
Cambridge Systematics, Inc.
238 Main St.
Cambridge, Mass. 02142

KEYWORDS

Automobile demand, modal split

OBJECTIVE OF MODEL

Automobile ownership is modeled as a function of service level of transportation to work, auto ownership costs, locational attributes, housing attributes, spatial opportunity, and socio-economic variables, using a multinomial logit model. The objectives of the model development were to determine the relationships between auto ownership and the transportation system, to assess the role that level of transit service plays in determining auto ownership, and to investigate the impacts of various transportation policies on different socio-economic groups.

RELATIONSHIP TO OTHER MODELS

This model is used as a basis for a combination model including shared rides as a mode, described in 76-364B.

ASSUMPTIONS

The average cost per year of owning an auto is assumed to be 1,000 dollars. Accessibility to nonwork destinations is a function of the level of service to them and the probability of travel to them. Auto ownership is assumed to depend on a combined income variable that measures the remaining income after essential expenditures. It equals annual household income minus 800 dollars for each household member, minus 1,000 dollars for each automobile, and minus 250 days of out-of-pocket costs of the work trip.

VALIDATION

The estimated coefficients are consistent with the theoretical structure and are statistically significant. Implied elasticities are said to be reasonable.

LIMITATIONS AND BENEFITS

Auto ownership is related to urban land use and the transportation planning and forecasting process. This model addresses the basic behavioral factors underlying household auto ownership decisions.

This model is an improvement over others because of its sensitivity and representation of a behavioral process. It can be shown what measurable effect transit service improvements may have on automobile ownership.

STRUCTURE

In this multinomial logit, or disaggregate probability model, the probability of a household choosing to own a given number of autos and to travel to work by a mode is equal to the utility of the auto ownership and mode to work combination over the sum of the utilities of all combinations. The utility functions are a linear combination of coefficients. The coefficients are determined using the variables described below:

Households are divided into distinct life-cycle groups: households consisting of single persons, households with a married couple under 45 years old and no children, households with children, and couples older than 45 years without children. Households are also grouped depending on whether the primary worker is blue or white collar or there is no primary worker. The set of ownership-mode combination variables used are: household owns zero autos and travels to work via transit; household owns one auto and uses transit; one auto owned and travels to work by car; two autos owned, and travels by car; and two autos, and travels by transit. The other variables, the use of which depend on the household grouping, are: autos per licensed drivers, remaining income, household lives in single family housing, time spent in vehicle on daily round trip to work, out-of-vehicle time spent over distance to work one way, generalized cost for shopping travel, and if workplace is downtown.

The estimated coefficients for the various ownership and mode choice combinations are shown in the model report.

MODEL CONSTRUCTION

Data used to estimate the model are from the home interview survey conducted in 1968 by the Metropolitan Washington (D.C.) Council of Governments, which included 26,544 households. The methodology used is that of disaggregate probabilistic choice models with a joint structure for highly interdependent choices.

DATA USED IN RUNNING MODEL

The model may be used to predict auto ownership trends, given values for income, dwelling and household characteristics, locations of households and workplaces, and levels of transit service.

REFERENCE

Ben-Akiva, M.E.; Lerman, S.R., Behavioral analysis of automobile ownership and mode of travel, volumes 1-3, U.S. Department of Transportation, Report no. DOT-OS-30056-1,2,3, March 1976.

Lerman, S.R.; Ben-Akiva, M.E., Disaggregate behavioral model of automobile ownership, Transportation Research Record 569, 1976.

76-364B

JOINT AUTO OWNERSHIP WORK MODE CHOICE MODEL WITH CARPOOL AS A MODE

Two sets of models describing the probability of automobile ownership and choice of mode for traveling to work were developed in 1976 by Cambridge Systematics, Inc. for the U.S. Department of Transportation. Both models use the same data base. The primary model, reported under 76-364A, allows for two modes. Other models were specified that describe only mode choice. The model reported here as 76-364B combines these into a combination model that describes auto ownership and three modes, driver alone, shared ride, and transit.

SPONSOR

U.S. Department of Transportation
Office of Transportation Systems Analysis and Information
Washington, D.C.

U.S. Department of Transportation
Federal Highway Administration
Office of Highway Planning
Washington, D.C.

AUTHOR

Moshe E. Ben-Akiva, William A. Jessiman, and Richard Nestle
Cambridge Systematics, Inc.
238 Main St.
Cambridge, Mass. 02142

KEYWORDS

Automobile demand, modal split

OBJECTIVE OF MODEL

A model is specified that describes the probability of owning a certain number of automobiles and of using a particular mode to travel to work.

RELATIONSHIP TO OTHER MODELS

This model is a combination of the auto ownership and mode split model described in 76-364A, and three mode choice models. These latter three model specifications include carpool as a mode. Thus, the combination model has both transit, shared ride, and driver-alone alternatives for mode of traveling to work.

VALIDATION

The estimated coefficients, shown in the model report, generally have the expected signs and the t-statistics indicate that they are almost all significant.

LIMITATIONS AND BENEFITS

Eight alternatives are available for prediction: three household ownership levels (zero cars, one car, two or more) with three modes to work (drive alone, shared ride, transit). The alternative, no cars and drive alone to work, is invalid.

STRUCTURE

The independent variables in this multinomial logit or disaggregate probability model include: autos per licensed driver, logarithm of residual disposable household income (income minus 800 dollars for each household member, minus 1,000 dollars for each auto owned, and minus 250 days of out-of-pocket travel costs), housing type (single family or not), in-vehicle travel time (adding 10 minute pick-up and drop off penalty for shared ride alternatives), out-of-vehicle travel time divided by distance, generalized cost for shopping travel, if workplace is downtown, yearly total out-of-pocket travel costs associated with each alternative (dividing by 2.5 for shared ride), if job is with government (which has ride-sharing incentives), number of workers in household, and employment density in work zone times travel distance for shared rides.

MODEL CONSTRUCTION

Data used to estimate the model are from the home interview survey conducted in 1968 by the Metropolitan Washington (D.C.) Council of Governments. The behavioral unit is the household, with only breadwinner work trips considered. In the preliminary mode choice models, which are combined into this model, the unit was the individual worker.

REFERENCE

Ben-Akiva, M.E.; Jessiman, W.A.; Nestle, R., Behavioral analysis of automobile ownership and mode of travel: volume 4--work mode choice models with carpool mode, U.S. Department of Transportation, Report no. DOT-OS-30056-4, March 1976.

REGIONAL ENERGY AVAILABILITY MODEL

The Regional Energy Availability Model was prepared in 1977 at Oak Ridge National Laboratory and was sponsored by the U.S. Department of Commerce, Economic Development Administration. Its purpose is to estimate future energy allocation situations for U.S. regions.

SPONSOR

U.S. Department of Commerce
Economic Development Administration
Washington, D.C.

AUTHOR

D.P. Vogt, P.L. Rice, and V.P. Pai
Oak Ridge National Laboratory
Regional and Urban Studies Section
Energy Division
Oak Ridge, Tenn. 37830

KEYWORDS

Energy consumption, vehicle manufacturing resource utilization, fuel consumption

OBJECTIVE OF MODEL

This model was prepared to provide a consistent base of historic and projected energy information in a standard format in order to aid regional policymakers in their consideration of how the local economy may be influenced by energy availability.

RELATIONSHIP TO OTHER MODELS

University of Maryland's INFORUM model and the PIES model (75-004) are used to forecast future national economic scenarios for input to the model. A model called MULTIREGION, also developed at Oak Ridge National Laboratory, disaggregates these scenarios by region.

ASSUMPTIONS

The only impact on energy conservation in the economic scenarios is assumed to be normal demand responses to higher prices.

STRUCTURE

Energy demand and supply are forecasted for each Bureau of Economic Analysis (BEA) local economic area, and the estimated shortfall of energy supply to the demand is made. This is done for five fuel sources such as crude oil and uranium, seven energy forms, including gasoline, three refining sectors, including petroleum refineries, and four final consuming sectors, one of which is transportation.

Energy demand or use analysis involves four steps:

1) Choose a national economic scenario.

2) Choose a national energy use scenario.

3) Regionalize the economic scenario.

4) Regionalize the energy scenario based on regional economic and population levels.

With allocations of demand complete, alternative ways of satisfying projected demands with supplies are analyzed. This contrasts with the more traditional econometric method of imposing supply and demand equilibrium conditions through a price adjustment mechanism.

Energy supply or availability analysis involves five steps:

1) Determine the present location of fuel sources.

2) Determine the present location of energy forms.

3) Determine the region-specific role of imported energy.

4) Examine the capacity of regional transport systems.

5) Reconcile projected energy uses and availabilities.

MODEL CONSTRUCTION

The local economic areas chosen in this model are the BEA areas, developed by the U.S. Department of Commerce. The aggregation of consuming sectors generally corresponds to that used by the Bureau of Mines.

DATA USED IN RUNNING MODEL

Fuel consumption and energy supply and transformation regional data are taken from Federal Energy Administration forecasts in the _1976 National Energy Outlook_. Regional economic activity projection data are from _1972 OBERS projections_: _Economic activity in the U.S._, _Series E population_. Other data sources are also used, mostly to disaggregate regional data.

REFERENCE

Rice, P.L.; Vogt, D.P., Energy availabilities for state and local development: a methodological and data overview, Oak Ridge National Laboratory, Report no. ORNL/TM-5890, June 1977.

Vogt, D.P.; Rice, P.L.; Pai, V.P., Energy availabilities for state and local development: projected energy patterns for 1980 and 1985, Oak Ridge National Laboratory, Report no. ORNL/TM-5890/54, June 1978.

Vogt, D.P.; Rice, P.L.; Pai, V.P., Energy availabilities for state and local development: 1973 data volume, Oak Ridge National Laboratory, Report no. ORNL/TM-5890/52, November 1977.

TSC FREIGHT ENERGY MODEL

A national-scale freight transportation network energy use model, including the highway mode, was developed by CACI, Inc., in 1978, for the Transportation Systems Center (TSC). It is designed to predict the impacts, on the cost of transportation of freight, modal shares, service levels, and energy consumption, of changes in technology, operations, and energy conservation policies.

SPONSOR

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

AUTHOR

Michael S. Bronzini
CACI, Inc.-Federal
Transportation Analysis Group
1815 N. Fort Meyer Dr.
Arlington, Va. 22209

KEYWORDS

Energy consumption, modal split, trucks, fuel consumption

OBJECTIVE OF MODEL

This network model allocates intercity freight traffic to specific transport modes and routes, and predicts transportation prices, service levels, and energy use, given commodity flow data and the capacity of the elements of the network.

It is designed to estimate the energy savings possible in U.S. intercity freight transportation that is possible with new technology, methods of operation, and network alterations within each mode.

RELATIONSHIP TO OTHER MODELS

This model is an aggregation of detailed network models originally developed by several federal agencies: the Federal Railroad Administration, the Federal Highway Administration, the Corps of Engineers (waterways), and TSC (pipelines). The highway model simulator includes a truck cost model developed by TSC and measures of truck speed developed by Oak Ridge National Laboratory. The truck cost model was originally developed for the railroads.

ASSUMPTIONS

Minimum paths through the system are shipper optimal, rather than globally optimal. This corresponds to transport market behavior without centralized control. Some shipments may be constrained to certain paths or modes. Paths are constrained so as not to be too circuitous. Some shipments may be constrained to repeat historical modal split patterns, which reflects realities of long-term shipper contracts and prevents oscillation due to small intermodal cost differentials.

VALIDATION

Comparison of model predictions and actual data for 1972 indicate that they agree quite well. The lack of short-haul intercity truck transport in the model tends to push the estimated cost per ton mile below the national average. The modal split accuracy of the model is judged to be good since the predicted ton-mile share is within 15% of the observed share for all share levels and modes.

An experiment testing the use of double trailers on divided highways indicated considerable savings in highway cost and energy use within the trucking industry and without capturing any more rail traffic. It appears there is considerable room for energy and cost savings in freight transportation.

LIMITATIONS AND BENEFITS

National aggregate impacts on the cost of transportation of all freight, on overall service levels and on modal market shares, are revealed. The methodology may be used to generate energy-optimal freight transport system configurations and usage patterns to aid development of government policy. It may be used to estimate potential modal share impacts for specific markets which would result from specific energy conservation strategies.

The main difficulty in assessing the accuracy of the model is the lack of comparable actual data. The authors say that unregulated intercity truck traffic is underrepresented, and that the model should be used only in evaluating differences in system performance. If absolute estimates of national freight statistics were required, it would be necessary to scale model outputs to reflect actual traffic.

STRUCTURE

The Freight Energy Model consists of a Transportation Network Model and Modal Simulators for rail, waterway, pipeline, and truck to which data on options, networks, and commodity flows are input. Energy conservation impacts are output from the network model. In the general methodology, the user-specified energy conservation options affect the transportation network, shipper behavior, and commodity flows. The network represents transport supply, and modal choice and route selection by shippers represent transport demand. The resulting decisions and commodity flow changes produce energy conservation impacts on the network, modes, carriers, shippers, and consumers. Changes in a given mode's supply of transportation, or adjustments in demand by shippers caused by changes in transportation prices, can have an impact throughout the nation's multimodal transportation system.

Each mode network consists of nodes connected to each other by linehaul links. Commodities travel between producing or consuming regions and the network modes along access links. Transfer links connect nodes in different mode networks. Each node and link has cost, capacity, and energy functions. Commodity flows are specified by origin region, destination region, and tons. Some flows may require the use of a specific mode or route. Shipments are assigned to paths (modes and routes) through the system that minimize impedance (time, cost, and energy).

The path impedance or disutility that is to be minimized is defined as:

$$Z_{ij} = \sum_{P_{ij}} a_m t_k + b_m c_k + w_m e_k$$

where:

Z_{ij} = disutility between origin region i and destination region j

P_{ij} = collection of network elements in the path from i to j

a_m = time weighting factor for commodity m, depends on value per ton and "inventory charge"

t_k = facility transit time

b_m = cost weighting factor for commodity m

c_k = facility shipping cost

w_m = energy weighting factor for commodity in (zero in most applications, since energy costs are included in c_k)

e_k = facility energy use

The regions used in the model are those defined by the Bureau of Economic Analysis. Outputs provided include path display, traffic volume, transit time, cost, and energy use for each element of the network, mode facility class, and shipment.

The highway link data include length, physical type, terrain, and identification of toll roads. The highway network has 582 nodes and 1,292 links.

DATA USED IN RUNNING MODEL

For each commodity, the origin, destination, transportation mode, and annual shipment tonnage are specified by the model user.

The truck cost model has the following inputs: travel time and fuel consumption estimates, truck purchase and maintenance cost, driver wages, fuel price, tire cost, oil cost, license fees, taxes, discount rate, cargo density, overhead costs, vehicle utilization, empty backhaul, trip length, and platform charges. The main outputs estimated are cost per ton and ton-mile linehaul and terminal portions of the cost are input to the Transportation Network Model.

REFERENCE

Bronzini, M.S., Freight transportation energy use, Institute of Transportation Engineers 48th Annual Meeting, Compendium of Technical Papers, pp. 310-317, August 1978.

Bronzini, M.S., Freight transportation energy use, four volumes, U.S. Department of Transportation, Report no. DOT-TSC-OST-79-1,I-IV, July 1979.

COMPUTER REQUIREMENTS

Graphical display with the model is possible, showing plots of the network elements, economic regions, place names, origin-destination paths, and cost, capacity, and energy usage functions for each element. The program is completely documented in Volume II of the report. It is written in SIMSCRIPT II.5. and is operational on the CDC CYBER 175 computer at CDC's facility in Rockville, Md. It is accessible through the CYBERNET system.

LIGHT DUTY VEHICLE FLEET FUEL CONSUMPTION MODEL (LDVFFCM)

The Energy and Environmental Analysis, Inc. Light Duty Vehicle Fleet Fuel Consumption Model (LDVFFCM) was sponsored by the U.S. Department of Energy and was built in 1978. It is intended to facilitate a better understanding of the trends in fuel consumption resulting from certain policy options relating to the transportation sector. The model was used in the 1978 Energy Information Administration (EIA) Annual Report to Congress to override the in-model projections of automobile fuel demand provided by the PIES Automobile Simulation Model (75-004A). It is being revised to include medium and heavy duty trucks.

SPONSOR

U.S. Department of Energy
Office of Conservation and Advanced Energy Systems Policy
Washington, D.C. 20461

AUTHOR

Energy and Environmental Analysis, Inc.
1111 North 19th Street
Arlington, Va. 22209

KEYWORDS

Fleet size, vehicle miles traveled, scrappage, fuel economy, trucks, fuel consumption

OBJECTIVE OF MODEL

This model is designed to forecast the total fuel consumption (leaded gasoline, unleaded gasoline, and diesel fuel) of passenger automobiles and light-duty trucks through 1986 as a function of selected past and projected characteristics of the vehicle fleet.

RELATIONSHIP TO OTHER MODELS

For its use in the 1978 EIA Annual Report to Congress, many of the exogenous inputs were supplied by the Data Resources, Inc. (DRI) macro model. Estimates of fuel-conservation shifts were provided by the Faucett Automobile Sector Forecasting Model (76-016). National forecasts of annual fuel consumption by vehicle class and fuel type derived from LDVFFCM with the aid of DRI and Faucett inputs (as well as others) were fed into the Sweeney Transportation Model (or PIES Automobile Simulation Model) (75-004A), which combined them with in-model predictions of fuel use from other models to arrive at the mid-term multimodal transportation fuel use figures for the Midterm Energy Forecasting System (MEFS) (S-78-419).

HISTORICAL BACKGROUND

In its original form, which was used in the EIA 1978 report, the model described here projects fuel demand for only light-duty vehicles. It has been recalibrated using more current data. It has also been expanded to include medium and heavy-duty trucks and has been renamed the Highway Fuel Consumption Model (HFCM). This revision will be reported on in a later edition of this inventory. Present plans do not call for including HFCM in MEFS, but it may continue to be used for off-line adjustments to MEFS forecasts.

ASSUMPTIONS

Scrappage rates of cars are assumed to remain the same in the future as in the 25 years preceding 1978. Vehicle miles traveled per vehicle is assumed to decrease with the age of each vehicle.

The model is based on the following assumptions which are necessary to extend data where they are incomplete:

- imported trucks are assumed to grow at an average annual rate of 3.5 percent per year from a level of 250,000 units in 1978;

- the level of new vehicle registrations at the end of the year for each projection is assumed to remain constant through 1995;

- between 1982 and 1985, the fuel economy of new light trucks is assumed to increase at the same rate as the mpg of passenger cars;

- the annual unleaded fuel penetration rate for 1980-1985 is assumed to be equal to the 1979 penetration rate;

- a twenty-five percent increase in fuel economy in diesel over the spark ignition engine is assumed for light duty vehicles.

STRUCTURE

The Light Duty Vehicle Fleet Fuel Consumption Model is an accounting model that forecasts fuel consumption in the transportation sector by calculating two parameters: annual vehicle miles of travel, and average on-the-road fleet fuel efficiency. It is a deterministic model in that output variations can be directly attributed to assumptions made about historical and future data on vehicle fleet characteristics. There are no behavioral equations that use macroeconomic parameters in an effort to derive forecasts of future fuel demand. All future values of parameters needed to forecast fuel consumption are derived from sources outside this model.

The calculation methods used to determine fleet vehicle miles of travel, average fleet fuel efficiency, and fleet fuel consumption in a given year appear below:

$$TVMT_j = \sum_i \sum_k SP_{kj} \times RG_{ij} \times VMT_{kj} \qquad (1)$$

where:

$TVMT_j$ = total VMT per vehicle type j (one of five categories of light-duty vehicles)

RG_{ij} = registration in year i of vehicle type j

SP_{kj} = scrappage (percent of new vehicle registrations of age k and vehicle type j left on the road)

VMT_{kj} = vehicle miles traveled of vehicle type j and age k

$$TFC_t = \sum_i \sum_k \sum_j RG_{ij} \times VMT_{kj} \times PCT_{ijk}/MPG_{ij} \times ADJ \qquad (2)$$

where:

TFC_t = total fuel consumed of type t (leaded, unleaded, diesel)

PCT_{ijt} = percentage of registrations in year i of vehicle type j and fuel type t (leaded, unleaded, diesel)

MPG_{ij} = the EPA-rated MPG of registrations of vehicles in year i and vehicle type j

ADJ = an optional discount factor that adjusts the EPA MPG to an on-road MPG

$$AMPG_j = TVMT_j/[\sum_i \sum_k (RG_{ij} \times VMT_{kj}/MPG_{ij})] \qquad (3)$$

where:

$AMPG_j$ = average fleet MPG for vehicle type j

DATA USED IN RUNNING MODEL

Inputs to the model include:

- annual new vehicle registrations (Source: Technical Assessment Division of National Highway Traffic Safety Administration [NHTSA]. Transportation Systems Center [TSC], and U.S. Department of Transportation [DOT]).

- scrappage rate of new vehicles (Source: NHTSA, TSC, and DOT).

- annual vehicle miles of travel per vintage car year (Source: NHTSA, TSC, and DOT.

- EPA test figures for vehicle average fuel economies (Source: U.S. Environmental Protection Agency [EPA]).

- on-the-road miles per gallon discount factor, which accounts for in-use driving conditions and reduces actual fuel economy below the EPA test values (Source: U.S. EPA).

All data points for future years are estimates provided by Data Resources, Inc., Wharton Economic Forecasting Associates, Inc., U.S. Department of Energy/Energy Information Administration, DuPont, and Michigan Technological University.

REFERENCE

Light duty vehicle fuel consumption model: recent modifications in the input data and methodology and resulting changes in estimates of fuel demand, April 19, 1979.

<u>Light duty vehicle fuel consumption model: 1975-1986</u>, Energy and Environmental Analysis, April 28, 1978.

Light duty vehicle fleet fuel consumption model--presentation notes, Energy and Environmental Analysis, January 1980.

<u>Review of historical and projected future trends in annual VMT/passenger car and fuel demand and calibration of the light duty vehicle fleet fuel consumption model</u>, Energy and Environmental Analysis, July, 19, 1979.

<u>Factors influencing automotive fuel demand</u>, Energy and Environmental Analysis, Inc., Feb. 6, 1979.

McNutt, B.; Dulla, R., <u>On-road fuel economy trends and impacts</u>, U.S. Department of Energy, Feb. 17, 1979.

<u>Medium and heavy-duty truck fuel demand module</u>, final report, Energy and Environmental Analysis, May 28, 1980.

COMMUTER POLLUTION EXPOSURE MODELS

The first-phase design of numerical computer and manual models for predicting the exposure of commuters to emissions pollution was developed in 1979 by SRI International for the U.S. Environmental Protection Agency. The models calculate traffic, emissions, and dispersion for different roadway types, using a combination of methodologies. The computer program and the specifics of the manual model are to be completed in another phase of the work.

SPONSOR

U.S. Environmental Protection Agency
Office of Research and Development
Environmental Sciences Research Laboratory
Meteorology and Assessment Division
Research Triangle Park, N.C. 27711

AUTHOR

Patricia B. Simmon and Robert M. Patterson
SRI International
333 Ravenswood Avenue
Menlo Park, Calif. 94025

KEYWORDS

Emissions, air pollution/air quality

OBJECTIVE OF MODEL

The exposure of commuters to emissions is modeled by two methods, a computerized numerical model, and a manual approach. Major commuter routes are identified; the traffic on them and the emissions generated and dispersed are calculated, taking into account whether the roadway is limited-access, unlimited access, or a street canyon, and the effects of congestion because of traffic signals. Background source pollution is treated in a simpler fashion. The modeling area to be defined for an application of the model should coincide with a Standard Metropolitan Statistical Area or an Air Quality Control Region.

RELATIONSHIP TO OTHER MODELS

The model makes use of existing dispersion algorithms. For limited-access pathways the Dabberdt ROADWAY model is used. On unlimited-access roadway segments a technique from the CALINE-2 model is used (described in 76-084). Street canyon pathways use APRAC (73-278) and for nonpathway sources the Hanna-Gifford dispersion treatment is used. For emissions modeling, the Automobile Exhaust Emission Model Analysis Model

(74-219) is used.

ASSUMPTIONS

Vehicle acceleration and deceleration rates are assumed to be constant. Annual average ambient air temperature is used when the model is in annual mode. In the morning all vehicles are assumed to be warmed up before getting to the commute routes. Cold and hot-start percentages are fixed for each locale type for morning and evening. On-the-roadway and in-the-vehicle concentrations of pollution are assumed to be equal.

VALIDATION

Since the model has not been completed, it has not been validated, but procedures for doing so are outlined. Ideally, a sample of commuters would carry devices to collect data on their exposure, which would be compared with the model's predictions. Alternatively, the individual components of the model could be evaluated. The traffic module and dispersion module could be compared by taking frequent measurements of traffic flow and emissions concentrations; the emissions module is less easy to test. Aggregate data for testing the model is available but the disaggregate data generally are not. The potential accuracy of the model is discussed at length by the model authors.

LIMITATIONS AND BENEFITS

The numerical model gives two kinds of output: (1) annual statistics and (2) the short-term, worst-case exposure for a single commute. Generally, state-of-the-art methodologies were incorporated into the model, but these techniques assume a steady-state situation. Some deficiencies of the model foreseen by its authors are that it does not treat all commuters, a semi-objective method of commuter pathway selection is used, Gaussian dispersion treatments cannot treat fumigation or stagnation, the nonpathway dispersion treatment does not allow variation of grid square emission rates, and no provision is made for the effects of precipitation.

STRUCTURE

In the numerical model, on pathways, the average route speeds and emission rates for each road segment are calculated. Signalization, congestion, and modal emissions are accounted for. For the annual mode both morning and evening rates are found; for the short-term mode a single emission rate for each segment is found with traffic volume varying with time.

Normalized exposures for each segment are computed from emission rates, using different dispersion methodologies for street canyons, limited-access, or unlimited access roads.

For nonpathway sources, emissions are calculated, given the traffic and land use locale data. Concentrations are found given wind conditions.

Concentrations from pathway and nonpathway sources are combined to produce statistics on commuter exposure. Concentrations on each segment are combined, multiplied by wind speed, and summed for each pathway. Pathways are weighted by either the morning or evening frequency of occurrence of weather conditions.

The methodology of the manual model is similar to that of the numerical model, but fewer and less complex calculations may be done. It consists of a set of worksheets, instructions, charts, tables, and nomographs. The manual model is intended to be used as a screening tool for finding potential problem areas to be studied in greater detail.

MODEL CONSTRUCTION

This is a physical systems model, using a variety of techniques to determine exhaust emissions, diffusion and concentration of pollution, and traffic movement and congestion.

DATA USED IN RUNNING MODEL

The study area must be defined, and commuter pathways defined by type and direction. For nonpathway emissions, vehicle miles traveled and land use for the area grid system must be input. For annual output, wind condition frequency distributions are input; for the short-term output, hourly weather conditions are needed. About 70 different kinds of information may be required as input to the numerical model; 30 for the manual model.

REFERENCE

Simmon, P.B.; Patterson, R.M., Commuter exposure modeling methodologies, U.S. Environmental Protection Agency, Report no. EPA-600/4-79-010, February 1979. NTIS no. PB-292 995.

COMPUTER REQUIREMENTS

The numerical model program has not been written. It is flowcharted and the methodologies are designed. The manual model also needs to be completed.

BROOKHAVEN ENERGY SYSTEM OPTIMIZATION MODEL (BESOM)

BESOM is a one-period linear programming model. The model, developed by Brookhaven National Laboratory in 1974, is designed to minimize an objective function, such as entire cost of producing a set of end-use energy services by choosing the mix of energy products, subject to resource, demand, pollution, and plant constraints. BESOM's sponsors include the Energy Research and Development Administration and later the U.S. Department of Energy. It has been used to evaluate energy technologies and policies at a national level including consideration of electric storage devices, interfuel substitution, and the role of electrification, coal as a transition fuel, and impacts of renewable energy on costs and environmental quality.

SPONSOR

U.S. Department of Energy

AUTHOR

Kenneth C. Hoffman and Ellen A. Cherniavsky
Brookhaven National Laboratory
Upton, N.Y. 11973

KEYWORDS

Energy consumption

OBJECTIVE OF MODEL

BESOM is a static linear programming model designed to examine interfuel substitution and evaluate energy technologies and energy policies within the total energy system. The model is generally used to minimize total energy systems costs.

RELATIONSHIP TO OTHER MODELS

In operation BESOM has been used alone and in conjunction with either or both of the Long Term Interindustry Model (LITM) (77-242) and the Brookhaven I-O Model (78-361).

HISTORICAL BACKGROUND

BESOM is the earliest of the Brookhaven National Laboratory linear programming models. Later versions of it include Dynamic Energy System Optimization Model (DESOM) (79-384) and Time-Stepped Energy System Optimization Model (TESOM) (79-383).

ASSUMPTIONS

BESOM is a one-period national model representing the entire energy system and a wide range of interfuel substitution possibilities. The technical assumptions in the model are captured in the constraints called the Reference Energy System (RES) developed by Kenneth Hoffman. The model represents the energy sector from resources, through conversion, to end-use demands. End-use demands, resource availability, pollution regulations, and energy conversion plant capacity are all exogenous. One may assume limits to market penetration of a particular fuel to represent capacity constraints or limits to retirement of old capacity.

LIMITATIONS AND BENEFITS

The model is designed to examine interfuel substitution and the effect of new technology, and to do policy analysis within the context of the entire energy system. It is a nondynamic one-period model which when used alone does not completely capture end-use demand nor resource supply elasticities. Representing costs by a linear function is a further simplification.

STRUCTURE

The model is a linear programming model. Assume there are J intermediate energy products, U natural resources, V end-use demands, W pollution constraints, and Y plant or capital constraints.

The model picks a vector Z of intermediate energy products that minimizes some objective function, usually system cost:

$$\underset{[1xj]}{C}\ ' Z$$

Subject to a set of constraints:

$$\begin{bmatrix} E_u \\ E_v \\ E_w \\ E_y \end{bmatrix} \times \begin{bmatrix} \\ Z \\ \\ \end{bmatrix} \leq \begin{bmatrix} B_u \\ B_v \\ B_w \\ B_y \end{bmatrix}$$

$[(U+V+W+Y)xJ]$ $\quad$ $[Jx1]$ $\quad$ $[Jx1]$

where:

C = the cost vector of producing J intermediate energy forms represented by vector Z

E_u = a matrix of technical coefficients that calculates energy resources required for producing energy product vector Z. B_u are the U resource constraints.

E_v = a matrix of technical coefficients representing the efficiencies of converting Z into end-use services. B_v are the V end-use demand constraints.

E_w = a matrix of coefficients that represent emissions from vector Z. B_w represent the air pollution constraints for W types of emissions.

E_y = technical coefficients for plant capacity needed for the production of Z. B_y are Y plant capacity constraints.

The end-use energy service demands for transportation are represented by three basic sectors: (1) auto transport measured in vehicle miles, (2) air transport which is an aggregate of passenger miles and ton miles, and (3) bus, truck, and rail which is an aggregate of all their services. For these end-use energy service demands, the cost of their production is included in the objective function total system cost; the technical constraints are embodied in the constraint matrices E_u, E_v, E_w, and E_y; and the possible fuels used for their production are liquid fuels from the resources: crude oil, shale oil, crude oil imports, or coal. The documentation implies that some versions include electrified mass transport as an end-use service demand and allow some auto vehicle miles to be produced by electric cars.

MODEL CONSTRUCTION

The technical constraints, E_u, E_v, E_w, and E_y, in BESOM are based on the Reference Energy System developed by Kenneth Hoffman, formerly of Brookhaven National Laboratory, and were further modified at Brookhaven National Laboratory.

DATA USED IN RUNNING MODEL

End-use demands are exogenous or input from a linkage with LITM (77-242) and the Brookhaven I-O model (78-361). Other necessary input includes demand and supply efficiencies, conversion, extraction, and fuel costs, environmental constraints, resource availabilities, and market penetration constraints for various fuels.

REFERENCE

Kydes, A.S., Brookhaven energy system optimization model--its variants and uses, Brookhaven National Laboratory, Report no. BNL 50873, May 1978.

Hoffman, K.C.; Jorgenson, D.W., Economic and technological models for evaluation of energy policy, Bell Journal of Economics, Vol. 8, pp. 444-466, 1977.

Fraser, J.T., Documentation of the Brookhaven Energy I-O and I-O BESOM linkage, Brookhaven National Laboratory, Report no. BNL 50856, August 1978.

Brock, H.W.; Nesbitt, D.M., Large scale energy planning models: a methodological analysis, Stanford Research Institute, May 1977.

Hoffman, K.C.; Wood, D.O., Energy system modeling and forecasting, Annual Review of Energy, vol. 1, pp. 423-453, 1976.

Tessmer, R.C.; Hoffman, K.C.; Marcuse, W.; Behling, D.J., Coupled energy system--economic models and strategic planning, Computer and Operations Research, vol. 2, no. 3/4, pp. 213-224, Dec. 1975.

COMPUTER REQUIREMENTS

BESOM is compatible with Control Data Corporation computers.

79-383

TIME-STEPPED ENERGY SYSTEM OPTIMIZATION MODEL (TESOM)

TESOM is a single-region time-phased linear programming model built at Brookhaven National Laboratory in 1978 under the sponsorship of the US. Department of Energy. This energy model was developed to improve on earlier models that examine interfuel substitution, energy technology, and energy policy. These models allocate energy resources and energy products and choose the mix of supply, energy conversion, and demand technologies that minimize total energy system cost or optimize over some other objective function such as resource consumption or environmental effects. Studies using TESOM include long-term economic analysis of future coal consumption.

SPONSOR

U.S. Department of Energy

AUTHOR

Andrew S. Kydes and J. Rabinowitz
Brookhaven National Laboratory
Department of Energy and Environment
National Center for Analysis of Energy Systems
Energy Data and Model Group
Upton, N.Y. 11973

KEYWORDS

Energy consumption

OBJECTIVE OF MODEL

TESOM is a linear programming model that can assist in studying the national energy system. The purpose of TESOM was to improve on the Dynamic Energy System Optimization Model (DESOM) (79-384) and provide an alternative to the Market Allocation Model (MARKAL) (78-398). This improved version:

a) reflects uncertainties by assuming imperfect knowledge of future supplies, demands, and technologies,

b) has an improved market penetration algorithm,

c) has a better representation of the vintage capital stock, and

d) has the option of step-wise resource supply functions.

RELATIONSHIP TO OTHER MODELS

TESOM can be used in conjunction with the Long Term Interindustry Transactions Model (77-242) and the Brookhaven I-O Model (78-361).

HISTORICAL BACKGROUND

TESOM is a second-generation DESOM (79-384), an alternative to MARKAL (78-398), and a third-generation BESOM (78-378).

ASSUMPTIONS

The technical assumptions for energy conversion in TESOM are captured in the Reference Energy System as in DESOM (79-384). End-use demands, step-wise resource supply schedules, pollution regulations and energy conversion plant capacity are all exogenous. One can assume limits to market penetration of a particular fuel or energy technology. These assumptions are similar to DESOM except that: (1) The amount of resource available in a given time period is fixed in DESOM, whereas in TESOM resource availability can be made a function of price, and (2) TESOM captures uncertainty by optimizing total system cost.

LIMITATIONS AND BENEFITS

Limitations and benefits are similar to DESOM except for the improvements cited above.

STRUCTURE

TESOM is a time-stepped linear programming model, or a temporal sequence of the BESOM model (78-378). It optimizes by minimizing total system cost, based on optimum levels for previous periods, capital retirement, lifetimes, efficiencies, age related operating and maintenance costs, and costs of stock in-place.

The end-use energy service demands for transportation are represented by three basic sectors: (1) auto transport measured in vehicle miles, (2) air transport which is an aggregate of passenger miles and ton miles, and (3) bus, truck, and rail which is an aggregate of all their services. For these end-use energy service demands: the cost of their production is included in the objective function total system cost; the technical constraints are embodied in constraint matrices; and the possible fuels used for their production are liquid fuels from the resources, crude oil, shale oil, crude oil imports or coal. The documentation implies that some versions include electrified mass transport as an end-use service demand and allow some auto vehicle miles to be produced by electric cars.

MODEL CONSTRUCTION

The data base used is similar to that for BESOM. The technical constraints E_u, E_v, E_w, and E_y, are based on the Reference Energy System developed by Kenneth Hoffman, formerly of Brookhaven National Laboratory, and have been further modified by Brookhaven National Laboratory.

DATA USED IN RUNNING MODEL

End-use demands are exogenous or input from a linkage with LITM (77-242) and the Brookhaven I-O model (78-361). Other necessary input includes demand and supply efficiencies, costs, environmental constraints, step-wise resource supply curves, market penetration constraints for various fuels or technologies, age-related variables for the capital stock, such as retirement, deterioration, average life times, and associated costs.

REFERENCE

Kydes, A.S.; Rabinowitz, J., Time-stepped energy system optimization model (TESOM): Overview and special features, Brookhaven National Laboratory, Report no. BNL 26456, August 1979.

Kydes, A.S., Brookhaven Energy System Optimization Model--its variants and uses, Brookhaven National Laboratory, Report no. BNL-50873, May 1978.

Groncki, P.J.; Marcuse, W., Brookhaven integrated energy/economy modeling system and its use in conservation policy analysis, preliminary copy, Brookhaven National Laboratory, Report no. BNL 51056, July 1979.

COMPUTER REQUIREMENTS

TESOM is compatible with Control Data Corporation machines.

DYNAMIC ENERGY SYSTEM OPTIMIZATION MODEL (DESOM)

DESOM is a multi-period linear programming model developed at Brookhaven National Laboratory in 1979 and sponsored by the Electric Power Research Institute. It is a national model that represents the entire energy system from resources through end-use service demands. The model minimizes total discounted system costs, subject to resource, end-use demand, pollution, and capacity constraints. Applications predict resource use from 1972 to 2017.

SPONSOR

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, Calif. 94304

AUTHOR

E.A. Cherniavsky, L.L. Juang, and H. Abilock
Brookhaven National Laboratory
National Center for Analysis of Energy Systems
Energy Data and Models Group
Upton, N.Y. 11973

KEYWORDS

Energy consumption

OBJECTIVE OF MODEL

The objective of DESOM was to improve on the Brookhaven Energy System Optimization Model (BESOM) (78-378), enabling better analysis of the electrical sector. DESOM is a multiperiod national dynamic linear programming model that chooses optimum energy products over an extended period of time. Time periods are linked together by capacity transfer and resource availability constraints. Software was developed to make structural and parameter changes easier. The representation of the electrical sector was extended to include load curves by season and by time of day.

RELATIONSHIP TO OTHER MODELS

DESOM has been used alone and in conjunction with the Long Term Interindustry Transactions Model (LITM) (77-242) and the Brookhaven I-O Model (78-361).

HISTORICAL BACKGROUND

DESOM is an extension of BESOM (78-378) and a precursor of the Brookhaven Market Allocation Model (MARKAL) (78-398) and the Brookhaven Time-Stepped Energy System Optimization Model (TESOM) (78-383).

ASSUMPTIONS

The technical assumptions for energy conversion in DESOM are captured in the Reference Energy System as in BESOM (78-378). End-use demands, resource availability, pollution regulations, and energy conversion plant capacity are all exogenous. One can assume limits to market penetration of a particular fuel or energy technology. These assumptions for DESOM are similar to those for BESOM (78-378) except that DESOM optimizes dynamically. It chooses energy resources, energy products, and energy conversion technologies that minimize total discounted energy system cost while knowing past and future supplies, demands, prices, and technologies.

LIMITATIONS AND BENEFITS

The model is designed to examine interfuel substitution and the effect of new technology, and to do policy analysis in the context of the entire energy system. It improves on BESOM by optimizing dynamically. When used alone the model does not completely capture end-use demand nor resource supply elasticities. Representing costs by a linear function is a further simplification.

STRUCTURE

DESOM is a sequence of single-period linear programming models with constraints that link time periods together. (See BESOM (78-378) for the basic one-period model). The equations linking time periods ensure that: cumulative resource use equals total resource consumption; capacity and resource growth limit usage in any year to some proportion of previous usage; fuel inputs to end-use devices must not be less than some fraction for the preceding period, to limit end-use device retirement; and that enriched uranium may be stockpiled. The objective function minimized for DESOM is total discounted system cost.

The end-use energy service demands for transportation are represented by three basic sectors: (1) auto transport measured in vehicle miles, (2) air transport which is an aggregate of passenger miles and ton miles, and (3) bus, truck, and rail which is an aggregate of all their services. For these end-use energy service demands: the total discounted cost of their production is included in the objective function total system cost; the technical constraints are embodied in constraint matrices, and the possible fuels used for their production are liquid fuels from the resources, crude oil, shale oil, crude oil imports or coal. The documentation implies that some versions include electrified mass transport as an end-use service demand and allow some auto vehicle miles to be produced by electric cars.

MODEL CONSTRUCTION

The model is based on BESOM (78-378) data with modifications done by Brookhaven National Laboratory. The technical constraints of the model are based on the Reference Energy System developed by Kenneth Hoffman, formerly of Brookhaven National Laboratory, and have been further modified by Brookhaven National Laboratory.

DATA USED IN RUNNING MODEL

End-use demands are input from linkages with LITM and the Brookhaven I-O model. Other necessary input includes demand and supply efficiencies, costs, environmental factors, resource availabilities, the discount rate, and market penetration.

COMPUTER REQUIREMENTS

DESOM is written in the PDS Magen software package and is compatible with any CDC, IBM, or UNIVAC machine that has Magen operational on it.

REFERENCE

Cherniavsky, E.A.; Juang, L.L.; Abilock, H., Dynamic energy system optimization model, Research Reports Center, Report no. EA-1079, May 1979.

Tessmer, R.C.; Hoffman, K.C.; Marcuse, W.; Behling, D.J., Coupled energy system--economic models and strategic planning, Computer and Operations Research, vol. 2, no. 3/4, pp. 213-224, Dec. 1975.

HOUSEHOLD SURVEY GASOLINE DEMAND MODEL

The Household Survey Gasoline Demand Model was prepared at the College of William and Mary and the Bureau of Labor Statistics, Division of Price and Index Number Research, and presented in revised form in November 1978. Its primary purpose is to estimate gasoline demand elasticities.

AUTHOR

Robert Archibald
College of William and Mary
Department of Economics

Robert Gillingham
U.S. Department of Labor
Bureau of Labor Statistics
Division of Price and Index Number Research

KEYWORDS

Fuel consumption

OBJECTIVE OF MODEL

This model was designed to estimate short-run elasticities of gasoline consumption to determine whether gasoline price manipulation can be used to lower consumption. Also, the model estimates the effect of demographic characteristics on gasoline demand.

HISTORICAL BACKGROUND

The authors state that recent models of gasoline demand, such as those by Chamberlain (73-041), McGillivray (75-054), Rasche, Ramsey, and Allen (71-048), and Burright and Enns (75-058) all used aggregated data, either at the state or national level. This model uses household data in interview and diary form.

ASSUMPTIONS

The model assumes that consumers combine gasoline, automobile services, and other goods with their own time to produce transportation services which enter into the household's utility function. It is also assumed that in the short run consumer preferences are conditional on the (exogenous) demographic characteristics of the household.

LIMITATIONS AND BENEFITS

The household level data allow examination of the effects of a wide range of household-specific demographic variables on the consumption of gasoline.

Cars were identified by the number of cylinders rather than by their fuel efficiency per se.

STRUCTURE

The demand equations are estimated in log linear form with the square of the logarithm of total expenditure added to the model specification.

$$\log(g) = \alpha_1 [\log(p)] + \alpha_2 [\log(u)] + \alpha_3 [\log(v)]^2 + \alpha 4 [\log(a_1, a_2 \ldots a_n)]$$

where:

g = quantity of gasoline consumed

p = relative gasoline price

u = real total expenditure on goods and services

v = vector of household characteristics

$a_1 \ldots a_n$ = vector of characteristics of each automobile owned by a household

$\alpha_1 \ldots \alpha_4$ = estimated coefficients

Elasticities are determined using data on average monthly gasoline expenditures, total gasoline expenditures, and region and degree of urbanization of residence location. Family type and composition is also used, as well as number and type of car and season of the year.

Two hypotheses were tested to explain why post-OPEC embargo price elasticities were lower than expected. One hypothesis, specification I, calculates price elasticity as a function of the level of relative prices. Specification II calculates price elasticity as a function of the rate of change of relative prices. The calculated elasticities are shown in the tables below.

MODEL CONSTRUCTION

This model draws on 1972-73 Consumer Expenditure Survey (CES) interview and diary data compiled by the Bureau of the Census for the Bureau of Labor Statistics. Gasoline price data were obtained from the Bureau of Labor Statistics average retail price figures for 23 metropolitan areas, published starting in October 1973. Estimates for earlier time periods were derived by deflating the average retail prices for October 1973 by unpublished price indexes used in the construction

Elasticities Using Diary Data

Estimated Total Household Expenditure Elasticities of Gasoline Demand

Sample	Specification I	Specification II
All households	.248	.248
One car households	.224	.224
Multi-car households	.277	.278

Estimated Short-run Gasoline Price Elasticities of Gasoline Demand

Sample	Specification I			Specification II (mean value)
	One std. dev. to the left of mean	Mean value	One std. dev. to the right of mean	
All households	-.942	-.662	-.382	-.642
One car households	-.930	-.739	-.548	-.695
Multi-car households	-.918	-.557	-.195	-.556

of the Consumer Price Index.

REFERENCE

Archibald, R.; Gillingham, R., Analysis of consumer demand for gasoline using evidence from household survey data. Presented at the meetings of the American Statistical Association, August 1978, San Diego, October 1978.

Archibald, R.; Gillingham, R., Consumer demand for gasoline: evidence from household diary data, November 1978.

Elasticities Using Interview Data

Estimated Total Household Expenditure Elasticities of Gasoline Demand

Sample	Specification I	Specification II
All households	.402	.403
One car households	.320	.321
Multi-car households	.603	.603

Estimated Short-run Gasoline Price Elasticities of Gasoline Demand

Sample	Specification I			Specification II (mean value)
	One std. dev. to the left of mean	Mean value	One std. dev. to the right of mean	
All households	-.609	-.511	-.412	-.549
One car households	-.930	-.739	-.548	-.651
Multi-car households	-.918	-.557	-.195	-.387

MARKET ALLOCATION MODEL (MARKAL)

MARKAL is a time-phased linear programming model developed for the International Energy Agency by the International Energy Agency, the National Center for Analysis of Energy Systems at Brookhaven National Laboratory, and Kernforschungsanlage in Julich, Germany in 1978. It was designed to study the effects of new technologies, conservation practices, and the current value of future resource scarcity by optimizing an objective function. It has been used to determine energy policy and strategy given uncertain future energy resources, demands, costs, and technologies.

SPONSOR

International Energy Agency
Paris, France

AUTHOR

International Energy Agency
Paris, France

Brookhaven National Laboratory
National Center for Analysis of Energy Systems
Upton, N.Y. 11973

Kernforschungsanlage
Julich, Germany

KEYWORDS

Energy consumption, national economic impact

OBJECTIVE OF MODEL

MARKAL is a single-region time-phased linear programming model and is a second generation of the Dynamic Energy System Optimization Model (DESOM) (79-384). Its basic purpose is to analyze new technologies, capital requirements, energy conservation, and future energy resource scarcity to determine energy strategy and policy options.

HISTORICAL BACKGROUND

MARKAL is a hybrid of the Dynamic Energy System Optimization Model (DESOM) (79-384), the Time-Stepped Energy System Optimization Model (TESOM) (78-383), and models by Kernforschungsanlage (KFA).

LIMITATIONS AND BENEFITS

New characteristics of MARKAL that improve on DESOM (79-384) include better representation: of plant shut-downs, of lags in nuclear construction and stock piling, of oil refinery mix, of seasonal hydroelectric availability of resource supply, and a data base generated through the use of a data base management system. Limitations include the incomplete representation of end-use demand and the assumption of perfect foresight of future energy supplies, demands, technologies, and prices.

STRUCTURE

MARKAL is a time-phased linear programming energy model that optimizes an objective function such as total system cost, security, social concerns, or some hierarchy of these criteria. Since MARKAL optimizes over the entire planning horizon, it optimizes using supply, demand, prices, and technology information for the past, present, and future, as in DESOM (79-384). Technology, except for cost, is represented as in TESOM. It incorporates a more flexible and detailed supply side from the KFA models.

MODEL CONSTRUCTION

The technical constraints of the model are based on the Reference Energy System developed by Kenneth Hoffman, formerly of Brookhaven National Laboratory, and have been further modified by Brookhaven National Laboratory, Kernforschungsanlage, and the International Energy Agency.

DATA USED IN RUNNING MODEL

Resource availability, technology characterization, cost, end-use demand, and choice of objective function, with a priority order for the country under study, are inputs. Demand and supply can be aggregated to varying degrees, depending on available data.

REFERENCE

Kydes, A.S., Brookhaven Energy System Optimization Model--its variants and uses, Brookhaven National Laboratory, Report no. BNL-50873, May 1978.

WHARTON EFA MOTOR VEHICLE DEMAND MODEL, MARK I

The Motor Vehicle Demand Model, Mark I, is a large complex econometric model designed by Wharton Econometric Forecasting Associates (WEFA) to forecast the long-run automobile market. The Mark I model is a revised version of the Wharton EFA Automobile Demand Model. The revisions occurred in 1978 and were sponsored by the Transportation Systems Center (TSC) of the U.S. Department of Transportation. The objectives of the revisions were to incorporate more current data and to have the model simulate only the automobile market. The Mark I model was designed to study the impact of alternative policies and socioeconomic scenarios on the long-run size and composition of U.S. automobile demand and stock. One application of the model has been a study of the impact of electric vehicle market penetration.

SPONSOR

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass.

AUTHOR

Colin J. Loxley, Tim Osiecki, Kate Rodenrys, and Sheela Thanawala
Wharton Econometric Forecasting Associates, Inc.
3624 Science Center
Philadelphia, Pa. 19104

KEYWORDS

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

OBJECTIVE OF MODEL

The objective of the model is to forecast the impacts of various federal policies on gasoline consumption, scrappage, vehicle miles traveled, and the demand for automobiles.

RELATIONSHIP TO OTHER MODELS

The model uses inputs from the Wharton EFA Annual Model.

HISTORICAL BACKGROUND

The model is a revision of the Wharton EFA Automobile Demand Model (77-046). The equations that are substantially revised for the Mark I model are size-class market shares, foreign and domestic shares, vehicle miles traveled, and fuel efficiencies. Revisions were performed in conjunction with another effort to incorporate light duty truck demand into the Wharton EFA Motor Vehicle Demand Model, Mark II (78-437). Whereas the auto model contains certain vans as full-size automobiles, the Mark I version is concerned solely with automobiles. The Mark II version essentially is the Mark I version with light duty truck demand incorporated into it. For a summary of the Wharton Auto Demand Model see 77-046; for a summary of the Mark II version see 78-437. Further revisions and improvements to the model and its computer program are presently underway at WEFA and TSC.

ASSUMPTIONS

As in the auto demand model, new car sales and the size-class market shares are estimated by using a stock adjustment approach. Desired automobile stock and desired stock shares are predicted using an econometric equation. 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 stock variables are discussed below under structure.

VALIDATION

A detailed analysis of the Wharton EFA Automobile Demand Model has been performed by the Highway Safety Research Institute of the University of Michigan. See Golomb, D.H.; Luckey, M.M.; Saalberg, J.H.; Richardson, B.C.; and 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. (S-79-224) A comparison between the various versions of the model has been done by Richardson, B.C.; Roberts, D.C.; Sanghvi, P.B.; and Joscelyn, K.B., A review of the revisions to the Wharton EFA Automobile Demand Model: Mark I and II, An Interim Report. Ann Arbor, Michigan: University of Michigan Highway Safety Research Institute, 1980, Report no. UM-HSRI-80-2. Under sponsorship of the Transportation Systems Center, Charles River Associates, Inc. is currently engaged in an analysis of this model.

LIMITATIONS AND BENEFITS

The model is intended for the long-run analysis of automobile demand rather than for precise short-term (i.e., 1-2 years) estimates of demand. The model has been used by Wharton EFA, Inc. to simulate the impact of electric vehicle market penetration.

STRUCTURE

The Mark I model is an econometric model desianed to forecast the long-run equilibrium levels of the size and composition of the U.S. automobile demand and stock.

Although the model is complex, much of the basic theory underlying it is typical of the auto demand models which have been constructed over the last 20 years. Fundamental to the working of a stock adjustment process 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 class of vehicle is computed. The eight classes of vehicles are: foreign subcompact, domestic subcompact, foreign compact, domestic compact, domestic midsize, domestic full-size, foreign luxury, and domestic luxury. 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 various economic and demographic variables, are used to determine the desired stock shares of the eight 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 nonautomobile related transportation indicators, is used to determine desired stock per family. Total desired stock is used to forecast new car registrations and scrappage. The desired stock shares are used to forecast new car market shares by class. Stock adjustment processes link the desired levels to the actual levels.

Also included in the model are equations for urban and rural VMT per vehicle, new and used car prices, scrappage, gasoline consumption, and fuel efficiencies (both EPA and on-the-road).

Several of the key equations of the model are as follows:

Desired Stock

$$\ln(KEND*AY/FM) = \underset{(-2.4058)}{-1.91069} + \underset{(3.13435)}{.563472}\,[\ln(RDIP4/FM)]$$

$$- \underset{(-1.9217)}{.101018}\,[\ln(PER15+/100)]$$

$$- \underset{(-.84659)}{.199696}\,[\ln(CPMTTCAP/PC)]$$

$$- \underset{(-1.4782)}{.0536255}\,[\ln(MTWNA/FM)] + \underset{(1.60921)}{.0990298}\,(NPMET/100)$$

$$+ \underset{(3.07246)}{.421331}\,[\ln(LD/FM)]$$

$\bar{R}^2 = .461$ DW = 1.684 SEE = .059563

where t-statistics are in parentheses, and

KEND*AY/FM = desired stock--number of cars in operation per family unit

RDIP4/FM = four-year moving average of real disposable income per family unit

PER15+ = fraction of families with income of 15,000 dollars or more

CPMTTCAP/PC = capitalized cost per mile of purchase and operation, all new autos, desired stock share weighted average

MTWNA/FM = number of non-auto commuters per family unit

NPMET = fraction of the state population within standard metropolitan statistical areas

LD/FM = licensed drivers per family unit

Midsize Class Desired Share

$$\ln(ODDMD) = \underset{(.032)}{.170431} - \underset{(-4.54)}{1.96554}\,[\ln(CPMM/T\text{-}M)]$$

$$- \underset{(-1.23)}{.151175}\,[\ln([YDI/FM]/CT*Q)] + \underset{(4.74)}{.789071}\,[\ln(NCFM3+4/FM)]$$

$$+ \underset{(3.99)}{.163106}\,(NPRNEW/R) - \underset{(-3.64)}{.126228}\,(NPRMTN/R)$$

$\bar{R}^2 = .681$ DW = 1.462 SEE = .078171

where t-statistics are in parentheses, and

ODDMD = desired share of midsize cars divided by one minus that desired share

CPMM/T-M = capitalized cost per mile for midsize cars, relative to a weighted average of the substitutable shares (compact and full-size)

[YDI/FM]/CT*Q = disposable income per family relative to capitalized cost per mile for all cars averaged using 1972 desired shares

NCFM3+4/FM = number of families with three or four members per family unit

NPRNEW/R = population in the New England census region relative to the rest of the U.S.

NPRMTN/R = population in the mountain census region relative to the rest of the U.S.

Mid-size Class Share of New Car Sales

$$\ln(ODDMDTNR) = \underset{(1.04808)}{.00723071} - \underset{(-42.5769)}{.916888}\,[\ln(ODDTMMDK\text{-}SC/ODDMD{*}A)] + [\ln(ODDMD{*}A)]$$

$\bar{R}^2 = .991$ DW = 1.927 SEE = 0.15492

where t-statistics are in parentheses, and

ODDMDTNR = midsize class new registrations share divided by the quantity, one minus that share

ODDTMMDK-SC = midsize class share of actual stock, after current year scrappage, with the sum of the shares equal to one, divided by the quantity, one minus that share

ODDMD*A = midsize class desired share divided by the quantity, one minus that desired share

<u>New Car Sales</u>

$$\ln(OMVUANR/[OPMVUAYEND(-1) - SCMVUA]) = \underset{(-32.2094)}{-2.64204}$$

$$+ \underset{(5.02245)}{2.45923} [\ln(KEND*AY/[OPMVUAYEND - SCMVUA])]$$

$$+ \underset{(5.7421)}{4.21669} [\ln(RDI/FM / RDIP4/FM)]$$

$$- \underset{(-2.64462)}{1.06590} [\ln(PUTOTNRL/PUTOTNR[-1])] - \underset{(-3.19509)}{.288736} (DUMAUTOS)$$

$\bar{R}^2 = .906$ DW = 1.841 SEE = .038985

OMVUANR = total new passenger auto registration

OPMVUAYEND = actual stock of autos in operations, year end

SCMVUA = total auto scrappage

KEND*AY = desired stock

RDI/FM = real disposable income per family

RDIP4/FM = four year moving average of real disposable income per family

PUTOTNRL = average new car price, weighted by previous year sales mix

PUTOTNR = sales weighted average new car price

DUMAUTOS = automobile strike dummy

Scrappage

$$\ln([SCMVUA - SCMVAGIV]/[OPMVUAYEND(-1) + OMVUANR]) = \underset{(-8.03122)}{-7.72820}$$

$$- \underset{(-5.3199)}{3.22087} [\ln(KEND*AY/[OPMVUAYEND(-1) + OMVUANR])]$$

$$+ \underset{(6.03368)}{3.45837} [\ln(AVAGE0\text{-}20)] - \underset{(-1.92125)}{.143134} [\ln(PUOLD/PSCRAPAV)]$$

$$- \underset{(-5.2452)}{.413961} [\ln(NRUT)] + \underset{(3.41749)}{3.44981} [\ln(VMT/K \,/\, VMT/K[-1])]$$

$$+ \underset{(5.11976)}{4.43955} [\ln(VMT/K[-1] \,/\, VMT/K[-2])]$$

$$+ \underset{(4.19666)}{3.28961} [\ln(VMT/K[-2] \,/\, VMT/K[-3])]$$

$\bar{R}^2 = .905$ DW = 2.634 SEE = .053941

SCMVUA = total auto scrappage

SCMUAGIV = "given" scrappage, all cars over 20 years

OPMVUAYEND = actual stock of autos in operations, year-end

OMVUANR = total new passenger auto registration

KEND*AY = desired stock

AVAGE0-20 = average age of auto stock

PUOLD = average price of old cars

PSCRAPAV = average scrap metal price series

NRUT = unemployment rate

VMT/K = miles driven per vehicle

Urban VMT per vehicle

$$VMTU^*/K = \underset{(-2.30747)}{-1.43792}$$

$$- \underset{(-7.76729)}{.371407} \left[\ln([(PURG/100)/AVMPGCVINT]/[PC/125.3])\right]$$

$$+ \underset{(2.32539)}{.298117} \left[\ln(NPMET \times LDMV/KMID)\right]$$

$$+ \underset{(19.9262)}{.61974} \left[\ln(.25\,[Y] + .5\,[Y(-1)] + .25\,[Y(-2)])\right]$$

$\bar{R}^2 = .988$ DW = 2.618 SEE = .010656

VMTU*/K = urban VMT per mid-year stock of cars

PURG = gasoline price in cents per gallon

AVMPGCVINT = average fleet city fuel economy, (Wharton estimate)

PC = overall consumer price index, 1967 = 100

NPMET = percent of population in SMSAs

LDMV = licensed drivers

KMID = mid-year stock of cars in operation

Y = real disposable income per capita, less taxes and certain transfer payments

MODEL CONSTRUCTION

The database used to build the model is quite extensive and indicated in the Mark I report and the Wharton EFA Automobile Demand Model documentation.

Wharton EFA estimated the desired stock and stock share equations over 1972 cross-section data by state. The assumption is made that the actual and desired values of the stock and stock shares are approximately equal in 1972.

To estimate the equations for new car registrations, scrappage, and new car market shares, Wharton EFA produced a historical time-series of desired stock 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. In predicting the historical values of the desired stock series, Wharton EFA made some assumptions that would produce more reasonable values.

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 characteristic assumptions. Forecasts of most economic input variables are from Wharton EFA's Annual Model. Forecasts of some demographic variables are available from the Bureau of the Census; other demographic forecasts are from Wharton EFA. A table of model input is provided below:

A. Economic Activity and Price Assumptions:

1) Average growth rate of GNP

2) Inflation rates

3) Gasoline prices

4) Personal income

5) Personal income taxes

6) Transfer payments

7) Real disposable income

8) Income distribution

9) Employment

10) Unemployment rate

11) Consumer credit rate for new autos

12) Price indexes (including CPI's related to auto operation and maintenance)

13) Steel scrap price

B. Demographic Assumptions:

1) Number of families

2) Number of unrelated individuals

3) Licensed drivers

4) Resident population aged 20 to 29

5) Distribution of families by size

6) Average population growth rate

7) Average family unit growth rate

8) Population by region

C. Transportation Mode Assumptions:

1) Number of nonauto travelers to work

2) Number of interstate highway miles

3) Urban fraction of VMT

4) Growth in urban transit passengers relative to employment

5) Growth in urban transit passengers relative to transit travelers to work)

D. Auto Characteristic Assumptions:

1) Curb weights for new cars by size-class

2) Engine displacements for new cars by class

3) Transmission types for new cars by class

4) Number of cylinders for new cars by class

5) MPG efficiency factors for new cars by class

6) Ratios of class prices to average, domestics

7) Used car price decay parameters

REFERENCE

Loxley, C.J.; Osiecki, T.; Rodenrys, K.; Thanawala, S., Revisions to the Wharton EFA Automobile Demand Model:: The Wharton EFA Motor Vehicle Demand Model (Mark I), Wharton Econometric Forecasting Associates, Inc., June 1978.

Loxley, C.J.; Luce, P.; Rodenrys, K., Market potential for hybrid vehicles, Wharton EFA, Inc., March 1979.

Schink, G.R.; Loxley, C.J., Analysis of the automobile market: modeling the long-run determinants of the demand for automobiles, three volumes, Wharton E.F.A. Inc., February 1977.

WHARTON EFA MOTOR VEHICLE DEMAND MODEL, MARK II

The Motor Vehicle Demand Model, Mark II, is a large complex econometric model designed by Wharton Econometric Forecasting Associates (WEFA) to forecast the long-run automobile and light truck markets. The Mark II version is a revised and expanded version of the Wharton EFA Motor Vehicle Demand Model, Mark I. The revisions occurred in 1978 and were sponsored by the Transportation Systems Center (TSC) of the U.S. Department of Transportation. The objectives of the revisions and expansion were to incorporate into the model the light truck market (both commercial and personal-use). This model is capable of analyzing the impacts of policies on the directly affected vehicle market as well as on the substitute vehicle market. The impact of alternative socioeconomic scenarios can also be examined.

SPONSOR

U.S. Department of Transportation
Transportation Systems Center
Kendall Square
Cambridge, Mass.

AUTHOR

Colin Loxley, Tim Osiecki, and Kate Rodenrys
Wharton Econometric Forecasting Associates, Inc.
3624 Science Center
Philadelphia, Pa. 19104

KEYWORDS

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

OBJECTIVE OF MODEL

The objective of the Mark II model is to forecast the impact of various federal policies on gasoline consumption, scrappage, vehicle miles traveled, and the demand for both automobiles and light duty trucks.

RELATIONSHIP TO OTHER MODELS

The model uses inputs from the Wharton EFA Annual model.

HISTORICAL BACKGROUND

The Wharton EFA Motor Vehicle Demand Models, Mark I and Mark II, are revised versions of the Wharton EFA Automobile Demand Model (77-046). The Mark I version (78-436) simulates impacts solely on the automobile market. The Mark II essentially extends the Mark I version by incorporating the light duty truck market.

Further revisions to the model and its computer program are presently underway at WEFA and TSC.

ASSUMPTIONS

The Mark II model forecasts the impacts of policies on personal-use and commercial-use vehicles. Personal use vehicles are comprised of automobiles and personal-use light duty trucks (LDTs). Commercial-use vehicles are comprised of commercial-use LDTs. LDTs are divided into the two types by assuming that certain model nameplate LDTs are used solely for personal use while others are used only commercially.

The predictions of the size and composition of vehicle demand and total vehicle stocks depend on the predictions of the desired stock and desired class share variables. 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 variable is discussed under the model structure below.

Equations were estimated for desired personal-use vehicle stock, desired automobile stock, desired stock of commercial-use LDTs, and for the desired stock shares of automobiles. The desired stock of personal-use LDTs is calculated as the difference between the desired stocks of personal vehicles and automobiles. The personal vehicle desired stock and the commercial-use LDT desired stocks were assumed to be approximately equal in 1976. The automobile desired and actual stocks and stock shares were assumed to be in equilibrium in 1972.

VALIDATION

A detailed analysis of the Wharton EFA Automobile Demand Model has been performed by the Highway Safety Research Institute of the University of Michigan. See Golomb, D.H.; Luckey, M.M.; Saalberg, J.H.; Richardson, B.C.; and 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. (S-79-224) A comparison of the various versions of the model has been made; see Richardson, B.C.; Roberts, D.C.; Sanghvi, P.B.; and Joscelyn, K.B. A Review of the Revisions to the Wharton EFA Automobile Demand Model: Mark I and II, An Interim Report, Ann Arbor, Michigan: The University of Michigan Highway Safety Research Institute, 1980, Report no. UM-HSRI-80-2. Under sponsorship of the Transportation Systems Center, Charles River Associates, Inc. is currently performing an analysis of the model.

LIMITATIONS AND BENEFITS

The model is intended for the long-run analysis of the automobile and truck demand rather than for precise yearly estimates of the demand. The model is capable of simulating the impact of federal policies on substitute vehicle markets. This is particularly useful for simulating those policies that affect only one market. The estimation of the personal-use LDT desired stock as the difference between personal vehicle and automobile desired stocks is noted by the authors as a limitation.

As this summary is based on draft documentation, the estimation process reported here may be revised.

STRUCTURE

The Wharton EFA Motor Vehicle Demand Model, Mark II, is an econometric model designed to forecast the long-run equilibrium levels of the size and composition of the U.S. automobile and light duty truck stock.

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. Fundamental to the working of a stock adjustment process 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 data, the desired stocks of personal vehicles, automobiles, personal use LDTs, commercial-use LDTs, and the desired stock shares of automobiles are estimated. These desired variables are used to forecast new vehicle registrations, scrappage, and new car market shares by size-class. The model includes other equations that forecast scrappage by type of vehicle, urban and rural vehicle miles traveled (VMT) for automobiles, VMT by personal-use LDTs, VMT by commercial-use LDTs, purchase prices, and gasoline consumption. Several of the key equations are:

Desired Automobile Stock:

$$\ln(KEND^*A/NPTLD) = \underset{(-5.00215)}{-3.7628} + \underset{(5.69864)}{0.646989}\,[\ln(RDIP4/NPTLD)]$$

$$- \underset{(-1.64943)}{0.385023}\,[\ln(CPMTTCAP{+}TX/PC)]$$

$$+ \underset{(3.68915)}{0.281795}\,(NCHOC/NCH) - \underset{(-3.72906)}{0.382618}\,[\ln(PER15{+})]$$

$\bar{R}^2$ = .526   DW = 1.835   SEE = 0.073471

where t-statistics are in parentheses, and

KEND*A = desired stock of automobiles

NPTLD = number of licensed drivers

RDIP4 = four year moving average of real total personal income minus personal taxes and transfer payments

CPMTTCAP+TX/PC = capitalized cost per mile, automobiles

NCHOC = number of households, outside central city in SMSAs (suburbs)

NCH = number of households, total

PER15+ = % of families with income 15,000 dollars or more in 1975

Desired Commercial-Use LDT Stock

$$\ln(KEND^*CT/NPTLD) = \underset{(-5.01546)}{-3.42604} + \underset{(2.12316)}{0.633354}\,\left[\ln\left(\frac{YAC/YPS}{CPMCVCAP/PC}\right)\right]$$

$$- \underset{(-5.59545)}{0.628733}\,[\ln(RWMMVR/RWMMV)]$$

$$- \underset{(-3.04774)}{0.644535}\,[\ln(NPR65{+}/NPR)]$$

$$- \underset{(-5.59545)}{1.29221}\,(NCHOC/NCH)$$

$\bar{R}^2$ = .764   DW = 1.646   SEE = 0.24024

KEND*CT = desired stock of commercial-use LDTs

NPTLD = number of licensed drivers

YAC = personal income earned in agriculture, construction, wholesale and retail trade, and services

YPS = total personal income

CPMCVCAP = capitalized cost per mile, commercial-use trucks

PC = state cost of living index

RWMMVR = road and street mileage, rural, in 1975

RWMMV = road and street mileage, urban, in 1975

NPR65+ = population aged 65 and over

NPR = total resident population

NCHOC = number of households, outside central city, in SMSAs (suburbs)

NCH = number of households, total

<u>New Automobile Registrations</u>

$$\ln(\text{OMVUANR}\ [\text{OPMVUAYEND}(-1) - \text{SCMVUA}]) = \underset{(-32.8001)}{-2.54817}$$

$$+ \underset{(4.94024)}{1.57795}\ [\ln(\text{KEND*AY}/[\text{OPMVUAYEND}(-1) - \text{SCMVUA}])]$$

$$+ \underset{(4.87402)}{4.46552}\ [\ln(\text{RDI}/\text{FM}\ /\ \text{RDIP4}/\text{FM})]$$

$$- \underset{(-2.81217)}{1.21568}\ [\ln(\text{PUTOTNRL}/\text{PUTOTNR}[-1])] - \underset{(-3.3948)}{0.35741}\ (\text{DUMAUTOS})$$

$\bar{R}^2$ = .866 DW = 1.566 SEE = 0.048115 Period = 1960-1976

OMVUANR = new registrations, automobiles

OPMVUAYEND = year-end stock of vehicles in operation, automobiles

SCMVUA = scrappage, automobiles

KEND*AY = desired stock, automobiles

RDI = real disposable income

RDIP4 = four-year moving average of real disposable permanent income

FM = number of family units

PUTOTNRL = vehicle mix

PUTOTNR = total purchase price, automobiles

DUMAUTOS = motor vehicle industry strike dummy

New Commercial LDT Registration

$$\ln(OMVUCTNROK/[OPMVUCTYEND(-1) - SCMVUCT]) = \underset{(-13.7336)}{-2.70262}$$

$$+ \underset{(1.28219)}{0.167762} [\ln(KEND*CT/[OPMVUCTYEND(-1) - SCMVUCT])]$$

$$+ \underset{(4.38457)}{7.32444} [\ln(YAC/YPS / YACP4/YPS)]$$

$$- \underset{(-1.60062)}{1.19021} [\ln(PRCTPUTOT/PRCTPUTOT[-1])]$$

$\bar{R}^2$ = .567 DW = 1.195 SEE = 0.10164 Period = 1959-1976

OMVUCTNROK = new registrations, commercial LDTs

OPMVUCTYEND = year-end stock of vehicles in operation, commercial LDTs

SCMVUCT = scrappage, commercial LDTs

KEND*CT = desired stock of commercial LDTs

YAC = sum of personal income from agriculture, construction, wholesale and retail trade, and services

YPS = total personal income

YACP4 = four-year moving average of YAC

PRCTPUTOT = total purchase price, commercial LDTs

Personal Vehicle Scrappage

$$\ln([SCMVUPV - SCMVPVGIV]/[OPMVUPVYEND(-1) + OMVUPVNROK]) = \underset{(-5.67406)}{-7.38438}$$

$$- \underset{(-2.47045)}{0.869979} [\ln(KEND*PV/[OPMVUPVYEND(-1) + OMVUPVNROK])]$$

$$- \underset{(-2.95811)}{0.168516} [\ln(PUOLD/PSCRAPAV)] + \underset{(4.15645)}{3.38872} [\ln(AVAGEPV)]$$

$$- \underset{(-5.0819)}{0.402411} [\ln(NRUT)] - \underset{(-3.17074)}{0.264277} (DUMAUTOS) + \underset{(2.5919)}{0.116095} (DUM73)$$

$$+ \underset{(5.08436)}{3.342789} [\ln(VMPV/K / VMPV/K[-1])]$$

$$+ \underset{(4.90658)}{3.65272} [\ln(VMPV/K[-1] / VMPV/K[-2])]$$

$$+ \underset{(3.45988)}{2.51009} [\ln(VMPV/K[-2] / VMPV/K[-3])]$$

$\bar{R}^2$ = .916 DW = 2.336 SEE = 0.0038617 Period = 1960-1976

SCMVUPV = total scrappage, personal vehicles

SCMVPVGIV = given scrappage, personal vehicle

OPMVUPVYEND = year-end stock of vehicles in operation, all personal

OMVUPVNROK = new registrations, all personal vehicles

KEND*PV = desired stock of personal vehicles

PUOLD = weighted average old used car price

PSCRAPAV = scrap metal price index

AVAGEPV = weighted average age of stock, personal vehicles

NRUT = national unemployment rate

DUMAUTOS = motor vehicle industry strike dummy

DUM73 = dummy variable for 1973

VMPV/K = total miles traveled per vehicle, personal vehicles

<u>Vehicle Miles Traveled, Commercial LDTs</u>

$$\ln(VMCT/K) = \underset{(-7.44286)}{-3.80197}$$

$$- \underset{(-5.49224)}{0.58952} [\ln(PURG/100/AVCTMPGVINT/[PC/125.3])]$$

$$+ \underset{(9.04371)}{2.67362} [\ln(.25 [YAC/YPS] + .5 [YAC/YPS(-1)]$$

$$+ .25 [YAC/YPS(-2)])]$$

$$- \underset{(-2.14489)}{0.056751} (DUM73.74)$$

$\bar{R}^2$ = .889   DW = .92   SEE = 0.028103   Period = 1960-1976

VMCT/K = total vehicle miles per vehicle, commercial LDTs

PURG = retail price of regular gasoline, cents per gallon

AVCTMPGVINT = fleet average fuel economy, commercial LDTs

PC = consumer price index

YAC = sum of personal income from agriculture, construction, wholesale and retail trade, and services

YPS = total personal income

DUM73.74 = dummy variable for 1973 and 1974

MODEL CONSTRUCTION

The database used to build the model is quite extensive and portions are described in the auto model documentation (77-046), the Mark I version documentation (78-436) and the Mark II documentation. Cross-section data from 1976 were used to estimate the equations other than the auto shares, for which 1972 data were used.

To estimate the equations for new registrations, scrappage, and new car market shares, the model authors produced 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. In predicting the historical values of the desired stock series, the authors made some assumptions that would produce more reasonable values.

DATA USED IN RUNNING MODEL

The input variables can be categorized into four major groups: economic, demographic, transportation mode, and auto characteristics. Forecasts of the economic input variables are from Wharton EFA's Annual Model. The demographic forecasts come from the Bureau of the Census and Wharton EFA. A table of model input is provided below:

A. Economic Activity and Price Assumptions:

1) average GNP growth rates

2) inflation rates

3) gasoline prices

4) personal income

5) personal income taxes

6) transfer payments

7) real disposable income

8) income distribution

9) employment

10) unemployment rate

11) consumer credit rate for new autos

12) nrice indexes (including CPI's related to auto operation and maintenance)

13) steel scrap price

B. Demographic Assumptions:

1) number of families

2) number of unrelated individuals

3) licensed drivers

4) resident population aged 20-29

5) family size distribution

6) average population growth rate

7) average family unit growth rate

8) population by region

C. Transportation Mode Assumptions:

1) number of nonauto travelers to work

2) number of interstate highway miles

3) urban fraction of VMT

4) growth in urban transit passengers relative to employment

5) growth in urban transit passengers relative to transit travelers to work

D. Vehicle Characteristic Assumptions:

1) curb weights for new cars by size-class

2) engine displacements for new cars by class

3) transmission types for new cars by class

4) number of cylinders for new cars by class

5) MPG efficiency factors for new cars by class

6) ratios of automobile class prices to average, domestics

7) used car price decay parameters

8) LDT fuel economies

REFERENCE

Loxley, C.J.; Osiecki, T.; Rodenrys, K., Demand for light duty trucks: The Wharton EFA Motor Vehicle Demand Model (Mark II), Wharton Econometric Forecasting Associates, Inc., December 1978.

Loxley, C.J.; Osiecki, T.; Rodenrys, K.; Thanawala, S., Revisions to the Wharton EFA Automobile Demand Model: The Wharton EFA Motor Vehicle Demand Model (Mark I), Wharton Econometric Forecasting Associates, Inc., June 1978.

Schink, G.R.; Loxley, C.J., Analysis of the automobile market: modeling the long-run determinants of the demand for automobiles, three volumes, Wharton E.F.A. Inc., February 1977.

LIVERMORE ENERGY POLICY MODEL (EPM)

The Livermore Energy Policy Model (EPM) is a general equilibrium model of the U.S. energy economy, based on the SRI-Gulf Energy Model (77-261). It was developed in 1978 at Lawrence Livermore Laboratory, under the sponsorship of the U.S. Department of Energy, and is implemented on the Livermore Economic Modeling System. It has been used in a study of the effect on future U.S. energy flows of the market penetration of automobiles with various types of energy storage systems.

SPONSOR

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

AUTHOR

Lawrence Livermore Laboratory
Energy and Resource Planning Group
Livermore, Calif. 94550

KEYWORDS

Energy consumption, fuel price

OBJECTIVE OF MODEL

The purpose of the model is to analyze the U.S. energy economy. It allows comparison of long-term effects of alternative energy scenarios, government energy policies, and alternative technologies on energy consumption and price, fuel mix, intermediate energy products consumption and price, and energy resource consumption and price.

RELATIONSHIP TO OTHER MODELS

The Livermore Economic Modeling System (EMS) is a software package for constructing, solving, and printing results of general equilibrium macro-models built from a network of microeconomic submodels, or nodes. It was designed to simplify construction of, maintenance of, and experimentation with the Livermore Energy Policy Model (EPM), but could be applied to other sectors of the economy as well. A new symbolic computer language was designed to be used with EMS to facilitate the design and construction of large models.

Vehicle mile demand price elasticities used in EPM were derived from the Wharton EFA Automobile Demand Model (77-046).

HISTORICAL BACKGROUND

EPM is based on the SRI-Gulf Energy Model (77-261). It was developed because the SRI-Gulf model is proprietary to Gulf Oil Corporation and is not publicly available. It is simpler, faster, and less expensive to use than the SRI-Gulf model, and network modifications are easier to make. Also, regulated energy markets (with price and volume controls) can be modeled, whereas SRI-Gulf is a free-market model.

ASSUMPTIONS

The assumptions are similar to those of the SRI-Gulf Energy Model.

LIMITATIONS AND BENEFITS

The model can be as complex as needed by combination of elements at the simplest level. Regional differences are modeled, and decisions depend dynamically on both previous decisions and projections of the future. These economic realities are modeled: economic rent, depending on the depletion of resources; end-use demand elasticity; financing; accounting and taxes; market share; initial energy balance; expansion and shutdown of industry; behavioral lags; and technological change.

The special modeling language allows for the easy conceptualization of processes, materials, and parameters for nodes, and the grouping of processes into submodels and the network. Detailed results can be retained for use as the starting point of a new solution.

STRUCTURE

EPM is a general equilibrium model with 9 demand regions and 12 supply regions. It is similar in structure to the SRI-Gulf Model (77-261), except for its increased flexibility, and the feature that allows regulation to be represented by several constrained algorithms. Two outputs can be constrained to a specified ratio. Price or quantity controls and regulations that can be represented by changes in cost, technology, or the energy network, can be easily simulated.

The basic elements of the model are the energy network; the computational submodels, representing conversion processes, transportation, markets, resource extraction, or government regulation; and arc variables connecting the submodels, representing price, quantity, shadow price, and special extra quantity. A model solution is a set of values for the arc vectors that satisfy the relationships of every computational submodel, found through an iterative process that employs relaxation techniques to find a convergent solution in fewer iterations. The model contains more than 3000 nodes.

A network is arranged with resource supply curves at the bottom, usable energy demand curves at the top, and various materials, processes, and transportation links between. The solution algorithm moves up the network calculating prices, and down calculating quantities.

Output of the model is arranged into some twenty-one categories, one of which is auto transportation fuels. Calculations are done through the year 2025.

The SIMPLE (and most general) kind of computational submodel contains the following quantity computations for the process being modeled: growth per period, plant life, replacements, construction and capacity, efficiency, primary and secondary input quantities, and capital cost learning factor. Price computations include: capital cost, borrowings, equity discount and interest rates, present value of debt, equity financing, depreciation tax credit, real estate taxes and insurance, shutdown-expansion factor, capital equipment cost adjustment, present value of fixed charges, fuel cost, operating cost, present value computations, actual future and perceived operating income, and final and relaxed output price.

DATA USED IN RUNNING MODEL

The data base is based on that for the SRI-Gulf Model with revisions by Lawrence Livermore Laboratory. The network must be described in the modeling language. A solution requires the input of program variables, process and market node parameters, end-use demands, resource volume estimates, initial market shares, and transportation process distances.

REFERENCE

Rousseau, W.F.; Sussman, S.S.; Castleton, R.N.; Rambo, J.T., Economic models and algorithms used in the Livermore Economic Modeling System, Lawrence Livermore Laboratory, Report no. UCRL-52527, August 10, 1978.

Rousseau, W.F.; Rambo, J.T.; Castleton, R.N.; Sussman, S.S., Computer code documentation for the Livermore Econometric Modeling Systems, Lawrence Livermore Laboratory, Report no. UCRL-52519, July 18, 1978.

Sussman, S.S.; Rousseau, W.F., New language for economic general equilibrium models, Lawrence Livermore Laboratory, Report no. UCRL-52507, July 1, 1978.

Schrot, M.D., Water--EPM: the incorporation of water into an energy policy model, presented at the ORSA/TIMS Joint National Meeting, October 15-17, 1979, Milwaukee, Wisconsin. Lawrence Livermore Laboratory, preprint UCRL-83469, October 12, 1979.

Rambo, J.T.; Coles, B.L., User's manual for the Livermore Economic Modeling System, Lawrence Livermore Laboratory, Report no. UCRL-52526, July 27, 1978.

Schrot, M.D., Energy modeling at the Lawrence Livermore Laboratory, presented at the Workshop on Validation of Mathematical Models, June

21-23, 1978, Dallas, Texas. Lawrence Livermore Laboratory, preprint UCRL-81357, July 1978.

Anderson, C.J., Lawrence Livermore Laboratory Energy Policy Model: a brief overview, Lawrence Livermore Laboratory, Report no. UCRL-52672, March 6, 1979.

Sussman, S.S.; Rousseau, W.F., Demonstration of the capabilities of the Livermore Energy Policy Model, Lawrence Livermore Laboratory, Report no. UCRL-52508, July 1, 1978.

Behrin, E.; Anderson, C.J.; Bomelburg, H.; Farahat, M.; Forsberg, H.C.; Hudson, C.L.; Kullman, B.C.; O'Connell, L.G.; Strickland, G.; Walsh, W.J., Energy storage systems for automobile propulsion: 1978 study, two volumes, Lawrence Livermore Laboratory, Report no. UCRL-52553, December 15, 1978.

COMPUTER REQUIREMENTS

The EMS consists of four programs, INPUT, SOLVE, PRINT, and PLOT. Most of the code is written in FORTRAN. The programs are implemented on the CDC 7600 computer at Livermore Laboratory. The documentation provides program documentation and a listing, a user's manual, and a guide to the modeling language. A base case analysis might take 30-40 minutes. 100 iterations of the model might take 12-15 minutes. Sensitivity analysis might take half as long as the base case.

3.0 ASSOCIATED LITERATURE ABSTRACTS

REFERENCE

Anderson, J.A., Analysis of the projections of 1985 fuel consumption by motor vehicles, Motor Vehicle Manufacturers Association, February 13, 1978.

CONCERNING MODEL:

Faucett Automobile Sector Forecasting Model (76-016), Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Fuel consumption

PERFORMING ORGANIZATION

Motor Vehicle Manufacturers Association
Policy Analysis Department
1909 K Street, N.W., Suite 300
Washington, D.C. 20006

ABSTRACT

This paper describes the projections of 1985 motor vehicle fuel consumption that appear to be used by policy makers and that contain well-documented assumptions and methodologies. The projections are aggregated to obtain an estimate of the total consumption of motor vehicle fuel in 1985. Historical trends in fuel consumption are also described. Projections from several models were included, such as the Faucett and Wharton automobile models.

S-77-176

REFERENCE

Final impact assessment of the automotive fuel economy standards, U.S. Department of Transportation, Report no. DOT-HS-803-183, 1976.

KEYWORDS

Automobile demand, vehicle miles traveled, national economic impact, fuel consumption

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Program Analysis
Planning and Evaluation
400 7th Street, S.W.
Washington, D.C. 20590

ABSTRACT

This study evaluates various micro-and macroeconomic impacts of the average fuel economy standards for model year 1981-84 automobiles. Microeconomic impacts analyzed include cost and price changes for both domestic manufacturers and the consumer. Macroeconomic impacts such as employment, energy consumption, and G.N.P. are also analyzed.

Conclusions from the study are: total gasoline consumption would not be reduced appreciably as a result of the standard, manufacturers would not encounter difficulty in meeting these standards, automobile prices should not rise significantly as a result of fuel efficiency induced changes, and consumers would realize substantial savings in operating and maintenance costs of these fuel efficient automobiles. [Author's abstract modified]

REFERENCE

Energy policy and conservation act, U.S. Congress, Public Law 94-163, 94th Congress, S.622, December 1975.

KEYWORDS

Energy consumption, fuel economy

PERFORMING ORGANIZATION

U.S. Congress
Washington, D.C.

ABSTRACT

This document is a copy of the Energy Policy and Conservation Act as enacted by the U.S. Senate and the House of Representatives on December 27, 1978. The intent of the act is to increase domestic energy supplies and availability, to restrain energy demand, and to prepare for energy emergencies. The fuel economy standards, enforced by penalties, that the automobile manufacturers are required to meet are enacted by the law. Several studies have been executed which attempt to model how the standards will affect automobile sales, market shares, fuel consumption, and automobile industry response and performance. The Faucett Automobile Sector Forecasting Model (76-016) is an example.

S-77-207

REFERENCE

Chock, D.P., General Motors sulfate dispersion experiment: assessment of the EPA HIWAY model, Journal of the Air Pollution Control Association, vol. 27, no. 1, pp 39-45, Jan. 1977.

CONCERNING MODEL:

HIWAY (76-095)

KEYWORDS

Model assessment, air pollution/air quality

SPONSOR

General Motors Corporation

PERFORMING ORGANIZATION

General Motors Corporation
General Motors Technical Center
General Motors Research Laboratories
Environmental Science Department
Warren, Mich. 48090

ABSTRACT

A major objective of the study was to investigate the validity of the EPA's HIWAY dispersion model. This model was the basis for the high roadside predictions of sulfate emissions made by EPA in 1975. Comparisons of measurements with predictions show that at the pedestrian level downwind from the road, the model works fairly well under unstable conditions, but overpredicts for stable conditions. Stability is defined as a function of roughness of terrain, plant life, and man-made objects, also of friction velocity and vertical gradients of wind and temperature in the atmosphere. For the upwind dispersion, however, the model is inapplicable. New dispersion parameters were determined which substantiate the expectation that mechanical mixing due to the traffic wake completely dominates the effects of atmospheric stability, except under extremely stable conditions. It is believed that the overprediction of the HIWAY model at ground level becomes worse as the number of traffic lanes increases. [Author's abstract modified]

REFERENCE

Mills, E.S.; White, L.J., Auto emissions: Why regulation hasn't worked, Technology Review, vol. 80, no. 5, pp. 54-63, Mar.-Apr. 1978.

KEYWORDS

Emissions

SPONSOR

Sloan Foundation
Princeton, New Jersey

PERFORMING ORGANIZATION

Princeton University (Mills)
Economics Department
Princeton, N.J.

New York University (White)
Graduate School of Business Administration
New York, N.Y.

ABSTRACT

This paper is an abstract of the paper prepared by Professors Mills and White for the Workshop on Air Pollution and Administrative Control, held at M.I.T., December 1976. It provides a brief but comprehensive history of emissions regulation by the U.S. and the Environmental Protection Agency from the early 1950s to the present. The U.S. program to control noxious motor vehicle emissions was a well-intentioned but poorly designed effort, according to this paper. This program's progress in controlling emissions has been slow, costs have been high, and incentives to help reduce the amount of vehicle emissions have been distorted. Problems inherent in motor vehicle emission control that distinguish it from other pollution control problems are discussed. The 1965 and 1970 amendments to the Clean Air Act are evaluated. An effluent fee program is proposed by the authors, in which manufacturers who produce clean cars are rewarded, and manufacturers who do not are punished. The effluent fee program would place a tax on different emission gases related to the cost of abatement for each vehicle. The formulation of the effluent tax is described in the paper.

S-79-221

REFERENCE

Technology assessment of changes in the future use and characteristics of the automobile transportation system, two volumes, Office of Technology Assessment, Report no. OTA-T-83, Feb. 1979.

KEYWORDS

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

PERFORMING ORGANIZATION

U.S. Congress
Office of Technology Assessment
Washington, D.C. 20510

ABSTRACT

This report deals with changes in the future use and characteristics of the automobile transportation system that are expected in the short term (by 1985) and those that might evolve over a longer period (through 2000 and beyond). The scope of the study is broad and includes all of the industries and services that contribute to use of the automobile as a mode of personal transportation. A summary of major findings is presented in Volume I. Detailed projections, policy analyses and technological forecasts may be found in Volume II: Technical Report. The objectives of this study are to (1) describe the factors that influence the characteristics of the automobile system, its use, and the services supporting its use, (2) to identify and characterize potential changes in automobile characteristics and use, and (3) to assess the near-term and far-term effects of various alternative federal government policies relating to automobile characteristics and use.

Contractors involved in the study include: Raytheon Service Co., Energy and Environmental Analysis, International Research and Technology, Purdue University Center for Interdisciplinary Studies, Science Applications, SRI International, Systems Design Concepts, Institute for Safety Analysis and the Urban Institute. See the following abstract for the report of some of these firms. [Author's foreword modified]

REFERENCE

<u>Technology assessment of changes in the future use and characteristics of the automobile</u>, background report, Systems Design Concepts, Inc., January 1978.

CONCERNING MODEL:

Wharton EFA Automobile Demand Model (77-046); Mathtech Electric Vehicle Demand Model (77-217); CRA Hedonic Market Share Model (76-025)

KEYWORDS

Automobile design

SPONSOR

U.S. Congress
Office of Technology Assessment

PERFORMING ORGANIZATION

System Design Concepts, Inc.

Energy and Environmental Analysis, Inc.

Institute for Safety Analysis, Inc.

ABSTRACT

This is a phase I technical background report for the Office of Technology Assessment's report of the same name (S-79-221). This report develops potential policy alternatives directly related to automobile transportation and analyzes their effects upon private industry and the public. Findings indicate that the automobile will continue to be the major form of passenger transportation to the year 2000 and the only threat to such continued auto use will be potential petroleum supply problems.

An in-depth analysis is conducted of the automobile transportation system and of five scenarios for the future: a base case, petroleum conservation, improved environment, increased mobility, and increased accessibility. For each case potential federal policies, technology assumptions, and impact assessment is outlined. These models were used in the analysis: Wharton EFA Automobile Demand Model, Mathtech Electric Vehicle Demand Model, and the CRA Hedonic Market Share Model.

S-78-223

REFERENCE

Darling, E.M., Jr.; Garlitz, J.D., Computer modeling of transportation-generated air pollution: State-of-the-art survey, II, U.S. Department of Transportation, Report no. DOT-TSC-RSPD-78-1, March 1978.

CONCERNING MODEL:

State-of-the-art survey, I (S-72-153)

KEYWORDS

Air pollution/air quality, emissions

SPONSOR

U.S. Department of Transportation
Research and Special Programs Directorate
Transportation Programs Bureau
Office of Systems Engineering
Washington, D.C. 20590

PERFORMING ORGANIZATION

U.S. Department of Transportation (Darling)
Transportation Systems Center
Kendall Square
Cambridge, Mass. 02142

Input Output Computer Services, Inc. (Garlitz)
689 Concord Ave.
Cambridge, Mass. 02138

ABSTRACT

This report updates a previous U.S. Department of Transportation survey (S-72-153) on the mathematical modeling of air pollution from transportation sources. Current information is presented on the characteristics of 22 presently operational air pollution dispersion models and on the availability of air quality data for use in transportation-generated air pollution modeling. [Author's preface modified]

REFERENCE

Golomb, D.H.; Luckey, M.M.; Saalberg, J.H.; Richardson, B.C.; Joscelyn, K.B., Analysis of the Wharton E.F.A. automobile demand model, UMI Research Press, an imprint of University Microfilms International, Report no. UM-HSRI-79-2, 1979.

CONCERNING MODEL:

Wharton E.F.A. Automobile Demand Model (77-046)

KEYWORDS

Model assessment

SPONSOR

Motor Vehicle Manufacturers Association
Detroit, Mich.

PERFORMING ORGANIZATION

University of Michigan
Highway Safety Research Institute
Policy Analysis Division
Huron Parkway and Baxter Rd.
Ann Arbor, Mich. 48109

ABSTRACT

This document reports the results of an analysis of the 1977 version of the Wharton E.F.A. Automobile Demand Model. The purpose of this report is to analyze specific capabilities of the model: the model's ability to forecast the long-run size and composition of U.S. automobile demand and stock, in total and by type of vehicle, and its ability to predict the response of these long-run variables to changes in economic, technological, and demographic conditions that can be influenced by government policy.

The analysis consists of four steps: (1) Model structure analysis, (2) Equation reconstruction, (3) Submodel evaluation, and (4) Full model evaluation.

Model structure analysis was applied to the model as a whole, and to the components--i.e., related groups of equations--that make up the model. The organization and operation of the model are outlined, including complete details of the input, output, identities, and equations of the model.

In equation reconstruction, the behavioral equations are analyzed in a two-stage process. First, they are reconstructed by means of a regression package and the reestimated equations are checked against those reported by the author. HSRI staff were able to exactly or closely replicate about 75% of the equations attempted.

The specifications of the individual equations are examined in order to understand the complete structure of the model. The signs of the estimated parameters are generally consistent with economic theory.

In the submodel evaluation, the forecasting behavior and dynamic properties of three submodels of the model are analyzed.

In full model evaluation, the forecasting behavior and dynamic properties of the model are examined over the same period as in the submodel analysis so that direct comparisons can be made. In another series of experiments, analyses are made of the tendency of the model to accumulate forecasting errors as the forecasting horizon increases.

The model was found by the authors to follow the trends of such variables as new car sales, automobile travel demand, and scrappage.

The model does not follow the trends of new car sales by type, and stock of cars by type and age.

In simulations over the period to which the model was fitted, yearly errors average 9.5% for new car sales and 14.5% for scrappage. Errors range from 13% to 97% for new car stock size-class shares. Some equations tend to accumulate large errors as the forecasting horizon is increased.

The model was found to be insensitive to changes in policy related variables and does not follow trends well of new cars by size-class.

REFERENCE

Seiferlein, K.E., Motor gasoline supply and demand 1967-1978, U.S. Department of Energy, Report no. DOE/EIA-0076, Aug. 1978.

KEYWORDS

Fuel consumption

PERFORMING ORGANIZATION

U.S. Department of Energy
Energy Information Administration
Office of Energy Data and Interpretation
Washington, D.C. 20461

ABSTRACT

The amounts of gasoline supply and demand for 1967-77 are described in detail. Forecasts are made for 1978-79 using a projection of trends, given high, medium or low demand, based on assumptions for the gross national product and real national income.

S-79-228

REFERENCE

Kaiser, R., Historic (1971-1975) cost-revenue analysis of the automotive operations of the major U.S. automotive products manufacturers, U.S. Department of Transportation, Report no. DOT-TSC-NHTSA-78-27, Jan. 1979.

KEYWORDS

Industrial financial performance

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Research and Development
Washington, D.C. 20590

PERFORMING ORGANIZATION

H.H. Aerospace Design Co., Inc.
Civilian Air Terminal
Bedford, Mass. 01730

ABSTRACT

In this accounting study, a cost-revenue analysis is performed for the manufacture of automotive vehicles between 1971 and 1975. The four major U.S. automotive manufacturers, American Motors Corp., Chrysler Corp., Ford Motor Co. and General Motors Corp. were the subjects of this study. Corporate financial data were disaggregated and data pertinent to automotive operators were identified or estimated at three levels: (1) worldwide automotive operations, (2) North American automotive operations, and (3) U.S. manufacturers of passenger vehicles and light trucks.

REFERENCE

Report by the federal task force on motor vehicle goals beyond 1980, draft, three volumes, U.S. Department of Transportation, September 1976.

CONCERNING MODEL:

Faucett Automobile Sector Forecasting Model (76-016); Air Quality Model

KEYWORDS

Fuel economy, accidents, air pollution/air quality

PERFORMING ORGANIZATION

Energy Resources Council
Federal Task Force on Motor Vehicle Goals Beyond 1980
12th St. and Pennsylvania Ave. N.W.
Washington, D.C. 20461

ABSTRACT

A task force was established in 1975 with representatives from the U.S. Department of Transportation, the Environmental Protection Agency, the Energy Research and Development Administration, Federal Energy Administration, and the National Science Foundation. There were eight study panels, and three volumes were produced: the Executive Summary, the Task Force Report, and Appendices. The purpose of this study is to set forth, in a single comprehensive paper, the various actions which can be taken to improve the fuel economy of individual automobiles that will be built in the future, as well as to make clear the implications of taking one or more of such actions. The study concludes that a 50% reduction in projected fuel use by the national automobile fleet is potentially achievable. Sections are included on the methodologies and results of several panels: Marketing and Mobility (Automobile Sector Forecasting Model 76-016); Air Quality, Noise and Health (Air Quality Model); Material Requirements and Availability; and Current Automobile Industry Research and Development. [Author's introduction modified]

S-79-231

REFERENCE

Carroll, J.M.; Schneider, R.P., Historical financial data--domestic automobile manufacturers, U.S. Department of Transportation, Report no. DOT-TSC-NHTSA-78-28, Jan. 1979.

KEYWORDS

Industrial financial performance

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Research and Development
Washington, D.C. 20590

PERFORMING ORGANIZATION

Arthur D. Little, Inc.
Acorn Park
Cambridge, Mass. 02142

ABSTRACT

A historical data base is developed using accounting procedures for the four major U.S. automobile manufacturers focusing on data associated with production and marketing of automobiles and light trucks for the period 1967-1976. Accounting and reporting policies of each manufacturer are studied. Accounts selected for analysis include (1) property, plant and equipment - annual capital investment; (2) special tools - annual capital investment; (3) maintenance, repairs and rearrangements - annual operating cost; (4) research and development - annual operating expense; (5) depreciation and amortization of assets - annual operation cost.

REFERENCE

Rudman, L.M., Vehicle miles traveled: An evaluation of existing data sources, U.S. Department of Transportation, presented at the Transportation Research Board, January 18, 1979.

KEYWORDS

Vehicle miles traveled

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C.

PERFORMING ORGANIZATION

U.S. Department of Transportation
Transportation Systems Center
Energy Programs Division
Cambridge, Mass. 02142

ABSTRACT

This report evaluates existing data sources for vehicle miles traveled (VMT) and gasoline consumption. Collection, reporting consolidation, and estimation procedures are addressed. The assumptions that enter into VMT estimates and their implications for hypothesis testing are examined. Two national methodologies and four state procedures for estimating automobile VMT are reviewed. [Author's abstract modified]

S-59-239

REFERENCE

De Janos, P.E., Factors influencing the demand for new automobiles, The Journal of Marketing, Vol. 23, no. 4, pp. 412-418, April 1959.

KEYWORDS

Automobile demand

PERFORMING ORGANIZATION

Standard Oil Company
General Economics Department
200 E. Randolph Dr.
Chicago, Ill. 60601

ABSTRACT

In this study, family characteristics and their relationship to new car purchases are examined. These characteristics include (1) disposable income, (2) car ownership status, (3) financial well being, (4) new car purchase plans, (5) actual and expected earning rates, (6) age of the head of spending unit, (7) marital status of the spending unit, and (8) size of the community. The relationship of these factors to new-car purchases by families is tested simultaneously through a multivariate statistical technique. Intentions to purchase new cars are found to be by far the most powerful characteristics, of those tested, in explaining family purchases of new cars.

REFERENCE

Schnapp, J.B., Corporate strategies of automotive manufacturers, Interim report, Volumes I-VII, Report no. DOT-HS-7-01783, July 1978.

Schnapp, J.B., Corporate strategies of automobile manufacturers, Final report, Volumes I-III, Report no. DOT-HS-7-01783, Nov. 1978.

KEYWORDS

Industrial financial performance, pricing

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
400 7th Street, S.W.
Washington, D.C. 20590

PERFORMING ORGANIZATION

Harbridge House
11 Arlington Street
Boston, Mass. 02116

ABSTRACT

This study describes and assesses the corporate decision-making processes of eight domestic and foreign automotive manufacturers: American Motors, Chrysler, Ford, General Motors, Honda, Nissan, Toyota, and Volkswagen.

The most important information resource for this study was highly focused interviews with executives of the eight automobile manufacturing companies and numerous automobile industry experts outside these companies. Strategic histories and a description of the decision-making process of each of the eight companies are presented, beginning in 1945 and projected through 1985. A description of pricing in the automobile industry is presented, as well as an examination of the marketing practices of the automobile industry. Likely automobile company responses to government regulation are discussed. Because of government regulation, Ford, General Motors, or both companies are predicted to increase their market shares at the expense of Chrysler and American Motors.

S-78-246

REFERENCE

Meader, M.W., _Seminar on automobile fuel efficiency: Vol. II--Proceedings_, MITRE Corporation, Metrek Division, May 1978.

KEYWORDS

Fuel economy, fuel consumption

SPONSOR

MITRE Corporation
Metrek Division
McLean, Va.

PERFORMING ORGANIZATION

MITRE Corporation
Metrek Division
McLean, Va.

ABSTRACT

This document is a record of the proceedings of the Seminar on Automobile Fuel Efficiency sponsored by the Metrek Division of the MITRE Corporation, held on May 11, 1978. The purpose of the seminar was to examine the trade-offs that exist between end-use motor vehicle transportation technology, fuel requirements, energy potential of the resources providing the fuel, and the environmental, health, safety, and economic impacts of the entire motor vehicle fuel cycle. A verbatim transcript of the discussion at the seminar is included. [Author's introduction modified]

REFERENCE

Bernard, M.J., III; LaBelle, S.J.; Millar, M.; Walbridge, E.W., Transportation energy scenario analysis: Technical report no. 1: Examination of four existing scenarios, Argonne National Laboratory, Report no. ANL/EES-TM-1, March 1978.

KEYWORDS

Energy consumption, fuel consumption, vehicle miles traveled, automobile demand, modal split

SPONSOR

U.S. Department of Energy
Assistant Secretary for Conservation and Solar Applications
Division of Transportation Energy Conservation
Data Analysis Branch
20 Massachusetts Avenue, N.W.
Washington, D.C. 20545

PERFORMING ORGANIZATION

Argonne National Laboratory
Energy and Environmental Systems Division
9700 South Cass Ave.
Argonne, Ill. 60439

ABSTRACT

The purpose of this report is to provide DOE/TEC with a long-range forecasting framework in which to evaluate potential changes to the U.S. transportation system. This initial report is the result of a consistent examination of four existing, but diverse, fifty-year scenarios of the future. It describes the scenarios and summarizes the changes in the major transportation system variables which would occur through the year 2025 in each scenario. [Authors' introduction modified]

S-78-249

REFERENCE

Millar, M.; Bernard, M.J., III, Transportation energy scenario analysis: Technical memorandum no. 2: Historical rates of change in the transportation stock, Argonne National Laboratory, Informal report no. ANL/EES-TM-6, September 1978.

KEYWORDS

Modal split, fleet size

SPONSOR

U.S. Department of Energy
Assistant Secretary for Conservation and Solar Applications
Division of Transportation Energy Conservation
Data Analysis Branch
20 Massachusetts Avenue, N.W.
Washington, D.C. 20545

PERFORMING ORGANIZATION

Argonne National Laboratory
Energy and Environmental Systems Division
9700 South Cass Ave.
Argonne, Ill. 60439

ABSTRACT

This study examines the historical effects of technological change on all major modes. Social and economic conditions are assumed to determine the implementation and acceptance of new technological developments. Modal shares are found to stabilize shortly after a major technological change. Change in modal split has often resulted from harnessing a new energy source. Major transportation system changes have been caused by economic conditions. This document intends to give background information with which to predict future results of transportation technologies.

REFERENCE

Daniel, W.A.; Heuss, J.M., Ambient air quality and automotive emission control, Journal of the Air Pollution Control Association, vol. 24, no. 9, pp. 849-54, September 1974.

KEYWORDS

Emissions, air pollution/air quality, model assessment

PERFORMING ORGANIZATION

General Motors Corporation
General Motors Technical Center
Fuels and Lubricants Department
Environmental Science Department
Warren, Mich. 48090

ABSTRACT

This paper is concerned with uncertainties involved in projecting ambient air quality. Ambient air quality is projected by assuming a linear dependence on estimated future emissions. Future automotive emissions are estimated by a method recommended by the EPA that involves projecting trends over time (S-72-251). Projections are made for the locations reported to have the highest ambient air concentrations of each pollutant. The sensitivity of the projections to several input parameters is then determined. The findings of this study are that uncertainty in projection of air quality due to the use of a maximum once-per-year concentration is large. The effects of uncertainties in arowth rates and fraction of emissions attributed to the automobile are also sizable. [Author's abstract modified]

S-72-251

REFERENCE

Kircher, D.S.; Armstrong, D.P., Interim report on motor vehicle emission estimation, U.S. Environmental Protection Agency, Report no. EPA-450/2-73-003, October 1972. NTIS no. PB 230/931AS.

KEYWORDS

Emissions, air pollution/air quality

PERFORMING ORGANIZATION

U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards
Research Triangle Park, N.C. 27711

ABSTRACT

In this paper, new gasoline-powered motor vehicle emission factors for carbon monoxide, hydrocarbons, and oxides of nitrogen are presented based on a recent nation-wide study of over 1,000 automobiles. These factors account for the model year, deterioration, and variation with average speed. Sample calculations are included to illustrate the method of obtaining emission factors that are most representative of a particular region, vehicle mix (age and type), and average speed. Methods are presented for obtaining area-wide emissions attributed to gasoline-powered vehicles using local traffic survey data. The new emission factors allow a more accurate computation of air quality, whether a proportional ("rollback") or a diffusion model is used. [Author's abstract modified]

REFERENCE

Review of leading state efforts in energy data and modeling, Mathtech Division of Mathemetica, Inc., Report no. IDOE-RS-76-02, May 1976.

KEYWORDS

Energy consumption

SPONSOR

Illinois Department of Business and Economic Development
Division of Energy
222 South College, Floor 1
Springfield, Illinois 62706

PERFORMING ORGANIZATION

Mathematica, Inc.
MATHTECH Division
3700 Science Center
Philadelphia, Pennsylvania 19104

ABSTRACT

This report presents a comprehensive picture of the energy information system in nine leading states or regions which have integrated energy planning activities. Data gathering, processing, and modeling efforts are examined for the nine states or regions in hopes that an awareness of what other states are doing may generate fresh ideas for new energy planning programs. [Author's preface modified]

S-79-255

REFERENCE

South, N.E.; Raja, R., In-service fuel economy, SAE Technical Paper Series, no. 790227, February 1979.

KEYWORDS

Fuel economy

PERFORMING ORGANIZATION

Ford Motor Company
Environmental Research
Dearborn, Mich. 48121

ABSTRACT

Ford Motor Company surveyed Ford management personnel who drive Ford Motor Company lease vehicles. From the responses, in-use fuel economy data were computed on over 10,600 1978 model year cars. Analyses of the data are presented which include: fuel economy summary statistics; regressions of fuel economy ratings versus in-use fuel economy; measures of the ability of the U.S. EPA ratings to rank in-use fuel economy; and the influence of car size class or transmission type on fuel economy regression and correlation. Wide ranges of fuel economies were found for each vehicle model type. The analysis shows no significant trend by size class in the relationship between in-use fuel economy and metro highway fuel economy ratings. [Authors' abstract]

REFERENCE

Noll, K.E.; Miller, T.L.; Claggett, M., Comparative analysis of HIWAY, California, and CALINE2 line source dispersion models, Transportation Research Record 648, 1977.

CONCERNING MODEL:

HIWAY (76-095)
CALINE2 (76-084)

KEYWORDS

Model assessment, emissions, air pollution/air quality

PERFORMING ORGANIZATION

Illinois Institute of Technology (Noll)
Department of Environmental Engineering
Chicago, Ill.

Enviro-Measure, Inc. (Miller, Claggett)
Knoxville, Tenn.

ABSTRACT

This paper provides a comparison of three different, idealized line source dispersion models--HIWAY, California Line Source, and CALINE2--that predict carbon monoxide concentrations near highways. All are based on the Gaussian dispersion equations. They are compared by means of sensitivity analysis and model validation by comparing carbon monoxide concentrations measured near a hiqhway with concentrations predicted by the models. Input parameters used are stability class, wind angle with respect to the roadway, and receotor distance to the highway. [Authors' abstract modified]

S-76-270

REFERENCE

Wallace, J.P.; DeYonker, L.G., Energy Policy and Conservation Act of 1975--part 1--Its effectiveness and economic impact, Chase Econometric Associates, Inc., May 1976.

CONCERNING MODEL:

Chase Macroeconomic Model

KEYWORDS

Fuel consumption, energy consumption

PERFORMING ORGANIZATION

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

ABSTRACT

This study evaluates the Energy Policy and Conservation Act of 1975 (EPCA) in terms of its likelihood of success in accomplishing its objectives. EPCA is evaluated with respect to its effect on U.S. domestic energy supply, energy demand and also with respect to its macroeconomic impact. The Chase macroeconomic model was used to estimate the impacts of EPCA. [Authors' abstract modified]

REFERENCE

Taylor, T., Jr.; Isaacs, M.C.; Cunningham, A.R., Domestic passenger automobile weight projections, 1979-1986 GM, Ford, Chrysler, AMC, U.S. Department of Transportation, Report no. DOT-HS-803-962, October 1978.

KEYWORDS

Weight, fuel economy, automobile design

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Office of Passenger Vehicle Research
Technology Assessment Division
Washington, D.C. 20590

PERFORMING ORGANIZATION

Corporate Tech Planning Inc.
275 Wyman Street
Waltham, Mass. 02154

ABSTRACT

A preliminary analysis for projecting curb weights of domestic passenger automobiles for the 1979 to 1986 model year period is presented. An estimate of potential weight reduction which each manufacturer might incorporate towards reaching the 1985 fuel economy goals was made based on known product plans and available technology. Weight losses from seven to thirty-two percent (depending on vehicle size) were estimated. Also estimated are potential fuel savings from weight reduction. Weight reduction methodologies include vehicle redesign, and sheet metal, component, and engine changes. [Authors' abstract modified]

S-78-275

REFERENCE

McVearry, A., Applied analysis modeling capability survey, "models index", U.S. Department of Energy, Technical memorandum no. DOE/EIA-0103/15, February 1978.

CONCERNING MODEL:

Project Independence Evaluation System (75-004)

KEYWORDS

Energy consumption, fuel consumption

PERFORMING ORGANIZATION

U.S. Department of Energy
Energy Information Administration
Washington, D.C.

ABSTRACT

This document is an index of models used by the Energy Information Administration concerning all aspects of energy use and development in the U.S. Models are presented with short descriptions of design and uses. Additional information sources are included. One of the models included is Project Independence Evaluation System (75-004). Another document that indexes similar models is described under S-79-468.

REFERENCE

Conn, W.D., Difficulty of forecasting ambient air quality--a weak link in pollution control, American Institute of Planners Journal, vol. 41, no. 5, pp. 334-346, Sept. 1975.

KEYWORDS

Air pollution/air quality, model assessment

SPONSOR

National Science Foundation
Washington, D.C. 20550

PERFORMING ORGANIZATION

University of California at Los Angeles
Department of Environmental Planning

ABSTRACT

In implementing the Clean Air Act amendments of 1970, it is very difficult to quantify the relationship between emissions into the atmosphere and ambient air quality. Short-, middle-, and long-term control strategies are discussed with an emphasis on the information needed for their effective assessment and implementation. It is shown that at their present stage of development, even the best diffusion models are limited in their application to decision making in air pollution legislation. [Author's abstract modified]

S-72-281

REFERENCE

Croke, E.J.; Croke, K.G.; Norco, J.E., Role of transportation demand models in the projection of future urban and regional air quality, Society of Automotive Engineers International Conference on Transportation and Environment Proceedings, SAE paper no. 720644, pp. 295-305, May 1972.

CONCERNING MODEL:

Argonne Transportation-Air Pollution Model

KEYWORDS

Air pollution/air quality

PERFORMING ORGANIZATION

Argonne National Laboratory
Argonne, Ill.

ABSTRACT

The authors indicate that an interface of the transportation system and the air pollution control planning processes is required for optimal urban and regional planning. Present planning models used in both the transportation and environmental fields, specifically traffic patterns and emission projections, were integrated into a transportation-air pollution policy evaluation model, the Argonne Transportation-Air Pollution Model. An application of this model for the Chicago metropolitan area is described. To the extent that manipulation of transportation demand models affects the rate of emission and spatial distribution of air pollutants, this model can serve as an effective air pollution control policy and strategy evaluation tool for the land use planning process.

REFERENCE

Males, R., R and D status report: Energy analysis and environment division, EPRI Journal, vol. 2, no. 5, pp. 34-36, June-July 1977.

CONCERNING MODEL:

MATHTECH Electric Vehicle Demand Model (77-217)

KEYWORDS

Energy consumption

PERFORMING ORGANIZATION

Electric Power Research Institute
Energy Analysis and Environment Division
3412 Hillview Avenue
Palo Alto, Calif. 94304

ABSTRACT

The latest developments and activities in the Electric Power Research Institute's energy analysis and environment division are reported. The role of the Wharton EFA Transportation Model in forecasting energy use for transportation is discussed. Preliminary calculations of the MATHTECH Electric Vehicle Demand Model are discussed and show that electric vehicles may not significantly impact time-of-day load patterns of electricity demand before the year 2000.

S-76-288

REFERENCE

Ohta, M.; Griliches, Z., Automobile prices revisited: Extensions of the hedonic hypothesis, Household Production and Consumption, N.E. Terleckyj, ed., 1976.

KEYWORDS

Pricing

SPONSOR

National Science Foundation
Washington, D.C. 20550

PERFORMING ORGANIZATION

Tohoku University (Ohta)
Sendai, Japan

Harvard University (Griliches)
Cambridge, Mass. 02139

ABSTRACT

This paper represents an application of the hedonic hypothesis to automobile pricing in an attempt to advance the state of the art of hedonic modeling. The study examines a few limited topics in the analysis of automobile prices, focusing on: (1) the role of "makes" or "brands" in explaining price differentials among different models of automobiles, (2) the additional information to be derived from analysis of used car prices, and (3) the gains to be had, if any, from using performance instead of physical (specification) characteristics in defining the relevant attributes of a commodity. "Hedonic" price indexes for automobiles are constructed and compared to official Consumer Price Indexes. It is found that, due to the fragmentary data bases available, that there is little to be gained from moving away from physical characteristics to performance variables for automobile price indexes. [Authors' introduction modified]

REFERENCE

Murrell, J.D., Light duty automotive fuel economy...trends through 1979, Society of Automotive Engineers Technical Paper Series, no. 790225, March 1979.

KEYWORDS

Fuel economy, weight

PERFORMING ORGANIZATION

U.S. Environmental Protection Agency
Washington, D.C.

ABSTRACT

In this paper, data bases relating to automotive fuel economy are developed and expanded. The pre-1975 Environmental Protection Agency fuel economy data base is expanded to over 6,600 cars, and these data on older cars are adjusted for odometer mileage effects on fuel economy. The data base for model years 1975-1977 certification cars is also updated, reflecting actual sales figures. The resulting trend analyses are thus (for the first time) consistent from year to year with regard to the representation of actual sales weighted new-car fleet fuel economy. The paper also presents a study of interactions between vehicle technology, fleet physical attributes, and post-1979 fuel economy standards. [Author's abstract modified]

S-78-292

REFERENCE

Final impact assessment of the light truck and van fuel economy standards for model years 1980 and 1981, National Highway Traffic Safety Administration, March 1978.

KEYWORDS

Trucks, fuel economy, vehicle miles traveled, industrial financial performance, energy consumption

PERFORMING ORGANIZATION

U.S. Department of Transportation
National Highway Traffic Safety Administration
Plans and Programs
Office of Program and Rulemaking Analysis
400 7th Street, S.W.
Washington, D.C. 20590

ABSTRACT

This document presents an analysis of impacts of an alternative to the fuel economy standards for light trucks and vans for model years 1980 and 1981. The paper includes a detailed discussion of the alternative's impacts on the automobile industry, on purchases of light trucks and vans, and on the national economy. Items covered include the capital investments of the auto industry required by these standards, possible retail price increases, employment impacts, and national fuel consumption reductions. The study also examines alternatives to these standards and concludes that the proposed course of action best meets the criteria established in the legislation for promulgating fuel economy standards.

REFERENCE

Hirst, E.; Herendeen, R., Total energy demand for automobiles, Energy Accounting as a Policy Tool, Congressional Research Service, Environment and Natural Resources Division, prepared for the subcommittee on Energy Research, Development, and Demonstration, U.S. House of Representatives, pp.589-595, June 1976.

KEYWORDS

Energy consumption, vehicle manufacturing resource utilization, fuel consumption

SPONSOR

National Science Foundation
Research Applied to National Needs
1800 G St., N.W.
Washington, D.C.

PERFORMING ORGANIZATION

Oak Ridge National Laboratory (Hirst)
Oak Ridge, Tenn. 37830

University of Illinois (Herendeen)
Center for Advanced Computation
Urbana, Ill.

ABSTRACT

This paper examines the direct and indirect energy requirements for automobiles in the United States. Findings indicate that direct gasoline consumption by automobiles amounted to 8,900 trillion BTU in 1970, equivalent to 13% of the total U.S. energy budget. Indirect energy consumption for automobiles, which includes energy consumed in petroleum refining, automobile manufacturing and sales, repairs, maintenance, parts, and highway construction was found to be an additional 5,500 trillion BTU in 1970. [Authors' introduction modified]

S-76-301

REFERENCE

Berry, R.S.; Fels, M.F., Energy cost of automobiles, Energy Accounting as a Policy Tool, Congressional Research Service, Environment and Natural Resources Division, prepared for the subcommittee on Energy Research, Development, and Demonstration, U.S. House of Representatives, pp. 595-605, June 1976.

KEYWORDS

Energy consumption, vehicle manufacturing resource utilization

PERFORMING ORGANIZATION

University of Chicago
Department of Chemistry
Chicago, Illinois 60637

ABSTRACT

This paper examines the energy cost of manufacturing automobiles, tracing the cost of manufacturing from the automobile input industry energy requirements, to the finished automobile. An in-depth energy cost map for the automobile is presented with energy values assigned to each step. Alternate policies to reduce energy costs for automobile production are considered.

REFERENCE

Bopp, A.E.; Neri, J.A., Price of gasoline: Forecasting comparisons, Quarterly Review of Economics and Business, Vol. 18, no. 4, pp. 23-33, winter 1978.

CONCERNING MODEL:

Gasoline Price Models

KEYWORDS

Model assessment, fuel price

ABSTRACT

The purpose of this paper is to compare the results obtained from forecasting the price of motor gasoline using three different methodologies, a Box-Jenkins (B-J) technique, a simple regression technique, and a more complex econometric technique, over two different forecast periods. The Simple Regression Model is a naive single equation model that links gasoline prices to crude oil prices. The model is used as a "base" model against which the other two models in this study can be compared. The ARIMA (1,1,1) model is a time-series model belonging to the general class of auto-regressive moving average models. A comparison of summary statistics from the three models shows that the ARIMA model performs well in the short run, but not as well as the others in the long run. The Inventory Adjustment Model is a two-equation dynamic system that was solved for the price and simplified to one equation. The study concludes that the econometric model is much superior in policy evaluation use and that, contrary to previous findings, the econometric model shows its greatest advantage over simpler models in the long-run. [Authors' introduction modified]

S-77-316

REFERENCE

Fowkes, A.S.; Button, K.J., Evaluation of car ownership forecasting techniques, Rivista Internazionale di Economia dei Transporti (International Journal of Transport Economics) Vol. 4, no. 2, pp. 115-143, Aug. 1977.

KEYWORDS

Model assessment, automobile demand

SPONSOR

Social Science Research Council
State House, High Holborn, WCIR 4th
London, England

PERFORMING ORGANIZATION

University of Leeds (Fowkes)
Institute for Transport Studies
Leeds, England

Loughborough University (Button)
Department of Economics
Loughborough, England

ABSTRACT

This paper reviews the historical development of different techniques for deriving car ownership forecasts. Simple extrapolation models are reviewed as well as econometric models. These models are now outdated but are often referred to in the development of automobile demand modeling. Some of the most frequently referenced articles that are discussed in this paper are: de Wolff, P., The demand for passenger cars in the United States, Econometrica, pp. 113-129, April 1938. Roos, C.F.; von Szeliski, V., Factors governing changes in automobile demand, in Dynamics of Automobile Demand, General Motors Corp., 1939. Farrell, M.J.; The demand for motor cars in the United States Journal of the Royal Statistical Society, pp. 334-347, 1959. Houthaker, H.; Haldi, J., Household investment in automobiles; an intertemporal cross-section analysis, in Proceedings of the Conference on Consumption and Saving, Vol. 1, Pennsylvania University Press, 1960.

REFERENCE

Skinner, L.E., Effect of energy constraints on travel patterns: Gasoline purchase study, U.S. Department of Transportation, Federal Highway Administration, July 1975.

KEYWORDS

Fuel consumption, vehicle miles traveled

PERFORMING ORGANIZATION

U.S. Department of Transportation
Federal Highway Administration
Urban Planning Division
Washington, D.C. 20590

ABSTRACT

Gasoline purchases over the five-month period from April 1 to August 31, 1974 were studied in this report. Major conclusions were that the demand for gasoline was not price responsive for the study population, which was high-income and small-city oriented, and that the only means available to reduce this amount of gasoline purchased for the study population was constrained availability either by gas rationing or by reduced allocations to stations.

S-72-325

REFERENCE

Berry, R.S.; Fels, M.F., Production and consumption of automobiles: An energy analysis of the manufacture, discard and reuse of the automobile and its component materials, University of Chicago, July 1972.

KEYWORDS

Vehicle manufacturing resource utilization, scrappage, energy consumption

SPONSOR

Illinois Institute for Environmental Quality
309 West Washington St.
Chicago, Ill. 60606

PERFORMING ORGANIZATION

University of Chicago
Department of Chemistry
Chicago, Ill. 60637

ABSTRACT

This report describes the system of the manufacture of automobiles, their discard, and the return of their components into the materials pool of our industrial society. The analysis involves the consumption of energy and stored thermodynamic potential associated with various processes in the preparation of the constituent materials and the fabrication of an automobile, and the extraction of inferences from the resulting figures. A detailed picture of materials flow for automobile manufacture, beginning with basic resources in the ground and ending with these same resources, returned to the earth in their "final" degraded form, is developed and used in the analysis. [Authors' introduction modified]

REFERENCE

Saalberg, J.H.; Richardson, B.C.; Joscelyn, K.B., Federal policy applications of the Wharton EFA automobile demand model, Ann Arbor, Mich.: UMI Research Press, an imprint of University Microfilms International, Report no. UM-HSRI-79-3, 1979.

CONCERNING MODEL:

Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Model assessment

SPONSOR

Motor Vehicle Manufacturers Association
320 New Center Building
Detroit, Mich. 48202

PERFORMING ORGANIZATION

University of Michigan
Highway Safety Research Institute
Policy Analysis Division
Ann Arbor, Mich. 48109

ABSTRACT

This document reports applications of the Wharton EFA Automobile Demand Model by federal agencies as a tool in policy analyses related to the motor vehicle transportation system. The objectives were to identify these agencies, what policy issues were evaluated using the model, how the model was used, and to determine how effectively and appropriately it was applied. Sixty-five persons in thirty-eight agencies were contacted in 1978-79. It was found that the model was used by the U.S. Department of Transportation, the International Trade Commission, the Environmental Protection Agency, the Office of Technology Assessment, the Council of Economic Advisers, the Department of the Treasury, and others. Policies analyzed include fuel economy standards, tax proposals, safety and emissions standards, and introduction of electric vehicles. It was found that users were generally unaware of the model's more serious limitations before using it, and that in some instances this resulted in misuse of the model.

S-73-334

REFERENCE

Clewell, D.H.; Koehl, W.J., Impact of automotive emissions regulations on gasoline demand, Proceedings of the Society of Automotive Engineers National Automobile Engineering Meeting on Energy and the Automobile, 1973, no. 730515, pp. 6-14, July 1973.

KEYWORDS

Fuel consumption, emissions

PERFORMING ORGANIZATION

Mobil Oil Corp. (Clewell)
New York, N.Y. 10017

Mobil Research and Development Corp. (Koehl)
New York, N.Y. 10017

ABSTRACT

This paper reviews trends in car design and usage that have affected gasoline consumption in the past and discusses such factors as emission controls that will affect future consumption, especially in light-duty vehicles. Between 1973 and 1985, demand for gasoline is expected to increase 50%, and perhaps 70% if the 1976 oxides of nitrogen emission standard were to stay in effect. The paper explores ways to moderate this demand, in terms of relaxation of emission standards, increased use of smaller cars, and increased use of public transportation. [Authors' abstract modified]

REFERENCE

Walton, H.; Emerson, F., Fact sheet: Forecasting automobile gasoline consumption, U.S. Department of Energy, Report no. DOE/EIA-0102/1, May 1978.

CONCERNING MODEL:

Project Independence Evaluation System (75-004)
Faucett Automobile Sector Forecasting Model (76-016)

KEYWORDS

Fuel consumption

PERFORMING ORGANIZATION

U.S. Department of Energy
Energy Information Administration
Assistant Administrator for Applied Analysis
Washington, D.C.

ABSTRACT

This report was prepared to present the method used by the Energy Information Administration in forecasting automobile gasoline consumption for the EIA Annual Report to Congress, May 1978. This method involves the Faucett Automobile Sector Forecasting Model's projections of total fleet fuel economy, the application of a degradation factor to convert to on-road fuel efficiencies, and the use of the Project Independence Evaluation System transportation fuel demand model. Impacts of the use of alternative assumptions on projected 1985 automobile gasoline consumption are discussed.

S-78-339

REFERENCE

Measuring energy conservation, U.S. Department of Energy, Report no. DOE/EIA-0103/18, Dec. 1978.

CONCERNING MODEL:

Faucett Automobile Sector Forecasting Model (76-016)
Light Duty Vehicle Fleet Fuel Consumption Model (79-368)

KEYWORDS

Fuel consumption

PERFORMING ORGANIZATION

U.S. Department of Energy
Energy Information Administration
Office of Energy Use Analysis
Washington, D.C. 20461

ABSTRACT

This paper discusses alternative methods for measuring energy conservation. Current methods used by the Office of Energy Use Analysis to forecast the impacts of energy conservation programs are also presented. Six econometric models which are used by the Office of Energy Use Analysis are described in the report's appendix. These are the Faucett Automobile Sector Forecasting Model, the Light Duty Vehicle Fleet Fuel Consumption Model, Natural Gas Pricing Model, Industrial Sector Technology Use Model, the Commercial Sector Energy Model, and the Residential Energy Use Model.

REFERENCE

Hausman, J.A., Project Independence Report: An appraisal of U.S. energy needs up to 1985, Bell Journal of Economics, Vol. 6, no. 2, pp. 517-551, 1975.

CONCERNING MODEL:

Project Independence Evaluation System (PIES) (75-004)

KEYWORDS

Model assessment, energy consumption

PERFORMING ORGANIZATION

Massachusetts Institute of Technology
Department of Economics
Cambridge, Mass.

ABSTRACT

This article presents a critique of the analytical techniques and assumptions used in preparing the first Project Independence Report (75-004). The original system contained a number of approximations and simplifications which enabled it to deal with the complex issues of the initial study. Since the completion of the first report, PIES has been used extensively for energy policy evaluation. During this period, revisions and additions of PIES have been undertaken, some of which are directed at limitations cited by Hausman in this article. Thus, some of the criticisms published here may be outdated.

S-79-365

REFERENCE

Richardson, B.C.; Joscelyn, K.B.; Saalberg, J.H., Limitations on the use of mathematical models in transportation policy analysis, Ann Arbor, Mich.: UMI Research Press, an imprint of University Microfilms International, Report no. UM-HSRI-79-46, 1979.

CONCERNING MODEL:

Wharton Automobile Demand Model (77-046)
Faucett Automobile Sector Forecasting Model (76-016)

KEYWORDS

Model assessment

SPONSOR

Motor Vehicle Manufacturers Association
320 New Center Building
Detroit, Mich. 48202

PERFORMING ORGANIZATION

University of Michigan
Highway Safety Research Institute
Policy Analysis Division
Ann Arbor, Mich. 48109

ABSTRACT

This paper describes models designed for use in policy analyses relating to the automotive transportation system, discusses limitations of these models, and poses questions policymakers should ask about a model to be sure its use is appropriate. These questions center on the model's performance record, results of model assessment, the purpose of the model, its appropriateness in specified applications, assumptions contained in the model, and availability of model documentation. [Authors' abstract and summary modified]

REFERENCE

McNutt, B.; Dulla, R., On-road fuel economy trends and impacts, U.S. Department of Energy, Feb. 17, 1979.

CONCERNING MODEL:

Light Duty Vehicle Fleet Fuel Consumption Model (79-368)

KEYWORDS

Fuel consumption, fuel economy, trucks

SPONSOR

U.S. Department of Energy
Office of Conservation and Advanced Energy Systems Policy
Washington, D.C.

PERFORMING ORGANIZATION

Energy and Environmental Analysis, Inc.

ABSTRACT

This report compares Environmental Protection Agency fuel economy measures to actual on-road fuel economy. EPA fuel economy standards were found to be accurate for 1974, but from 1975 to 1977, EPA overestimates fuel economy up to 30%. The results are used in conjunction with the Light Duty Vehicle Fleet Fuel Consumption Accounting Model. The model projects fuel consumption for 1978 to 1990 by both vehicle and fuel type. Other inputs used are econometrically based auto sales estimates, information on vehicle miles traveled, and auto scrappage data. Projected automobile fuel demand peaks near 1980 and then falls and levels off by 1990.

S-77-372

REFERENCE

Kulash, D.J.; Mudge, R.R.; Prywes, D., Urban transportation and energy: The potential savings of different modes, Congressional Budget Office, December 1977.

KEYWORDS

Modal split, energy consumption, fuel consumption

PERFORMING ORGANIZATION

Congressional Budget Office
Natural Resources and Commerce Division
Washington, D.C.

ABSTRACT

This paper attempts to describe the energy requirements of alternative urban transportation modes. In order to generate estimates of energy use for each mode, a comprehensive review was made of available estimates of urban transportation energy use, including both theoretical and applied studies. Van-pools were found to be the most fuel efficient mode of urban transportation. This is due to its peak-hour-only, single direction, prearranged nature. Fuel efficiency on a per-passenger-mile basis is followed, in order, by car pools, buses, and light rail. Rapid rail ranks low in overall energy economy. In terms of operating energy, rapid rail is the most fuel efficient. However, when construction, station operation, mode of access (driving to the station by car), and the circuity of route are figured in, the energy per productive mile for the whole trip is larger than for all public modes except dial-a-ride. Because of low load factors and high route circuity, dial-a-ride is energy wasteful. Dial-a-ride is of use to the elderly and handicapped, therefore its energy use must be weighed against its social contributions. Automobiles are expected to gain on public modes in energy efficiency in the future, due to the minimum fuel economy standards.

REFERENCE

<u>Consumer behavior towards fuel efficient vehicles</u>, U.S. Department of Transportation, Report no. DOT HS-804 775,6, April 1978.

KEYWORDS

Fuel economy, automobile demand

SPONSOR

U.S. Department of Transportation
National Highway Traffic Safety Administration
Washington, D.C. 20590

PERFORMING ORGANIZATION

Charles River Associates, Inc.
200 Clarendon Street
Boston, Mass. 02116

ABSTRACT

This study is directed toward understanding and anticipating consumer behavior toward motor vehicles that would be redesigned to meet federally legislated automotive fuel economy standards. Attitudes of consumers were surveyed in group interviews in four major metropolitan regions: Boston, Atlanta, Chicago, and San Francisco. Each group represented car owners whose members were all of the same sex and age group and were owners of the same size class of car. This report finds that a general resistance to government regulations currently exists within all market segments, but that attitudes differ by market segment. Small car drivers are more open-minded toward the legislation than drivers in other markets. Large car owners are convinced that the outcome of the legislation will be "less car for more money". [Author's introduction and summary modified]

S-78-385

REFERENCE

<u>TEC: Transportation energy conservation model: User's guide</u>, Jack Faucett Associates, Inc., Report no. JACKFAU-78-159-3, September 1978.

CONCERNING MODEL:

Automobile Sector Forecasting Model (76-016)

KEYWORDS

Energy consumption, modal split

SPONSOR

U.S. Department of Energy
Division of Transportation Energy Consumption

PERFORMING ORGANIZATION

Jack Faucett Associates, Inc.
5454 Wisconsin Ave.
Chevy Chase, Md. 10015

ABSTRACT

This report explains how to run the Transportation Energy Conservation Model, a multimodal model. The Automobile Sector Forecasting Model may be used as part of TEC. For specific instructions see the Automobile Sector Forecasting Model User's Guide. The other modes involved are described by submodels, each provided with detailed instructions on programming. The other modes are: railroad, bus, air, ship, truck, light truck, pipe, and motorcycle. The management of the TEC model within the computer is explained also, for users desiring to adapt the model to their special needs.

REFERENCE

National transportation policies through the year 2000: Executive summary and final report, National Transportation Policy Study Commission, June 1979.

CONCERNING MODEL:

TECNET (79-020); Faucett Automobile Sector Forecasting Model (76-016); Market Oriented Program Planning Study (MOPPS); INFORUM; Wharton EFA Automobile Demand Model (77-046)

KEYWORDS

Modal split, vehicle miles traveled, fuel price, accidents, national economic impact, noise pollution, air pollution/air quality, fuel consumption, energy consumption, trucks

PERFORMING ORGANIZATION

National Transportation Policy Study Commission
Washington, D.C.

ABSTRACT

The objective of this study, performed by a Congressional commission, is to formulate the broad outlines and primary themes of improved transportation policy for the United States. The report discusses the present and the future of the U.S. transportation system including externalities, energy, and policy. The INFORUM model was used to predict future economic trends. The SRI National Energy Model (NEM) gives estimates of future consumption of fuels; TRANS, a submodel of Inforum estimates the performance of the transportation modes; a National Transportation Planning model (NTP) forecasts passenger and commodity flows.

Projections of several mathematical models and studies are compared in the areas of: various aspects of GNP, population projections, vehicle miles traveled, energy consumption, and automobile demand. Projections compared are those from the U.S. Energy Research and Development Administration (ERDA), Transportation Energy Conservation Division; the TECNET model; Stanford Research Institute; Committee on Nuclear and Alternative Energy Systems; Jack Faucett Associates; ERDA's Market Oriented Program Planning Study; U.S. Department of Transportation; Ford Energy Policy Project; the Wharton EFA Automobile Demand Model; and the Federal Aviation Administration.

Several models were used in producing forecasts.

S-57-413

REFERENCE

Chow, G.C., Demand for automobiles in the United States, North-Holland Publishing Co., Amsterdam, January 1957.

CONCERNING MODEL:

U.S. Automobile Demand Model

KEYWORDS

Automobile demand

PERFORMING ORGANIZATION

University of Chicago
Department of Economics
Research Group in Public Finance
Chicago, Ill.

ABSTRACT

The problem of demand for consumer durables is divided into two components: demand for total stock of durables at a point in time and the demand for new purchases per period of time to adjust to desired stock.

Two theories are proposed within this framework: the first theory accounts for services from durable goods, such as automobiles, to be components of an individual's consumption plan. The second hypothesizes that durable goods will be considered as assets as well as consumption expenditures. The two theories are modeled mathematically to determine desired stock.

These durable goods theories are used to examine empirically the demand for automobiles in the United States from 1921 to 1953. The first theory utilizes two concepts of income, disposable personal income and Milton Friedman's "expected income." Price elasticity and income elasticity are estimated in round figures at -1 and 2 respectively. When disposable income is used, a trend indicating a constant rate of increase at 1.5% per year in demand for total stock is found, although when expected income is used, this trend disappears.

The stock of money is used in a demand function consistent with the second theory. Price and income elasticities are estimated at about -1.5 and 1.5 respectively. Expected income is asserted to be the best variable for the demand functions, followed by the stock of money and personal disposable income.

A static theory of the demand for total stock of automobiles is

presented. Desired purchase during a period equals the difference between the desired stock at the end of the period and the depreciated old stock surviving from last period.

A more accurate dynamic model is presented using expected income, total stock, old stock, and disposable income as independent variables.

Two other studies of automobile demand are summarized. [Author's introduction modified]

S-57-413

REFERENCE

Chow, G.C., Statistical demand functions for automobiles and their use for forecasting, Amsterdam: North-Holland Publishing Co., May 1958.

CONCERNING MODEL:

U.S. Automobile Demand Model

KEYWORDS

Automobile demand

SPONSOR

Massachusetts Institute of Technology
School of Industrial Management
Cambridge, Mass.

ABSTRACT

This paper assesses the findings of Chow's earlier work, Demand for Automobiles in the United States, utilizing four years' additional data. The model is shown to make long-run forecasts indicating the effects of projected increases in per capita income and population on the demand for automobiles under the arbitrary assumption that relative price of automobiles is constant. The emphasis is on adjustment of existing stock rather than adjustment of desired stock as in long-term forecasting. The short-run model for purchase price is not very useful because it yields a large standard error.

The model and results from Chow's earlier study are also discussed. See the previous abstract.

REFERENCE

Annual report to congress 1978, three volumes, U.S. Department of Energy, Report no. DOE/EIA-0173/1,2,3, 1978.

CONCERNING MODEL:

Mid-term Energy Forecasting System (MEFS), Transportation Sector Model (a version of 75-004A), Faucett Automobile Sector Model (76-016), State level Transportation Energy Demand Model (78-263), Light Duty Vehicle Fleet Fuel Consumption Model (78-368), Short-Term Petroleum Product Demand Model (78-336), Long-Term Energy Analysis Program (LEAP) (77-286), and Dynamic Generalized Equilibrium Model (DGEM) (78-243)

KEYWORDS

Energy consumption

PERFORMING ORGANIZATION

U.S. Department of Energy
Energy Information Administration

ABSTRACT

One of the Energy Information Administration's tasks is to provide objective information about historical energy trends and to make disinterested projections of future trends. Volume I of this report describes the activities of energy data acquisition and interpretation, applied analysis, information validation, and provision of services. Volume II is a compendium of statistical series. Volume III is a compendium of forecasts of the U.S. energy system sources, conversion, distribution, and uses, and of the impacts of these on employment, regional economies, household expenditures, and air emissions. A section discusses energy use in the transportation sector.

The major tool used to produce forecasts is the Mid-term Energy Forecasting System (MEFS). Some of the models included in this system are: Transportation Sector Model (a version of 75-004A), Faucett Automobile Sector Model (76-016), State Level Transportation Energy Demand Model (78-263), Light Duty Vehicle Fleet Fuel Consumption Model (78-368), Short-Term Petroleum Product Demand Model (78-336), Long-Term Energy Analysis Program (LEAP) (77-286), and Dynamic Generalized Equilibrium Model (DGEM) (78-243).

S-79-468

REFERENCE

Mabrey, E., Applied analysis model summaries, technical report, U.S. Department of Energy, Report no. DOE/EIA-0183/6, May 1979.

CONCERNING MODEL:

Midterm Energy Forecasting System (S-78-419), Transportation Sector Model (known by other names, see 75-004A and 79-254), Automobile Sector Forecasting Model (76-016), State Level Transportation Energy Demand Model (78-263), Light Duty Vehicle Fleet Fuel Consumption Model (79-368), Long-term Energy Analysis Program (77-286), and Dynamic Generalized Equilibrium Model (78-243)

KEYWORDS

Energy consumption, national economic impact, model assessment

PERFORMING ORGANIZATION

U.S. Department of Energy
Energy Information Administration
Assistant Administrator for Applied Analysis
Office of Analysis Oversight and Access
Washington, D.C.

ABSTRACT

This report contains descriptions of 70 models used by the Energy Information Administration (EIA). Each model and its operation are described in a comprehensive and brief format, indicating its purpose, available documentation, and responsible EIA staff. The models are used for projecting and analyzing future flows of energy and energy products, their costs and prices, and the economic and other impacts in the future. The model results are published each year in the EIA's Annual Report to Congress and in other analyses. Some of the models described are the: Midterm Energy Forecasting System (S-78-419), Transportation Sector Model (known by other names, see 75-004A and 79-254), Automobile Sector Forecasting Model (76-016), State Level Transportation Energy Demand Model (78-263), Light Duty Vehicle Fleet Fuel Consumption Model (79-368), Long-term Energy Analysis Program (77-286), and Dynamic Generalized Equilibrium Model (78-243).

4.0 INDEXES

4.1 Model Name Index

4.2 Report Title Index

4.3 Keyword Index

4.4 Personal Author Index

4.5 Organizational Author Index

4.6 Sponsor Index

ABSTRACT

This is the first supplement to a volume that 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 generally describe some impact that is related to the motor vehicle transportation system 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, 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. Twenty-five subject areas are covered, including: automobile demand, fuel consumption and economy, air pollution, vehicle size-class market share, and vehicle miles traveled.