FEDERAL POLICY APPLICATIONS OF THE WHARTON EFA AUTOMOBILE DEMAND MODEL

FEDERAL POLICY APPLICATIONS OF THE WHARTON EFA AUTOMOBILE DEMAND MODEL

James H. Saalberg
Barbara C. Richardson
Kent B. Joscelyn

Policy Analysis Division
Highway Safety Research Institute
The University of Michigan

UMI RESEARCH PRESS

Published by UMI Research Press,
an imprint of University Microfilms
International, Ann Arbor, Michigan 48106.
Printed and bound in the United States
of America.

UM-HSRI-79-3

Library of Congress Cataloging in Publication Data

Saalberg, James H 1931-
Federal policy applications of the Wharton EFA
Automobile demand model.

(Transportation research, policy analysis studies)
Bibliography: p.
1. Automobile industry and trade—United States—
Mathematical models. 2. Motor vehicles—United States—
Mathematical models. 3. Supply and demand—Mathematical models. 4. Transportation and state—United States.
I. Richardson, Barbara C., 1947- joint author.
II. Joscelyn, Kent B., joint author. III. Title. IV. Series.

HD9710.U52S22 338.4'7'62922220973 79-23873
ISBN 0-8357-1082-3

ACKNOWLEDGMENTS

The efforts of many people were involved in completing this study and producing this report. Their assistance and cooperation are gratefully acknowledged.

This document is one of the work products of a more general study of the use of mathematical models. The general research design was developed by Kent B. Joscelyn and Barbara C. Richardson, the co-principal investigators of the project. Barbara C. Richardson and James H. Saalberg developed and the latter implemented the specific research approach that resulted in this report.

Other members of the HSRI Policy Analysis Division staff assisted in the collection and analysis of information for the report. These include: James M. Deimen, D. Henry Golomb, Murray Greyson, Michael M. Luckey, and Lawrence D. Segel. The latter four, along with Thomas C. Anderson, Ralph K. Jones, and Paul A. Ruschmann--as well as the co-principal investigators—reviewed and critiqued the text.

The report was produced under the supervision of Jacqueline B. Royal. Anne L. VanDerworp served as lead typist and was assisted by Deborah M. Dunne and Jackie L. Stadler. The report was edited by James E. Haney.

As is clear from the text, many persons provided information for this study. Particular thanks go to the personnel of the National Highway Traffic Safety Administration, the Office of Intermodal Transportation and the Transportation Systems Center of the U.S. Department of Transportation, the Department of Energy, the Office of Technology Assessment, the International Trade Commission, Mathtech, Inc., and Wharton Econometric Forecasting Associates, Inc.

Lawrence E. Slimak and Christian H. van Schayk of the Motor Vehicle Manufacturers Association (MVMA) provided useful comments and suggestions. Members during FY 1978 of the MVMA Ad Hoc Committee on Federal Simulation Models that served as an advisory committee for this project included Richard H. Shackson, chairman, Samuel M. Zentman, Jack H. Merritt, and James F. Marquardt. Alternate committee members were Neil E. South and Irene E. Szopo. In FY 1979 MVMA established a standing Federal Studies Committee, and the advisory function on this project was given to the new Subcommittee on Federal Simulation Models. The members of this subcommittee for FY 1979 have been Jack H. Merritt, chairman, Sol Drescher, Thomas H. Ronayne, and Neil E. South.

Without the cooperation provided by these individuals the study would not have been possible. While every attempt has been made to accurately report and interpret the information provided, the responsibility for any errors lies with the authors and not with the willing respondents.

Kent B. Joscelyn
Co-principal Investigator

Barbara C. Richardson
Co-principal Investigator

EXECUTIVE SUMMARY

This document reports applications of the Wharton EFA Automobile Demand Model by federal agencies in policy analyses related to the motor vehicle transportation system. It was prepared by staff of the Policy Analysis Division of The University of Michigan's Highway Safety Research Institute as part of a larger project entitled, "Analytical Study of Mathematical Models of the Motor Vehicle System."

The Wharton EFA Automobile Demand Model was developed by Wharton Econometric Forecasting Associates, Inc. for the U.S. Department of Transportation's Transportation Systems Center in 1976. It is one of the more prominent analytic tools that have been developed for use in policy analyses related to the motor vehicle transportation system.

The major objectives of this study were to identify the agencies that have used the Wharton EFA Automobile Demand Model, to determine what policy issues have been evaluated using it, to investigate how the model has been used, and to determine, to the extent possible, how effectively and appropriately the model has been applied.

A companion HSRI study has analyzed the model and is reported separately under the title, An Analysis of the Wharton EFA Automobile Demand Model. This analysis found much in the model that was innovative, but also documented significant weaknesses that limit its usefulness as a policy analysis tool. The model was found to reproduce trends in the total demand for automobiles, but did not reflect very accurately specific levels of demand. The model proved to be weak even in estimating trends of disaggregated demand by type of car. Its forecasts were found to be insufficiently sensitive to changes imposed from the outside, including the very policy changes it had been designed to evaluate.

The information for the present survey was assembled through personal contacts with the authors, sponsors, and users of the model and by

reviewing the relatively small body of written documentation covering policy applications of the model. Some sixty-five persons in twenty-nine federal agencies and nine nongovernmental consulting and research groups were contacted to determine where and how the model had been used. Most respondents were interviewed over the telephone. Personal meetings were also held at agencies where particularly significant work with the model was identified. The interviews and meetings concerned applications of the model from the spring of 1977 (the time of its first known uses) to March 1979.

The most significant findings are:

1. The Wharton EFA Automobile Demand Model has been used as a policy analysis tool by a number of key governmental units. The most frequent use has occurred in the Department of Transportation and particularly in the National Highway Traffic Safety Administration (NHTSA), the Office of Intermodal Transportation, and the Transportation Systems Center. Other agencies that have applied the model include the International Trade Commission (ITC) in studies for the Senate Finance Committee, the Environmental Protection Agency, the Congressional Office of Technology Assessment, the Council of Economic Advisors, and the Department of the Treasury.

2. A variety of major policies have been analyzed, the most prominent being policies related to energy issues. Specifically, the model has been used by several agencies to study the economic impact of proposed automobile fuel economy standards and of the "gas guzzler" tax proposals. Additionally, the model has been used to analyze the impact of vehicle safety proposals (such as passive restraints) and of vehicle emission control standards. It has also been used to study the potential market impact of battery-powered automobiles.

   It appears that the model output has influenced the formulation of policy in several instances. There is, however, a wide variance of opinion on just how important the role of the model has been in these specific applications.

3. The "uses of the model" ranged from actual operation of the model on a computer by policy analysts to the employment of selected output by policy analysts who did not have direct contact with the model. The most common mode was found to be use of model output without direct access to the model. This was the case even in such important applications as the NHTSA analysis of fuel economy standards and the ITC studies of gas guzzler tax proposals.

4. The limitations of the model have not been fully appreciated. Few analysts actually exercised the model directly or had time to study and become familiar with it in detail. Incomplete understanding of the model by analysts appears to have led to excessive reliance on or inadequately qualified prominence accorded to some results. This is particularly true of those that depend heavily on the forecast shares of the automobile market by car type or on the split between foreign and domestically produced shares of the market. Neither of these facets of the model functioned well in the early version of the model that was used in all but one of the applications examined. (The most recent known application involved use of a newer version of the model in which at least the foreign-domestic share equations have been made functional.)

5. The important issue of forecasting accuracy received very limited attention in the applications reviewed. For example, forecast differences in automotive sales of approximately two percent led to opposite conclusions in two of the studies included in this survey. The NHTSA study of fuel economy standards concluded that a difference of this size was insignificant, while results of similar magnitude from the ITC study of gas guzzler tax proposals apparently impressed the Senate Finance Committee as being significant. Without some measure of forecasting accuracy, there is little objective basis for judging which conclusion is more valid. In general, serious doubt about how to interpret the meaning of model forecasts correctly will remain until the problem of

measuring forecasting accuracy is solved and dealt with more explicitly.

The number and variety of applications of the Wharton EFA Automobile Demand Model identified in this survey are illustrative of the growing use of complex econometric models in federal policy analyses. The purported capability of this and similar models to approximate the complex relationships of real-world systems, to process large amounts of data, and to produce detailed forecasts of policy impacts is likely to increase reliance on this type of analytical tool by policymakers. In light of this, **the most important conclusion of this study is that policy analysts and decision-makers need to understand better the nature and limitations of the models they employ.** Only in this way can misuse of models be guarded against and the full potential of these analytical tools to enhance the policymaking process be realized.

CONTENTS

1.0 INTRODUCTION AND BACKGROUND

This report presents the results of a study by the Highway Safety Research Institute (HSRI) of The University of Michigan to investigate the use of the Wharton Econometric Forecasting Associates Automobile Demand Model (Schink and Loxley 1977) as a policy analysis tool by the federal government. The study was completed for the most part between February and June 1978, with a follow-up survey occurring in early 1979. It was part of a larger project sponsored by the Motor Vehicle Manufacturers Association: "Analytical Study of Mathematical Models of the Motor Vehicle System," initiated early in 1977.

The use of complex mathematical models to estimate, forecast, and evaluate the impacts of existing or proposed public policies has become common in recent years. Given the complexity of the real world, decision-makers face great difficulties in arriving at important policy decisions because many interrelated factors must be taken into account to produce a "best" solution. Mathematical models attempt to distill the significant relationships among various factors into a systematic and explicit reflection of the real world and to reduce large masses of data to key numbers and statistics. Because of this they have obvious attractions to policymakers.

One sector that has been the subject of extensive development of models is the motor vehicle transportation system. Models have been developed to assist in resolving a series of complex national issues involving the motor vehicle and the motor vehicle industry. These issues have included the development of a viable national transportation system, problems of highway safety and environmental pollution, and most recently the energy crisis. The extensive use of models in the Project Independence Evaluation System (PIES) studies (Jack Faucett Associates and Interagency Task Force on Energy Conservation 1974) and by the Federal Task Force on Motor Vehicle Goals Beyond 1980 (U.S. Department of Transportation 1976) to produce forecasts of automobile demand, vehicle miles traveled, and gasoline consumption are among the more notable examples of recent applications.

In 1975 the Department of Transportation (DOT) contracted with Wharton Econometric Forecasting Associates, Inc. to develop an econometric model of automobile demand that could be used by DOT in policy studies related to vehicle regulation. The first documented version of the model was reported to DOT in March 1977, and the first identified uses of it occurred in the spring of 1977. HSRI selected this model as the subject of its first examination of the application of large-scale econometric models of the motor vehicle transportation system because of its prominence.

In the remainder of this first section the background and objectives of the study are discussed, and a brief description of the model is presented. Section 2 describes the study approach. The results of the survey of applications are presented in Section 3. Section 4 presents the study conclusions. Appendix A is a list of references, and Appendix B contains a more complete description of the Wharton EFA model than is included in Section 1.3.

1.1 The HSRI "Analytical Study of Mathematical Models of the Motor Vehicle System"

Recognition that models are proliferating and that they are increasingly being applied to solve critical problems of national policy led the Highway Safety Research Institute in 1976 to initiate a preliminary inquiry into the use of models in federal policy formulation. This study identified approximately thirty models dealing with vehicle production and resource accounting, vehicle miles traveled, automobile sales and pricing, simulations of vehicle fleet attributes, and energy factors.

By the end of this inquiry it was apparent that the universe of relevant models related to the motor vehicle transportation system was considerably larger than was possible to encompass in the initial effort. Furthermore, the number of models was continuing to grow. Early consideration of how to evaluate models effectively led to the conclusion that it would be necessary to exercise or operate models if definitive conclusions about their capabilities and limitations were to be made.

The Motor Vehicle Manufacturers Association, recognizing the importance of this new type of policy analysis tool, agreed to sponsor a more extensive effort aimed at expanding the original inventory of models and undertaking detailed analyses of selected models. This larger study, entitled, "Analytical Study of Mathematical Models of the Motor Vehicle System," began in early 1977. By the end of June 1978, some seventy-eight models had been selected and summarized for inclusion in the first published version of the inventory of models related to the motor vehicle transportation system (Richardson et al. 1978).

The Wharton EFA Automobile Demand Model was chosen to be the first subject of a detailed analysis. This choice was made because the Wharton EFA model had gained the reputation of being a state-of-the-art analytic tool and because it was known to be in use for policy analysis purposes. The complete program of the model was obtained in July 1977 from the Transportation Systems Center of the U.S. Department of Transportation. An extensive study was undertaken of the conceptual, structural, and operational characteristics of the model, and the model was tested in actual operation. The report of this analysis is in preparation (Golomb et al. 1979).

In the course of research for the inventory and the early stages of the Wharton EFA model analysis, it became evident that a full examination of the model ought to include assembly of information on model applications and a critical evaluation of the ways in which the model was being used in policy formulation processes. In late 1977, plans were developed to parallel the technical analysis of the Wharton EFA model with an investigation of its applications in federal policy studies. Work was begun in February 1978 and was completed in March 1979. The present publication is the report of this applications study.

1.2 Objectives and Focus of the Wharton EFA Automobile Demand Model Policy Applications Study

The Wharton EFA model was created not as an academic exercise but for the specific purpose of providing federal policymakers with an advanced analytic tool for evaluating and aiding the formulation of important public policies. It was developed by Wharton Econometric Forecasting Associates, Inc., in 1975-1976 under a contract from the Transportation Systems Center, the research arm of the U.S. Department of Transportation (DOT). The first documented version of the model was reported to DOT in March 1977, and the model has been applied in a number of federal policy analyses since that time. The model is widely considered to be among the most advanced econometric tools available specifically for studies of the automobile sector of the economy.

The general objective of this applications study has been to determine where and how the Wharton EFA model has been used in studies related to national policy. The specific objectives have been: (1) to identify federal agencies that have used the model; (2) to determine which policy questions have been analyzed using the model; (3) to ascertain how the model has been used operationally; (4) to assemble information concerning the importance of the role that the model has played in policy formulation; and (5) to develop--to the extent possible--conclusions concerning whether the model has been used effectively and appropriately.

Because this investigation was planned as a first and exploratory effort, primary emphasis has been placed on developing as broad and comprehensive a picture as possible of the types of uses that have occurred and the policy issues that have been addressed. In-depth analysis of each use has been of secondary concern, although a number of details have been brought to light and are covered at appropriate points.

Two terms—"policy" and "model use"—need to be defined to clarify the focus of this investigation. The primary concern of this study is with public or governmental policy at the federal level, specifically those policies related to the motor vehicle and the vehicle manufacturing sector of the economy.

Federal policy is most concretely expressed in specific rules, regulations, legislation, or executive directives. Therefore, for practical purposes, the policy analyses that are focused upon are mostly those related to the formulation or evaluation of rules, regulations, legislation, or executive directives. The analyses may be conducted by the staff of a federal agency or by a nongovernmental research or consulting group under contract to a federal agency. The analyses may occur in the process of developing policy recommendations, or may be aimed at defining the policy and selecting among alternatives. Alternatively, they may be aimed only at providing support for or evaluating a previously selected policy.

Model use or application, as used in this report, refers to any use of the results of running a mathematical model in the course of an analysis or study related to the policy formulation process. The use may involve actual manipulation of the model by the analysts performing the study, or it may involve analysts using only selected results of the model which they excerpt from already existing output or reports prepared by others. As long as the model can be identified definitely as the source of the numbers that are used, an application of the model is considered to have occurred.

1.3 The Wharton EFA Automobile Demand Model: A Brief Overview

This section presents a brief summary description of the Wharton EFA Automobile Demand Model. As noted previously, Appendix B contains a more detailed introduction to the model. Those who would like to study the model in depth should see the Wharton EFA documentation volumes and the HSRI analysis report (Schink and Loxley 1977; Golomb et al. pending).

The Wharton EFA model is a large system of interrelated mathematical equations that forecasts long-term automobile demand. The initial version of the model contained almost 400 mathematical statements, involving over 600 variables. An expanded version is now being developed by Wharton EFA to include light trucks and vans as a separate market class, thereby permitting a more complete analysis of the motor vehicle population.

The major outputs of the model are forecasts of the size and composition of U.S. automobile demand (sales) and total stock, given projected vehicle characteristics and general economic and demographic conditions. Other significant outputs that may be derived with additional assumptions include forecasts of fuel consumption, industry employment, and tax revenues flowing directly from sales and vehicle operations.

Although the Wharton EFA model is complex and contains significant innovations, the basic theory underlying it is typical of that employed in automobile demand models constructed over the last twenty years. The central concept of the model is that the automobile market operates by a stock adjustment process. The basic assumption is that demand for a commodity such as automobiles can be calculated as the difference between a "desired" or target stock and the stock already in existence, taking into account scrappage, i.e., the need to replace old stock as it wears out.

Desired stock is the key concept in a stock adjustment model. It is defined as the long-run "steady state" or equilibrium number of units that would exist if all the factors that affect automobile demand, such as population characteristics, income, tax rates, and costs were held constant in the future, allowing any existing discrepancy between supply and demand to be resolved by normal market forces. The desired stock of automobiles and the desired shares within the total stock for each defined class of vehicles (five size classes in the initial version of the model) are the numbers of vehicles that would be in existence if the consuming public owned and operated all the automobiles it needed, wanted, and could pay for under prevailing price and income conditions.

Desired stock and desired shares by type of car are derived within the model from historically determined relationships between key demographic, household income, and vehicle cost variables, on the one hand, and the number of vehicles in operation on the other. Note that a fundamental assumption of this model and others like it is that the future will be essentially similar to the past. Specifically, the model assumes that the dominant economic, technological, and demographic factors or forces that have influenced automobile demand in the past will continue to do so in the future. It is also assumed that the relationships among these factors and automobile demand will remain basically the same. Only if these assumptions are largely true is the model valid. If these assumptions are incorrect, the model is likely to produce misleading or meaningless results.

The demographic variables in the Wharton EFA model include number of households and number of licensed drivers per household. Vehicle costs include both the costs of initial purchase and the stream of operating costs that occur over the average useful life of a vehicle. Without reference to any particular formulation, it appears reasonable that the public should want cars in numbers directly proportional to the actual or projected number of licensed drivers and to the ability to pay represented by income and inversely proportional to the cost of owning and operating a vehicle. Given the desired target and a number of vehicles already in being and subtracting out vehicles that are wearing out or being scrapped for other reasons (e.g., accident damage), the difference is intended to represent likely new car sales. Desired stock, however, in the Wharton EFA model, is fitted to data from a cross-section of states. This is an important weakness of the model because of the low state-to-state variation in price.

In simplest terms, the Wharton EFA model calculates new car sales as described above. Its complexities come from the fact that the system it is representing is exceedingly complicated. The relationships among the parts of the system are not simple, and many of the elements are highly interdependent.

1.4 The Wharton EFA Automobile Demand Model: Some Limitations

The Wharton EFA Automobile Demand Model, as it existed when all but one of the applications discussed in this report were investigated, had significant limitations that are discussed extensively in the HSRI analysis, and the interested reader is referred to that report.

It is not the purpose of this report to analyze these limitations, nor to comment on the validity of the uses of the model provided here. Three important limitations of the model are:

(1) The model operates with reasonable accuracy in simulating historic trends in total new car registrations, scrappage, and vehicle miles traveled, but it is much less accurate in tracking the specific levels of these variables. That is, the model can re-create increases, decreases,

and changes in direction of movement over the historical period, but is less successful in re-creating year-by-year figures. It is unlikely that the model will be more accurate in forecasting the unknown future than it does in "predicting" the past to which it was fitted.

(2) Focusing on the disaggregated forecasts, as distinguished from totals, the model is weak at accurately simulating even the historical trends, much less the levels, of the major segments of the market, especially the subcompact and compact shares of the market, two size classes that are of particular importance in the policy analyses considered in the present study. Further, as Wharton EFA itself notes in the model documentation, no workable way had been found to simulate the split between the foreign and domestically-produced shares of the market. In fact, the Wharton EFA modelers had to project these shares exogenously. The basis for these projections is, unfortunately, not explained. In sum, the HSRI analysis indicated that the disaggregated outputs of the 1977 version of the model should be used only with great caution, if at all.

(3) The final result to be noted here concerns the long-run insensitivity of the model. The HSRI analysts found that significant changes in exogenous variables such as income, car prices, and operating costs produced little or no effect on the new-car market after several years. Substantial near-term increases or decreases in sales rapidly balanced out to near zero. With respect to many of the potential components of change, such as gasoline, insurance, and maintenance costs, the HSRI analysts concluded such a result was reasonable. In the case of income, however, the analysts noted that the inelasticity of sales with respect to changes in consumer income was inconsistent with most previous work. This raises a question concerning whether the income factor had been properly interpreted in the model.

The limitations and characteristics of the Wharton EFA model cited above are clearly important in considering the use of the model in policy studies. It is also important to recognize that few of these attributes are easy to identify or to evaluate without a detailed examination or exposition of the model.

2.0 STUDY APPROACH

Several factors conditioned the approach followed in this study. First, because the primary objective was to find the maximum number of policy-oriented applications of the Wharton EFA Automobile Demand Model within the time available, emphasis was placed on covering as many agencies as possible. In-depth probing of details related to individual applications was accomplished as a secondary objective and only as time allowed.

Second, because the Wharton EFA model was of recent origin, relatively little about its applications could be expected to have surfaced in published literature or readily available reports. Furthermore, it was anticipated that some applications would be part of staff studies which often are summarized only in internal memoranda and are not reported in public documents. This was the basis for anticipating that most information would have to be gathered through personal contacts with the model authors, sponsors, or users.

Third, again because of the newness of the model, it was expected that users would not have become well known to each other; that is, a network of mutually aware users would not as yet be highly developed. Thus, any effort to identify users and gather information from them would have to involve extensive searching.

Finally, the time allotted for this initial investigation was relatively short. Given time and resource constraints, a formal questionnaire survey, which otherwise might have been an efficient method, was judged to be impractical.

The procedure followed to gather information for this report involved beginning with the known and branching out from that base. Several reports discussing early use of the model had been identified in the process of preparing for the detailed analysis of the model. These were reviewed. In addition, contact was made with the Department of

Transportation's Transportation Systems Center (TSC) in Cambridge, Massachusetts, which had funded development of the model. Wharton Econometric Forecasting Associates, Inc., the creators of the model, was contacted, as were several key people at the National Highway Traffic Safety Administration, where early application of the model was known to have occurred. On the basis of these early contacts and of staff estimates of where use of a model like the Wharton EFA one would be most likely to occur, an initial list of agencies and persons to be contacted was prepared.

An outline of questions to be used in gathering information was developed. These questions were not to be used rigidly; they were intended rather to serve as a guide to ensure that key points were covered. The general questions covered during contacts included the following:

1. What was the level of acquaintance the respondent had with the Wharton EFA Automobile Demand Model?
2. What uses, if any, had been made of the model in the respondent's agency, particularly in the area of policy analysis?
3. If the model had been used, what operational mode had been employed, e.g., actual running of the model, analyses of outputs received from a source outside the subject agency, or use of a preexisting report of model results?
4. How significant or important a role had model results played in reaching analytic conclusions related to policy development?
5. What, if any, were the planned or prospective uses of the model?

In addition to these questions, a request was made for written documentation of applications where these were identified. Several significant documents were found in this process. These were reviewed along with the written material already in hand.

The great majority of contacts to gather information were made by telephone. A lesser number of contacts took the form of in-person meetings. These were generally of a follow-up nature and were limited to individuals found to have had particularly significant experiences with the model. Several of the phone contacts were lengthy. In some cases they included two or three separate conversations totaling more than an hour of discussion concerning the model.

As noted above, the process of gathering information started with an initial list of agencies and persons identified in early model-analysis research. During each contact, respondents were asked specifically to identify other agencies or individuals whom they considered worthwhile to query because they were known by the respondent to have used the Wharton EFA model, were known to be interested in models of this type, or were likely to know of others who were using the Wharton EFA or similar models.

Time constraints caused a cut-off to be imposed. However, toward the end of the process, most respondents were referring back to others who had already been contacted. This fact provides some reasonable basis for concluding that most of the significant users and uses of the Wharton EFA model had been identified.

Except for preliminary contacts made as early as July 1977, information for this study was gathered for the most part in the period February through June 1978. A brief updating survey was conducted in early 1979. Sixty-five persons in twenty-nine federal agencies and nine nongovernmental consulting and research groups were contacted. Table 2-1 presents a list of the organizations contacted.

Several limitations of the study need to be noted. First, because of time constraints, it was not possible to explore any application of the model in great depth. Respondents were generally cooperative and forthright with both facts and opinions about applications of the model. There was insufficient time, however, to do much cross-checking of viewpoints. Nor was there time to trace the flow of reports and recommendations based on the model's output through various stages and levels of the policy-formulating process.

A second limitation is that heavy reliance had to be placed on

TABLE 2-1

ORGANIZATIONS CONTACTED

Federal Governmental Contacts

The Congress
- Congressional Budget Office
- Congressional Research Service
- Joint Congressional Committee on Internal Revenue and Taxation
- Office of Technology Assessment (2)*
- Senate Finance Committee

Council of Economic Advisors

Department of Commerce
- Bureau of Domestic Advisors
- Bureau of Economic Analysis (3)
- Office of the Chief Economist
- Transportation and Capital Equipment Division, Bureau of Domestic Business Development

Department of Energy
- Energy Division, Oak Ridge National Laboratories
- Energy Information Administration
- Office of Conservation and Solar Applications (2)
- Office of Energy Research
- Office of Policy and Evaluation (2)*

Department of Transportation
- Federal Aviation Administration
- Federal Railway Administration
- National Highway Traffic Safety Administration (9)*
- Office of Intermodal Transportation (6)
- Transportation Systems Center (4)*
- Urban Mass Transportation Administration

Department of the Treasury (2)

Environmental Protection Agency
- Motor Vehicle Emissions Laboratory (5)
- Noise Abatement Office
- Office of Economic Analysis
- Office of Mobile Source Air Pollution Control

Research Center, North Carolina

General Accounting Office (2)

International Trade Commission (2)*

Other Contacts

Energy and Environmental Analysis, Inc.

Massachusetts Institute of Technology Energy Laboratory

Mathtech, Inc.

Michigan Energy and Resource Research Association

Operations Research, Inc.

Purdue University

SRI International, Inc.

Technology and Economics, Inc.

Wharton Econometric Forecasting Associates, Inc.*

Numbers in parentheses indicate number of individuals contacted if more than one within the organization.

Asterisks (*) indicate in-person visits; all other agencies contacted only by telephone.

respondents' memories. In some cases documentation of the results of analyses was found in formalized reports that had been published or were made available. Even where documents were found, however, relatively few details were usually provided about exactly how the model was used. The path from model output to conclusions was most often not clear, and information on final policy results and the significance of model outputs in achieving these results were not covered.

A third limitation is that the Wharton EFA model had been operational only since early 1977. While there had been time for some uses to be publicized, there was insufficient time for information about all significant uses to become widely known. Similarly, as had been anticipated, a network of mutually aware professionals with a technical interest in the model had not been fully developed. The existence of such networks increases the probability that all the significant uses of a new technology will be identified once one or two important users have been located. That this had not yet happened with the Wharton EFA model meant that more time had to be spent in search activity to minimize chances of missing significant uses.

The final limitation is that the Wharton EFA model is still a new analytic tool, and a certain amount of controversy surrounds its use. In some instances those most directly involved in the first round of analysis and development of policy recommendations were reluctant to accord much influence to model results in the shaping of decisions. The validity of these stated low estimates is questionable, given the prominence of model results in available written documents covering these same applications. Possibly the somewhat controversial nature of the new model may have led some respondents to be guarded in their comments and opinions.

3.0 APPLICATIONS OF THE WHARTON EFA AUTOMOBILE DEMAND MODEL

This section summarizes information assembled during this study on uses of the Wharton EFA Automobile Demand Model. Table 3-1 lists the agencies and the policy issues that have been studied using the model and provides an overview of applications. In the following subsections each identified user agency is discussed in turn.

3.1 Department of Transportation (DOT)

Among the agencies surveyed, the greatest single number of applications of the Wharton EFA model were found within the Department of Transportation (DOT). This result is not surprising, inasmuch as development of the model was funded by DOT's Transportation Systems Center for the specific purpose of providing the department with a means of assessing and forecasting the most significant long-run economic impacts of changes in government policy relative to the automobile and the automotive industry.

It is also no surprise that the most numerous and best-documented uses in DOT (and, indeed, in other agencies) have related to fuel conservation and energy policy, because the model was developed to assist DOT to establish automotive fuel economy standards required by the Energy Policy and Conservation Act of 1975. However, the model can be used to test major auto-related economic impacts of any policy proposal that can be translated into cost or price terms or fuel efficiency (miles per gallon) numbers. Thus, while uses related to fuel economy have been predominant in DOT, applications related to safety standards have also occurred.

Four constituent agencies within DOT account for all identified uses: the National Highway Traffic Safety Administration, the Office of Intermodal Transportation within the office of the Assistant Secretary for

TABLE 3-1

AGENCIES USING WHARTON EFA MODEL AND POLICY ISSUES ANALYZED

Agency	Policy Issues
National Highway Traffic Safety Administration	1981-84 fuel economy standards Gasoline tax proposal Gas guzzler tax Passive restraint
Office of Intermodal Transportation	1981-84 fuel economy standards Gasoline tax proposal Passive restraint 55 mph speed limit
Transportation Systems Center	Electric car
Federal Railway Administration	Gasoline Price Increase Affect AMTRAK Travel
Senate Finance Committee/ International Trade Commission	Gas guzzler tax
Office of Technology Assessment/SRI International, Inc.	Future of the automobile
Electric Power Research Institute/Mathtech, Inc.	Electric car
Environmental Protection Agency	Vehicle emission standards
Department of Energy	Advanced vehicle power plants
Council of Economic Advisors	President's energy program
Department of the Treasury	Gasoline tax proposal

Policy and International Affairs, the Transportation Systems Center, and the Federal Railway Administration.

3.1.1 National Highway Traffic Safety Administration (NHTSA). The most prominent application of the Wharton EFA model made by NHTSA during the period of this study related to establishment of the 1981-1984 passenger automobile fuel economy standards. The Energy Policy and Conservation Act of 1975 (EPCA) required mandatory fuel economy standards to be met by automobiles manufacturered in the United States or imported into this country. Congress set specific standards through 1980 and for 1985, but left to the discretion of the Secretary of Transportation the exact level of standards for the years 1981 through 1984.

The standard for a given year refers to the average fuel economy of all automobiles produced by each manufacturer in that year. The law requires penalties to be assessed against any company if the average miles per gallon for all cars produced by that company for U.S. consumption in any model year falls below the standard for that year by a tenth of a gallon or more. The penalty is $5.00 for each tenth of a mile per gallon for every car produced by the company, regardless of whether a particular car does or does not meet the standard. A credit of $5.00 per car per tenth of a mile per gallon is allowed for a year in which a company's average miles per gallon exceeds that year's standard. The credit may be balanced against penalties. The target 1985 standard is 27.5 miles per gallon. The 1981-1984 standards were to be set so this target could be reached in smooth steps within the bounds of "technological feasibility," "economic practicability," and the need to conserve energy.

The Secretary of Transportation was required under EPCA to set the 1981-1984 fuel economy standard no later than July 1, 1977. The setting of these standards obviously involved, among other things, estimating what costs would be added to new car prices, what the impact on sales would be, what average fuel economy (mpg) would likely result for each company, and what overall fuel conservation would occur.

Because the standards set in 1977 were of great significance and because of the various hearing and noticing requirements, considerable documentation exists to explain how the standards were selected and to support the decision made by the secretary. The most relevant documents are cited in the references listed in Appendix A.

Even a cursory perusal of the documents supporting the 1981-1984 standards substantiates the assertion by NHTSA staff that an enormous amount of data and analysis was involved in the rule-making process and that, in terms of the total effort, the Wharton EFA model occupied a relatively small part. The development of technological information, cost data, information concerning manufacturing feasibility, and data on probable fuel economy by car type, for example, did not involve the Wharton EFA model. In fact, all of these analyses had to be in place before the model could be used.

The same documents, however, do make it evident that the model was relied upon to produce key estimates of economic impacts. The documents also show that alternate sets of standards were run through the model, although it is not determinable either from these documents or from conversations with NHTSA staff to what degree the analyses derived from the model influenced the final selection.

In particular, the model was exercised to develop forecasts of new car sales and sales by type of car for each year, 1981-1984. Additionally, the model produced estimates of the average fuel efficiencies that would be achieved, given the number and mix of cars in the forecasts. Together these outputs were intended to make it possible to estimate how sales would be affected by the proposed standards and various alternates. These impacts were measured against what would occur under a "baseline" case in which no stringent fuel economy standards were imposed.

Having developed sales estimates and comparisons against a baseline case, it was possible to derive estimates of impacts on employment, auto tax revenues, and foreign trade. The sales plus scrappage estimates permitted estimates of overall fuel savings. All of these impact estimates were relevant both to determining a "best" set of yearly standards and to providing an explicit justification for the promulgated standards.

To illustrate the character of the predictions derived from the Wharton EFA model, the NHTSA impact analysis forecast, on the basis of model runs, that imposition of the proposed standards would cause a decrease of 210,000 in sales of new cars by the 1984 model year. This short-fall represented 1.8 percent of the 1984 total sales forecast to occur if no new standards were imposed. NHTSA also forecast a decline of 47 billion gallons of gasoline over the ten-year lifetime of the cars sold in this period, representing a twenty percent savings in fuel. This estimate was based on the forecast mix of cars to be produced and sold. It is obvious that the modest decline in sales and the substantial saving of gasoline as projected by the model were important underpinnings to the arguments for the standards.

Apart from the fuel economy standards, NHTSA has used the Wharton EFA model in studies of at least three other policy issues. None of these have been documented in writing, so that little can be said about them in detail. Two of the applications involved energy-related matters. The model was employed to study the impacts of the president's proposed gasoline tax and the various versions of the "gas guzzler" tax on fuel-inefficient automobiles. Details of the gas guzzler tax proposals are outlined in Section 3.2, where the well-documented International Trade Commission study of alternatives for the Senate Finance Committee is reported. The gasoline tax proposal, which was killed early in the Congressional consideration of the energy plan, called for a tax increase of five cents per gallon in any year when national consumption exceeded a targeted conservation level.

Both the gasoline tax and gas guzzler vehicle tax proposals translate readily into changes in car prices or operating costs. This would enable the Wharton EFA model to be applied to study impacts on sales, overall fuel consumption, employment, and the like. In the case of the gas tax proposal, the model could also be used to forecast fuel consumption and, therefore, to indicate when the additional tax would be triggered.

The final NHTSA use identified was in the safety area, in a study of the impact of introducing the passive restraint air bag. The cost of the air bag system, once determined, can be fed into the model as an automobile price increase, with the model then generating sales and other impact changes. Of note is that this application is one within NHTSA where it was specifically reported that another model, the Faucett Automobile Sector Forecasting Model (Difiglio 1976), was used concurrently, to provide a cross-checking of forecasts.

In none of the above applications was the model run by NHTSA personnel. According to staff reports, the actual runs of the model took place at the Transportation Systems Center in Cambridge, Massachusetts, and were performed by Center staff. No remote terminal capability to run the model was put in place at NHTSA in Washington, although this was technically feasible. NHTSA staff indicate that remote capability is to be introduced at NHTSA and plans exist to train agency staff to run the model.

The lack of in-house capability to run the model is significant. When an analyst has to depend upon others to run the model, this limits his opportunity to experiment with it and to gain an understanding of how the model works. A thorough understanding of the model, based on detailed study of its structure and sufficient experimentation, is crucial to valid interpretation of its outputs. However, NHTSA staff reported that the pressures of work had made it impossible for them to undertake such an analysis.

Lack of direct contact with the model or of a detailed analytic investigation of its workings by the analysts using Wharton EFA model results is a circumstance that will be noted repeatedly in the descriptions of applications by other agencies. In exceptional instances this was not the case.

It was difficult to determine what weight was given to the Wharton EFA model results, relative to the many other factors taken into account in the various analyses. Agency staff stated that to date the model has influenced rulemaking and other policy decisions in only a minor way. However, only in the case of the 1981-1984 fuel economy standards is written documentation available to provide some objective check on the validity of this report. It is possible that model output was not considered important in the selection of the standards, as has been asserted. From the documentation, however, it seems reasonably clear that model output—in particular, forecasts of sales and derived estimates of fuel consumption--provided prominent supporting justification for the standards that were selected. Therefore, it seems fair to conclude that the use of the model in this instance was important in the policy-making process.

With respect to the appropriateness and effectiveness of the way NHTSA used the model, certainly it was used to analyze issue questions within its capacity to produce relevant predictions. Whether the model was used most effectively, however, may be questioned. The NHTSA staff apparently did not have a deep understanding of the model's workings. This may account for the reluctance of NHTSA staff to admit that much weight was attached to model results, despite the apparent prominence of outputs in such documentation as exists.

Finally, a question needs to be raised concerning how the inherent uncertainties of the model outputs were dealt with. This matter is of general concern and will be noted in a number of other instances below.

It seems clear that NHTSA staff were and are aware that the Wharton EFA model is only an approximation of reality and that its forecasts have a degree of uncertainty associated with them. The uncertainty inherent in the forecasts is referred to at several points in the documentation for the fuel economy standards. However, these references are general and brief. There is no quantification of ranges of estimate within which forecast numbers might be expected to fall under the principles of statistical probability. Such ranges (or confidence bands) are difficult to establish because of the mathematical complexity of the model. Nevertheless, because the arguments in support of one set of standards over another at times rely on differences as small as a few tenths of a percent, the question of how accurate the forecast numbers are is important.

One example of a troublesome conclusion is the NHTSA statement concerning the estimated impact of fuel economy standards on automobile sales. Using the Wharton EFA model, NHTSA forecast that the 1984 standard of twenty-seven miles per gallon would lead to 210,000 fewer new car sales than if the 1980 standard of 20 miles per gallon were maintained. This difference was 1.8 percent of forecast 1984 sales. NHTSA labeled this difference as "insignificant, given the difficulties of projecting the sales initially" (NHTSA 1977b). Without some measure of the statistical variability of the forecast, there is no objective basis for determining the correctness of the conclusion.

The question of forecasting accuracy is clearly important, because on it turns the judgment whether key differences are sufficiently meaningful (i.e., significantly different from zero in the statistical sense) so that they consistute a valid basis for formulating decisions. It is likely that most of the policymakers who reviewed the fuel economy standards documents and made decisions based on them were limited in their knowledge of mathematical models and statistics. These individuals would have been able to assess the modeling results better if the question of the uncertainty of the forecasts had been handled more explicitly. Failure to deal sufficiently with the question of accuracy has been a serious weakness of this and many other applications of complex models.

3.1.2 Office of Intermodal Transportation (OIT). The Office of Intermodal Transportation is within the Office of the Assistant Secretary for Policy and International Affairs. Two OIT functions are to perform analyses of proposed policy actions for the top administration of DOT and to check on major analyses, such as policy impact studies, performed by constituent agencies of the department. These analytic functions are largely the responsibility of the Division of Forecasting and Evaluation within OIT.

For some time energy policy considerations have dominated OIT's analytic work. It is therefore not surprising that the Wharton EFA model was used a number of times. Because the work of OIT is generally for internal consumption, no written documentation of analyses employing the model or its output is available. All the information presented here is based on information provided by OIT staff.

Four specific applications and two attempted applications of the Wharton EFA model were identified by OIT respondents. OIT analysts ran the model to check the NHTSA impact analysis of the 1981-1984 fuel economy standards described in the previous subsection. The model was also used to study the probable economic and fuel consumption effects of the president's proposed gasoline tax and the gas guzzler tax. Finally, the economic impact of the passive restraint air bag system was analyzed using the Wharton EFA model. In this last case the model was reported to have been particularly useful, since it is designed to allow for explicit integration of projected insurance savings, a capability not handled as well in other available models.

The two unsucessful attempts to use the model involved evaluations of the fifty-five mile per hour speed limit and the pending fuel economy standards for lightweight trucks and vans. The speed limit analysis was dropped because it was impossible to determine a supportable relationship between aggregate vehicle miles traveled and fuel efficiency (i.e., miles per gallon) or to differentiate fuel economy achieved from lowering the speed limit, reduction in travel, and vehicle fuel efficiency improvements. The light truck and van analysis was outside the explicit capabilities of the current Wharton EFA model, and the attempt to assume similarity between the automobile sales and the sales of trucks and vans proved to be questionable.

With respect to the mode of operation, the OIT analysts, like those in NHTSA, did not manipulate the Wharton EFA model directly; they were supplied with output from the Transportation Systems Center. Thus they operated with the same constraints on flexibility of use as did the NHTSA analysts. The OIT staff apparently had considerable understanding of the general workings and key characteristics of the model but, as with NHTSA, they had not studied it in detail prior to using it.

What is particularly notable about the OIT applications is that in most instances the Wharton EFA model was used along with two other models: the Faucett model (Difiglio and Kulash 1976) and the Automotive Fleet Fuel Consumption model (Horton 1977). Parallel forecasts were produced from the three models, even though the staff believed that the Wharton EFA model was, in general, the most valid model. Their explicit purpose was to deal with the uncertainty inherent in all the models. Such parallel applications allowed for cross-checking of results. The divergent forecasts that resulted from the several models were also used to provide some sense of a likely range of estimation. The procedure thus provided some protection against the pitfall of using a single-point estimate of undetermined accuracy.

No information is available about exactly how OIT analyses were employed in specific policy formulation processes. It was reported that the Wharton EFA model was the preferred model to employ and that OIT analyses are drawn upon by the DOT secretary's office in the preparation of policy statements and decisions. It is known that OIT acts as a cross-check on significant analyses performed by other parts of DOT. Therefore, it is reasonable to conclude that the Wharton EFA model has had a reasonably direct role of some significance at this high administrative level within DOT. In what specific ways and to exactly how great a degree could not be determined on the basis of the information available.

Turning to a consideration of the appropriateness and effectiveness of OIT applications, apparently there were attempts to apply the Wharton EFA model in situations beyond its capabilities, as in the light truck and van study and the attempt to evaluate the fifty-five mile per hour speed limit. This may have been done as a result of an erroneous assumption concerning the capabilities of the model. However, one respondent indicated that it was done because an attempt with little chance of success was considered to be better than no attempt at all.

3.1.3 Transportation Systems Center (TSC). The Transportation Systems Center (TSC) sponsored and funded the original development of the Wharton EFA model. It has continued to support Wharton EFA in work currently aimed at improving weaker parts of the model and modifying the model to include light trucks and vans. TSC has recently approved the first federally sponsored in-depth evaluation of automotive demand models. Although the exact content of this study is not yet known, it is certain to include the Wharton EFA model. Finally, during the time period covered by this study, TSC was the major operator of the model for other parts of DOT, providing them with outputs on request.

None of this can be classified, strictly speaking, as model application. Only one instance of direct TSC use of the model for analytic purposes was identified. In this case the model was not run at TSC, but was run by a TSC contractor at its own facility. Given that TSC does engage in research, both in-house and through contractors, it is doubtful that all TSC applications of the Wharton EFA model have been identified. It is unfortunate that more examples of Wharton EFA model use were not identified in TSC, because it appears that the analysts with the greatest knowledge of the model in the federal government are on the TSC staff.

The single identified application directly linked to TSC was an extension of an analytic study conducted by a private research firm for a nongovernmental customer. The study was done by Mathtech, Inc. for the Electric Power Research Institute (EPRI). It involved developing a forecast of the potential impact that introduction of electric vehicles would have on the demand for utility-generated electric power. This study is discussed more fully in Section 3.4.

The work Mathtech performed for TSC involved taking the Wharton EFA model as modified for the EPRI study and running it under a set of vehicle operating characteristics and cost assumptions specified by TSC to forecast the demand for electric battery-powered vehicles under normal market conditions and under ten different types and combinations of subsidies. Because of the constraints imposed by TSC in terms of limitations on vehicle range and high cost relative to traditional automobiles, very limited demand for electric vehicles was forecast through the end of the century without a major subsidy being provided.

This result was at considerable variance with the result produced in the analysis that Mathtech performed for EPRI. The TSC forecast was for 279,000 electric vehicles in operation by 1995 without subsidy. The most pessimistic 1995 forecast in the EPRI study was for 4.2 million vehicles. In the EPRI analysis, electric vehicle operating characteristics and costs were calculated from a special design submodel. This led to a less conservative and constrained composite picture of battery-operated vehicles than the single characterization imposed on the model in the TSC analysis (Marfisi et al. 1977; Upton and Agnew 1977).

The study is an example of the potential adaptability and versatility of a model like the Wharton EFA Automobile Demand Model. The model itself was modified and expanded to incorporate a new class of vehicle. Moreover, an extensive variety of policy alternatives was studied in a short amount of time (about a month) and at relatively low cost.

This application also illustrates the general truth that the results of any use of a model must be read with careful attention paid to the assumptions and constraints imposed on the input side. In this instance application of the model produced results that led to estimates of the future for electric vehicles quite dissimilar from those of a seemingly similar study. This occurred because the key characteristics of the vehicle were defined differently in the two studies. Judgment as to which estimate is more valid must depend largely on which input specifications for the vehicle are more credible.

3.1.4 Federal Railway Administration (FRA). During February 1979 the Federal Railway Administration sought information from the Transportation Systems Center concerning the impact an increase in gasoline prices might have on reducing travel by car and diverting this to AMTRAK. TSC used the latest version of the Wharton EFA model, the Mark II, to forecast how much vehicle miles of travel would decline if gasoline prices were increased by fifty cents a gallon, roughly seventy percent above the 1977 average price. This application of the model is the most recent known use and the only one that has employed the Mark II.

This use of the model is a good example of both the utility and limitations of the model. TSC was able to provide FRA with a forecast that total vehicle miles of travel would decline by between nine and eleven percent on a year-to-year basis under the pessimistic scenario it used. It could not project how many of these miles would be diverted to AMTRAK because the Wharton EFA model does not have the capability to generate such modal split data. Therefore, the question of how such a drop would affect AMTRAK could not be answered directly by use of the model.

3.2 Senate Finance Committee/International Trade Commission (ITC)

This use of the Wharton EFA model to analyze proposed energy-related legislation represents one of the most interesting cases of application to date. This is so first because it was possible to gather significant information on the process that led to the selection of the Wharton EFA model. Second, the documentation of the analysis was published by the Senate Finance Committee, is readily available, and is well reported (U.S. International Trade Commission 1977a,b). Finally, it was possible to assemble some credible, if conflicting, opinion on the impact of the analysis on the opinions of members of this powerful Congressional committee relative to an important part of the president's energy program.

In April 1977, President Carter proposed to the Congress his comprehensive National Energy Act, intended to begin implementation of a long-term energy policy for this country. One of the significant parts of the president's bill was the Fuel Efficiency Incentive Tax Proposal. In general, this proposal called for a schedule of manufacturers' excise taxes to be levied on sales of new automobiles and other light-duty vehicles that failed to meet established fuel economy standards. The taxes would be graduated according to how much the fuel economy of a vehicle fell below the standards established by the Department of Transportation under existing legislation. The trigger level at which the taxes would be imposed would increase each year as the miles per gallon standard rose.

Balancing the penalty of taxation, the president proposed a system of rebates to be paid from the general treasury to manufacturers for passenger automobiles and other light duty vehicles that exceeded the applicable standard each year. Manufacturers would be required to pass the rebates on to the ultimate purchasers of the vehicles. The rebates would also be graduated, in this case according to how much the applicable standard was surpassed.

Both taxes and rebates could be substantial. For 1978 the proposed tax would start at $52 for cars achieving less than 18 miles per gallon and increase to $449 for cars giving less than 13 miles per gallon. The rebate would be $47 at 19-20 miles per gallon and rise to $473 for cars giving 38 or more miles per gallon. By 1985 the maximum tax would rise to $2,488 at less than 12.5 miles per gallon, and the maximum rebate would be $473 at 38.5 miles per gallon or more. The president's plan thus constituted a significant "carrot and stick" method to induce the production and sale of more fuel-efficient vehicles.

In August 1977, the House of Representatives, in passing the amended version of the president's energy bill, substituted what became known as the Gas Guzzler Tax proposal for the president's tax/rebate incentive plan. The main difference between the two plans was that the House version dropped the rebates and kept only the taxes. The tax proposals were similar in concept and differed mainly in details. For example, the House bill would impose taxes beginning in 1979 rather than in 1978 as proposed by the president. The House also shifted downward the minimum trigger level of miles per gallon at which taxes would begin. In 1985 the House bill would impose taxes only below fifteen miles per gallon, whereas the fuel economy standard that would trigger the president's taxes and rebates in that year would be nineteen miles per gallon. Balancing somewhat the greater leniency of these provisions, the House version called for generally higher tax levels.

Faced with the two proposals, the Senate Finance Committee asked the International Trade Commission to provide a comparative analysis of the likely economic and fuel consumption effects of the alternatives. A major reason for selecting the ITC to do the analysis was that both schemes would apply to vehicles of foreign as well as domestic manufacture. Given the fact that foreign cars were dominantly small and already fuel efficient, a major concern was whether sales would be shifted significantly toward foreign manufacturers to the detriment of domestic companies and employment.

Because one purpose of the analysis was to compare the House and presidential proposals, the ITC dealt with the president's plan by studying the impact in two ways. It analyzed both the combined tax/rebate scheme and the tax portion alone, this latter being a close parallel to the House version.

Summarizing the results, the ITC analysis projected a loss in total 1985 sales of 30,000 units under the president's tax/rebate scheme and 40,000 under his tax scheme considered alone. This was based on forecast total sales of fourteen million units. The House scheme was forecast to have no significant overall sales impact relative to the "baseline" or nontax sales projection.

While the aggregate sales impacts of even the president's scheme were forecast to be small, the domestic to foreign shifts were greater. The president's combined tax and rebate scheme was projected to shift approximately 300,000 units from domestic (United States/Canadian) to foreign manufacturers, while his tax scheme considered alone was projected to lower domestic sales by 140,000 and increase foreign sales by 100,000. In contrast, forecasts of the House plan indicated 300,000 more domestic units and 200,000 fewer foreign would be sold than under the president's tax/rebate plan in 1985.

In terms of employment, the ITC analysis forecast 21,000 automotive jobs lost during 1985 if the tax/rebate scheme were implemented and 9,000 lost if the president's tax plan went into effect without the rebates. The House scheme was projected to have a negative employment impact of only 2,000 jobs.

Finally, with respect to fuel economy, the ITC analysis concluded that the House plan would be less effective in deterring demand for fuel-inefficient automobiles. However, it also concluded that the tax/rebate scheme "would not contribute meaningfully to the domestic industry's ability to meet the fuel economy standards" (U.S. International Trade Commission 1977a, p. 6). Neither proposal, therefore, was foreseen as promoting the goal of achieving significantly lower fuel consumption.

The central analytic tool used by the ITC staff in this study was the Wharton EFA model. The model was used to project automotive sales, product mix, and retail prices of vehicles. Although the model produces no direct forecast of employment, the ITC analysts used projections of sales in combination with a well-established worker-to-vehicle production ratio to generate estimates of domestic employment. Differences in the forecast of these factors among the alternatives studied and the baseline case were the focus of the ITC evaluation. It is fair to say, therefore, that the Wharton EFA model played a central role in this policy-related study.

The ITC approached the selection of the Wharton EFA model with considerable care. The economist leading the study reviewed the significant available models, including those developed by Jack Faucett Associates; Charles River Associates; Data Resources, Inc.; and Chase Econometrics, and he read the three volumes of Wharton EFA documentation. Concerning his study of the Wharton EFA model, this economist reported that, as in most other analyses discussed in this report, no in-depth study of the logic and structure of the model was made, largely because of time constraints. Thus, even in this instance where considerable care was taken in selecting the Wharton EFA model as an analytic tool, the analyst involved was not completely informed about the detailed workings of the model. He did, however, gather opinion and recommendations from some thirty different sources, including other users of the model and automotive company economists. His selection of the Wharton EFA model was based on his own study, the weight of recommendations, the availability of the model, and the relative cost of using it.

Operationally, the runs of the model for the ITC study were done by Wharton EFA itself, so that in this case also the analysts did not work directly with the model. The ITC analysts did not employ the normal procedure of having required forecasts of general economic trends including employment, gross national product, gas price levels, and disposable personal income (i.e., exogenous variables) fed into the automotive demand model from a run of the Wharton Macroeconomic Model or some similar aggregate econometric tool. Instead, the ITC analysts provided their own set of entry or exogenously determined values. This procedure requires care and economic skill, since these exogenous variables are functionally interrelated (e.g., growth of GNP is associated with changes in employment levels). Any set of values used for these exogenous variables must be internally consistent, or forecasts produced by the model will not be meaningful.

The central role of the model in the analytic process has already been noted. However, more can be said about the significance of the application in this case. Two quite different opinions of the impact of the study were expressed by respondents in this study. The ITC staff were of the opinion that the results of their analysis had little impact on the Senate Finance Committee. From their several observations of committee debate, they concluded that the members' positions had been fixed from the start of the hearings, and no amount of analysis was going to change votes.

The committee staff person who worked with the ITC had an opposite view. He contended that the majority of the committee was inclined to favor some kind of gas guzzler tax proposal at the start, but that the ITC analysis was greatly instrumental in shifting sentiment to the negative. The study indicated to the committee, he said, that both the presidential and the House proposals would do little to foster fuel economy, while both would cost at least some automotive jobs, shift sales to foreign manufacturers, and add another tax that was likely to anger voters.

If one places more weight on the opinion of someone who was in close and continuing contact with the committee, then there is evidence in this case that an analysis based predominantly on Wharton EFA model output had a noticeable impact in a major policy formulating process, at least in the early stages of consideration.

Given evidence that use of the Wharton EFA model in this application led to a significant impact, the question of how effectively and appropriately the model was employed is of particular relevance. It has already been noted that the model was studied with some care, although not in great depth, by the ITC staff. It has also been noted that the staff did not run the model themselves. The comments made in previous cases with respect to the limited understanding and the loss of flexibility these circumstances produce are also applicable in this instance.

The ITC staff was careful in specifying their particular assumptions. They also warned explicitly that the projections produced by the model could not be read as being exact. The following quote is exemplary, and stands as a good example of the least that ought to be said in all reports incorporating model results, given the present state of the art:

> As in the use of any econometric model which attempts to project the future, there may be a significant margin of error inherent in estimating the impacts of the House proposal and the Administration proposal on the future U.S. passenger automobile industry. While a uniform methodology was applied to the Commission's projections, in certain cases the margin of error may be as great as the projected differences between the impacts of both proposals. (U.S. International Trade Commission 1977b, p. 3.)

Having made the point about the "inherent errors" of estimates, the report nevertheless focuses on differences which sometimes appear large in terms of absolute numbers, but are very small in percentage terms. For instance, the estimate that in 1985 the House proposal would cause 300,000 more domestically produced vehicles to be sold than the president's plan actually amounts to a difference between the two projections that is only slightly more than two percent of total estimated sales. How meaningful the two percent difference actually is cannot be evaluated with any accuracy, because no range or error of estimate is provided. That is, this apparent difference may not be sufficiently different from zero in statistical terms because of the errors of estimate in the two forecasts. If this were so, no firm conclusion could be based on the difference.

It is notable that in this case a two percent difference was apparently viewed as significant by the policymakers involved. Yet in the NHTSA study of fuel economy standards discussed previously, a difference in forecast sales of about the same size was judged to be insignificant. Without some measure of variability, there is little objective basis for determining the significance of either difference. The conclusions drawn depend primarily on the point of view or bias of the person interpreting the results.

The question of how the projections of foreign versus domestic sales were generated exemplifies a different type of problem. The ITC reports state that the Wharton EFA Model was the source of these forecasts, and the ITC analysts report they believed the forecasts were generated by the model, i.e., were endogenously computed. In fact, however, the model equations to produce forecasts of the foreign and domestic split on new car sales for subcompact, compact, and luxury cars were incapable of generating statistically supportable projections. These splits were therefore set exogenously by the Wharton EFA analysts and were not computed within the model. The aggregate foreign and domestic split was also largely determined exogenously and varied only slightly as the desired size-class of cars (in which domestic and foreign cars are grouped together) shifted over time.

Establishing the foreign and domestic splits as exogenous to the model was not in and of itself bad practice. It is a cause for concern, however, that this was not more fully discussed by Wharton EFA and that no source for the projected splits is given. Thus, it is not surprising that the ITC analysts were unaware of this fact. It is suprising that they were not told of the exogenous nature of these key variables by the Wharton EFA staff who exercised the model to produce the forecasts.

That the exogenously set splits appear questionable is further cause for concern. The Wharton EFA-projected splits were kept constant for the years past 1980 and were the same for the baseline case and for the three versions of the tax proposals analyzed. This hardly seems reasonable. Furthermore, what this did was to impose the assumption that the several alternatives would not redistribute market shares within the main size classes between foreign and domestic producers. Yet this was one of the significant impacts the model was being run to evaluate.

Because the shifts in sales and employment to foreign producers played a particularly important part in the ITC analyses, the clouded situation surrounding these forecasts is particularly unfortunate. It serves to illustrate, however, the crucial point that in the present stage of rapid development of models, it is important that the capabilities and limitations of any version of a model be made very clear by the model authors. It also should serve as a warning to analysts to take particular care to determine exactly the operational status of complex models at the time they are being applied. Failure to do this can only weaken analyses, damage the credibility of analytic efforts, and confound the policy formulation process.

3.3 Office of Technology Assessment (OTA)

The Office of Technology Assessment (OTA) is a research arm of the Congress whose primary mission is to project and evaluate likely future technological developments. In 1976 OTA initiated a study of the likely future of the automobile transportation system. The major objective of this study was to evaluate the effectiveness of alternative federal policies associated with the automobile and to project the economic, social, and environmental impacts of these policies. As part of this study, OTA awarded two parallel contracts to research organizations to perform the essential forecasting and analytic work. Both studies involved use of econometric demand models to provide several quantitative forecasts. One of these efforts was performed by SRI International, Inc., and involved use of the Wharton EFA model.

This application of the Wharton EFA model is less directly related to the policy formulation process than most of the uses discussed in this report. Furthermore, although the technical work using the model has been completed, the results are still under consideration by OTA. No determinations have been made public, no recommendations have evolved, and additional work may yet be undertaken which could substantially alter what has been done to date. Therefore, no conclusions can yet be drawn concerning the impact of the application or the operational significance of this use of the Wharton EFA model.

In implementing its study, SRI created three alternate scenarios of the potential future of the automobile and its use. The three futures were described in general terms as "high economic growth," "economic frustration" (i.e., relative stagnation), and "changing values." The last scenario postulated a significant change in life styles, moving generally away from the present domination of the traditional work ethic and more toward individual self-fulfillment.

OTA staff commentary on the total effort has been that the use of the models in the two contractual efforts was helpful, but that the role the models played was minor. The SRI report lends support to this in the case of the Wharton EFA model. Most of the report deals with the scenario development; it covers an immense amount of techhnological and social prognostication that does not involve use of the model. The Wharton EFA model was exercised to forecast the size and character of the auto fleet, vehicle sales, miles of auto travel, and fuel consumption to the year 2000 under each of the three scenarios. However, little of the discussion involves these estimates, and it is not easily discernable what part they played in the total study or how the model was used.

Perhaps the relative lack of prominence given to the model results comes from the fact that the difference between the highest and lowest estimates for the most significant variables to the year 2000 is on the order of ten percent, except for level of gasoline consumption, for which the difference is about twenty percent. While these differences are not trivial, they are small, given the great uncertainties that attach to other factors considered in the scenarios and the extended time frame. SRI is careful to note that the differences are questionable, given the uncertainty inherent in the model itself.

The most interesting aspects of this application of the Wharton EFA model relate not to its impact or importance, but to the way it was applied. This is one of two applications so far identified where the model was actually brought in-house and run by the analytic research team. Possibly because the model did not play a central role, the documentation of its application provides only limited detail on how it was used. Nevertheless, it is clear from what is included that the SRI analysts developed a deeper understanding of the model than appears to be the case in other applications covered in this study. One evidence of this is an appendix that presents a concise but informative explanation of the model's structure and operating characteristics, and more importantly, contains significant critical commentary that informs the reader of some key strengths and weaknesses of the model. For instance, comment is made about the weakness of the model in handling imports and taking transit into account. In general, the report provides considerable evidence that the analysts interacted closely with the model and were aware of limitations in the accuracy of its outputs.

3.4 Electric Power Research Institute/Mathtech, Inc.

The Electric Power Research Institute (EPRI) is a research organization cooperatively funded by the electrical utility companies to perform studies of concern to the total industry. In mid-1977 EPRI contracted with Mathtech, Inc., to forecast the impact of electric vehicles on the demand for electricity to the year 2000. Mathtech employed a modified version of the Wharton EFA model as a major part of the larger forecasting model created to conduct the study.

In strictest terms, this application is somewhat outside the scope of this investigation, because EPRI is a nongovernmental agency and not within the federal policy-making establishment. As reported in Section 3.1.3 above, however, one extension of this study was a smaller analysis conducted for the DOT Transportation Systems Center, using the EPRI-funded model as the analytic tool. In any case, certain unusual characteristics of the Mathtech work are worth noting and justify coverage in this report.

To summarize the Mathtech effort, the central analytic approach was to create as detailed a model as possible for forecasting the sales, growth of total stock, and electrical power requirements of battery-operated vehicles to the year 2000. To do this, Mathtech developed a cluster of models on the supply side to project the likely design and operating characteristics of electric vehicles, given present knowledge of probable battery technology. This supply side also included models that projected electricity operating costs and the costs of purchasing and operating battery-powered vehicles. Because several types of battery technology could reasonably be expected to become available at different times, the supply models were constructed to generate different vehicle configurations, each internally consistent in its characteristics, and to output appropriate cost and operating values for each.

The Wharton EFA model was used as the basis for developing a model to forecast sales and growth of vehicle stock. These forecasts then fed into a module that estimated electricity consumption. Mathtech had to make significant changes in the Wharton EFA model, in particular modifying the whole vehicle-type share structure, to permit the forecasting of desired shares for electric vehicles and the resultant sales and growth of stock. This was done by creating a cost structure for electric vehicles and developing cross-elasticities of demand between electric vehicles and other types of automobiles. The more limited range of the electric vehicle was taken into account in the cost structure by building in a penalty cost for annual miles that could not be driven. This took the form of an opportunity cost penalty (i.e., an added cost) to allow for longer trips that would be impractical to make in electric cars because of the long recharging time required by batteries, but which would be practical to make in a traditional gasoline-powered vehicle.

The details of this analysis are worth studying, and the care and creativity with which the Wharton EFA model was employed is notable. The Mathtech report presents the details of the study in exceptional detail and includes the full computer program that was created. An in-depth discussion of the details is beyond the scope of this report, but the interested reader is urged to secure a copy of the Mathtech report (Marfisi et al. 1977).

Two substantive points are worth noting. First, the forecast of electric vehicles in operation by the year 2000 ranged from 11.0 to 12.5 million, depending on whether a pessimistic or optimistic scenario was followed. Even with this substantial number of vehicles, representing about nine percent of projected total stock, the impact on electricity demand was forecast to be negligible, i.e., less than one percent of total peak demand.

Secondly, as noted previously the estimates of electric vehicle sales produced by the model in this study were significantly different from the estimates produced for the TSC analysis, described in Section 3.1.3 above. In the TSC analysis the baseline projection was for an on-the-road stock of less than 300,000 vehicles by 1995. Even under heavily subsidized conditions the maximum estimated stock was about 9.3 million. The comparable 1995 optimistic and pessimistic figures in the EPRI study are

7.4 million and 4.2 million, neither of which involves any subsidy.

The reason for the great difference is that the TSC analysis assumed more severe constraints on the characteristics of the electric vehicle than did the EPRI study. These included significantly higher costs, lower operating characteristics, and a more pessimistic estimate of when advanced battery technology would become available. In the EPRI study, cost and operating characteristcs were estimated within a design model that built up values for operating range, electrical consumption, and cost from forecasts relating to each of the major technological components. In the TSC study, the necessary values were predetermined by TSC staff on the basis of their estimates. The importance of constraints or assumptions imposed on a model is dramatically illustrated by the differences in results from the two studies.

The operational approach of the Mathtech application was notable in several respects. First, the analysts developed a detailed knowledge of the model. This was obviously necessary if they were to adapt it to their particular needs and to rewrite parts of the program. Second, this is another case in which the analysts themselves ran the model in-house. Direct operation was required if the newly written program was to be developed and debugged effectively and efficiently.

This is also a case where the question of the sensitivity of the model was dealt with explicitly. Direct operation of the model certainly facilitated this. Several runs were made to test how much forecasts would change as a result of altered values for key input variables, such as trends in gasoline prices and electricity costs. The report also comments on the need to use resulting numbers with caution, given the probable uncertainty of estimate inherent in the model.

It is clear that the Wharton EFA model played an important role in this analytic effort, although there is no way now of judging what the impact of the analytic results will be. The significance of this application is that it illustrates how adaptable the Wharton EFA model (and others like it) is to a variety of uses. The detailed documentation that is presented should stand as an example for other analysts to follow in reporting their applications.

3.5 Environmental Protection Agency

The Environmental Protection Agency (EPA) has funded another application of the Wharton EFA model that results in a further expansion of its capability. In October 1976, EPA funded A.T. Kearney Associates, Inc., with Technology and Economics, Inc. as a subcontractor, to develop an analytic methodology for forecasting the impacts of new emissions standards on the automotive industry and specifically on automotive demand. The Wharton EFA model was selected by the contractors and the EPA as a central tool for the methodology that was developed.

As of this writing, the final report on the EPA project has not yet become available. From the information available in the draft final report it is clear that this EPA adaptation of the Wharton EFA model represents an important step in expanding its potential for use. A procedure was developed to calculate the costs per vehicle of controlling emissions from mobile (i.e., vehicle) sources and stationary (i.e., vehicle and supplier manufacturing plant) sources. Changes in operating costs due to changes in fuel economy and maintenance costs were also estimated. These costs were then converted to incremental costs per mile of vehicle operation. These costs were then usable as policy-induced changes to be evaluated by the Wharton EFA model.

In general, the approach here appears to be similar to that employed in the EPRI study of electric vehicles and in the DOT air bag studies. All of these illustrate the versatility of the model. As long as valid vehicle cost data can be developed relative to a proposed policy, the model can be used to forecast the impact of the policy.

While adaptations on the cost input side are interesting, the extensions on the output side appear unique and of greater potential importance. An additional model was created to take the sales forecasts and from these create **pro forma** balance sheets for each of the major automobile companies. This was done to enable the forecasting of impacts on the financial condition, profitability, and competitive position of the several companies.

From the draft report, it is clear that this application has involved careful use of the model. Extensive sensitivity tests were carried out to determine how much results would vary under a variety of different exogenous economic assumptions. Particularly notable is the explicit recognition that the emission control costs, the impact of which the model was used to evaluate, are estimates subject to error. The analysis included separate forecasts based on costs thirty percent above and fifteen percent below the cost figures generated from a detailed technological and financial study. These higher and lower figures were selected because they were believed to be reasonable upper and lower bounds. They thus permitted a range of estimate--that is, a rough confidence band—to be estimated in the forecasting process.

In general, the model forecasts indicated that the emission control standards currently in effect should have no significant adverse impacts on automotive demand, employment, or corporate financial stability. In the short term, i.e., the first two years, the $300 price increase estimated to result from the added costs of meeting emission control requirements was predicted to have some significant negative effects. New car registrations were forecast to drop three to four percent and employment in the industry to decline 1.5 to 2.5 percent. In the longer run, however, the cumulative effect on new car registrations and employment was forecast to be a decline of less than 0.5 percent. Counterbalancing these adverse impacts, in addition to cleaner air, would be a forecast two percent improvement in the average fuel economy of all cars in use and a two percent reduction in gasoline consumption (amounting to about 1.7 billion gallons in 1985). Both of these effects would result largely because of trading down from larger to smaller, more fuel-efficient cars.

None of the alternate forecasts that were run, using higher and lower emission control costs or alternative trends for such exogenous factors as gasoline prices and unemployment, produced results that were greatly different from the ones just cited. The analysts concluded that the results appeared likely to hold true under a wide range of foreseeable circumstances. A question not considered was whether this stability of model results was reasonable to expect or whether it might be due to unrealistic insensitivity of the model. The question of insensitivity was touched on in Section 1.4 of this paper. The importance of resolving this question is apparent in the results of this EPA use of the Wharton EFA model.

As of the last opportunity to check (March 1979), this EPA version of the Wharton EFA model had not been used for any specific policy application. Therefore, nothing can be said yet about its operational importance, its impact on policy, or the appropriateness of its use. Changes to the Clean Air Act of 1963 as amended that encompass vehicle emission standards will be up for consideration in about a year. It is probable that this expanded version of the Wharton EFA model, updated to incorporate the latest version of the automobile demand model, will be used to evaluate proposals to be considered at that time.

According to reports from EPA staff this initial industry financial model is a first approximation and is relatively crude. As is noted in Section 3.10 below, further work on this financial model is now being funded by NHTSA in the Department of Transportation.

3.6 Department of Energy

Only limited information is available about applications of the Wharton EFA model in the Department of Energy (DOE). No documentation has been uncovered, and only very general information about the uses has been obtained from personal contacts. The most significant facts, therefore, are that uses are reported to have occurred and that significant issues can be identified as having been addressed.

The Office of Conservation and Solar Applications has used output from the Wharton EFA model as well as from the Faucett model in its analyses of the possible impacts of introducing gas turbine and Sterling engines in automobiles. DOE staff are also reported to have been the initiators of the request that led to the Mathtech work on the electric vehicle, sponsored by TSC. They are also familiar with the study done by Mathtech for EPRI. However, the Wharton EFA model does not yet appear to have been used directly in policy determination.

3.7 Council of Economic Advisors

The Council of Economic Advisors' (CEA) use of the Wharton EFA model occurred in the spring of 1977 as part of the work to prepare the administration's national energy program. This is the program that the president presented to the Congress in April of that year. It included the gasoline tax and gas guzzler tax and rebate proposals discussed at several points above.

Reportedly, the CEA staff that used the Wharton EFA model selected it after studying other available models. The choice was made because this model was judged to be conceptually sounder in key respects, notably in the data base employed to build the model and in its use of cross sectional data. The respondent reporting on the CEA use did state that the full documentation on the model was not available to him at the time the application was conducted. Because the impact on imports of the proposed program was reported to have been a primary concern and because the initial version of Wharton EFA model was weak in its handling of the domestic/import shares split, it is unfortunate that greater detail is not available concerning how the forecasts pertaining to imports were generated and whether the model was appropriately employed in this respect.

On the basis of what has been reported about this application, the most significant information appears to be that the model was employed in the initial formulation of important presidential legislative proposals. This differentiates the CEA application from several of the applications noted above. In those the model was used to study the impacts of previously defined policy proposals.

3.8 Department of the Treasury

The Wharton EFA model was used by the Department of the Treasury as part of the process of evaluating elements of the president's proposed energy bill. The specific use reported was in the evaluation of the president's proposed gasoline tax. In this instance forecasts of car sales and fuel consumption derived from the model were used to estimate what revenues would accrue to the federal government if the tax were imposed. The significance of this application is, as in other instances, that it occurred at a high executive level in one of the senior cabinet departments.

3.9 Instances of Negative Results

In the course of this study, the chain of referrals led to two instances in which one or more respondents indicated that applications of the Wharton EFA model might have been expected to occur, but no applications could be identified. The most significant of these was the Department of Commerce (DOC). Although checks were made with the DOC Bureau of Economic Analyses, several industrial analysis units, and the Office of the Chief Economist, no application of the Wharton EFA model or any similar automotive demand model was uncovered. Because this department does extensive economic and industrial research and, in fact, is a major source of industrial and economic statistics, the absence of any readily identified application is notable.

A considerable amount of work with forecasting models has occurred in the General Accounting Office. In fact, the Program Analysis Division has been carrying on a project on Program Evaluation Methodologies which was previously called Large Scale Model Evaluation. So far no application or evaluation of the Wharton EFA model has occurred in this agency, although there is an awareness of the model.

3.10 Current Developments

To this point the applications of the Wharton EFA model that have been discussed are ones that have either been completed or are in the final reporting stage. This section turns to a brief summary of developments reported to be in progress. These developments indicate that substantial work is being done to improve, adapt, and expand the scope of the Wharton EFA model. They imply that a new round of potentially significant applications may be expected in the near future.

First, it must be noted that Wharton EFA under the continuing sponsorship of TSC is currently expanding the scope of the model to include light trucks and vans. Additionally, several weaker elements in the original model are being reconsidered and improved.

As mentioned previously, the EPA-sponsored development of an industry financial model grafted on to the Wharton EFA model is now being carried further under the sponsorship of NHTSA. This is being done so that this agency can better fulfill its responsibility to evaluate the impact of proposed rule-making on the competitive aspects of the automotive industry.

In a second NHTSA-sponsored effort, H.H. Aerospace Design Co., Inc., is developing a risk analysis model. One segment of this is a Price Module that derives car prices and the product mix of demand by using the Wharton EFA model. The purpose of this effort is to permit quantified estimates of the major marketing, technological, manufacturing, and financial risks imposed on the automobile companies by proposed fuel economy standards.

In another recent development that will involve the Wharton EFA model, Purdue University has received federal funds to establish an automotive and surface transportation research group. One of the initial projects of this group is to develop an econometric model that will encompass both energy conservation and environmental aspects and be usable particularly for analysis of the potential for electric-powered vehicles. The aim is to develop a single model usable by the three major federal agencies involved, DOT, DOE, and EPA. The first stage of this project includes careful evaluation of three existing models, one of which is the Wharton EFA model. On the basis of this evaluation, an improved model—either a composite or a new one—is to be created.

A final development planned by the Transportation Systems Center is a contract effort to evaluate the major automotive demand models. On the basis of this detailed evaluation, an improved model is to be developed either by altering an existing model or creating a new version. Since the contract for this work has only recently been awarded to Charles River Associates as of this writing (March 1979), it is not known what specific direction the study will take. It is known that the Wharton EFA model will be among the several given most attention.

3.11 Summary of Findings

The survey of applications of the Wharton EFA Automobile Demand Model provided the following major findings:

1. The model has been used in policy-related studies by significant units of the federal government in both the executive and legislative branches. The most frequent use has occurred in the Department of Transportation, which sponsored the development of the model. Use of the model was also identified in the Department of Energy, the Environmental Protection Agency, the President's Council of Economic Advisors, the Department of the Treasury, the Office of Technology Assessment, and the Senate Finance Committee.
2. The model has been used to project key economic impacts of various policy issues related mainly to energy questions. The specific energy policies analyzed have included proposed automobile fuel economy standards, several versions of the so-called "gas guzzler" tax, and the president's gasoline conservation incentive tax. Other policies analyzed have included vehicle emission control standards and safety proposals, such as passive restraints.
3. Statements of survey respondents differed on the question of the relative importance assigned the forecasts of the model in policy studies where the model was used. Model results are prominent in several of the reports reviewed, and in one case, the International Trade Commission studies for the Senate Finance Committee, a credible report asserts that model results were a major influence in the policy-making process. Model results have been prominent and appear to have influenced conclusions in some of the applications studied.
4. With respect to how analysts worked with the model, the dominant mode was to rely on computer output produced

by sources outside the analysts' agency. In only two documented cases did the analysts involved in an application operate the model directly.

5. Few analysts who used the Wharton EFA model results appear to have had a deep understanding of the model, including some of its significant limitations. This is especially true for analysts who did not directly operate the model. In most instances, lack of time was given as a reason for not being able to study even the model documentation in detail. The HSRI analysis of the model demonstrates, however, that the documentation, while voluminous, was not complete enough to enable a reader to understand the model fully.
6. Lack of familiarity with details of the model appears related to inappropriate and inadequately qualified prominence being accorded to some model results. This is particularly true for studies that placed emphasis on projections of market sales by car type and on projected splits between foreign and domestic car sales. The HSRI analysis of the model showed that the former projections were subject to significant error. The foreign and domestic shares are actually set exogenously and are not computed by the model, a fact that is obscurely indicated in the Wharton EFA documentation. It is notable that in the two reported cases where analysts operated the model directly, i.e., the studies by Mathtech, Inc., and SRI International, Inc., such limitations of the model were recognized and discussed as study results were reported.
7. The general lack of adequate attention to the question of forecasting accuracy constitutes a major weakness in the applications studied. Sensitivity analyses were used in some instances to indicate how much forecasts, e.g., of sales, would vary if key exogenous assumptions, like

the growth rate of gross national product, were changed. In other cases, one or more other models were used in conjunction with the Wharton EFA model, to provide a cross-check and to gain some idea of how much estimates might vary. These are only partial and approximate answers to the question of how much variability is inherent in the point estimates generated by the model. Without some measure of accuracy, there is little basis for judging whether forecast differences in the impacts of two or more policy alternatives are large enough to be statistically and thus practically meaningful. The cases of the NHTSA fuel economy standards analysis and the ITC study of the gas guzzler proposals illustrate how similar differences can be read differently. In the absence of some objective measures, there is little basis for determining which of the two conclusions is more valid.

4.0 CONCLUSIONS

A wide variety of federal agencies have used the Wharton EFA Automobile Demand Model in important policy-related studies. While it has not been possible to determine precisely how much reliance has been placed on model results in formulating policy, nevertheless, based on the breadth of use and the prominence of results in several important studies, it is clear that the Wharton EFA Automobile Demand Model has become a significant policy analysis tool.

Further, dependence on this type of analytic tool in evaluations of proposed governmental policies related to the motor vehicle transportation system will likely increase. The use of econometric models to evaluate, support, and criticize a wide range of proposed and existing governmental policies is a rapidly expanding phenomenon. There is every reason to believe that policy analysis related to a sector of the economy as important as the motor vehicle transportation system will share in this increasing emphasis.

Because of this, it is important to note two major concerns about how the Wharton EFA model was used in its early applications. First, because many analysts who used the model appear to have had an incomplete understanding of it, undue and inadequately qualified prominence has been accorded some model results, in particular the projections of disaggregated size-class shares and the foreign and domestic split of the market. By contrast, the most self-critical and creative uses of the model have occurred in cases where analysts actually ran the model and studied it in detail.

The reason most frequently given for limited understanding was lack of time. As one respondent put it, "We simply could not afford the luxury of taking the time to analyze the model." Yet it seems clear that taking the time to understand the model cannot be considered a luxury. All analysts involved in using the models for policy-evaluation purposes need an adequate understanding of the models being used, if inappropriate applications and interpretations are to be avoided.

Second, it seems clear that modelers and users gave only limited attention to the question of the accuracy of the model forecasts. Yet an adequate interpretation of analytic results and the credibility of recommendations based upon them hinge heavily on this issue. While numbers produced by the model appear to be precise, they are actually estimates of unknown true values which, with specified probabilities, lie within ranges about the forecast values. Thus, in forecasts of the impacts of two or more alternate policies, apparent differences may have little real meaning because they are too small to be statistically different from zero. This problem is compounded in long-run forecasts like those produced by the Wharton EFA model, because the uncertainty of estimates tends to become greater as the projections are extended in time.

Policy analysts need to give more prominent and complete consideration to the question of the accuracy of forecasts. Decision-makers who use the policy analysts' reports are unlikely to be statistically sophisticated; and unless analysts state clearly the cautions that need to be observed in using the numbers produced by the models, the danger exists that invalid conclusions will be drawn, further confounding the already difficult policy-making process.

APPENDIX A

REFERENCES

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

Golomb, D.H.; Luckey, M.M.; Saalberg, J.H.; Richardson, B.C.; and Joscelyn, K.B. (1979). An analysis of the Wharton EFA Automobile Demand Model. Ann Arbor, Michigan: UMI Research Press, an imprint of University Microfilms International.

Horton, J. 1977. Automobile fleet fuel consumption model: Fuel. Transportation Systems Center report no. DOT-TSC-NHTSA-78-1.

Jack Faucett Associates and Interagency Task Force on Energy Conservation. 1974. Project independence blueprint. Final task force report. Project independence and energy conservation: Transportation sectors. Volume III. Washington, D.C.

Marfisi, E.P.; Upton, C.W.; and Agnew, C.E. (Mathtech Inc.). 1977. The impact of electric passenger automobiles on utility system loads, 1985-2000. Palo Alto, California: Electric Power Research Institute.

National Highway Traffic Safety Administration. 1978. Automotive fuel economy contractors' coordination meeting. 24-26 April 1978. U.S. Department of Transportation report.

National Highway Traffic Safety Administration. 1977a. Data and analyses for 1981-1984 passenger automobile fuel economy standards, Document 1: Automobile demand and marketing. U.S. Department of Transportation report.

National Highway Traffic Safety Administration. 1977b. Final impact assessment of the automotive fuel economy standards for model year 1981-84 passenger cars. U.S. Department of Transportation report.

National Highway Traffic Safety Administration. 1977c. Rulemaking support paper concerning the 1981-1984 passenger auto average fuel economy standards. U.S. Department of Transportation report.

Richardson, B.C.; Joscelyn, K.B.; Golomb, D.H.; Luckey, M.M.; and Segel, L.D. 1978. An inventory of selected mathematical models relating to the motor vehicle transportation system. Ann Arbor, Michigan: The

University of Michigan report no. UM-HSRI-78-28.

Richardson, B.C., and Joscelyn, K.B. 1978. Analytical study of mathematical models of the motor vehicle system: Phase III report. Ann Arbor, Michigan: The University of Michigan report no. UM-HSRI-78-54.

Schink, G.R., and Loxley, C.J. 1977. An analysis of the automotive market: Modeling the long-run determinants of the demand for automobiles. Volume I: The Wharton EFA automobile demand model. Volume II: Simulation analysis using the Wharton EFA automobile demand model. Volume III: Appendices to the Wharton EFA automobile demand model. Transportation Systems Center final report DOT-TSC-1072.

SRI International. 1978. Potential changes in the use and characteristics of the automobile: Phase 1 contractor report. Draft. Report to the Office of Technology Assessment, U.S. Congress. Palo Alto, California.

U.S. Department of Transportation. 1976. Interagency Task Force on Motor Vehicle Goals Beyond 1980, The report by the federal task force on motor vehicle goals beyond 1980, Draft.

U.S. International Trade Commission. 1977a. The fuel efficiency incentive tax proposal: Its impact upon the future of the U.S. passenger automobile industry. Report to the Committee on Finance of the United States Senate. Washington, D.C.: U.S. Government Printing Office.

U.S. International Trade Commission. 1977b. The gas guzzler tax proposal: a comparison of its impact with that of the fuel efficiency incentive tax proposal upon the future of the U.S. passenger automobile industry. Report to the Committee on Finance of the United States Senate. Washington, D.C.: U.S. Government Printing Office.

Upton, C.W., and Agnew, C.E. (Mathtech, Inc.). 1977. An analysis of federal incentives to stimulate consumer acceptance of electric vehicles. Transportation Systems Center technical report.

APPENDIX B

DESCRIPTION OF THE WHARTON EFA AUTOMOBILE DEMAND MODEL

This section presents a general overview of the logic, operational characteristics, input, and output of the Wharton EFA Automobile Demand Model. The details of mathematical structure are not dealt with, nor are any theoretical questions considered. The reader interested in details of the model is referred to the documentation of the model published by Wharton EFA and to the HSRI analytic study of the model referenced in Appendix A (Schink and Loxley 1977; Golomb et al. pending).

The Wharton EFA model is divided into six large computational blocks of equations. These are:

- Block A, in which fuel efficiency estimates, i.e., miles per gallon, are generated for each size class of new car and for the total fleet of new cars.
- Block B, in which new car prices are estimated.
- Block C, in which the cost of owning and operating a typical car in each size class is estimated, taking into account both purchase costs and the stream of operating costs over an average ten-year life-span, discounted back to current dollar values.
- Block D, in which the desired shares of each class of car and for the total stock are estimated.
- Block E, in which actual demand, essentially total new car sales, is estimated, along with total scrappage and used car sales and scrappage.
- Block F, in which actual (as opposed to desired) total stock and stock by class shares, are up-dated and estimated.

Figure B-1 depicts the way the blocks are related in the Wharton EFA model program and gives a general sense of the structure and flow of the model. A further sense of what happens within the model, what the model requires, the complexities inherent in it, and the range of outputs obtainable from it can be gained from reviewing Table B-1, which shows the required informational inputs and the major outputs for each block, and Figures B-2 through B-7, which detail the program flow for each of the major blocks of the model.

The Wharton EFA model requires a considerable amount of data to be entered before it can be run. These exogenous data must be derived from sources outside the model. They include information on existing conditions, such as current tax levels, forecasts of general economic and demographic trends from other models, such as projected gross national product from a macroeconometric model, and data that represent essentially speculations based on most-informed opinion, as is the case with future car characteristics.

One additional fact needs to be noted to highlight the complexity of the model. Estimates that are computed within one block as endogenous variables are frequently required as inputs or exogenous variables in other blocks, including prior computed blocks. For example, the new-car-share estimates predicted in Block F are needed to calculate the used car prices estimated in Block E. There is, therefore, no simple one-way computational flow from a beginning to an end. Within the model several iterative calculations occur to bring related estimates into line.

While exogenous variables are specified from appropriate outside sources endogenous variables--those computed internally--are initially established at some known or previously estimated base year values. In the version of the Wharton EFA model made available to HSRI for analytic study, this base year was 1974, or, in the case of lagged variables, 1973.

A solution is generated by solving the equations in each block sequentially, starting with Block A and ending with Block F. If the solution of an equation requires the value of a variable that is actually estimated farther down in the program, an exogenously set base year

FIGURE B-1

FLOW DIAGRAM OF THE WHARTON EFA MODEL

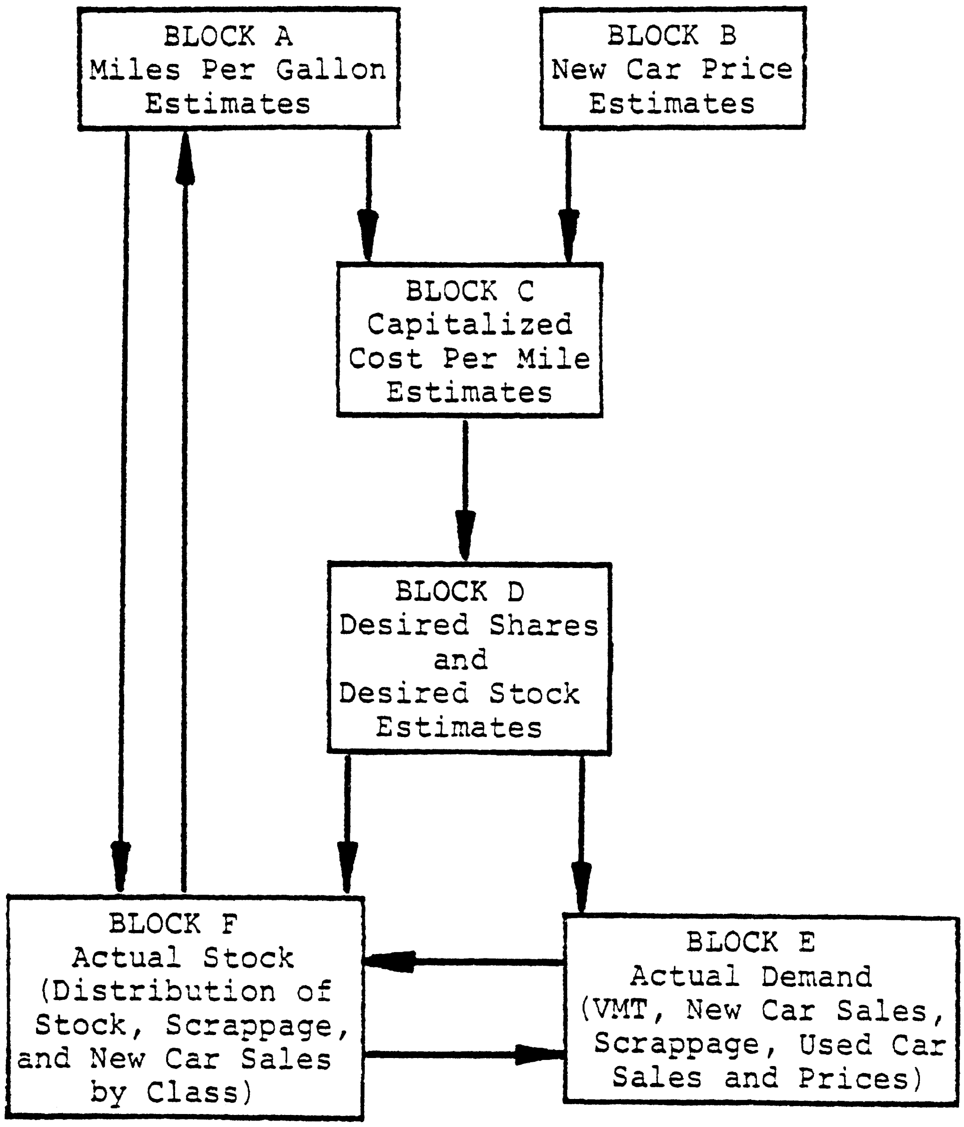


TABLE B-1

WHARTON EFA MODEL EXOGENOUS INPUT AND MODEL
OUTPUTS BY BLOCK

Model Exogenous Input	Model Output
Auto Characteristics Assumptions Curb Weight by Class Engine Displacement by Class Fraction of Cars with 4 Cylinders by Class Fraction of Cars with 6 Cylinders by Class Fraction of Cars with Overdrive by Class Fraction of Cars with Auto Transmission by Class MPG Efficiency Factors by Class **Economic Activity Assumption** Ratio of City to Total VMT	BLOCK A MPG Estimates for New Cars by Class • City • Highway • Combined • EPA Estimates
Economic Activity and Price Assumptions Transportation Price Index Foreign Auto Export Price Base Price Ratio of Class to Fixed Weight Average Index of Input Costs Consumer Price Index Real Disposable Income Max Price of Installed Options by Class Total State and Local Taxes on New Car by Class **Demographic Assumptions** Number of U.S. Families	BLOCK B New Car Price • Transportation Charges by Class • Base Price by Class • Expenditures on Options by Class • Purchase Taxes by Class • Total New Car Price by Class

TABLE B-1 (Continued)

WHARTON EFA MODEL EXOGENOUS INPUT AND MODEL OUTPUTS BY BLOCK

Model Exogenous Input	Model Output
Economic Activity and Price Assumptions Finance Charge Discount Factor Gasoline Price Insurance Cost Index Tire Cost Index Parking, Tolls Cost Index Motor Oil Cost Index Repair Cost Index **Policy Variable** Ownership Tax by Class	BLOCK C Capitalized Cost Per Mile • Capitalized Cost Per Mile by Class
Economic Activity and Price Assumptions Ratio of Total Retail Outlets to Foreign Retail Outlets Real Disposable Income **Demographic Assumptions** Percent People Living in Metropolitan Areas Ratio of Pacific Population to Total Population Ratio of Mountain Population to Total Population Ratio of New England Population to Total Population Ratio of West South Central Population to Total Population Ratio of Resident Population, 20-29, to Total Number of Families Ratio of Families with 3 and 4 Members to all Families Number of U.S. Families Ratio of Families with 5 or More Members to All Families Licensed Drivers Per Family **Transportation Mode Assumption** Persons Travelling to Work by Non-Auto Means	BLOCK D Desired Shares and Desired Stock • Desired Shares by Class • Desired Shares/Domestic Foreign • Desired Stock Per Family

TABLE B-1 (Continued)

WHARTON EFA MODEL EXOGENOUS INPUT AND MODEL OUTPUTS BY BLOCK

Model Exogenous Input	Model Output
Economic Activity and Price Assumptions Gasoline Price Real Disposable Income Unemployment Rate Scrap Metal Price Index Rate of Decline in Used Car Prices by Size Class	**BLOCK E** Actual Demand • Total Scock • VMT • New Car Sales • Scrappage • Used Car Sales by Class • Used Car Prices by Class • Number of Trade-Ins by Age
Economic Activity and Price Assumptions Domestic Share of New Car Sales by Size-Class Total Number of Makes of Cars by Class Real Disposable Income Number of Makes by Class Number of Dealers by Class **Demographic Assumptions** Number of Persons 25 Years and Older with 4 or More Years of College Ratio of Resident Population, 20-29, to Total Families Percent Population in Metropolitan Areas Pacific Population to Total Population Ratio of East North Central Populations to Total Population	**BLOCK F** Actual Stock • Scrappage Adjustment Factor • Scrappage Probabilities by Age • Shares of New Cars by Class • Cars in Operation by Class • Scrappage of Cars by Class • Shares of Cars by Class after Scrappage • Expected Scrappage for Older Cars • Mid-Year Stocks by Age • Average Age of Stock • Vintage Weighted VMT

FIGURE B-2

FLOW DIAGRAM OF BLOCK A
MILES PER GALLON EQUATIONS

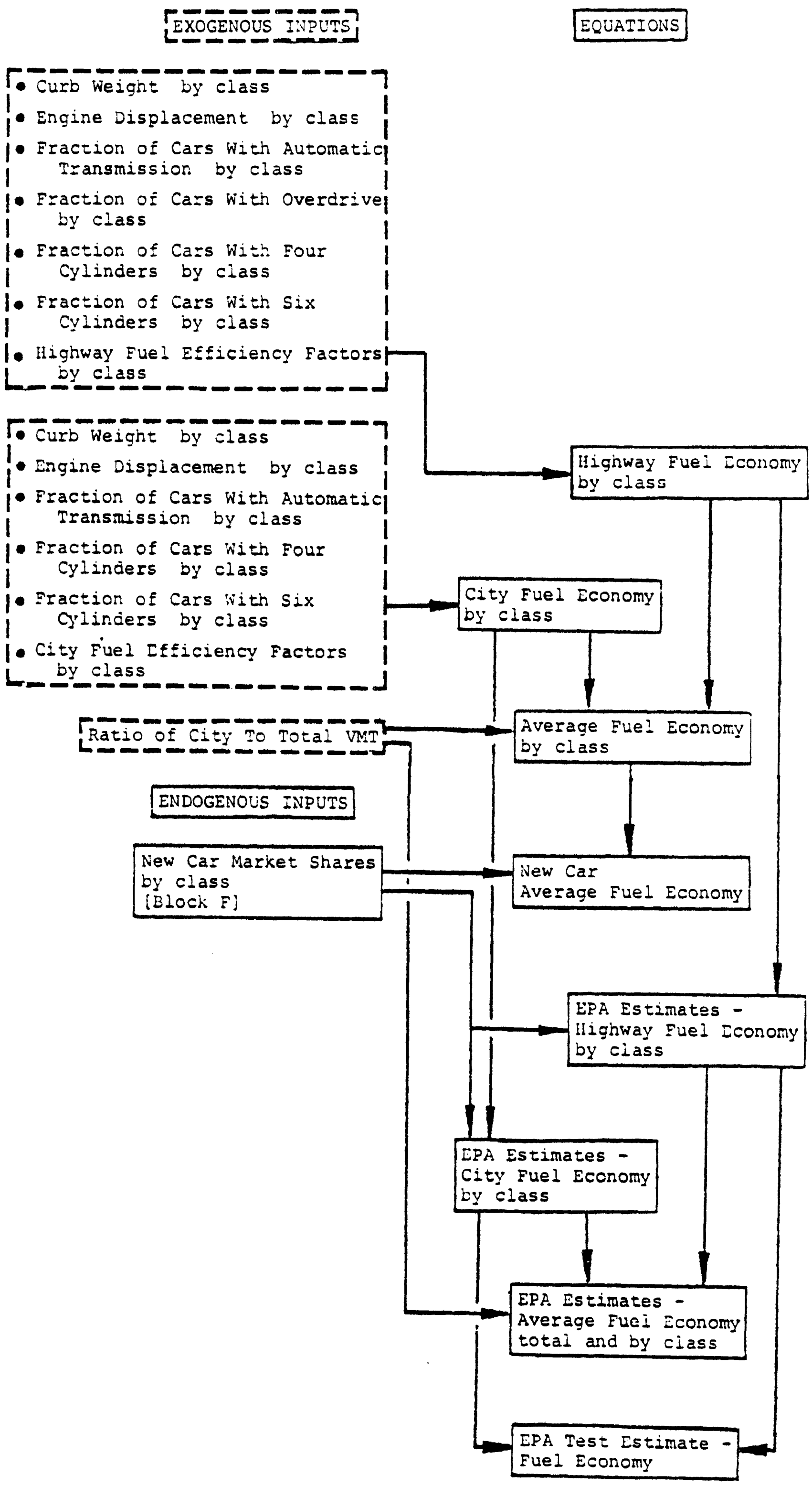


FIGURE B-3

FLOW DIAGRAM OF BLOCK B
NEW CAR PRICE EQUATIONS

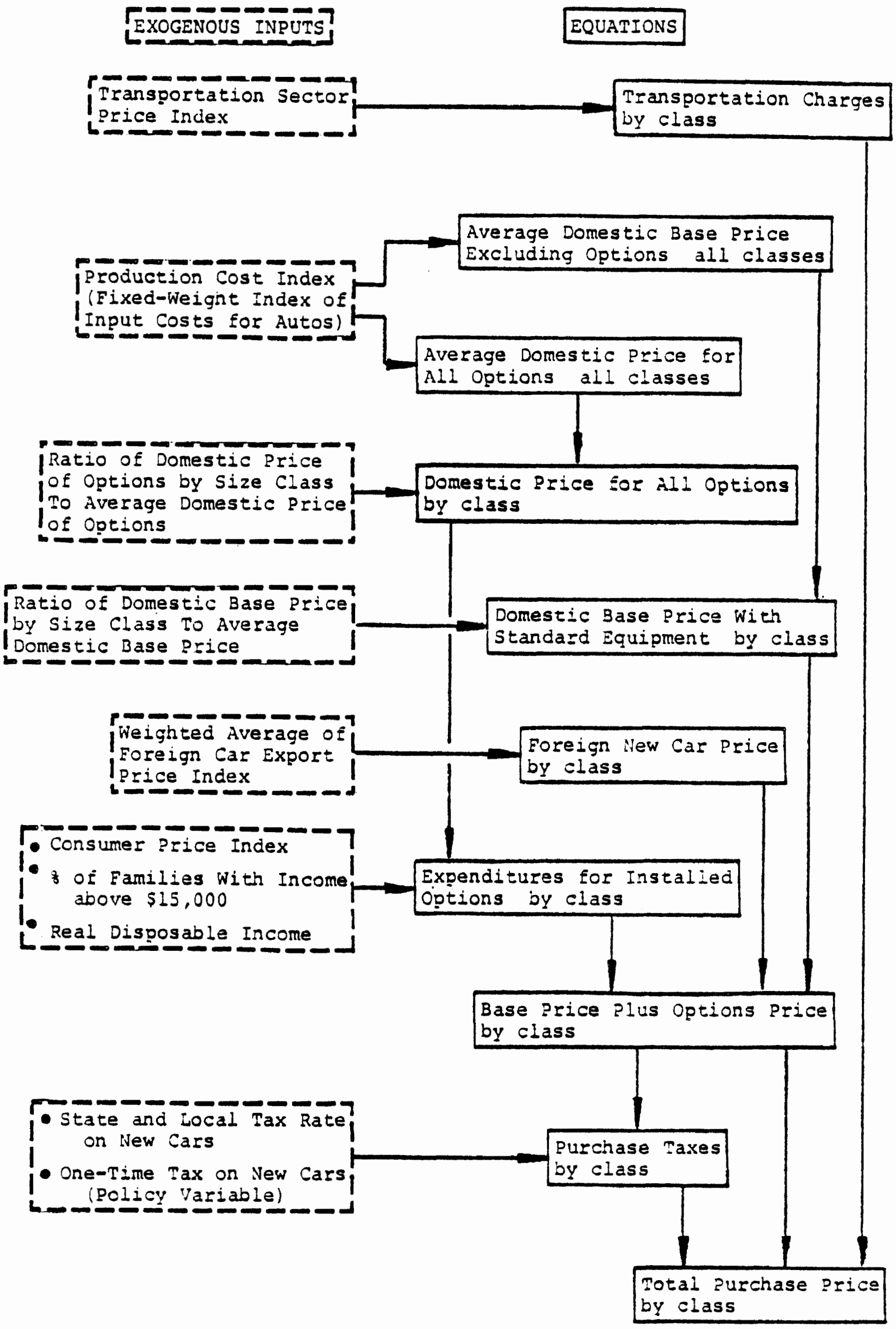


FIGURE B-4

FLOW DIAGRAM OF BLOCK C
CAPITALIZED COST PER MILE EQUATIONS

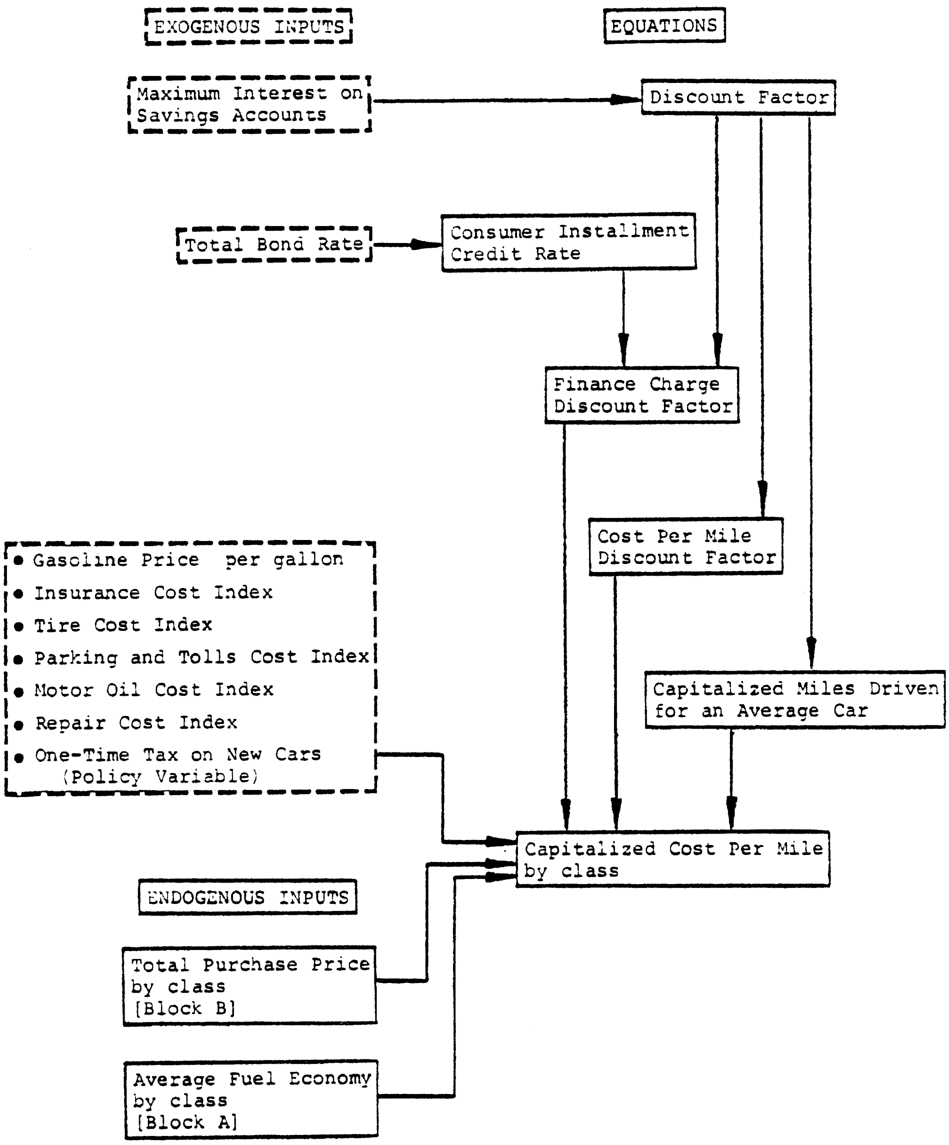


FIGURE B-5

FLOW DIAGRAM OF BLOCK D
DESIRED STOCK AND DESIRED STOCK SHARE EQUATIONS

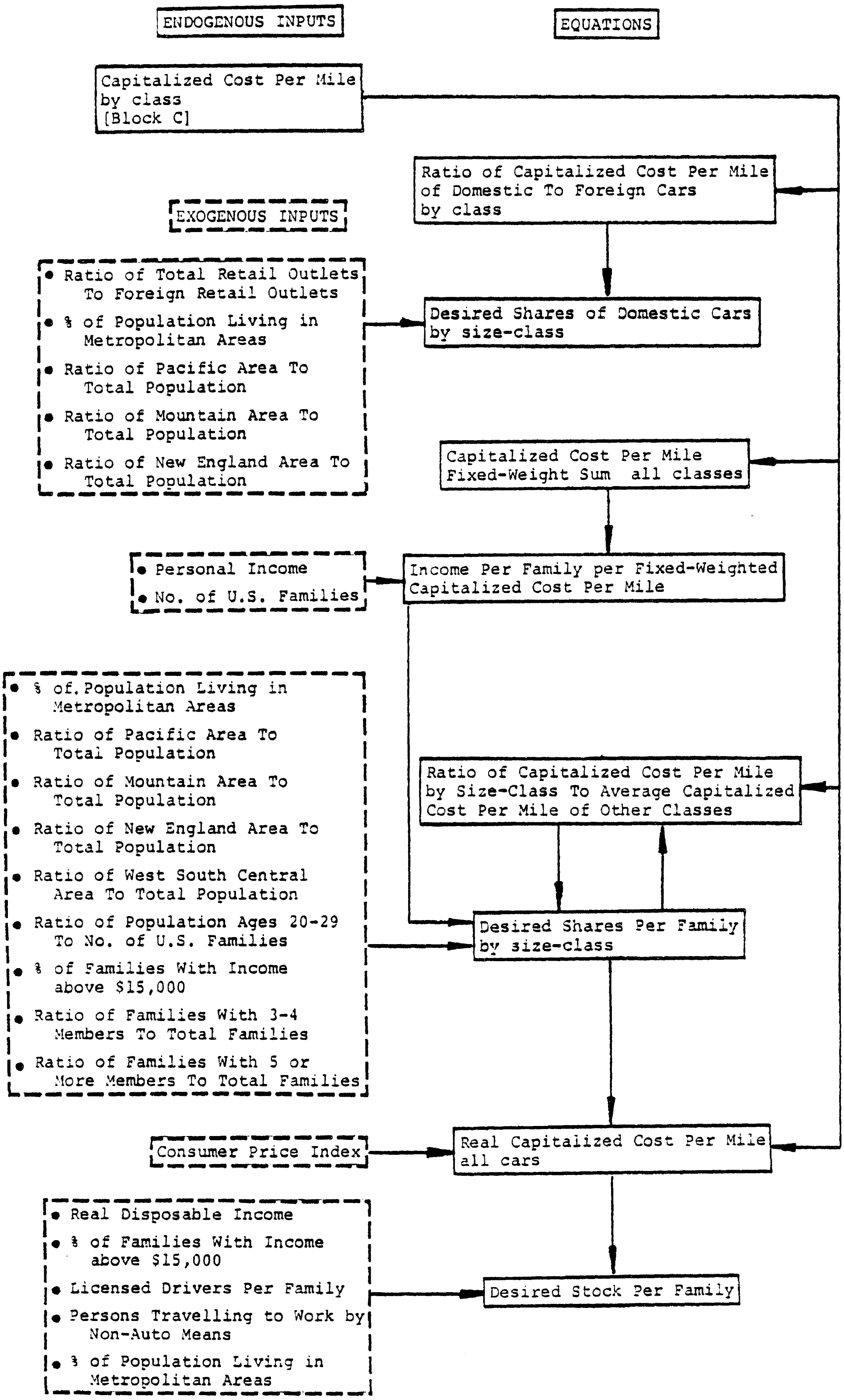


FIGURE B-6

FLOW DIAGRAM OF BLOCK E
ACTUAL DEMAND EQUATIONS

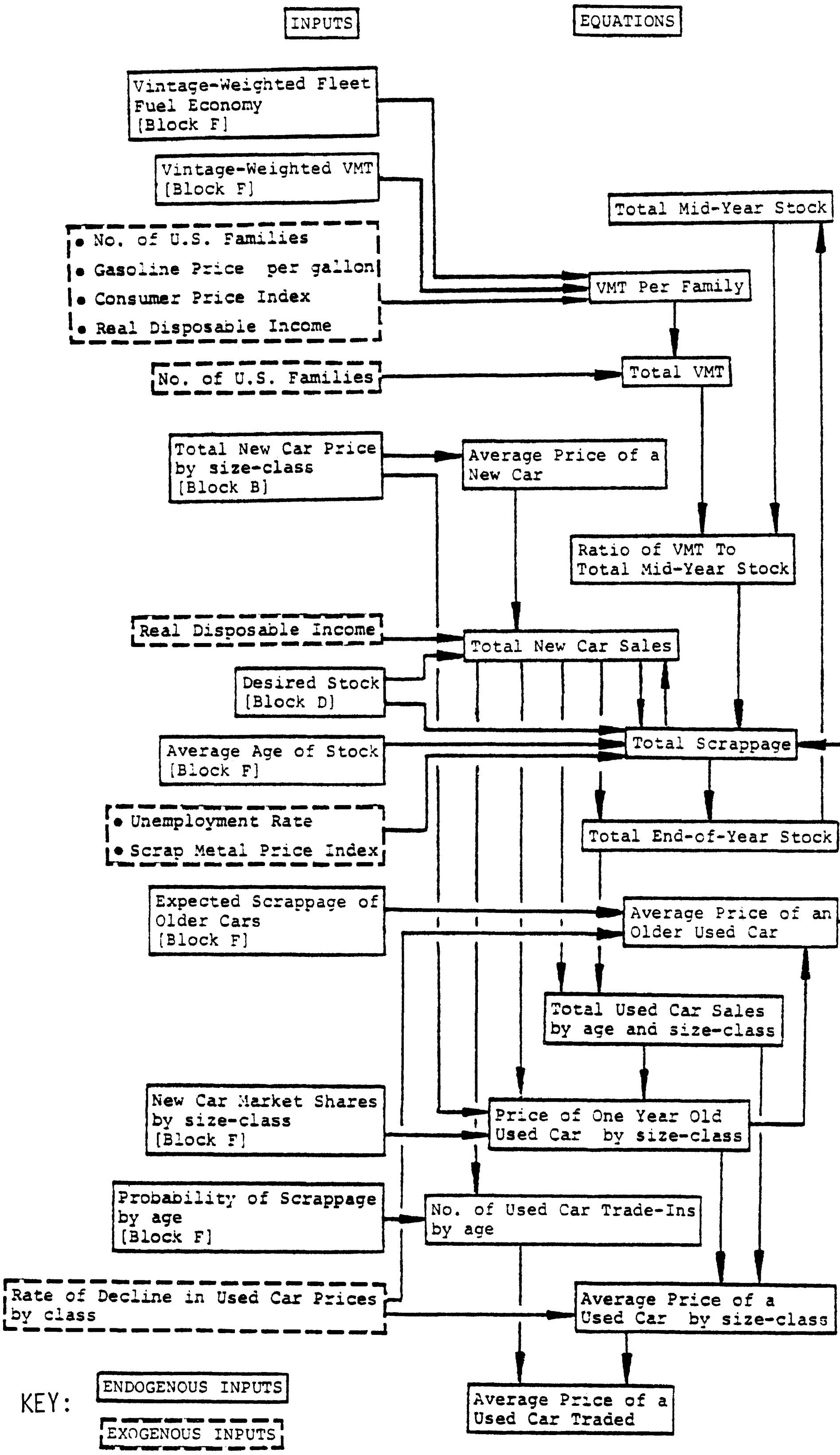
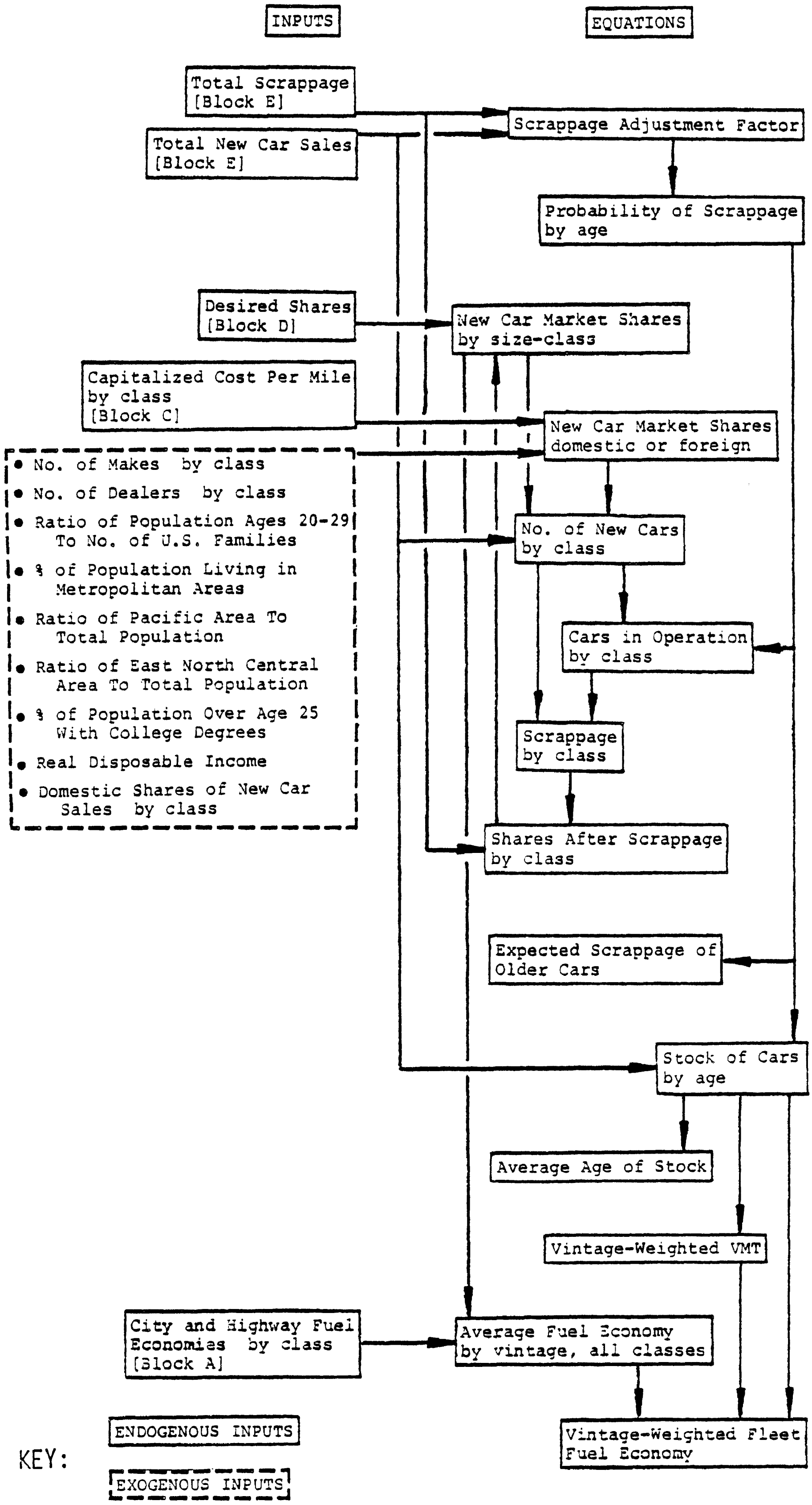


FIGURE B-7

FLOW DIAGRAM OF BLOCK F
ACTUAL STOCK EQUATIONS



value of that variable is used first. Then the estimated value of the variable is calculated. If the new value differs significantly from the initialized value, a repeated series of recalculations takes place to bring the values into line, i.e., to within some small difference judged to be insignificant.

In Block A the necessary fuel economy estimates for new cars in each of five size classes are generated from preestablished characteristics of the vehicles and the relationship of these characteristics to historical data on fuel economy. These relationships were developed by the Wharton EFA authors on the basis of data drawn from Environmental Protection Agency tests and actual driving surveys assembled by Consumers Union.

Independently of Block A, Block B produces estimates of total purchase price for each class of new cars and for each of the four components which make up the purchase price--i.e., base price, expenditures for options, transportation charges, and purchase taxes. Blocks A and B feed into Block C where the combined cost figures of owning and operating a typical car in each size class over an average ten-year, 100,000 mile vehicle life are estimated. Operating costs include fuel, insurance, maintenance and repair costs, and parking and tolls. These are, in effect, set exogenously, since they are all forecast on the basis of their relationships to the Consumer Price Index.

Essentially, Block A provides the estimate of the fuel cost component of operating costs, given an exogenously set cost per mile of gasoline. Block B provides the estimate of purchase or first costs. Because the operating costs are projected to occur over a ten-year period, these cost estimates are discounted to take into account the economic concept that future dollars are perceived by people to be less valuable than presently available dollars (this is a sophisticated version of the old adage that a bird in the hand is worth two in the bush). Discounting is distinct from the concept of current dollar values, which takes estimated future inflation into account. All dollars are deflated to current (1974) values. The discounting of costs occurs in addition to this. In the case of the current Wharton EFA model the discounting factor is 5.5 percent. Combined purchase and operating costs are reduced to a per mile basis, producing the centrally important capitalized cost per mile estimates for each type of car.

In Block D the desired stock of vehicles and the desired shares of stock for each of the five size classes are estimated. These estimates are of critical importance to the model because they constitute the targets toward which existing stock will move in the stock adjustment process. The computations to arrive at desired shares and desired total stock are complex. In simplest terms, they are derived on the basis of the relative costs of the different classes of cars. Specifically, the relative cost indexes are the ratios of the capitalized cost per mile for each car type relative to family income, with the new car fleet average capitalized cost per mile relative to income taken as a reference point. The estimate of total desired stock is computed on the basis of a share weighted capitalized cost per mile which is related to estimated family income and drivers per family to yield a desired stock per family. Multiplied by an estimate of the total number of families, this yields an estimate of total desired stock.

In Block E total new car sales, scrappage, total vehicle stock, and total vehicle miles traveled are estimated. Each of these estimates is heavily dependent on the other three; i.e., the estimates are highly simultaneous. In addition, new car sales and scrappage are dependent on the estimates of desired stock derived in Block D, as well as key elements estimated in Block F. The strong interrelationship between Blocks E and F is indicated by dual arrows on the Figure B-1 flow diagram.

Block F contains two sets of equations, one that predicts the total stock of cars by size class and age, the other of which estimates the new car market shares and the number of new cars sold by size class. The predictions of the total stock of cars by size class and age are dependent in part on the scrappage and new car sales estimates which are generated in Block E, because the stock of cars at the end of any year is in general equal to the stock at the beginning of the year plus the new cars sold and minus those scrapped during the year. Separate scrappage estimates based on a vehicle survival model are made in Block F, using historical information on the proportion of cars that have survived one, two, three, etc. years in each of the last twenty model years. The two estimates of scrappage from Blocks E and F are adjusted to produce a single estimate.

The computation of new car sales and shares by size class draws upon the estimates of desired stock generated in Block D and the estimates of the actual or existing stock shares generated in Block E.

In summary, the Wharton EFA model at the completion of a simulation produces forecasts of automobile sales year-by-year for the total market and for each of the five general size classes distinguished in the current version of the model. Similarly, it estimates the changes in the aggregate number of vehicles in operation for each size class and for the total fleet, taking into account additions from new sales and subtractions resulting from scrappage. The model makes these forecasts by tracing through the complex relationships that pertain between the estimated prices of new and used cars, the public's available income, and the public's desire to own and operate cars. The mathematical statements which represent these relationships are approximations based on best available knowledge, historical data, and reasonable assumptions about key overall economic and technological trends.

Based on estimates of fuel efficiency (miles per gallon) for each type of car projected into the future, the model forecasts the average fleet miles per gallon for new cars and for the total fleet in operation year-by-year.

From the basic forecasts of the vehicle fleet and fuel efficiency (miles per gallon), combined with forecasts of total vehicle miles of travel the model permits derivation of total fuel consumption year-by-year. Additionally, given estimates of the productivity relationship between number of workers and number of vehicles produced, forecasts of employment are derivable from the model.

In terms of policy analyses focusing on the motor vehicle transportation system, most changes in laws, regulations, or programs affect price or costs and fuel economy. Once the cost/price or fuel economy changes that will result from a policy proposal are calculated, these numbers can be fed into the model. The model will then produce estimates of changes (impacts) on sales, fleet size, overall fuel economy, and, by derivation, fuel consumption and employment.

ABSTRACT

This report describes how and by whom the Wharton EFA Automobile Demand Model has been applied in policy-related analyses by federal agencies from its first known uses in the spring of 1977 to March 1979. The study was conducted in the spring of 1978 with a follow-up in early 1979. Information was gathered from published documents and from more than sixty personal contacts with the users, potential users, sponsors, and authors of the model.

The model has been applied by the National Highway Traffic Safety Administration, the International Trade Commission, the Council of Economic Advisors, and other federal agencies in analyses of energy-related issues, vehicle safety standards, pollution control standards, and other issues. The ways in which the model has been used and how its capabilities and limitations have been dealt with in policy analysis settings are reported.