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Method for Estimating Market Acceptance of Technologies and Fuels of the Partnership for a New Generation of Vehicles

Phase I

Final Report

For the Period September 30, 1998 through May 31, 1999

Prepared for the U.S. Departments of Commerce, Energy, and Transportation

Barbara C. Richardson
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May 31, 1999

Report No.: UMTRI-99-15

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16. Abstract:

The members of the Partnership for a New Generation of Vehicles (PNGV) are developing new technologies aimed at improving fuel economy of passenger cars to 80 MPH by 2004. The objective of this study is to recommend a methodology to identify the conditions under which the market will accept PNGV fuels and technologies in the United States. The method proposed includes focus groups to identify the major concerns of owners of cars and light trucks; interviews with purchase managers of fleets; drawing of random samples of new-vehicle purchasers (separately for individuals and fleets); development of survey instruments; and conducting telephone surveys of the samples to ascertain the probabilities of purchase of vehicles using the different PNGV fuels and technologies. Included in the surveys will be alternative prices of vehicles and consequences (e.g., changes in mpg) of the new fuels and technologies.

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INTRODUCTION

This document is the final report of phase I of the project entitled "Partnership for a New Generation of Vehicles Market Acceptance Study". The project was sponsored jointly by the U.S. Departments of Commerce, Energy, and Transportation under order number 40SBTK867125. It was initiated because of the concern of the federal government about the market acceptability of future vehicles of the Partnership for a New Generation of Vehicles (PNGV). Phase I is intended to develop a methodology, and phase II, which will be a separate activity, is to execute the methodology to answer questions about the market acceptance of the vehicles of the PNGV.

This report is organized as follows. In this introduction are subsections describing the background of the project, its objectives, and the method used in this phase. In the following section is an overview of the methodologies identified and reviewed for potential use in the second phase of the study. The third section describes the method recommended for application in phase II. Appendix A is a listing of the references containing the methods reviewed. Appendix B is a set of tables summarizing the evaluations of each of the methods reviewed. Finally, appendix C presents summaries of each of the documents reviewed for relevant methods.

BACKGROUND

The Partnership for a New Generation of Vehicles is a partnership between the U.S. federal government (seven agencies and twenty federal laboratories) and DaimlerChrysler[1], Ford, and General Motors. It aims to strengthen America's competitiveness by developing technologies for a new generation of vehicles. On September 29, 1993, President Clinton, Vice President Gore, and the CEOs of the domestic motor-vehicle manufacturers announced the formation of the PNGV. This national government / industry research program also includes research support for over 350 automotive suppliers, universities, and small businesses.

The long-term goal of the PNGV is to develop an environmentally friendly car with up to triple the fuel efficiency of 1993 midsize cars without sacrificing affordability, performance, or safety. In addition, the PNGV seeks to significantly improve national competitiveness in automotive manufacturing and to apply commercially viable innovation to conventional vehicles. It is planned to have production prototype vehicles produced by each car company by 2004. While initial design work has been focused on the mid-sized family sedan, the technologies can be used to develop new high-mileage designs for any light-duty car or truck.

[1] Chrysler Corporation merged with Daimler Benz in 1998. The merged company is DaimlerChrysler, and it remains a member of the PNGV.

Transportation sustainability[2, 3] is dependent upon both the development of new technologies and the behavior of transportation users. This project addresses the interaction of these two requirements. A purpose of the PNGV is to develop vehicles that will contribute to a sustainable transportation system by consuming less fuel while maintaining lower levels of pollutants and climate-change gases, particularly carbon dioxide; and improving vehicle safety. The government anticipates that the vehicles developed to meet those goals may be very different from those now available with regard to type of fuel, infrastructure requirements, operating characteristics, and pricing, and that marketplace acceptance is not guaranteed. This concern is reinforced by the poor marketplace response to the electric vehicle (EV). The marketplace acceptance challenge is that these vehicles initially are likely to have a price premium associated with them while utilizing technologies with which the customer is not familiar. A reasonable estimate is that they could be thousands of dollars more expensive than comparable, but less efficient, cars. The benefits of purchasing these cars are that they would use only a third of the fuel (about a $500 annual saving for the average American driver) and produce very low emissions. Unfortunately, the benefits from a strictly financial standpoint may or may not outweigh the initial costs (though the long-term savings on fuel could bring down total operating costs). The vehicles will have many new technologies, which may also heighten consumer caution. The challenge is to develop a strategy that encourages a significant volume of purchasing of these vehicles given this cost differential. On the plus side, the cost will ultimately come down as more cars are sold and as the technology further matures.

Part of the motivation to perform this study is the recent availability of results from the sales of electric vehicles recently introduced in California. EVs have been available in the United States for about three years and thus far have had only very few sales or leases, fewer than 1,700.[4] The EV has a driving range between charges of 70 miles in the city and 90 miles on the highway and a lease price in the range of $400 per month. The low sales volume of the EV suggests that other innovative vehicles might be unacceptable to consumers and, thus, would not contribute to the national objective of transportation system sustainability, including decreased fuel consumption and air pollution. The experience with the electric vehicle firmly establishes that government can mandate production but cannot ensure product sales.

Another factor motivating this study is the anticipation of production of a large number of alternative-fueled vehicles. A panel of automotive industry executives predicts that, of the passenger cars produced in North America in 2007, 5% will use diesel fuel, 2% electricity,

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[2] "A sustainable condition for this planet is one in which there is stability for both social and physical systems, achieved through meeting the needs of the present without compromising the ability of future generations to meet their own needs." (United Nations World Commission on Environment and Development, 1987)

[3] The World Bank in 1996 defined sustainable transportation as embodying three main components: "(a) the economic and financial component, which includes issues of adequacy of transportation infrastructure funding, organization, and scale; (b) the environmental and ecological component, which includes issues of how transportation investments and mode options influence travel and land use patterns and how these in turn influence energy consumption, emissions, air and water quality, and habitats; and (c) the social component, which emphasizes adequate access to transportation services by all segments of society." (*Sustainable Transport*. Washington, D.C.: The World Bank)

[4] *Automotive News*, September 14, 1998. "High Cost, Low Range Keep U.S. Electric-Vehicle Sales Sputtering", p 3,17.

and 5% hybrid-electric/combustion fuel technology.[5] Billions of dollars are required to develop new vehicles. In the long run, from a business perspective, demand for alternative-fuel vehicles needs to be adequate to contribute to the profitability of the firm. To avoid repeating California's experience, alternative vehicles that consumers truly want or need must be produced.

OBJECTIVE OF THE STUDY

The original purpose of this project, which was planned to be divided into two phases, was to collect information and perform analyses that would assist the PNGV in developing a technology strategy that would contribute to marketplace acceptance of PNGV vehicles, thereby achieving decreased fuel consumption and air pollution. Phase I is intended to develop a methodology, and a separate phase II is to execute the methodology to address the following questions.

- Will the American public buy high-mileage vehicles that will meet the PNGV targets (i.e., up to 52 and 80 miles per gallon) given some of the differences between these vehicles and their lower-efficiency counterparts? These differences include:

  Higher purchase price
  New propulsion system
  Lower total vehicle weight
  Possibly less storage space.

- For both the 52- and the 80-mpg cases, what incentives and other marketplace stimuli (for example, education, government incentives, regulations) would significantly increase marketplace acceptance?

After the completion of most of the work of the study, the authors and sponsors agreed (April 12, 1999) to revise the objective statement to:

- Under what conditions will the market accept PNGV technologies and fuels in vehicles in the United States?

Acceptance of PNGV technologies, fuels, and vehicles is highly dependent upon the availability of the infrastructure to support them. This study focuses on the former and leaves the consideration of infrastructure to other studies.

METHOD

The original objective of phase I of the study was to develop a methodology for generating answers to the questions stated above. That methodology must be capable of handling technologies and fuels that are different from those used in current vehicles. In order to address those questions, the following tasks were undertaken.

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[5] Cole, D.E. and G.F. Londal. *Delphi IX Forecast and Analysis of the North American Automotive Industry.* Volume 2, Technology. Ann Arbor, MI: Office for the Study of Automotive Transportation, University of Michigan Transportation Research Institute. 1998.

Literature searches were conducted on fifteen major databases (indexes) and through the libraries of the University of Michigan and the World Wide Web. Searches were conducted for the time period 1990 through the present. The following keywords were used in various combinations in the searches.

Alternative Fuels	Electric Vehicles
Consumer Acceptance	Estimating Demand
Consumer Preference	Forecasting
Demand	Market Potential
Demand and Innovation	New Consumer Products
Diffusion and Innovation	New Product Technology
Durable Goods	PNGV
Efficient Vehicles	User Acceptance

The searches resulted in several hundred books, articles, and reports being identified by either title or abstract. Abstracts were obtained for all titles that appeared relevant to forecasting the marketability of really new products, including (primarily) durable goods and innovative automobiles. These abstracts along with the ones originally identified were reviewed for relevance. For those that were relevant, the complete document was obtained. These were then reviewed in their totality.

Part of the review included searching the bibliographies of the documents collected for additional documents of relevance to the project. Some documents thus identified predate 1990.

Of the hundreds of titles originally identified, sixty-six documents have been identified as describing methodologies that have been used in forecasting the marketability of really new products. Many documents were discarded because the description of the methodology was inadequate or because the content was irrelevant (despite a title that indicated relevance). These sixty-six documents have been summarized in a standardized format and included in this report as appendix C. The standardized format for each document includes: reference, keywords, abstract, method, and evaluation reported by the author. A complete list of the references is in appendix A.

Keywords for each document were selected from a preestablished list that was appended as necessary. The complete list is shown in table 1. Following the review of the various candidate methodologies, they were summarized in a set of tables that organized the methods by type: economic models, product clinics/field tests, surveys, and other. The evaluations of these methods are summarized in the tables of appendix B.

Based on the evaluations reported by the document authors and the experience of the project team, the different methods were reviewed for potential use in development of a method to estimate demand for the PNGV vehicle, and a recommended method was constructed from the various options available.

TABLE 1
KEYWORDS

Method

Bayesian updating procedure
chi-square
conjoint analysis
consumer flow model
cost analysis
daily travel distributions
Delphi
demand estimation
diffusion model
disaggregate econometric studies
discrete choice analysis
dynamic latent class models
econometric
economic model
economic criteria
economic incentives
empirical evaluation
explicit purchase probability
factoring
forecast
gaming simulation
hedonic price analyses
image factor analysis
incentive analysis
interviews
Kalman filter
logistic regression
logit
market research
market simulations
marketing theory
maximum likelihood methodology
methods survey
multiattribute utility model
multinomial logit
multinomial model
multistage approach
new product research
new product-concept positioning
optimization
orbit model
ordered choice model
policy analysis
preference analysis
preference reversals
probability estimate
product demonstration
qualitative choice analysis
reflexive design
regression
scenario development
simulation
survey
technological substitution model
test vehicle
tobit model
travel demand models
user survey
utility theory
vehicle field test
willingness to pay

Product

airbags
alternative fuel vehicles
alternative fuels
automobile
color televisions
computers
consumer durables
diesel
electric vehicle
hybrid vehicle
intelligent transportation systems
intelligent vehicle highway systems
limited-range vehicles
low-scan televideo
motor vehicles
natural gas vehicles
nondurable products
personal vehicles
PNGV

Output

consumer acceptance
consumer attitudes
consumer choice
consumer expectations
consumer intentions
consumer preferences
consumer surplus
emissions
environmental concerns
fuel consumption
gross domestic product
housing
incentives
infrastructure
market acceptance
market potential
personal market potential
potential customers
product demand
purchase behavior
purchase intention
ratings
regulation
vehicle size classes
vehicle usage allocation

Scope

activity-based
commercial sector
fleet
household fleets
housing
life cycle
vehicle owning companies
smokeless cigarettes
solar power
video product

Data

consumer marketing
driver logs
experts
focus groups
in-person interview
interactive stated response
longitudinal survey
mail survey
mixed mode
national household panel data
non-random sample
panel study
probabilistic sample survey
product clinic
questionnaires
random sample
sales data
sample
secondary data collection
stated preference surveys
stratified random sample
survey data
telephone interview
test market data
travel diaries
travel surveys
trip length
trip purpose
user group interviews
vehicle-range requirement
workshop

OVERVIEW OF CANDIDATE METHODS FOR ESTIMATING MARKET ACCEPTANCE OF PNGV TECHNOLOGIES AND FUELS

There are many methods available to forecast the market acceptance of new vehicle technologies and fuels.[6] How well the different methods work is discussed in turn below. To introduce the topic of purchase of new vehicle technologies and fuels, it is useful to consider the acceptance of innovative vehicles over the last four decades. Asking the questions of which ones were successful in the marketplace and why this was so gives insight into what are the requirements of a forecasting method and what incentives or policies or external factors are necessary for success.

HISTORICAL ACCEPTANCE OF INNOVATIVE VEHICLES

A fundamental question is why do people buy vehicles, and particularly innovative vehicles. Four significant successful innovative vehicles (not necessarily high-tech) over the last four decades are the VW Beetle in the 1960s, small cars in the 70s, minivans in the 80s, and sport-utility vehicles in the 90s. The Beetle was a low-cost, unusually styled vehicle in the United States in the 1960s, favored by young people. It was both affordable and had a cult following. The fuel shortages and high fuel prices of the 1970s, coupled with Corporate Average Fuel Economy Standards (CAFE), fostered the growth of sales of small, higher miles-per-gallon (mpg), cars. In the 1980s, the leading edge of the boomers with their expanding families supplied the demand for minivans that offered more space in a vehicle that drove like a car and had relatively favorable fuel economy and price. The 1990s saw the tremendous increase in the demand for sport-utility vehicles. Despite their relatively lower fuel economy and higher emissions, and spurred by the record-low price of fuel, sales skyrocketed. Buyers sought more space and the safety and security offered by these large, high-profile vehicles. Another vehicle innovation of the early 1990s was the Saturn. It was not so much the vehicle technology, but the sales experience and service associated with it that were innovative. It drew a large demand from a population seeking a reliable car of moderate price who were attracted to Saturn's one-price, low-sales-pressure atmosphere.

The factors that supported the success of these vehicles are desired vehicle characteristics (interior space, safety, security, fuel economy, good service) coupled with demographics (boomers), economics (income levels – both high and low – by societal segments), and governmental policy (CAFE). Essentially, the auto industry supplied what people wanted, and exogenous factors fell into place to support the purchases of these innovative vehicles. The questions for the PNGV are what will people want in 2004 and beyond, and what exogenous variables can be influenced or controlled. The latter factors are those that will be the basis for incentives or policy and are discussed below.

DEMAND FOR A PNGV VEHICLE VERSUS PNGV TECHNOLOGY AND FUELS

The value that a PNGV vehicle, as originally described, offers to prospective buyers is increased fuel economy, decreased pollution, and new technologies. There are two issues that make the first two attributes of little importance to potential buyers. One revolves around the tragedy of the commons: essentially, there is little financial motivation for one person to spend the resources to make a marginal improvement in the environment because the benefit he individually derives is very small.

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[6] Prior methods include guesstimates, Delphi studies, payback model, revealed preference models, and stated preference models. (Patterson, Philip. "PNGV Market Analysis: Some Thoughts". Presentation. Washington, D.C.: U.S. Department of Energy. August 3, 1998.)

In fact, his costs far outweigh his benefits. Second, the price of fuel is so low currently, that fuel economy is not a major factor in new-vehicle-purchase decisions at this time. It is interesting to consider that when a consumer pays an amount for a feature, say an airbag for safety, s/he may derive a great deal of benefit (e.g., life saving) directly from that expense. On the other hand, if that consumer pays an amount for an environmental enhancement, s/he derives only 1/5,000,000,000 of the benefit (shared with the rest of the population of the world). Why then, would anyone voluntarily pay for an environmental enhancement? It is necessary for many people to do so before either societal or individual benefits are reaped. Though there is research that shows the importance people place on environmental issues, those attitudes do not necessarily translate into actions such as purchase of environmentally friendly vehicles.[7] The likelihood of purchase of such a vehicle may be increased if people believe that they are acting as part of a larger group with the same goals and expected behavior.

There are several reasons that people would not want to purchase a PNGV vehicle as originally described. The characteristics of such a vehicle which would probably make it unattractive are its new but unproven technology, its unproven reliability, its lighter weight and the resultant perception of decreased safety, uncertainty about refueling, its possibly smaller storage space, and its higher price (possibly 10% above its list price).

In order to sell a PNGV vehicle as originally described, it will be necessary to overcome some of the consumer concerns with the vehicle. Methods to do this include providing something that the buyer will want, or incentives, or perhaps an education program. For example, people want and pay for a desirable image in a vehicle. Incentives such as large taxes on traditional fuel, or free nontraditional fuel, or subsidies or rebates to those who purchase the vehicle might influence people to buy or lease such a vehicle. It will be necessary to include incentives in the demand estimation because they will be part of the package that the consumer is likely to face in the marketplace. A program to educate the consumer of the benefits (individual and societal) of purchasing a PNGV vehicle might provide the extra push needed for some people to buy it. An understanding of the externalities related to the demand will be necessary in interpreting the results of any forecasting method used.[8]

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[7] Interestingly, according to a recent survey reported April 1999, p. 46, in *American Demographics*, nearly half of the 1000 respondents indicated they were very concerned about the environment, with 33% of respondents saying that air pollution was the most serious environmental threat. Respondents were asked to rank from 1 to 10 their priorities for environmentally related automobile improvements. Three of the top five were: (1) use less gasoline (8.23 average ranking), (2) reduce harmful tailpipe emissions (8.16), and (3) use alternative fuel rather than electricity (7.23).

[8] Leiby and Rubin examine the transitional period of alternative fuels and vehicle use. The authors state, "The long run penetrations for alternative fuels and vehicles...are not likely to be achieved without measures to encourage the expansion of vehicle production and fuel availability." Their model (TAFV) is a dynamic optimization model (nested multinomial logit) that integrates fuel supply and demand, vehicle production, and how these would be affected by changes in mandates, subsidies, and tax credits. (Leiby, Paul and Jonathan Rubin. *The Alternative Fuel Transition: Draft final results from the TAFV Model of Alternative Fuel Use in Light-Duty Vehicles 1996 - 2010.* Review Copy. Oak Ridge: Oak Ridge National Laboratory. 1998.)

INNOVATORS AND IMITATORS

The first buyers of new technologies are often referred to as the innovators. These are followed later in the marketplace by the imitators and then the laggards. There are several examples of this pattern in which sales start slowly with the innovators, and the future sales of the target product can be forecast based on the early sales.[9] The underlying principle is that once the imitators see that the new product works and that others are successfully using it, they, too, will acquire it.

It is expected that the first buyers/leasers of the PNGV vehicles, technologies, and fuels will be either strong environmentalists or those who tend to be high-tech innovative purchasers. If the vehicle is an entry level vehicle, then younger buyers may be more willing to take on the role of early adopters. This was the ccase for the early Beetles and Saturn. A way of approaching the estimation of demand for these is to look for purchases by these groups (which could be called innovators) in the initial years of the offering of the PNGV vehicles, technologies, and fuels, followed in turn by the imitators and laggards in the following years. There are several problems in attempting to forecast PNGV demand based on the behavior of innovators and imitators. First, there is no existing initial innovator demand history. Second, there is not a model that can do the initial forecasts. Third, there is not an adequate definition of innovators. Higgins (1992)[10] presents a procedure to do this, but it is probably not applicable to new-vehicle purchases. Kurani (1993) discusses the difficulty of disaggregating potential electric-vehicle buyers by the categories of environmentalists and innovators who would most likely be the first purchasers of PNGV products.

OVERVIEW OF MATHEMATICAL MODELING APPROACHES

There are several mathematical options available for estimating the demand for PNGV technologies and fuels from the methods reviewed, not one of which is a clear winner.

Two standard ways to estimate demand for transportation services or vehicles are aggregate-demand econometric models and discrete-choice (individual) models that then must be aggregated over the population. Much has been written on these. See, for example, an overview of limitations of the aggregate models by Richardson et al.[11] Besides the inherent computational difficulties, the most important drawback to using econometric models is that historical databases of both the dependent and independent variables are required to forecast the future. If the historical series on a variable of interest does not exist, that variable cannot be included in the model. Even if the perfect set of independent variables was specified, it would be impossible to forecast PNGV demand accurately because there is no historical series on PNGV demand to use in estimating the coefficients of the model. A way around this is to use demand for a surrogate variable (another car, for example) in estimating the model. But, there is no appropriate surrogate vehicle. The one that comes closest is the electric vehicle, but it is not adequate because of major differences such as size, refueling requirements, and range restrictions, especially the latter. Further, of the many EV forecasts reviewed in the literature search, none has been shown to be reliable when "actuals" and "predicteds"

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[9] For instance, Heeler (1980) states, "Innovators...are the first to purchase new products. As time progresses, adoption decisions become increasingly influenced by the process of word-of-mouth communication." The author says that while his model's predictive ability is limited in the early years, if parameters of innovator adoption can be established, the model becomes much more reliable as a predictive tool of imitator and laggard adoption.

[10] Citations of this format have been reviewed for this study and are summarized in appendix C.

[11] Richardson, B. C., K.B. Joscelyn, and J.H. Saalberg. *Limitations on the Use of Mathematical Models in Transportation Policy Analysis*. Ann Arbor, MI: UMI Research Press, an Imprint of University Microfilms International. 1979.

are compared. Even within an individual study (Pohl 1998) that compared the results of a model with a field test, the comparison showed the lack of accuracy of the model.

The other primary modeling method, discrete-choice models, estimates the probability that an individual will purchase a specific choice from a set of choices. The drawbacks of discrete-choice models, used for estimating both vehicle and mode demand, are that an observation of behavior is necessary and that the aggregation of the disaggregate data is not reliable. None of the documents reviewed in this study reported accurate forecasts using this methodology.

A third, less widely used, modeling method, is the disaggregation of characteristics of the vehicle or mode to determine demand. This method appears in different disciplines under different names. While different in approach, the essence is to break the product down into its characteristics and estimate the value of, or demand for, the whole based on the sum of its parts.[12] In economics, this method is called the Lancaster Consumption Model (Ryans 1974). In transportation demand modeling, it is called the abstract-mode model or attributes model. The challenge in this methodology is that the respondent may not know enough about the product to respond appropriately to questions about it. This method would not be useful in estimating the demand for the PNGV because there is only theoretical, untested work on this in nonautomotive, noninnovative products.

Another mathematical-modeling method is related to those above and generally referred to as hedonic modeling. In this method, demand for the product is estimated based on the value people are willing to assign to different products that manifest different attributes. Empirically, prices or revenue for a large number of vehicle types is correlated with differences in key attributes across the models. A dollar value can be assigned for change in the level of each attribute. Hedonic modeling can be accomplished at low cost through the use of existing information regarding actual vehicle sales. Fairly precise estimates of the relative value of marginal differences in vehicle attributes can be determined with this method. However, the technique is limited, of course, by its reliance on historical information. The market value of large changes in product attributes cannot be reliably estimated through the use of this information. Also, the lack of reliable and precise price data or revenue information by vehicle model has restricted the use of this estimation technique.

OVERVIEW OF FIELD TESTS AND CLINICS

Field testing and product clinics are both good ways of understanding consumer responses to different products or aspects of products. In both cases, however, it is necessary to have a product to test. Although there are different technologies and fuels to test at this time, they are not packaged, as they will be five years from now, and are likely to be perceived by the consumer as incomplete or inferior. Further, after clinics and field tests, a survey of a random sample of the population would still be required to generalize to the population as a whole. There is no PNGV vehicle available at this time to test. Simulation testing, such as that by Urban et al. (1996) has limitations such as the high cost of doing the testing and the requirement of a great deal of managerial judgment in estimating demand.

[12] For example see Calfee (1985) which employs discrete choice analysis to estimate EV demand using fully disaggregated vehicle attributes. Attributes considered were price, operating costs, capacity, top speed, and range.

OVERVIEW OF SURVEY APPROACHES

There is a strong history over the past fifty years in the U.S. of the use of surveys to measure buying behavior as well as attitudes. The U.S. government uses the monthly Bureau of Labor Statistics' Consumer Expenditure Survey to produce the Consumer Price Index (CPI), and the monthly Current Population Survey is used to measure labor force characteristics, labor supply, labor force participation between demographic groups, and wage rates and earning trends for specific groups. There are a variety of social science research projects such as the government-funded Index of Consumer Expectations which tracks the current attitudes of Americans about their near-term economic prospects and is used as a leading indicator of economic recession, and the Panel Study for Income Dynamics which follows the effects of the economy on individuals and families over time. These surveys have yielded accurate estimates of consumer buying behavior based primarily on the representativeness of their samples to the U.S. population, the correct method of administration of the survey, the proper set of questions asked, and the correct analyses performed on the resulting collected data. These issues cannot be over-emphasized in their importance to the survey process.

Collection of data for a study is itself is a highly specialized area of practice. One could collect primary or secondary data. Within primary data collection, probabilistic sample surveys or nonprobabilistic surveys can be conducted. Among the probabilistic samples are random and stratified random samples. Non probabilistic surveys include convenience samples and focus groups. In order to be able to generalize the results of the survey to the population of interest, it is necessary to draw a random sample.

Focus groups are useful when conducted with a relatively small group of people, perhaps seven to ten, for the purpose of determining what these specific individuals think about a certain topic. They are not useful in determining what the entire population thinks about that topic, nor in determining how they will behave regarding a specific product. However, they are very useful in providing guidance on what topics should be explored in surveys. Such surveys can be administered to a sample of the population in such a way that the results can be generalized to the entire population being studied.

Surveys can be administered by mail, by telephone, in person, by computer, or by a combination of modes. Further, within each of these categories, there are various ways to collect the data requested, for example, by computer-aided personal interview or by self-administered questionnaires.

The way that questions are asked has a great influence on the quality of the responses. A frequently used method in survey research is to ask consumers if they will buy a certain product. This is referred to as the stated-preference method.[13] This method is quite unreliable in forecasting demand in comparison with revealed preferences. Revealed preferences are those expressed by the actual purchase of the product in question. Another method used in survey research is questioning respondents about purchase probabilities. Juster (1966) has shown that purchase probabilities are much better than buying-intention data in forecasting accurate motor-vehicle demand. These probabilities are quite accurate in determining the differential likelihood of consumers purchasing one product in relation to another.

[13] See Moore et al. (1998) where consumer-derived utilities for various vehicle attributes were estimated from data collected in a 1995 national stated preference survey.

Finally, there are many ways of analyzing the data that are collected through a survey. Generally, these include descriptive analysis, data reduction, inference, and prediction. Each of these has a wide range of specific analytical techniques available to use.[14]

[14] Barabba, Vincent P. "The Market Research Encyclopedia". *Harvard Business Review*. Jan-Feb 1990.

RECOMMENDED APPROACH FOR PHASE II

The recommended approach for estimating the market acceptability of PNGV technologies and fuels in vehicles in the United States beginning in 2004 is to begin with a small number of focus groups. Following that will be a selection of a random sample of new-vehicle purchasers of both fleet and non-fleet vehicles. A separate telephone survey will be performed on each of these sets of recent buyers (based on their past five years' purchases) focusing on the new vehicle buying decision process, particularly whether a buyer is an innovator, imitator, or laggard in terms of adopting new technologies/vehicles. This survey will also include respondents' attitudes toward alternative fuels/technologies/vehicles, possible incentives, and purchase probabilities for these types of vehicles. Analysis of the data will follow in which generalizations of the concepts measured will be explored, and matched to household population to generate potential demand estimates.

Several of the documents reviewed in this study provide methodological and subject-matter guidance, and they will be used in developing the survey instrument. For example, Golob et al. (1997) used computer-aided telephone interviews (CATI) to conduct their surveys and point out some of the limitations of vehicle trials. Morrison (1979) provides guidance on how to ask questions on future vehicle purchases. Segal (1995) suggests questions for use in forecasting demand for alternative fuel vehicles. Walls (1996) describes, through a Lancasterian model approach, methods of differentiating vehicle characteristics to obtain a better understanding of the value consumers place on such characteristics. A similar approach is used by Donndelinger and Cook in which they analyze the value of automobiles to customers with a focus on improvements to specific attributes.[15] Turrentine et al. (1992) suggests a set of issues important in the vehicle purchase process.

FOCUS GROUPS AND INTERVIEWS

Approximately ten focus groups will be held throughout the United States with individual purchasers of new vehicles. Five will be for recent buyers of new passenger cars, and five will include recent purchasers of other new light-duty vehicles. These will be held in different regions throughout the country in cities such as Los Angeles, Chicago, Detroit, New York, and Atlanta.

Participants will be identified and invited to attend. A facility will be identified and booked. A focus group facilitators' guide will be developed and used in leading the discussions. The discussions will be structured to the extent required to elicit responses needed for developing questions for the survey. No attempt will be made to influence the thoughts of the participants. Visual aids or hands-on technology will be used as considered appropriate for the focus groups.

In addition, a separate set of face-to-face interviews will be conducted with fleet purchasing managers in the same cities and at the same time as the focus groups. These interviews will focus on identifying the issues these managers face when deciding on potential alternative fuel vehicles. The purpose of these interviews, like the focus groups, will be to guide the development of a phone interview survey with fleet purchasing managers. Though these focus groups will give researchers insight into the opinions of the participants, these people do not represent the total population of new vehicle buyers and thus cannot be used to generate reliable estimates of demand or the market conditions that will lead to consumer acceptance of these vehicles. Only a random sample of the total U.S. vehicle buying population can generate these estimates.

[15] Donndelinger, J.A. and H.E. Cook. "Methods for Analyzing Automobiles". SAE Paper No. 970762. 1997.

TELEPHONE SURVEY OF NEW-VEHICLE-BUYING HOUSEHOLDS

Random Sample of New-Vehicle-Buying Households

The basis for estimating market acceptance or the market conditions that will facilitate the sale of the PNGV vehicle will be a consumer telephone survey based on a random sample of new-vehicle-purchasing households. The random sample of new-vehicle-purchasing households (non-fleet) over the last five years will be obtained from The Polk Company (formerly R. L. Polk & Company). The Polk Company, the primary provider of this type of data for the U.S. market, maintains household automotive purchases (based on vehicle registrations and manufacturer sales data) for all fifty states going back thirty years or ten vehicle purchases (new or used). Though vehicles are registered individually, the high cost of a new vehicle makes the purchase a household decision and is based on the needs of the household's fleet needs. Some early research on electric vehicles speaks about "hybrid households" where it was hypothesized that an electric vehicle would be a possible replacement for the part of the household fleet that does not travel more than 80 miles a day (due to the range limitation of electric vehicles). Though the vehicles in this proposed study do not have the range limitations of electric vehicles, households may in fact be looking at themselves as hybrid households as they decide whether to purchase an alternative vehicle. For early purchasers there will be more unknowns with alternative vehicles than with conventional vehicles, and households may balance the risks involved within the context of the household's fleet.

The project team chose to use a random sample of recent new-vehicle-purchasing households rather than a random sample of all households because they believe that previous new-vehicle-purchasing households more realistically represent the sampling frame of households that are more likely to purchase a new vehicle compared to households that have not purchased a new vehicle. Left out of the sample are households that have not purchased a new vehicle over the last five years. This includes households that have never purchased a new vehicle as well as those that may have purchased a new vehicle six years ago or longer. Having a sample composed of buyers over the five-year span provides views of buyers who have recently purchased a vehicle as well as those who may be considering another purchase.

A sample of 3000 households will be drawn randomly with a set of 2000 used for the initial survey with the remaining households re-sampled and used to supplement the survey as needed. The project team expects a 65% response rate for this telephone survey and estimates 1000 interviews will provide the confidence needed to perform the analyses for this project. This sample size will yield a confidence interval of plus or minus three percent for the analyses for the study.

The decision to use a telephone survey is based in part on the traditionally low response rates generated by mail surveys. Despite numerous re-mailing and follow-up of non-respondents in mail surveys, response rates for mail surveys continue to hover in the 20%-30% range. But telephone surveys, as performed by the Survey Research Center of the Institute for Social Research at the University of Michigan, in combination with letters mailed in advance of the first call consistently yield response rates of 60%-70%. Telephone surveys offer the respondent a variety of times in which to respond and keep the respondent focused for the 25-30 minutes needed to complete the interview. They also elicit a higher level of commitment by the respondent because of the personal contact involved. Also, trained interviewers are able to sort out and help respondents who may need help with some of the concepts of this admittedly complex topic. The drawback to phone interviews is the cost of the interview. Estimates for one phone interview are around $100, while mail questionnaires cost much less, but often reflect a non-respondent bias.

The crucial question becomes one of representativeness. Taking the highest average response rate for each method, if only 30% of the sampled population responds to a mail questionnaire, 70% of the sampled population is not being represented. This is in comparison with a phone interview in which 70% of the sampled population is represented, and 30% is not represented. Clearly, a reader would have more confidence in a survey that had a 70% response rate.

A separate sample of fleet managers will be drawn from The Polk Company's fleet list. Fleet purchases represent about 20% of annual light vehicle sales. They are considered good targets for alternative-vehicle sales because of their volume purchases and their internal, common fueling facilities or their general willingness to experiment with alternative vehicles given appropriate incentives. A response rate of 60%-70% for the telephone survey is expected from a sample of about 500 companies nationally, resulting in about 250 interviews. The sample draw will be weighted by the number of vehicles purchased by the company, so companies that purchase 200 vehicles for their fleet will have a higher probability of being drawn than companies that purchase 10 vehicles.

Interview Design and Administration

The University of Michigan project team, in collaboration with project sponsors, will develop the interview questions using focus group, fleet interviews, and other input. As previously stated, the interview will include sections on the new-vehicle-buying decision process, respondent attitudes towards alternative fuels/technologies/ vehicles, purchase probabilities for these types of vehicles, and the effects of possible incentives. Care must be taken not to overly influence respondents either through literature or the interview process to prefer alternative vehicles over conventional vehicles. One of the key issues in the new-vehicle-buying process is finding out how consumers narrow their choices of all the potential vehicles available to them, thus generating a smaller consideration list that is used to make their final decision. Finding out how an alternative vehicle can make it onto the consumer's consideration list will be a topic for both the focus groups and the interviews.

One of the tasks to be completed will be the selection of the combination of technologies and fuels to include in the survey. This will be done in conjunction with the sponsors of the study. It is necessary to specify these items at the beginning of phase II of the project as opposed to the end of phase I because of the rapid development of new technologies and the lack of certainty of the inclusion of present-day considerations in the vehicles of the future. It will be necessary to specify the technologies and fuels that will be considered to be PNGV-related as well as the attendant benefits of these technologies (higher mpg, lower emissions) and real or perceived limitations (vehicle: interior space, range, safety, reliability; cost: vehicle, fuel, taxes; convenience: repair, refueling; and other factors).[16] Agreement on the combinations of vehicle and fuel innovations, their implications for the vehicle, its use, cost, incentive options, and time horizon of the forecast will also be required.

Another issue to be decided is the range of public policy alternatives that will be included in the survey. There are two general ways in which public policy can influence the rate of technological

[16] Maples et al. develop a discrete-choice, multi-attribute logit Vehicle Size/Consumer Choice (VSCC) model to help define the successful introduction of technologies in light vehicles by vehicle size class. The consumer demand for alternative vehicles is defined as a function of the vehicle attributes and the type of fuel used. Vehicle attributes were disaggregated from historical vehicle purchase data, and then market penetration estimates were calculated by summing the consumer-derived utilities that are associated with alternative fuel vehicles. This study will build upon the vehicle attributes noted in Maples' study and, through the household survey instrument, gather consumer purchase probability data to derive market penetration estimates.

adoption. Traditional command-and-control regulatory policies, such as manufacturer production mandates, can serve to dramatically increase adoption rates of PNGV technology, but in an era of strong forces acting upon the economy—such as historically low gasoline prices—the increased adoption of PNGV technology will be seen as questionable, at best. However, market-based incentives, especially incentives that are indexed to an economic condition, such as subsidies that increase as the price of gasoline decreases, or vice-versa, are more likely to encourage strong long-term PNGV technology adoption. A combination of these two policy approaches, such as vehicle production mandates together with a purchase tax credit, could be the logical solution. A third approach, education of the public about the benefits of PNGV technology, should be adopted coincidental to one or both of the other approaches. Table 2 lists candidates for public policy alternatives. It includes incentives, disincentives, and educational programs identified during the literature search. It will be necessary in phase II to agree with the sponsors upon the ones to be included in the survey.

Following decisions regarding the specifics of the fuels and technologies and incentives, the survey instrument will be developed in order to determine market conditions that will lead to the purchase of PNGV fuels and technologies. This will require careful attention to detail so that the accuracy of the estimation will be maximized. The focus of the survey will be on purchase probabilities. The essential structure of questions is to ask an individual to indicate the likelihood of purchase (on a scale of 0 to 100) of a specific technology or bundle of technologies given different prices of that technology or bundle of technologies. It will be necessary in conducting the survey to explain enough of the fuels and technologies so that the respondents can answer the questions or, prior to the survey, mail them an informational package on the topic. As mentioned before, the challenge in a study of this kind is not to overly influence respondents to prefer alternative products over conventional products. Consumers who know little or nothing about these types of vehicles can very easily be persuaded to prefer them. The challenge for this survey will be to find how an alternative vehicle or technology can make it onto the consumer's consideration list and what they think their true purchase probability will be in the future.

TABLE 2
PUBLIC POLICY ALTERNATIVES

Command-and-Control

Clean Air Act—Tier Two emission standards
CAFE standards
Fleet Alternative Fuel Vehicle purchase requirements[17]
California Air Resources Board ZEV and ULEV mandates (manufacturer production quotas)
Mandated public access refueling sites

Incentives

Federal income tax credits
State/Federal income tax reductions
Sales and use tax reduction—initial purchase and support equipment
Personal property tax reduction
Direct grant
Low interest loans
Rebates
Exemption from transportation control measures:

- Unrestricted use of high occupancy vehicle lanes
- Free/Reserved/Preferential parking
- Reduced toll fees

Vehicle registration fee reduction/waiver
Reduced leasing rates
Exemption from emission inspections
Infrastructure tax credits—for example natural gas refueling stations
Emission reduction credits
Fuel tax exemptions
Prohibitions on vehicle insurance surcharges
R & D grants
Manufacturers' tax credits

Education

Net Present Value comparison of PNGV vehicle versus conventional vehicle
Societal benefits of increased mpg and decreased emissions
Information about new technologies and their potential benefits to consumers and society

[17] Leiby and Rubin (1998) state, "In the absence of any specific requirement that fleet AFVs use alternative fuel, fleet AFV purchase mandates may be met with dual- or flex-fueled vehicles, and little alternative fuel may be used. However, if fleet AFVs are also mandated to use some fraction of alternative fuel, and if they refuel at publicly accessible commercial stations, then the barrier of limited retail fuel availability is diminished."

Questions will be asked regarding future purchase probabilities. It is a hypothesis that the demand will begin slowly and increase over time. This generally occurs because the technology improves, becomes less expensive, and becomes more visible and more accepted by consumers, or when government regulation drives adoption.

While no method ensures perfect estimation of future behavior, purchase probabilities across different combinations of technologies and fuels yield a reliable estimate of the relative probabilities given different prices. Juster (1966) notes that "purchase probabilities explain about twice as much of the cross-section variance in automobile purchase rates as buying intentions." Further, this study will yield unbiased estimations of the purchase probabilities, and the error on the output based on the planned sample size is $\pm$ 3%. High accuracy results with purchase probabilities regarding demand for fuel alternatives are corroborated by Greene.[18]

In sum, no other method has been demonstrated to produce accurate estimates of demand for innovative motor vehicles and technologies; the relative accuracy of the results of purchase probabilities in comparison with other survey question methods is compelling; and purchase probabilities have been demonstrated to be superior to buyer-intention data. This method is being applied in other areas in which measures of future behavior have been developed and are proving to be reasonably accurate.

Once designed, the interview will be reviewed by the interviewing organization's staff and programmed into the CATI (Computer Aided Telephone Interview) module. With this program, interviewers will enter responses directly onto a computer screen while speaking with respondents, eliminating the cost of data entry at the end of data collection (though the savings involved in eliminating data entry are absorbed in the upfront programming of the questionnaire).

Pre-testing the interview will take place after the CATI programming . Interviewers will be trained concerning the questions to be asked and will interview 20-30 households to test the CATI programming as well as the questions in the survey, looking for inconsistencies or breaks in logic that confuse or bias respondents. These interviews will be analyzed, and the interview will be revised based on the findings.

ANALYSIS OF RESULTS

Analysis of the results of the survey will be designed to answer some of the questions that challenge the alternative-vehicle portion of the automotive industry. These questions include:

- What is the likelihood of recent new vehicle buyers (and fleet managers) purchasing a vehicle with PNGV fuels or technologies during its first and subsequent years of production?
- How do recent buyers (both fleet and non-fleet) view alternative technologies/fuels/vehicles?
- What could be done to promote alternative vehicles within the public domain?
- What are the barriers and facilitators to alternative vehicles' entry onto the potential buyer's (both fleet and non-fleet) consideration list?
- What purchase decision factors have the most effect on potential buyers' final decision to purchase a conventional or an alternative vehicle?
- What effects will incentives have on the purchase decision?

[18] Greene, D.L. "Survey Evidence on the Importance of Fuel Availability to the Choice of Alternative Fuels and Vehicles." *Energy Studies Review*. Oct. 1998.

- Which incentives for alternative fuels/vehicles are perceived by consumers as the most attractive in terms of influencing their purchase?

ESTIMATED TIME AND COST

It is expected that the project, as outlined, will take about 24 months to complete. It should be directed by a Research Scientist who will be assisted by a Senior Research Associate, a Research Associate, and a Research Secretary. Two student positions should also be included in the budget. The budget for a project such as this can be broken into four major activities: focus groups/interviews, sample generation, interview development / administration / coding / analysis, and report/article writing and presentations. Outside vendor costs include sample generation ($10,000) (The Polk Company), and interview administration ($111,000) (survey research organization). The estimate for the focus groups/interviews, not including personnel time is $36,000 that includes travel, room and board, facility rental, and participant payment. All costs paid for through the project are charged university indirect costs (52%) and all personnel costs include both indirect costs (52%) and benefits (52%). A preliminary estimate of the cost of a project such as this, covering 24 months, is about $1,100,000.

APPENDIX A

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APPENDIX B

TABLES OF EVALUATION OF METHODS

Economic Models

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Bass 1969	Growth in sales of color TVs and consumer durables		Regression based on previous buyers	Had initial sales data available	Good R^2 Good actual v. predicted		Data are old Product forecasted is not vehicular
Beggs et al. 1981	Consumer demand for EVs	Individuals do not seem receptive to EVs with limited range and long refueling periods. Lower operation costs of EVs do not counterbalance these shortcomings	Discrete choice model Logit Econometric Defines EVs as a bundle of 9 underlying attributes 16 vehicle types	Ranked choice data Random sample Survey	Significant improvement over specification with identical coefficients. Better than specification with population variation modeled by socioeconomic variables		Allows for separate taste parameters across individuals Fairly old work
Bunch et al. May 1993	Demand for clean-fuel vehicles as a function of attributes that distinguish them from conventional gasoline vehicles	Range between refueling is a particularly important attribute in cases where a clean-fuel vehicle has a range that is considerably lass than that of existing gasoline vehicles. Vehicle preferences are relatively less sensitive to fuel availability when range and fuel costs are comparable to gasoline.	Multinomial logit model Binomial logit models	Stated preference survey	Statistical significance, ease of interpretation and stability of the SP choice modeling results are encouraging and provide a useful database for estimating preferences for clean-fuel vehicles in the California South Coast Basin.		
Calfee 1985	Predicting potential market share for EVs as second cars	Due to current distance constraints, EVs are unlikely to achieve a significant market share, even with a substantial increase in gasoline prices.	Probabilistic choice model	Non-random sample questionnaire		Author looked at private demand, not business demand, looked only at cars, not trucks or vans. Assumed EVs as a second vehicle	Restricted socio-economic segment of the auto-consuming public
Chiu et al. March 1999	Potential demand for electric motorcycles (EM) in Taiwan	Female motorists are the potential target market for EMs.	Multinomial logit model Nested multinomial logit model Multinomial probit model	Stated preference surveys	Statistical significance and ease of interpretation of SP methods help to build the model for analyzing the potential demand of EMs.		

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Eliashberg et al. 1992	Insights for better positioning a discontinuous innovation based on product attributes	Empirical studies in the context of new 'smokeless cigarette' suggests that the modeling approach has some validity under the specified scenario.	Two surveys, one to address the attributes of a new product, and the second to address the positioning of the product			Obtaining precise analytical expressions becomes intractable for three or more segments.	
Golob et al. January 1997	A new model of household vehicle use behavior by type of vehicle	Forecasts of future vehicle emissions critically depend upon the ability to forecast vehicle-miles traveled by the fuel type, body style and size, and vintage of the vehicle.	Vehicle-type use model in travel demand forecasts Vehicle-type choice model	Computer-aided telephone interview Customized postal questionnaire Follow-on CATI survey	The structural elegance of the models and their statistical fit to the sample data provide support to the authors' modeling approach. Jointly estimated RP-SP model simultaneously captures the endogenous effects of vehicle reallocation along with perceived changes in utilization associated with EV characteristics.	SP questions in 1993 household survey are primarily focused on issue of vehicle choice and are potentially limited in capturing the full range of effects on other attributes.	
Greene 1985	A method for estimating daily travel distributions for individual vehicles applied it to a recent survey	Results confirm the existence of a very substantial potential applicability for limited-range vehicles.	Maximum likelihood	Longitudinal survey of vehicle use by 2290 households.	Model is successful in estimating daily vehicle usage distributions.	This still does not get to the actual usage each day; it is only an average per day between refueling.	This is an attempt to more accurately reflect the range of daily usage of a vehicle. These data will then be applied to the constraints of limited-range vehicles such as EVs.
Hauser 1984	New technology, slow-scan televideo equipment demand	Results can enable R&D new product teams to focus technological innovations on the set of user benefits that are most likely to increase consumer acceptance	Multinomial logit	From focus groups, questionnaire was developed and sent to 800 people at Los Alamos Scientific Laboratory	Paper demonstrates how consumer theory, market research, and quantitative analysis can improve effectiveness of R&D.		Survey sent to R&D professionals only.

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Heeler et al. 1980	Application of a forecasting model using historical data from sales of refrigerators, color TVs, B&W TVs, washing machines, and others	It is difficult to estimate the early rate of market development. Later sales are easier to predict and closely match the actual historical sales data.	Multiple regression	Historical data are used to test the predictability of the model	If the model user can supply parameters of early sales data, the model can be reliable as a predictive tool.	The model's use as a predictive tool is quite limited during the early period of a new product's life and in many international settings, due to contamination of data.	Discusses the problems associated with predicting early adoption by consumers (innovators). Sales to later adopters (imitators) can be more accurately predicted when the innovator's rate of adoption is known.
Higgins et al. 1992	Identifies purchasing characteristics and barriers to purchase of consumers grouped according to "lifestyle groupings"	The authors identify groups of consumers most likely and least likely to purchase new technologies.	Logistic regression	Mail questionnaire used to ascertain demographic and lifestyle characteristics of high technology consumer innovators (first purchasers)	Analysis determined characteristics of consumers most likely to purchase new technologies, and consumers least likely to buy.	Study was performed in one city in middle America. Needs to be duplicated elsewhere.	Results are to be used to more effectively target consumers. This could serve as a proxy to demand if the size of the innovator group can be ascertained.
Hill 1987	Estimation of EV use by commercial firms	If EVs proved to be a less costly way of doing business, firms would be willing to adopt the technology even in the face of the limited range	Tobit model	Representative sample survey of national commercial businesses	Estimated responses are plausible—both theoretically and behaviorally		
Juster 1966	Comparison of purchase probability survey to an intentions survey	Purchase probability surveys explain about twice as much of the cross-section variance in automobile purchase rates as do buying intention surveys	Regression analysis	Random sample of 800 households that had participated in buying intentions survey were reinterviewed a few days later with the experimental probability survey.	A reasonably good proxy for household purchase probability can be obtained from a survey of subjective purchase probabilities. The probability survey is able to attract information that is not obtainable from intention surveys.	In this survey, few supplementary data, which may have enabled more accurate judgments, were obtained.	

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Mannering 1983	Model of individual vehicle utilization in multi-vehicle households	The ability of multi-vehicle households to substitute the use of more efficient vehicles for less efficient ones should be considered in VMT-price elasticity estimates and their varying effects on different groups.	An econometric model of individual vehicle use in multi-vehicle households	1979-1980 Household Transportation Panel Survey	All variables were properly signed, and all except one were significant at the 90% CI. Miles driven were less for drivers over 50, females, urban households, and when a "competing" household vehicle was driven.	Model fit could be enhanced with more detailed data relating to type of activity the principal driver actually undertakes.	
Mannering et al. 1995	Explanation of recent growth in the adoption of airbags in new automobiles	Airbags were offered by automakers because consumers were willing to pay for them. The market for airbags worked efficiently, placing doubts on the social value of safety regulations and efficacy of nonexperimental safety information campaigns	Multinomial logit	National household panel	The model shows what consumers are willing to pay for airbags.		
Maples et al. January 1999	Final documentation for Quality Metrics 2000	Cost comparison indicates that alternative fuel vehicle technologies are consistently more expensive than conventional	Vehicle choice / consumer choice model (household based, discrete choice, multi-attribute logit model) utility-maximization	Reference case projections of the Energy Information Administration, surveys, historical data		Major limitation in estimating potential household market penetration: lack of revealed preference data due to limited number of alternative-fuel technologies commercially available.	
Moore et al. 1998	Assessment of the potential of diesel engine light-duty vehicles to reduce consumption and greenhouse gas emissions	If negative attributes of diesel were eliminated, the potential exists for increased use of diesels.	Vehicle size/consumer choice model (multinomial logit structure for vehicle size and consumer-derived utilities) Telephone survey	Historical diesel vehicle sales behavior and sales forecasts of conventional and alternative-fuel light-duty vehicles	Survey results are corroborated by market penetration analysis indicating that improved diesels can be strong competitors of gasoline engine vehicles		

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Morrison 1979	A framework for collecting, analyzing and interpreting purchase data, and a method to transform stated purchase intentions into purchase probabilities	Researchers may use the presented framework to follow up purchase intention studies with purchase behavior studies. Empirical regularities may emerge which make purchase intentions data much more useful.	The model provides a method for transforming an estimate of true intention into a purchase probability estimate.		The model forces the researcher to consider: the reliability of stated intentions, the number of points on the intention scale, adjectives associated with points on the scale, distribution of intentions across the population, the appropriate time frame of intentions, systematic discrepancies between intentions and purchase probabilities.	There is not currently an adequate set of purchase intentions with follow up purchase behavior studies in the literature to evaluate the model.	
Nakicenovic 1986	Description of technological substitution in the automobile	Technological changes for road transportation has occurred with great regularity and was much more rapid than for other modes of transportation. The evolution of motor vehicles can be seen as a series of interlaced technological changes of production methods and vehicles.	Historical observation				
Ryans 1974	Model designed to estimate the level of preference consumers exhibit toward differentiated brand at a given price in a multibrand durable good market	The model was tested in a laboratory setting and needs to be tested in a real market	Draws on Lancaster utility maximization models and incorporates pricing assumptions. Subjects provided information on their perceptions of 12 brands as well as their relative preferences for each of the brands.		The predictive ability of the model was quite encouraging. To validate the model in an actual marketing setting would involve incorporating estimates of the number and types of stores likely to be visited by a customer and the brands and models likely to be displayed in these stores.	This work needs to be replicated for other durable good product classes using larger sample sizes in order to test the model.	
Segal 1995	Forecast for alternative vehicle use in California	The market for EV vehicles in California is too small to support that state's ZEV mandates, but there might be a large market for natural gas vehicles.	Hedonic tradeoff analysis Economic tradeoff analysis Market niche analysis Conjoint analysis	Mailed questionnaire	This analysis method provides a framework for defining the appropriate pace of AFV technology development.		Assumption is made that individuals can evaluate multi-attribute product profiles on a category rating scale so their judgements can be later used to simulate choices in hypothetical choice exercises.

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Train 1979	Review of existing automobile demand econometric studies	Existing studies focus on aggregate demand rather than vehicle class and largely ignore characteristics other than price.	Review of existing models		More usable information could be gained by utilizing variation both across households and vehicle types. Experimental methods such as conjoint analysis might be used to elicit consumers' values of various characteristics.	Independence from irrelevant alternatives must be guarded against. This property requires that the ratio of probabilities of two alternatives be the same independent of the characteristics or availability of other alternatives.	Study was completed in 1979.
Train 1980	Estimate of market share for non-gasoline powered vehicles in 2000 and 2005	Nickel-zinc battery and hydrogen–powered vehicles were forecast to capture little market share but high temperature batteries would capture more. Hybrid vehicles were forecast to capture a significant market share.	Vehicle forecast model using likely and optimistic scenarios for characteristics of non-gasoline powered vehicles		Results were compared to those projected by other sources: they were close to SRI results but lower than Mathtech forecasts.	Limited range of battery powered vehicles could not be included in the model. Weight is an important determinant of vehicle choice in the Lave/Train model, but is more likely a proxy for other characteristics such as safety or roominess.	Twenty-year old forecast: current market shares are very different from 2000 forecast.
Urban et al. April 1993	New product forecasting models which include categorization and consideration	The submodel and measurement for understanding categorization, elimination, and consideration can be used or adapted whenever a model is conditioned on evoking a specific brand awareness.	Developed a model, measurement, and estimation technology and then applied it empirically in the context of a new-car launch	Original, adjusted, and actual sales forecasts	The model attempts to integrate behavioral science with quantitative managerial modeling to improve market strategy formulation.	A major issue is the quality of aggregation represented in the model. Though individual differences in categorization, elimination, and consideration are incorporated explicitly into the model, the authors assume that there is only one true market structure.	
Walls 1996	Average per car consumer surplus losses associated with a mandate to use natural gas vehicles	Consumer surplus losses per vehicle are estimated to be between $1100 and $3200, with 20-50% of losses due to changes in vehicle characteristics. Costs appear to be greater than environmental benefits but comparable to other methods for reducing vehicle pollution.	A Lancasterian model is used to evaluate consumer utility based on vehicle attributes such as reduced cargo space, increased weight, decreased acceleration and increased price.		Considering the full costs of regulation is important, including the loss of consumer surplus caused by changes in the product characteristics.	Because of the lack of cost and other information about natural gas vehicles, educated guesses were used.	

Product Clinics/Field Tests

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Heiman et al. 1996	Method for evaluating the optimal product demonstratio n time	The authors found that firms offered a longer demonstration time than needed and failed to properly segment customers with regard to prior knowledge of the product. Customers with prior knowledge of the product should require less demonstration time.	By segmenting the product demonstration cases according to the length of the demonstration period, the authors evaluated its effect on product purchase behavior.	225 demonstrations of an automobile product and 46 demonstrations of a computer printer	By identifying the amount of prior knowledge a customer has, demonstration time and the costs associated with it can be adjusted to specific customers.		
Golob et al. 1998	Electric vehicle use by households	Households can use EVs for most of everyday trips usually made in conventional-fuel vehicle, but some trips will be shifted to other vehicles in household fleet. People desired a range of 100 miles or more even though most trips were less than 50 miles.	Vehicle trails with manufacturer prototypes by households for 2 weeks Trial diaries	Travel diaries Pre-trial and post-trial surveys	Trials are useful for collecting data. Duration period was reasonable; could have shorter period. Daily recording of VMT was fairly accurate. Trial may be essential for describing detailed travel behaviors.	Results are not unbiased. Novelty of the trial can introduce changes in driving behavior. Exaggerated reports of use, were recommend studying complex intra-vehicle switching.	
Kostyniuk et al. March 1997	User perceptions of ITS equipment (Ali-Scout) in passenger cars	The Ali-Scout system (beacon-based route navigation) was received positively by majority of drivers.	Field trials for 4 weeks by individuals aged 19-80 Drivers' log during entire trial Questionnaires at end of trial	Questionnaires and driver logs	Some good data on user acceptance were reported and provided insight into the usefulness of the technology.	The authors report that some of the data are biased. Some participants want to please the study team and report overly positive responses. Also, there was an age/gender bias in which young males underreported difficulty of tasks in operating the equipment.	This study is different from a PNGV study in that the equipment was available for testing.
Kostyniuk et al. November 1997	Usability of ITS technology (in-vehicle navigation systems) by older drivers	Co-pilots are often used by the elderly in driving. Some ITS systems can serve as a co-pilot for elderly drivers. The elderly have wide variation in computer skills. Participants wanted context-specific help and hands-on training.	Field trials for one month Focus groups Drivers' logs of trips Survey of perceptions	Questionnaires, driver logs, focus groups	Some good data on user acceptance were reported and provided insight into the usefulness of the technology.	The authors report that data are biased due to participants wanting to please the study team. Focus groups yield data that is not generalizable to the population.	

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Turrentine et al. April 1992	Consumer response to alternative fueled vehicles	Majorities of participants were convinced that AFVs are the solution to air quality problems in Los Angeles.	Test drive, interviews, post test-drive focus groups Survey of CNG home refueling unit owners and entire California population Interviews using gaming techniques Panel studies	Interviews, focus groups, surveys	Data on consumer response were reported as well as types of attributes consumers must consider when confronted with AFVs. Early market segments identified.	Report is not designed to predict percentage of EV sales.	This study is different from a PNGV study in that the equipment was available for testing.
Urban et. al. April 1990	Prelaunch model and measurement system to the marketing planning of a new automobile	Durable goods do present unique problems. "Price" forecasting problem, validation of production-constrained forecasting, search and experience, and word of mouth are critical phenomena relevant to durable goods.	Clinic format with control group Customer-flow models	Sales forecasts Predicted vs. actual sales	The initial results suggest customer-flow models are useful in capturing the unique aspects of durable goods marketing. The models can be calibrated empirically and implemented with managers.	Application challenges: efficient measurement. Clinics require detailed and expensive consumer intelligence. Scientific challenges: authors' flow model is somewhat ad hoc.	Authors' applications relied on "calibration", which mixed direct measurement, modeling, judgement, and fitting.
Urban et. al. January 1996.	Illustration on how to face the challenge of forecasting consumer reaction for a "really new" product	Information acceleration provided valuable data, but has limitations in terms of cost, managerial judgement, order-of-entry effects, and other characteristics.	Combination of existing forecasting methods with new information acceleration method	Estimated sales of the GM Impact and GM EVs	The two information acceleration studies provided valuable data on which to base managerial decisions.	Information acceleration is expensive. Information acceleration forecasts depend on managerial judgement. Authors could not simulate order of entry effects.	Study focuses on pre-market forecasting of "really-new" products – GM EVs.
Wilton et. al. September 1981	Methods that can overcome knowledge and readiness deficiencies of innovative products	Stated choices of individuals for an innovation can be reasonably predicted on the basis of modified perceptual and effective judgements.	Eight groups of subjects including two control groups – pre-and postexposure to a unique information treatment Questionnaires Multiple discriminant analysis and multivariate probit analysis	Questionnaires and focus groups	This method of analysis appears to be an efficient approach to predicting the level of acceptance of innovative new products.	Validity of actual market behavior remains untested.	Study is almost twenty years old.

SURVEYS

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Blattberg et al. 1978	A forecasting model that generates year-end sales forecasts based on only 3 months of test market data	The model is fairly accurate and inexpensive to use.	Three months of survey test market data is used to forecast of sales as well as a products strengths and weaknesses. It also includes inputs such as advertising and price.	Survey data (rather than panel data)		Accurate inputs to model had not yet been generated.	
Bockenholt et al. 1997	Measuring preference changes based on preferences measured before and after a new product has been introduced	Dynamic latent class models provide a comprehensive framework for understanding how a new product changes the competitive landscape.	Sum-paired comparison ratings by consumers used before and after a new product introduction (or in pretest marketing) analyzed using dynamic latent class models	Sum paired comparisons Latent class models		If respondents differ in their use of sum paired comparison-rating scales between before and after testing, failure to account for such differences can confound and lead to bias preference estimation.	
Harris 1998	Estimate of whether EVs can meet the needs of fleets	Many but not all fleet needs can be met with EVs.	Suitability based on focus group with fleet managers, demonstration vehicle driver surveys, EV driver logs, and statistical data on electric company fleet vehicle use.	Focus groups, mail/paper survey, driver log notes, mileage data from fleet logs	Using a number of inputs helps identify major issues.	Life cycle cost was not considered in this study. Additional barriers to acceptance of EVs were found: initial cost, acquisition method, and internal fleet buying processes.	
Jamieson et al. 1989	Trying to predict purchase behavior by combining purchase intention with willingness to consult others before purchase, affordability, liking, and availability	Results suggest that extension variables can lead to the development of modifiers of intention for use in predicting trial purchase	Tested other intention-related variables as predictors of purchase behavior. Two different models were used: Morrison's modified beta-binomial model and the linear modified intention model.	Database of results of telephone interviews	Results suggest that extension variables can lead to the development of modifiers of intention for use in predicting trial purchase. Authors think the measures can also be used on other new consumer products.	Stimulation with intention to buy questions could contaminate the sample.	
Kling et al. May 1991	Estimation of costs of emission control	There may be sizeable cost savings associated with a permit system relative to an inflexible standard.	Emission control costs for conventional gasoline vehicles. Survey of twelve vehicle manufacturers	Total emission control costs, manufacturer and dealer mark-up costs	Research suggests there may be sizeable cost savings associated with a permit system relative to an inflexible standard.	Results are preliminary.	

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Kurani 1996	Estimate of vehicle demand for reduced-range, home-recharged EVs among multi-car households	Purchases of battery powered EVs by hybrid households would account for between 7 and 18% of annual light duty vehicle sales in CA. EVs sold to fleets and other households would be in addition to those identified by the study.	A multi-stage, experimental and process-oriented approach. 1) Initial survey of households for vehicle holdings, purchase intentions, demos. and environmental attitudes. 2) Three-day travel diary and survey of travel and refueling behavior. 3) Informational video demonstrating features of EVs. 4) Choice experiments related to next vehicle purchase	Questionnaire responses, travel diaries, experimental data	This identifies a substantial market for reduced-range, home-recharged EVs.	Studies that try to estimate market segments mis-estimate future demand because consumers have not yet constructed preferences for novel technologies. The results are to be seen as illustrative, not forecasts. Sales could be far more or less depending on prices, performance, marketing strategies, gov't incentives or regulations. Questions on whether consumers regard EVs offered to them as affordable, viable options.	
Mander et al. 1998	Applying a methodology to measure the potential market for EVs and the impact of those EVs on load and revenue	By 2007, the number of EVs in the Twin Cities region will be less than 3% of the region's vehicles. They will just begin penetrating the market.	Questionnaires mailed to electric utility customers to determine household or firm EV potential. Factor sample up to population of population of vehicles, resulting in population market potential. Market penetration factors based on analogy to minivans.	Survey data, past market penetration factors, area characteristics and vehicle demographics	Very reasonable and consistent results. Cost effective way of learning about EV potential and impacts for an area. Could also be used to estimate air quality and energy impacts of EVs in a region. A car dealership could use it to determine if EVs could be a viable product line.		Potential does not translate directly into sales. Minivan may not be best representative vehicle to calibrate market penetration.
McNeil 1974	Assessment of consumer expectations, intentions, and attitude studies	Aggregate purchase plans were not a predictor of aggregate purchase behavior.	Comparison of predicted purchases generated by surveys with actual levels of purchases among the same group of consumers	Survey responses and actual purchase behavior		Cross-section tests are necessary but not sufficient to predict purchase behavior. Attention must be paid to specifying cross-section tests, and the utmost caution must be paid to using cross-section results to infer time-series performance.	
Moyer et al. 1998	Possible futures for electric vehicles	A limited but viable market can be built, but then there is a need to create an infrastructure that can support a broader market if costs can be decreased and range increased.	Analysis of 40 questionnaires and interviews with experts in the field including OEMs, battery makers, component suppliers, electric utility reps, gov't agency reps, trade organizations, researchers, and academics	40 questionnaires and interviews	A number of possible futures are proposed.	No guarantees of market acceptance.	

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Pohl 1998	Theoretical and applied study of purchase of electric vehicles	Theoretical study found that 46% of the work from 1600 cars and 1550 trucks could be done with electric vehicles. The applied study offered these companies electric vehicles and very few purchased. Reasons for not buying EVs included: only one working day was considered, range is not the only important factor, and new technology is not adopted directly by everybody.	Field study of 2002 vehicle owners. Attempts to sell electric vehicles through a 3-year, full-service lease at a comparable or slightly higher price to companies that showed that they could use electric vehicle based on range as well as test drive the vehicles. Follow-up interviews with companies.	Logs of one working day based on distances covered, number of passengers, and weight load.			
Pringle et al. 1982	Modeling program that generates forecasts of consumer awareness, trial, repeat purchase, usage, sales, and market share of a new brand	The program seems to have worked well in predicting demand for new products.	Bayesian analysis techniques based on accurate inputs of estimates. Primarily based on consumer surveys or store audits.	Secondary source materials, prior and current custom marketing research, related product experiences. Consumer surveys or store audits	Accurate predictions based on pre-test markets or early market results.		Can this be applied to very new products or very expensive items such as vehicles?
Underwood et al. 1991	Forecast of market penetration of IVHS technologies	Institutional barriers are unlikely to provide adequate support.	Delphi survey of experts in the field	Survey data	Details barriers to implementation, driving forces, government policy, and social impacts	Unconventional nature of institutional problems posed by IVHS limits the ability to predict relevant social, political, and economic events with any degree of certainty	Survey of experts does not represent possible consumer purchase.
Vyas et al. 1997	Projected vehicle characteristics for EVs and HEVs and future characteristics of 10 battery technologies for the period 2000-2020 Procedure to compute battery replacement costs	With the battery replacement costs added to the fuel and maintenance costs, the conventional ICE vehicle is projected to have a clear advantage over electric drive vehicles over the projection period.	Two-stage Delphi study	Forecasts for 2000, 2010, and 2020			

Other

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Apogee Research, Inc. 1997	Develops analytical process for evaluating the market potential for Intelligent Transportation Systems	A fundamental hypothesis of the undertaking is that initial investment in ITS will leverage additional investment from the private sector and investments in basic ITS will establish a foundation for the adoption of more advanced ITS-related services.	Evaluations of: 1)potential private sector investment 2)linkages between various ITS packages and the effects of linkages on success of deployment 3)identification of packages which are either autonomous or dependent on base infrastructure 4)linkages between market packages and specific services and 5)undertaking market analysis of different market segments and products/services.				
Bernard et al. 1990	Sales of electric/hybrid vehicles	Sales of electric/hybrid vehicles in 1999 of more than 150,000 and over 500,000 in 101 cities by 2003.	Scenario development	Projected EV production plans Urban population Cost of utilities			
Brand January 1997	Evaluation process for the preparation of ITS plans	The proposed criteria structure simplifies ITS evaluation	Proposed ITS evaluation criteria based on criterion type (supply and demand) and time scale (short, medium, long term).		Criteria structure simplifies ITS evaluations by separating supply and demand impacts of ITS; makes it difficult to underestimate the benefits of ITS.		
Charles River Associates October 1996	Identification of 3 problems inherent in new product studies	Demand for a new product is influenced by stochastic and deterministic factors. For radically innovative categories of products, the appraisal of potential customer demand must necessarily be based on stated preferences as well as (or instead of) revealed preferences evidence. Consumer surveys about hypothetical products or new product concepts are very prone to bias.	Literature search on consumer acceptance of ATIS.				

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
Das 1996	Costs of ITS technology: IVIS		Define market packages; compile prices of components; calculate life-cycle costs; project future costs		Cost estimates are high	Results are order-of-magnitude because of uncertainty about future technology and assumptions about market penetration.	Assumes ITS architecture will be in place
Jaffee 1994	Factors determining rate of diffusion for energy conserving technology	Understanding the causes of gradual diffusion of energy-conserving technologies is key to identifying appropriate policy responses.	Simulation of scenarios	Simulated effects of factors and public policy on adoption rate of energy-conserving technologies	Identifies "nonmarket-failure" and "market failure" causes of gradual diffusion of energy-conserving technologies	The selection of appropriate policy instruments will depend upon importance of various underlying explanations of the gradual diffusion of energy-efficiency technologies	
Kurani July 1993	Evaluation of early market segments' response to EVs	Little evidence is found to support the supposition that the samples of innovators or environmentalists are willing to pay a purchase price premium to be among the first buyers of OEM EVs.	Test Drive Clinics Focus Groups	Statistical comparisons of innovators and environmenta-lists		Examines two hypothetical market segments (innovators and "green") for a product not yet available. Cannot identify "innovator" and "early adopter" a priori. Definition depends on comparisons of persons in these groups to later buyers of the product.	On several attributes, "environmentalists" cannot be distinguished from the "EV innovators, " most notably characteristics which were to have defined them as environmentalists. 15 of 26 participants chose one of the prototype OEM vehicles they tested assuming that the prototypes would be similarly priced to gasoline vehicles of similar body styles.
Mahajan 1988	Evaluation of new-product forecasting models	New product forecasting models need to enhance their utilization in evaluating new product decisions and better meet needs of users of forecasting models	Evaluation of forecasting models	Review of forecasting models	Directions for research and implementation – improving the utility of existing models and broadening the scope that better meet the needs of users of forecast models.	The three types of forecasting models vary with respect to the stage in the new-product-development process for which they are most appropriate.	

Document/ Date	Output	Conclusions	Method	Data	Evaluation - Benefits	Evaluation - Limitations	Special Considerations
U.S. Department of Transportation 1996	Snapshot of consumer Automated Traffic Information System (ATIS) products available for purchase today	The price for any new in-vehicle ATIS product would need to be below that of an air conditioner, in-vehicle ATIS products will not debut as OEM equipment, and as a communications application outside of the car, traffic information would need to be combined with other services on a multi-purpose platform to be saleable	Narrative analysis and review of ATIS marketplace	Compilation of consumer ITS products and services		In the absence of direct survey and sales data, it is impossible to describe ATIS consumers with any precision or reliability. What data exist are contained within some of the field test evaluations, but even these data have limited applicability.	

APPENDIX C

ABSTRACTS OF REVIEWED DOCUMENTS

REFERENCE

Apogee Research, Inc. and Wilbur Smith Associates. ITS National Investment and Market Analysis, Technical Working Paper: Task D – Market Analysis. Washington, D.C.: Intelligent Transportation Society of America, May 1997.

KEYWORDS

New product forecasting, intelligent transportation systems.

ABSTRACT

This working paper, third in a series of reports, focuses on the market potential for Intelligent Transportation Systems (ITS) equipment and services. This report examines the domestic market potential leveraged from the basic ITS. It is important to distinguish between "market potential" and the "benefits" of ITS. Although market development does generate benefits (for example, employment in new industries and for international trade), the focus of this report is not on evaluating the benefits of basic ITS deployment.

A fundamental hypothesis in undertaking an analysis of the market potential and opportunities resulting from investment in basic ITS services is that this initial or core investment will leverage additional investment from the private sector. This, in turn, will lead to a greater realization of the full potential of ITS. Initial public sector investment in basic ITS services establishes the foundation for future investment in more advanced ITS-related services, and broadens the opportunities of the private sector in realizing the full market potential of ITS. The goal of this working paper is to undertake a comprehensive analyses of the potential market opportunities for the private sector that are either directly leveraged from the initial investment or accelerated by the nationwide deployment of ITS.

METHOD

The primary goal of this study is to identify potential ITS market opportunities for the private sector and develop estimates for the total size of the market by the year 2015. It is assumed that private sector investment logically follows initial public sector investment in the deployment of the base ITS infrastructure. Market opportunities arise for the private sector after the initial investment and deployment phase, and are enhanced by additional investment — by both the public and private sector — in intermediate and advanced ITS services and products.

The first step of the analytical process involves identifying the underlying assumptions used to evaluate expected market opportunities for the private sector. This step is important to clearly define the long-term investment assumptions and the time frame of the analysis before any evaluation of the potential market for ITS products and services can take place.

The second step in the process involves evaluating the market packages and establishing linkages between base packages and more advanced packages. A clear linkage outlining the development and deployment of market packages over time is established in this step. The market package evaluation tracks the evolution of ITS from the initial deployment of basic ITS, to intermediate market packages, to more advanced market packages that may not be fully developed or deployed for 15 or 20 years.

The third step of the analytical process involves distinguishing between autonomous and dependent products. Dependent ITS market packages and services depend directly on the deployment of certain base market packages or basic ITS services before they can be refined and deployed themselves. Other market packages are autonomous in nature (stand-alone), and do not directly depend on the development or deployment of the basic ITS market packages. The market for autonomous services and products may develop without the deployment of base market packages, however, the market for dependent services and products is directly linked to the deployment of base market packages.

The fourth step of the process involves linking the various market packages with specific services and products. The link between user services and market packages is provided in the architecture, while information on the specific

products and equipment associated with each market package is based on primary research. Information about many of the ITS products and equipment can be found in publications such as *ITS World* and *ITS International*, and from private sector vendors. At this point, a comprehensive linkage has been established which links user services and products to the various market packages.

The fifth step focuses on undertaking the market analysis of the different market segments and products/services. After a determination is made on what services and products are expected to be derived from the deployment of basic ITS services, historical data were collected for a variety of highway and transit conditions. These include transit passenger trips, transit fare collection, VMT for selected functional classes, percentage of congested VMT, etc. Historical data trends were then projected into the future using straight-line extrapolation by year based on five-year data trends.

EVALUATION REPORTED BY THE AUTHORS

None.

REFERENCE

Bass, Frank M. (Purdue University) "A New Product Growth for Model Consumer Durables." Management Science, Vol. 15, No. 5, January 1969.

KEYWORDS

Economic, regression analysis, color televisions, consumer durables.

ABSTRACT

A growth model for the timing of initial purchase of new products is developed and tested empirically against data for eleven consumer durables. The basic assumption of the model is that the timing of a consumer's initial purchase is related to the number of previous buyers. A behavioral rationale for the model is offered in terms of innovative and imitative behavior. The model yields good predictions of the sales peak and the timing of the peak when applied to historical data. A long-range forecast is developed for the sales of color television sets.

METHOD

The growth model developed in this paper for the timing of initial purchase of new products is based upon an assumption that the probability of purchase at any time is related linearly to the number of previous buyers. There is a behavioral rationale for this assumption. The model implies exponential growth of initial purchases to a peak and then exponential decay.

The basic assumption of the theory is formulated in terms of a continuous model and a density function of time to initial purchase. The linear probability element is referred to as a likelihood.

EVALUATION REPORTED BY THE AUTHOR

Data for consumer durables are in good agreement with the model. Parameter estimates derived from regression analysis when used in conjunction with the model provide good descriptions of the growth of sales. From a planning viewpoint, probably the central interest in long-range forecasting lies in predictions of the timing and magnitude of the sales peak. The model provides good predictions of both of these variables for the products to which it has been applied. For ten of the new products tested over time periods between 1926 and 1961, the R^2 of the forecasting model ranged from .473 to .953, with six of them being above .85.

REFERENCE

Beggs, S. and S. Cardell (Charles River Associates) and J. Hausman (Massachusetts Institute of Technology). "Assessing the Potential Demand for Electric Cars". Journal of Econometrics, Volume 17, No. 1, September 1981.

KEYWORDS

Electric vehicle, random sample, econometric modeling, logit.

ABSTRACT

An ordered logit specification for use on ranked individual data is used to analyze survey data on consumer demand for electric cars. In many situations in economics and marketing it is desirable to be able to forecast consumer demands for goods which have not yet appeared in actual markets. By defining goods as a bundle of underlying attributes, and using discrete choice models, consumer evaluations can be estimated. Then new good demand is forecast by use of the estimated coefficients to compare consumer evaluation of the new good to existing choices. When ranked individual data are available, separate coefficients can be estimated for each individual rather than assuming identical coefficients as is usual with logit models. The results indicate considerable dispersion in individual coefficients. This finding can have important implications for new product analysis.

METHOD

Survey data are on balance inferior to market data. Revealed preferences of consumers in markets do not have the possibility for confusion or unstated assumptions that exist in survey responses. On the other hand, surveys do have two advantages over market data. First, the new product can be described in detail so those potential customers can describe their reactions to the product and its attributes. Use of existing market data to forecast new demand depends heavily on correct model specification and the requirement that consumers value attributes similarly for different products. Also, more information can be elicited from a given person since he can be asked to rank the products in preference order or to specify a demand curve for attributes. But hypothetical situations still can not be made equivalent to market situations. Thus, it seems important to check the consumer valuations, which arise from survey data with similar valuations, which arise in market data for attributes, which exist in both situations. Validation should increase the confidence, which can be placed on the survey responses if the attribute valuations are similar in both situations.

In this paper, survey data on electric car demand gathered by the National Opinion Research Corporation for Arthur D. Little (ADL) were used. Each survey respondent was asked to rank order 16 car designs that differed over 9 attributes. Seating capacity, maximum speed, purchase price, and operating costs are all attributes whose valuations can be observed in existing market data. However, the most important attribute that distinguishes electric cars is their limited daily range. The author felt that only survey data allowed for proper treatment of this attribute. Thus, they developed an 'ordered logit model' for the survey data that allows for use of ranked preference data. It differs from the usual logit model of qualitative choice that considers only the most preferred alternative. The ordered logit model is estimated over approximately 200 people in the sample. The main empirical finding is that consumers place an extremely high negative valuation on the limited range. Thus, the results cast considerable doubt on the possibility of much consumer demand for electric cars given the existing technology.

EVALUATION REPORTED BY THE AUTHORS

The authors demonstrated how ordered logit analysis can be used to analyze ranked choice data where separate coefficients are estimated for each individual. The ordered logit model offers an alternative approach to the conjoint analysis method used very widely in the marketing literature.

The authors made full use of the individual rankings of alternative choices to estimate a model that allows for separate taste parameters across individuals. The specification leads to a significant improvement over the specification with identical coefficients. It also does better than the specification with population variation modeled by socioeconomic variables. The policy conclusions are that individuals do not seem receptive to electric cars that

have limited range and long refueling periods. The lower operating costs of electric cars do not provide a sufficient counterbalance to these perceived shortcomings of electric vehicles.

REFERENCE

Bernard, M.J. III, M.K. Singh, and K. Heitner, (Argonne National Laboratory). Three Scenarios for Electric and Hybrid Vehicle Commercialization. Report No. ANL/ESD/TM-13, November 1990.

KEYWORDS

Electric vehicle, hybrid vehicle, scenario development.

ABSTRACT

Three electric and hybrid vehicle (EHV) market-penetration scenarios are developed for 1995, 2000, 2005, and 2010. The first scenario is intended to maximize the substitution of electricity for gasoline in the 101 metropolitan areas of the U.S. that are nonattainment areas for ozone; by 2010, 12 million EHVs are projected to be operating in those areas. The second scenario focuses on the nine metropolitan areas with the worst ozone problems and projects six million electric vehicles in the nine areas by 2010. The third scenario, like the first, projects 12 million EHVs in operation by 2010 but distributes the vehicles to all metropolitan statistical areas. The vehicles are distributed to the metropolitan areas as a function of area population and off-peak marginal cost of electricity for the local power pool. The scenarios contain several different EHV cars, vans and trucks (differences include battery type, a.c. or d.c. drive, and hybrid or straight electric mode). Daily electricity consumption is calculated for each metropolitan area for the country by scenario year.

METHOD

The scenarios under development draw from other studies to estimate potential penetration by each alternative-fuel vehicle in each scenario, given different scenario objectives.

The first scenario, the "energy security" scenario, focuses on the potential energy security benefits of displacing a significant amount of oil.

The second scenario the "environmental" scenario, is motivated solely by environmental concerns.

The third scenario developed in the course of the present study is based on the assumptions of the 101-city (energy-security) scenario, except that all consolidated metropolitan statistical areas (CMSAs) and all MSAs not in CMSAs are used. This "all-city" scenario was developed because many cities in the Southeast and in the upper tiers of states west of the Great Lakes are attainment areas for ozone; thus, they are not in the 101-city scenario and are not EHV markets.

An earlier study has concluded that, on the basis of the performance and recharging requirements of EHVs, 45% of all light-duty vehicles (LDV) could be EHVs, if cost were not a consideration. Given this sizeable potential market and assuming that EHVs are economically competitive with conventionally fueled vehicles (CVs) and/or that policies are in place to foster or require the use of EHVs, EHV market penetration by 2010 is expected to be constrained largely by the rate at which vehicle (mainly battery) production facilities can be built and put into operation.

Currently announced plans for EV production in the next few years are more modest than these projections, and there are no announced plans for the production of HVs. For these reasons, the authors delayed the above time frame of projections by four years. In both the energy security and the environmental scenarios, a more advanced battery (with a range of as much as 200 miles) is assumed to be introduced in the 2000-plus time frame.

It is assumed that, all other things being equal, the price of off-peak electricity will determine the number of EHVs per capita in each metropolitan area. EHVs are expected to be recharged during the evening hours ("off peak").

The distribution from the production scenarios to the cities in each year is linearly proportioned as follows:

$$N_{mt} = POP_m \times MCF_m \times MF_t$$

N_{mt} = the number of EVs or EHVs in metropolitan area
POP_m = the 1987 population of metropolitan area (m)
MCF_m = the marginal cost factor for metropolitan area m's utility
MF_t = the mapping factor, which for year t maps the national EHV fleet onto each POP_m.

Neither urban population nor utility marginal costs are forecast for future years in the scenarios.

In 1999, in both scenarios, more than 150,000 EHVs/EVs are projected to be sold. Over the next four years, EHV sales are projected to be 545,000 by 2003 in the 101-city scenario and 270,000 in the nine-city scenario. Thus, the production scenarios shown here are realizable by the automotive industry, if sufficient economic incentives exist.

EVALUATION REPORTED BY THE AUTHORS

None.

REFERENCE

Blattberg, Robert (University of Chicago) and John Golanty (Leo Burnett Co. Inc.). "Tracker: An Early Test Market Forecasting and Diagnostic Model for New Product Planning." Journal of Marketing Research, Vol. XV, May 1978.

KEYWORDS

New product forecasting, survey, test market data.

ABSTRACT

A new product-forecasting model is described which uses survey data (not panel data) to predict year-end test market sales from early test market results (usually three months). In addition to offering a sales forecast, the model is designed to provide diagnostic information about a new product's strengths and weaknesses. By relating advertising expenditures, price and perceptions of performance/acceptability of the product to sales, the model indicates how an unsuccessful product can be redesigned or the marketing mix changed to make possible a successful introduction. The model also can be used for new product planning. Given a media plan, price, sampling level, couponing, and some estimate of repeat usage, a pre-test market forecast of year-end sales can be made which allows management to evaluate different marketing plans to see which best meets profit or sales goals.

METHOD

A model was developed to forecast total brand awareness for new products based on advertising, the percentage of triers of the new product by time period, and year-end market shares of the new product.

The model presented here has several distinct features. First, it requires only three months of test market data, whereas many other models require longer time periods (commonly six months or longer). Second, it uses survey data. Almost all other models require panel data, which are much more expensive and take longer to recover and process from the marketplace. Third, the model is inexpensive to use. Fourth, the model is very easy to understand and to use.

The procedures used to estimate the model were not stated by the author. Readers are instructed to contact the author to obtain information about the estimation procedures. Some parameters of the market-share portion of the model were estimated by using telephone surveys and by other subjective means.

EVALUATION REPORTED BY THE AUTHORS

A new forecasting model that is fairly accurate and inexpensive to use is presented. The model uses survey data rather than panel data. It also uses marketing inputs such as advertising and price. The model can forecast year-end sales after only three months of test marketing so that a quick decision about the success of the product can be reached. The model also gives diagnostic information about the reason for low awareness, trial, or repeat purchasing. It thus helps firms to redesign the product or the introduction strategy. Finally, the model also can be used for evaluating alternative marketing strategies. The next step is to develop accurate inputs to the model before test marketing so that the model can be used to predict success or failure of products without requiring test marketing. Thus the high cost of test marketing can be avoided.

REFERENCE

Bockenholt, Ulf (University of Illinois at Urbana-Champaign) and William R. Dillon (Southern Methodist University). "Some New Methods for an Old Problem: Modeling Preference Changes and Competitive Market Structures in Pretest Market Data." Journal of Marketing Research, Vol. XXXIV, p. 130-142, February 1997.

KEYWORDS

New product forecasting, focus group, dynamic latent class models.

ABSTRACT

Despite the enormous amounts of resources devoted to concept and product testing and the continued use of pretest market (PTM) modeling procedures, estimates of new product failures are still alarmingly high. The primary objectives of PTM modeling are to forecast the market share/sales volume of a new product and to determine the sources of new product share at the aggregate market level.

METHOD

The authors describe a new approach that is designed to provide a parsimonious description of competitive changes before and after a new product is introduced by identifying latent segments (i.e., groups of consumers) that vary in size and composition with respect to the relative preferences for a set of brands before and after a new product is introduced. Each latent segment represents a particular preference state characterized by a set of segment-level choice probabilities. The modeling framework is based on a class of dynamic latent class models that explicitly recognize two major types of preference heterogeneity: (1) heterogeneity caused by before-after changes in latent preferences for the brands (i.e., time-varying relative choice probabilities) and/or (2) heterogeneity caused by consumers changing their latent preference segment in response to a new product (i.e., time varying latent segment probabilities). As is demonstrated in the empirical application, the dynamic latent class models provide a comprehensive framework for understanding how a new product changes the competitive landscape.

EVALUATION REPORTED BY THE AUTHORS

Constant sum paired comparison ratings have a long history in psychology and marketing research and will continue to be used to calibrate preferences for established and new product introductions in PTM studies. The authors describe a dynamic latent change framework that can provide important information on competitive structures before and after a new product is introduced. The models allow for various types of heterogeneity and in so doing provide a framework for testing a panoply of hypotheses concerning, among other issues, whether latent preferences have changed in response to the new product and/or whether the new product introduced has induced respondents to change their latent segment membership. The authors also show how the proportional draw hypothesis can be tested within the LSC and LPC models and the utility of these models in assessing the competitive effects. Finally, an important conclusion from the models proposed and application presented is that respondents may differ in their use of constant sum paired comparison rating scales and failure to account for such differences can confound various sources of heterogeneity and ultimately lead to biased preference estimation.

REFERENCE

Brand, Daniel (Charles River Associates). "Criteria and Methods for Evaluating Intelligent Transportation System Plans and Operational Tests." Transportation Research Record 1453, p.1-15, January 1997.

KEYWORDS

Intelligent transportation system technology, demand, ITS.

ABSTRACT

An evaluation process for the preparation of intelligent transportation system (ITS) plans that is sensitive to the differences between ITS and conventional transportation improvements is described. A relatively complete set of evaluation criteria for ITS improvements is presented that is structured to clarify the confusion between the supply and demand impacts of ITS. This separation between "efficiency" and "output" measures means that it is possible to distinguish between ITS technology efficiency benefits and the individual and corporate demand responses to ITS that actually increase output (benefits) over those produced by the technology alone. The proposed criteria structure also incorporates the time scale of the impacts. This highlights certain fundamental correlations between the criteria that can lead to double counting of benefits and to highly correlated outcomes, which are not helpful in choosing between alternatives.

METHOD

A comprehensive list of appropriate ITS evaluation criteria are presented. The major structure of the criteria is along the two dimensions of: criterion type (increased operational efficiency — supply, and demand adjustments that further increase output) and time scale (short, medium, and long term).

This structure deals head-on with the great confusion between supply and demand impacts in ITS evaluation. The separation between efficiency and output measures means that it is possible to separate the ITS technology benefits from the individual and corporate demand responses to ITS that actually increase output (benefits) over those produced by the technology alone. This separation also makes it possible to evaluate induced travel.

The structure also deals explicitly with the time frame of the impacts. Some impacts occur quickly, typified by travel behavior responses to ITS changes. Some take more time to occur, as exemplified by ITS technology investments and investments in other plants and equipment to increase the productivity of the economy. Finally, there are the long-term impacts such as infrastructure cost savings and changes in long-run demand. In most cases, the impacts that occur over various lengths of time are responses to the same underlying benefits of ITS. Therefore, the same benefits may be considered (double counted) a number of times. Organizing the impacts according to their time scale highlights certain fundamental correlations between the criteria and helps simplify the evaluation process. This is discussed further.

EVALUATION REPORTED BY THE AUTHOR

The criteria structure facilitates selection by decision-makers of greatly reduced criteria sets to simplify ITS evaluations. By recognizing the separate supply (efficiency) and demand (increased output) impacts of ITS, it is also possible to avoid dramatically underestimating the benefits of the new technology and to avoid serious mistakes in assessing the safety, environmental, and energy impacts of ITS alternatives. Default values to evaluate ITS improvements for inclusion in transportation system plans are provided. The criteria and default values highlight where research and operational tests can provide improved values and information that will most quickly advance the state of the art of ITS evaluation.

REFERENCE

Bunch, David S. (University of California-Davis), Mark Bradley (Hague Consulting Group), Thomas F. Golob (University of California-Irvine), Ryuichi Kitamura (University of California-Davis), and Gareth P. Occhiuzzo (California Energy Commission). "Demand for Clean-Fuel Vehicles in California: A Discrete-Choice Stated Preference Pilot Project." Transportation Research, Part A, Vol. 27A, No. 3, pp. 237 – 253, May 1993.

KEYWORDS

Clean-fuel vehicles, stated preference, multinomial logit model.

ABSTRACT

A study was conducted to determine how demand for clean-fuel vehicles and their fuels is likely to vary as a function of attributes that distinguish these vehicles from conventional gasoline vehicles. For the purposes of the study, clean-fuel vehicles are defined to encompass both electric vehicles and unspecified (methanol, ethanol, compressed natural gas or propane) liquid and gaseous fuel vehicles, in both dedicated or multiple-fuel versions. The attributes include vehicle purchase price, fuel operating cost, vehicle range between refueling, availability of fuel, dedicated versus multiple-fuel capability and the level of reduction in emissions (compared to current vehicles).

METHOD

In a mail-back stated preference survey, approximately 700 respondents in the California South Coast Air Basin gave their choices among sets of hypothetical future vehicles, as well as their choices between alternative fuel versus gasoline for hypothetical multiple-fuel vehicles. Estimates of attribute importance and segment differences are made using discrete-choice nested multinomial logit models for vehicle choice and binomial logit models for fuel choice. These estimates can be used to modify present vehicle-type choice and utilization models to accommodate clean-fuel vehicles; they can also be used to evaluate scenarios for alternative clean-fuel vehicle and fuel supply configurations.

EVALUATION REPORTED BY THE AUTHORS

The statistical significance, ease of interpretation and stability of the SP choice modeling results are very encouraging. Thus, the results provide a useful database for estimating preferences for clean-fuel vehicles in the California South Coast Air Basin.

Estimates of attribute importance and segment differences are made using discrete-choice nested multinomial logit models for vehicle choice and binomial logit models for fuel choice. These estimates can be used to modify present vehicle-type choice and utilization models to accommodate clean-fuel vehicles; but they can also be used to evaluate scenarios for alternative clean-fuel vehicle and fuel supply configurations.

REFERENCE

Calfee, John E. (Bureau of Economics, Federal Trade Commission, Washington, D.C.) "Estimating the Demand for Electric Automobiles Using Fully Disaggregated Probabilistic Choice Analysis." Transportation Research, Part B, Vol. 19B, No. 4, August 1985.

KEYWORDS

Electric vehicle, non-random sample, questionnaire, potential customers, regression, discrete choice analysis, personal market potential, survey, utility functions.

ABSTRACT

This study uses probabilistic choice models to predict potential demand for electric cars. Survey data are employed to estimate separate utility functions for each of 51 subjects. This provides a sample distribution of consumer preferences for vehicle attributes including price, operating cost and range. The results indicate great diversity in individual trade-off among attributes, with range and top speed generally being highly valued. The sample of utility functions is then used to predict potential market shares for various kinds of electric vehicles as second cars. Demand is quite limited, except when (a) electric cars are considerably more advanced than anything likely to be available in the near future, and (b) consumers fear massive gasoline shortages. The latter effect derives from an observed "bias" in favor of electric autos, which is plausibly interpreted as a hedge against disruptions in the gasoline market.

In this research the author attempts to estimate potential demand for electric automobiles. The goal, however, is not so much to predict demand for electric cars now feasible as to predict what kind of cars consumers will purchase if greatly improved electric vehicles appear in the market. The study takes the popular approach of dealing with attributes common to all products in the market of interest, so that new products can be represented by unfamiliar bundles of familiar attributes. This technique lends itself to the use of discrete choice models, although care is required to avoid misusing such models in this context.

METHOD

When market data are useless or extremely costly to acquire, the marketers of new products often choose to gather data using what might be called artificial means. The data are artificial in the sense that they represent consumer choices made in conditions other than *bona fide* markets. Such data are conceptually inferior to that generated by markets, where the motives underlying decisions cannot be impugned, but clearly there is often no choice about where the data will come from. The present study is an example: it is either artificial data or no data at all, and the trick is to gather artificial data that will be a good predictor of market behavior.

Preference data were collected from 51 members of a church in Berkeley, California. Each subject was given a form to take home, fill out, and return a week hence. For each completed form a small sum was contributed to the Sunday school's toy fund. The form began with a set of instructions that described the experiment, provided necessary information about electric vehicles (including performance limitations and the fact that battery replacement costs would be included in operating cost), and explained that the choices were for the family's second car. The instructions were followed by 30 choices, in each of which the subject was asked to express a preference for 1 of 3 vehicles. The three vehicles were described purely in terms of five numbers: price, operating costs (in cents per mile), capacity (number of passengers), and, for electric cars, range and top speed. Subjects were asked to assume that other attributes such as comfort and support facilities were the same for all alternatives.

The form also included two questionnaires, one gathering socio-economic data, and the second, given at the end, asking a variety of questions about the experiment itself. The subjects generally comprised a nonrandom sample of mainly middle and upper-middle class households living in the bedroom communities of the East Bay suburbs of San Francisco.

EVALUATION REPORTED BY THE AUTHOR

This study predicts that electric vehicles of modest performance, such as could be produced very soon, are likely to have no significant market, even were gasoline to increase greatly in price. There *may* be a market for more powerful vehicles, with ranges of 150 miles or more, although in this work presented there is only a single segment of the auto market, one that is unusually susceptible to the attractions of electric cars.

The author looked only at private demand, not demand from businesses, and considered only automobiles, not trucks or vans (which may provide the first significant success for electric vehicles.) All demand is assumed to be for second cars in multi-car households, and data were gathered from only a restricted socio-economic segment of the automobile-consuming public — one that seemed more likely than the average population to choose electric vehicles.

A second limitation is in the kind of data used: non-market data gathered from choice "experiments" with 51 automobile owners serving as subjects. This was necessary because the current market cannot produce the data required to estimate the demand for attributes such as vehicle range.

REFERENCE

Charles River Associates Incorporated. User Acceptance of ATIS Products and Services: What do we currently know? Prepared for the U.S. Department of Transportation, Intelligent Transportation Systems Joint Program Office, CRA Project No. 852-03, October 1996.

KEYWORDS

New product forecasting.

ABSTRACT

This report is concerned with the user acceptance of Automated Traffic Information System (ATIS) products and services. It was prepared as an early product from a program of research into Intelligent Transportation System (ITS) products and services, funded by the U. S. Department of Transportation's Intelligent Transportation Systems Joint Program Office, and forms part of that office's work on evaluation and program assessment.

The primary purpose of the document is to survey the extant relevant evidence about ATIS consumer acceptance — or at least that part of the evidence that is in the public domain. In order to place that evidence in context and interpret its relevance, the paper also describes a conceptual basis for structuring market research into ATIS, and summarizes some key methodological considerations that affect how such research should be designed and interpreted.

METHOD

The primary method of this study is a literature search on consumer acceptance of an intelligent transportation technology (automated traffic information systems). A contribution of this report is a description of three problems inherent in new product studies.

- It is important to recognize at the outset that the demand for any new product is influenced significantly by stochastic as well as by deterministic factors. That is, essentially "random" factors can easily sway the fortunes of any particular product launch.

- For radically innovative new categories of products, for which there's no strong analog currently in the marketplace, the appraisal of potential customer demand must necessarily be based on stated preferences as well as (or instead of) revealed preference evidence.

- Consumer surveys about hypothetical products or new product concepts are very prone to response biases. In particular, respondents are apt to express more enthusiasm for "new ideas" in response to survey questions than they may later when asked to vote with their dollars. Great care must consequently be taken to find ways of minimizing such response biases.

EVALUATION REPORTED BY THE AUTHOR

None.

REFERENCE

Chiu, Yi-Chang and Gwo-Hshiung Tzeng (University of Texas at Austin). "The Market Acceptance of Electric Motorcycles in Taiwan Experience Through a Stated Preference Analysis." Transportation Research, Part D, Vol. 4D, No. 2, March 1999.

KEYWORDS

Electric motorcycle, air pollution, energy use efficiency, discrete choice model, stated preference.

ABSTRACT

The environmental and energy concerns of using motorcycles in urban areas have fostered the rapid development of electric motorcycles (EMs) in Taiwan in recent years. EMs' zero emission, low noise level, and high-energy efficiency features provide the promising potential to alleviate the severe environmental pollution problem caused by the existing gasoline motorcycles. This study summarizes the recent development of the EM. More specifically, this study aims to analyze the potential demand for EMs based on an interview survey using stated preference modeling approaches. Study results show that female motorists are the potential target markets for EMs. Developmental and energy-use issues of EMs are also discussed in this study.

METHOD

The survey in this study was composed of two stages. The first-stage survey mainly focused on identifying pertinent attributes and tolerance limits of attributes, both of which would be used for describing the hypothetical choice alternatives. Literature review and consultation with experts were involved in the final determination of attributes. The second-stage survey is the extensive Stated Preference (SP) survey.

In the first-stage survey, respondents were randomly selected and interviewed at gas stations in Taipei City. The questionnaire contained three parts: socio-economic data, important factors in choosing motorcycles, and corresponding tolerance limits. The first part included motorcycle ownership, use frequencies, use purpose, weekly driving range, and need to buy a motorcycle in the coming 3 years. The second part contained 15 pre-specified potential attributes. Respondents were asked to freely specify up to 7 attributes. For each attribute that the respondent selected, the tolerance limit was also requested. The tolerance limit of an attribute was defined as an upper or lower bound beyond which the associated alternative was definitely rejected from consideration. For those attributes contributing negative utilities, the upper limits were requested; otherwise, the lower limits were requested.

In the second-stage survey, a total of 256 random households in Taipei were recruited and interviewed by several researchers. One male and one female over 18 years old were interviewed in each household. Contributing households were selected and supplementary interviews were conducted for those households that did not generate two respondents. The questionnaire contained two parts: (a) household and personal socio-economic information and (b) motorcycle choice questions. The socio-economic information included variables such as gender, age, highest education, household size, and personal and household income.

In coding and analyzing the data, the authors obtained valid entries from all male respondents and from 244 out of the 256 female respondents. Several possible models were calibrated with the data. Multinomial logit model (MNL), nested multinomial logit model (NMNL), and multinomial probit model (MNP) are the three major model specifications that were calibrated.

EVALUATION REPORTED BY THE AUTHORS

This paper summarizes the recent significant progress of EMs from legislative and technological perspectives. The aim of this paper is to shed light on opportunities for EMs from consumer behavior standpoints. The SP modeling framework is adopted in this study because EMs are still new to the market and the Revealed Preference information is not available for analysis. The statistical significance and the ease of interpretation of SP methods help to build the model for analyzing the potential demand of EMs.

REFERENCE

Das, Sujit, Regina K. Ferrell, and Russell Lee (Oak Ridge National Laboratory), Juan Noltenius (Science Applications International Corporation, Oak Ridge, TN), Fred L. Stephens (University of Tennessee). Costs of In-Vehicle Information Systems and Associated Infrastructure. Report No. ORNL/TM-13672, Oak Ridge National Laboratory, March 1996.

KEYWORDS

Intelligent transportation systems, cost estimation, life cycle, infrastructure.

ABSTRACT

The purposes of this report are to develop a cost estimation methodology that makes projections of the costs of in-vehicle information systems (IVIS) and associated infrastructure, and to illustrate the application of this methodology. The illustration of this methodology is limited to personal vehicles, but it can easily be adapted to commercial and transit IVIS, and to intelligent transportation systems (ITS) in general.

METHOD

The methodology developed here for estimating the costs of IVIS-related systems is a "bottom-up" approach that calculates the costs of these systems based on the costs (i.e., prices) of their basic equipment components. The methodology takes the national ITS architecture as a fundamental starting point. In this architecture, ITS technologies provide services to their users through the deployment and use of market packages of technologies (such as interactive traveler information). Each market package consists of *equipment packages* (such as vehicle route guidance), which in turn consists of *components* (such as geographic information system). The market package cost is thus estimated as the sum of the cost of individual components in the equipment packages that comprise the market package, both inside and outside (i.e. infrastructure) the vehicle. Costs at the market package level are estimated for a specific deployment in a *life cycle* context. For infrastructure-related equipment packages, the life cycle cost includes the total capital, operating, and maintenance costs of individual components over a pre-determined deployment period. For in-vehicle equipment packages, the costs are estimated over the life of the vehicle (typically 14 years). The corresponding annualized, or *levelized,* cost is calculated as well. Since deployment of an IVIS is typically a multi-year endeavor, projections of the future costs of the components are based on the historical price trends of electronic and other components available from the Bureau of Labor Statistics.

EVALUATION REPORTED BY THE AUTHORS

The projected cost estimates for the five IVIS-related market packages discussed in this report probably represent the high end because they are based on the assumption that none of the ITS technology currently deployed can be retrofitted or used. Also, the estimates reflect some double-counting of costs in the "private" and "consumer" categories, and for components used in more that one equipment package (the costs of equipment packages are estimated as if they are stand-alone systems, independent of their intended use with specific market packages). Costs of different market packages should *not* be added to estimate the total cost due to double-counting of infrastructure costs common to several of these market packages.

IVIS technologies are still under development. Uncertainty about future technologies makes it difficult to project their costs. Thus, the estimates in this report should be regarded as order-of-magnitude projections that reflect assumptions about market penetration and other factors.

REFERENCE

Eliashberg, Jehoshua (University of Pennsylvania) and Ajay K. Manrai (University of Delaware). "Optimal Positioning of New Product-Concepts: Some Analytical Implications and Empirical Results." European Journal of Operational Research, Vol. 63, No. 3, p. 376-397, December 1992.

KEYWORDS

New product-concept positioning, utility theory, consumer preferences, consumer marketing, smokeless cigarettes.

ABSTRACT

This paper presents an analytical approach to determine optimal target positions (locations) for a discontinuous innovation in the perceived product-attributes space. This paper focuses on qualitative insights and generalizable location implications. The authors rely on the concept of consumer preference, choice, market segmentation, and technological constraint to derive various analytical insights in the context of new product-concept positioning. Empirical studies addressing these issues in the consumer marketing are presented, and directions for future research are also provided.

Positioning is a crucial strategic decision for pioneering brands as well as for other brands competing with them. The basic problem is to identify product/service position(s) (location(s)) in a multidimensional perceptual space as targets which have the potential to optimize certain objective of the firm (e.g., profit, market share, or sales revenue) and determine the set of actions necessary to achieve the desired position(s). Focus of this paper is on identifying the product/service position.

METHOD

In order to motivate the discussion, consider the optimal new product-concept positioning problem faced by a company interested in launching a single new product/brand resulting from a discontinuous innovation.

The propositions presented in the paper rely on a number of premises and scenarios which, fortunately, can be subjected to empirical testing. Two separate studies were performed in this regard. The first was to construct parsimoniously the product-attributes space for a hypothetical new 'smokeless cigarette'. The second study was designed to test the empirical validity related to the number of segments, the identification of the parameter corresponding to the vector model of preferences, and the choice probability model.

In the first empirical study, the subjects were 103 undergraduate business students at a major Eastern university in the United States. A questionnaire was constructed, pretested, and administered. It contained two major parts assessing the subjects' belief ratings and importance evaluations concerning twenty attributes elicited earlier via a number of focus groups. The major parts of the questionnaire employed two 1-5 scales (strongly disagree to strongly agree and very unimportant to very important). The other questions were constructed in an open-ended format.

A second empirical study was conducted to test: (1) the predictive performance of the choice model which is an important component of the optimal new product-concept positioning approach presented earlier; and (2) the nonhomogenous preference-based market assumption. The subjects were (again) 108 undergraduate business students at a major Eastern university in the United States. They were requested to indicate their accept/reject choice decision for 19 positioning alternatives of hypothetical new 'smokeless cigarette' concepts.

EVALUATION REPORTED BY THE AUTHORS

In this paper the authors have focused on the problem of identifying specific locations or subregions for optimal new product-concept positioning in the perceptual product-attribute space. Their aim was to obtain sharp and generalizable insights for better targeting a discontinuous innovation. The analysis indicates that obtaining precise analytical expressions becomes intractable for three or more segments. Consequently, they had to employ various approximations under these circumstances in order to identify the subregion(s) of optimal new product-concept

positioning. Empirical studies in the context of a new 'smokeless cigarette' suggest that the modeling approach has some degree of validity under the specified scenario.

REFERENCE

Golob, Thomas F. (University of California-Irvine), David S. Bunch (University of California-Davis), and David Brownstone (University of California-Irvine). "A Vehicle Use Forecasting Model Based on Revealed and Stated Vehicle Type Choice and Utilization Data." Journal of Transport Economics and Policy, Vol. XXXI, No. 1, January 1997.

KEYWORDS

Travel demand forecasts, household vehicle use, stratified random sample survey.

ABSTRACT

This research describes a new model of household vehicle use behavior by type of vehicle. Forecasts of future vehicle emissions, including potential gains that might be attributed to introductions of alternative-fuel (clean-fuel) vehicles, critically depend upon the ability to forecast vehicle-miles traveled by the fuel type, body style and size, and vintage of the vehicle.

METHOD

The data are from a 1993 survey conducted using geographically stratified pure random digit dialing. The survey, covering most of urbanized California (excluding San Diego County), contained three distinct components: an initial computer-aided telephone interview (CATI), a customized postal questionnaire, and a follow-on CATI survey.

The standard structural equations model (without latent variables) is given by $y = By + \Gamma x + \varsigma$ (1)

where y is an *m* x 1 column vector of endogenous variables, and x is an *n* x 1 column vector of exogenous variables. The structural parameters are the elements of the matrices:

$\underset{(m \times m)}{B}$ = matrix of causal links among the endogenous variables, and

$\underset{(m \times n)}{\Gamma}$ = matrix of direct causal (regression) effects from the *n* exogenous variables to the *m* endogenous variables.

The error-term parameters are the elements of the variance co-matrix:

$\underset{(m \times m)}{\Psi}$ = $E(\varsigma\varsigma)$ = symmetric variance-covariance matrix of the unexplained, or unique, portions of the endogenous variables.

For identification of system (1), B must be chosen such that $(I - B)$ is non-singular, where I denotes the identity matrix of dimension *m*.

The total effects of the endogenous variable on each other are given by

$$H = (I - B)^{-1} - I. \quad (2)$$

The total effects of the exogenous variables on the endogenous variables in a structural equations model of this type are given by $T = (I - B)^{-1}\Gamma$, which are the parameters of the reduced-form equations. (3)

This model is being applied in a dynamic microsimulation forecasting system (Bunch et al., 1996), where a sociodemographic transition model and vehicle transactions models are used to forecast changes in households' sociodemographic structure and composition of the vehicle fleets. The use model is then exercised to forecast VMT for both the before and after situations for the household. The calculated change in forecasts is then applied as a percentage change to the actual base level of use for the household in the before situation.

EVALUATION REPORTED BY THE AUTHORS

The structural elegance of the models and their statistical fit to the sample data provide support to the authors' modeling approach. Moreover, the correspondence between pure RP results (Golob et al., 1995) and the present SP-RP results is encouraging. The author are also encouraged by the advantages associated with a jointly estimated RP-SP model that simultaneously captures the endogenous effects of vehicle reallocation along with perceived changes in utilization associated with electric vehicle characteristics. These effects are not available from RP data alone. The approach automatically produces estimates that are consistently scaled, and yields reduced-form equations that are convenient for forecasting utilization of alternative-fuel vehicles.

However, the SP questions in the 1993 household survey from which these data were extracted are primarily focused on the issue of vehicle choice, and are potentially limited in capturing the full range of effects on use attributable to fuel availability, peak and off-peak recharge costs for EVs, cargo capacity, performance, and other vehicle and fuel-system characteristics that might distinguish future vehicles. These issues are being pursued through a second household survey, conducted in 1994, that contained a different vehicle-use SP protocol. When the 1994 data are available, the robustness of the present model results can be assessed, and hopefully the model can be extended.

REFERENCE

Golob, Thomas F. (University of California at Irvine) and Jane Gould (London Business School). "Projecting Use of Electric Vehicles From Household Vehicle Trials." Transportation Research, Part B, Vol. 32, No. 7, p. 441-454, 1998.

KEYWORDS

Electric vehicles, vehicle trials, travel diaries, travel surveys, stated preference surveys, trip purpose, trip length.

ABSTRACT

Vehicle trials are an important source of information about how households would use battery electric vehicles. However, trial data are potentially biased because the novelty of the trial can introduce short-term changes in driving patterns and a positive effect for the technology can result from giving respondents special attention. In this study, the authors examine these methodological issues using data collected from travel diaries and pre-trial and post-trial surveys as part of an extensive trial of prototype electric vehicles (EVs) conducted by a major vehicle manufacturer. Households demonstrated that they can use the electric vehicle to make most of the everyday trips that were previously made on a conventional-fuel vehicle, but some trips will be shifted to other vehicles in the household's fleet. However, experience with electric vehicles does not change perceptions of desired vehicle range. Keeping a travel diary gave users direct feedback that they were usually travelling less than 50 miles per day, but there remained an expectation that vehicles should have a range of 100 miles or more.

METHOD

In the present vehicle trial, efforts were taken to minimize the problems cited above. The duration of household trials was two weeks, so that respondents had some time to familiarize themselves with the vehicles and use them routinely. The authors also incorporated some questions in a travel diary to test for use of the vehicle in 'demonstration' trips. To help control for a 'Hawthorne effect,' participants were mostly chosen from a sample of respondents for which we had pre-trial-selection opinion data. Although they were not able to randomize drivers across EV makes and models, the authors did administer their survey instrument in two other trials that used different types of EV. Unfortunately, results from these other trials are proprietary.

The vehicles trials were conducted in Southern California in 1995 and 1996. They were organized by a domestic automobile manufacturer in co-operation with two regional electric utilities. The sample was drawn from households which had previously participated in a state-wide University of California study about vehicle transactions and usage. The five criteria used to select participants are listed below. Importantly, the criteria did not include vehicle miles of travel (VMT) since the authors wished to explore how drivers coped with restricted vehicle range. Trial selection criteria were:

1. Live within 40 miles of a designated EV service center,
2. Be a customer of the major electric utilities in the area,
3. Agree to participate and complete all forms, surveys, and interviews,
4. Have a verifiable good driving record,
5. Home has a 240 V, 30-amp circuit, or is easily retrofitted for it.

The vehicles used in the trials were manufacturer's prototypes. Between each trial they were sent to a designated electric vehicle service center for cleaning and testing. The two-passenger vehicles were equipped with an advanced climate control system, sound system, and in-car phone. The exterior of the vehicle was not especially marked, and the body style did not differ radically from current vehicles. Participants were told that the EV range between recharges would depend on driving conditions and topography, but that it could do at least 100 miles under optimal conditions.

Trial data were collected using several methods. First, pre- and post-trial survey instruments were designed that incorporated many questions used in the panel survey. These survey instruments were first tested in 1994 by an

electric utility, during and 18-month-long trial of six conversion EVs. A travel diary with extensive testing from other transportation studies was administered.

EVALUATION REPORTED BY THE AUTHORS

The authors have argued throughout this paper that although trials are useful for collecting data, the results are not unbiased. They tried to identify some of the biases that trials introduce, and reconcile differences through a comparison of data collection techniques.

The novelty of participating in an EV trial does lead to exaggerated reports of use. The inclusion of demonstration trips inflated the estimates of daily VMT. In this study, the sponsors chose to administer the pre-trial, seven-day travel diary for only one household vehicle. This limited the ability to study complex intra-vehicle switching, and the authors had to make inferences about this based on more indirect data techniques. They believe that this is an issue which future trials research may wish to address, and would recommend that multi-vehicle household diaries be used.

In this study, respondents were studied over a two-week trial, and there was evidence that this duration was a reasonable period for participation adaptation. The evidence indicates that it might also be possible to have a shorter trial period without adversely affecting the quality of the usage data. The study also provided evidence that people were fairly accurate at recording daily VMT over this period.

Since VMT and other important measures can be collected using less obtrusive research methods, researchers may have to weigh the costs and benefits of staging vehicle trials. However, for certain types of information, a trial may be essential, particularly for describing detailed behaviors and patterns of vehicle use.

REFERENCE

Greene, David L. (Oak Ridge National Laboratory). "Estimating Daily Vehicle Usage Distributions and the Implications for Limited-Range Vehicles." Transportation Research Journal, Part B, Vol. 19B, No. 4, pp.347-358, August 1985.

KEYWORDS

Limited-range vehicles, daily travel distributions, vehicle-range requirement, electric vehicle, hybrid vehicle longitudinal survey, sample, and maximum likelihood methodology.

ABSTRACT

Understanding the potential market for limited-range vehicles is important to planning research and development programs for electric and hybrid vehicles and for gaseous-fueled vehicles as well. Studies of consumer preferences and perceptions have shown vehicle range to be a very important vehicle attribute. Studies of household vehicle use, on the other hand, have suggested that the range requirements most households place on vehicles are quite modest. The latter, however, have been severely limited by the absence of longitudinal data on the usage of individual vehicles. Instead, they have relied on single-day surveys on many vehicles, an inappropriate data source. This study develops a method of estimating daily travel distributions for individual vehicles and applies it to a recent longitudinal survey of miles and days between refuelings for over 2000 vehicles. Every vehicle in the sample has at least 3 consecutive refueling intervals. A variety of measures of "range requirement" are defined and calculated. The results confirm the existence of a substantial potential marker (230-50% of all household vehicles) for vehicles with ranges on the order of 100 miles. Future research using these data and this method could describe the nature of vehicles with limited-range needs and the households that own them.

METHOD

The objective of this study is to improve on market niche studies by using more appropriate data that have recently become available. The data in question came from a longitudinal survey of vehicle use by a large sample (2290) of households. Specifically, each household recorded the odometer reading of each vehicle it owned at each refueling and the date. This provides information on the number of miles traveled and number of days in each refueling interval. While this is still not precisely the information desired (that would be the miles traveled on *each* day), it does permit one to infer, subject to certain assumptions, the underlying distribution of daily travel. This approach, too, has limitations that will be detailed below. However, it permits estimation of the daily range requirements of *individual* vehicles, which was not possible before. In addition, because the survey also contains information on household and vehicles characteristics, it is possible to describe the limited-range vehicle market niche, as well as estimate its size. Clearly, one cannot expect this study to resolve all the remaining questions about the market potential of electric vehicles. Instead, it is hoped that it will make a significant contribution to understanding the potential market, and that this will be useful to planning electric vehicle research and development.

The theory developed is based on the assumption that daily travel may be regarded as a series of independent random values drawn from a particular probability distribution. The problem is then one of determining the parameters of the underlying daily travel distribution for each vehicle, given observations on the sum of daily travel between refuelings and the number of days between refuelings. This type of data is known to exist in at least two major surveys. The assumption of independence implies that there will be no correlation between vehicle use one day and the next. Of course, it is much more likely that there is some positive association between current and past daily travel. It can be easily shown that such an association necessarily leads to an overestimate of the variability of daily travel under the presumption of independence. As a result, the importance of long-distance travel will be overestimated to an unknown degree. For the purpose of evaluating the applicability of limited-range vehicles then, the study results will be conservative. Maximum likelihood methodology provides a means of estimating the daily vehicle usage distribution for an individual vehicle, given the number of miles and number of days in each refueling interval. The National Family Opinion (NFO) Poll Gasoline Diary Panel survey provides an impressive quantity of the source of vehicle refueling data.

It was found that almost half of the vehicles in the sample have 95% of one-year's daily travel ranges of less than 100 miles. For 25% of the vehicles, a 75-mile range would satisfy 95% of annual daily travel. For 5%, a mere 41-mile range would suffice. The sensitivity of range requirements to the percent of annual daily travel to be satisfied is quite pronounced. At the 90% level, a range of 104 miles would be adequate for 75% of vehicles in the sample. At the 99% level (all but 3-4 days per year) a range of nearly 250 miles would be required. The results imply that, to cover the last few percentage points, or the last few days of vehicle use requires substantial increases in vehicle range.

EVALUATION REPORTED BY THE AUTHOR

A method has been developed for estimating the annual daily vehicle usage distributions for individual vehicles, and it has been successfully applied to survey data on distances and days between refuelings for a large number of vehicles. Previous studies of the potential market for limited-range vehicles have been forced to employ data on the single-day travel of a cross section of vehicles. As these researchers have noted, these data are inappropriate. The results of this method confirm the existence of very substantial potential applicability for limited-range vehicles.

REFERENCE

Harris, Kent S. (Pacific Gas and Electric Company). Fleet Markets: Will EVs Meet Fleet Needs? http://www.evs.org/evs.org/evs14.

KEYWORDS

Electric vehicle, driver logs, focus groups, fleet, mail questionnaire, drivers.

ABSTRACT

The issue of whether electric vehicles (EVs) can meet the needs of fleet operators has been the focus of several internal studies conducted by the Pacific Gas and Electric Company (PG & E). This paper draws from those studies conducted over the past four years. Both empirical and opinion data are used. The empirical data comes from the Company's fleet database. Demonstration vehicle driver logs comments, driver surveys, and utility fleet manager focus group results help to provide a comprehensive picture of the EV's ability to meet fleet needs.

Arguments have been made both favoring as well as refuting EVs' capability to meet real world operation needs of fleet users. The conclusions from the analysis reported in this study indicate that there are many fleet needs that can be met by today's EVs.

Since 1992 PG&E has conducted several investigations into the nature of fleet needs for vehicles and how EVs can meet fleet operational needs. There are four types of data used in this study.

- Utility feet manager focus group on the usability of various types of EVs
- Demonstration vehicle driver surveys
- EV driver logs
- Statistical data on PG&E fleet vehicle use

The opinion information was compiled over a period beginning in June 1993 and ending in May 1997. Several types of EVs were involved: Ford Ecostars, Honda CUVs, Honda EV Plus, General Motors Impacts (EV1s) and a Toyota RAV4 EV. Surveys were given to repeat fleet drivers.

Performance data for the generation of EVs being introduced into the marketplace by 1998 was used to determine the whether EVs could meet current fleet requirements. Life cycle cost, an important acquisition decision variable, was not considered in the context of this study.

METHOD

As a routine matter, PG&E logs the number of miles driven on a monthly basis for most of its vehicles. For this study, the researcher extracted mileage data for light duty passenger cars and pick-up trucks for the 12 months of 1996.

The second major resource used to determine the suitability of EVs for fleet operations was opinion information. This came in tree forms-focus group comments, driver log notes and driver surveys. The information collected through these means is used to qualitatively shape the conclusions. The driver log notes came from hundreds of entries over a 5-year period. Driver surveys are requested of each driver, though most do not complete the questionnaire provided. For this study, 38 surveys with relevant comments were used.

It was found that there are additional barriers to acceptance of EVs into normal fleet operations. Factors such as initial costs, acquisition method, and internal fleet buying processes can all present barriers to introducing EVs into a fleet.

EVALUATION REPORTED BY THE AUTHOR

None.

REFERENCE

Hauser, John R. "Consumer Research to Focus R&D Projects." Journal of Product Innovation Management, Vol. 1, No. 2, p. 70-84, April 1984.

KEYWORDS

Focus group — experts, questionnaires, stratified random sample, market potential, preference analysis, logit, multinomial model, low-scan televideo, utility functions.

ABSTRACT

The effectiveness of research and development (R&D) can be greatly improved by the application of consumer theory, market research, and quantitative analysis. Such an approach provides the R&D team with managerially relevant diagnostic information to guide product design.

In a study funded by the National Science Foundation to develop slow-scan televideo equipment, 429 questionnaire responses from personnel at Los Alamos Scientific Laboratory were subjected to perception, preference and behavior analysis to obtain diagnostic information and benefit segmentation data and to identify potential users of the new technology. While the final success of the technology still depends on effective R&D, the development and analysis of consumer models can enable the R&D team to focus its technological innovations on the appropriate set of user benefits most likely to increase consumer acceptance.

METHOD

The first step was a series of three focus groups in which groups of six to eight scientists, engineers, and managers from the target market were brought together. Based on these focus groups and a series of pretests, a questionnaire was developed that was mailed to 800 scientists, engineers, and managers chosen randomly from the staff directory at Los Alamos Scientific Laboratory. For preference analysis a standard statistical technique known as preference logit was used. Preference logit adjusts the relative weights of effectiveness and ease of use until the product that a consumer is most likely to prefer has the largest utility where:

Utility of a technology = (weight of effectiveness) x (effectiveness of a technology) + (weight of ease of use) x (ease of use of a technology).

To predict the impact of changes in perception and preference, preference to behavior was linked by way of a behavioral prediction model. The statistical model used to predict behavior is the multinomial model.

EVALUATION REPORTED BY THE AUTHOR

This paper demonstrates how consumer theory, market research, and quantitative analysis can improve the effectiveness of R & D. The methodology presented is feasible and provides managerially relevant diagnostic information to the R & D team. However, it is only a guide. R & D and further market research are necessary to physically design the product.

REFERENCE

Heeler, Roger M. (York University) and Thomas P. Hustad (Indiana University). "Problems in Predicting New Product Growth For Customer Durables." Management Science, Volume 26, Number 10, October 1980.

KEYWORDS

Regression, sales data, consumer durables.

ABSTRACT

A popular model of new product diffusion is applied in an international setting. Several limitations on its use are noted: instability with limited data, environmental differences, and systematic under-reporting of estimated time to attain peak level of first purchase sales.

A recurrent problem facing marketers of new products is that of forecasting the rate of market development. With consumer durables, where replacement purchases are delayed, the problem becomes predicting the growth rate for consumers' first purchases.

Innovators make independent adoption decisions and are the first to purchase new products. As time progresses, adoption decisions become increasingly influenced by the process of word-of-mouth communication. Later adopters are more able to speak with earlier adopters to see or learn about the new product. For simplification, it is possible to label purchasers who are influenced by word-of-mouth as imitators. Imitators are influenced in the timing of adoption by other members of the social system. This process, in aggregate, creates an adoption curve that lends itself well to mathematical modeling.

METHOD

This paper explores the accuracy of forecasts made with the model using varying lengths of input data. First, for convenience and comparability, the products studies by Bass were used. Data for some products studied by Bass and Nevers were not available in the published articles, and the data series for one (refrigerators) was complicated by the intervention of World War II. Data for the seven available products were taken from the graphs published by Bass. This led to slight differences between the results reported by Bass and reported here owing to the inaccuracies of interpolating from graphs. None of the differences are sufficient to affect the conclusions of the article. Sales forecasts were made for each product using 4, 6, 8, 10, 12, and all-year series as input data. Second, time series sales data were obtained for fifteen products in a variety of countries. As before, sales forecasts were made for each product using 4, 6, 8,10, 12, and all-year series as input data.

Bass' method of estimation was followed throughout. First, multiple regression was used with domestic and international data to fit the model for sales of products such as refrigerators, color TVs, black and white TVs, washing machines, air conditioners, and others.

EVALUATION REPORTED BY THE AUTHORS

The model was fitted with historical data to test it in a forecasting mode. At least ten years of data were needed to get reliable forecasts for the U.S. market for the consumer durables analyzed. While the model has structural validity, it is too unstable as a forecasting tool with short periods of actual sales data as input.

The Bass model shows the value of a quadratic form in fitting adoption time series data. Its value as a predictive tool is limited in the early years of a product's life and in many international settings. This early point is when a forecast would be of most value. If the user can supply some of the parameterization through hindsight-quality estimates, the model becomes more reliable as a predictive tool; however, in international settings the timing to peak first purchase sales is often greatly underestimated.

REFERENCE

Heiman, Amir (University of California) and Eitan Muller (Tel Aviv University). "Using Demonstration to Increase New Product Acceptance: Controlling Demonstration Time." Journal of Marketing Research, Vol. XXXIII, p. 422-430, November 1996.

KEYWORDS

Consumer behavior, product demonstration, product acceptance, motor vehicles, computers, maximization model.

ABSTRACT

One of the major ways that manufacturers decrease the uncertainty that is involved in making a choice between competing brands of experience goods is through demonstrations of their new products. The authors investigate the issue of the length of a demonstration and, in particular, provide answers to the following three questions: What is the optimal length of a demonstration? Does the optimal length vary between different products? Does the optimal length vary between different consumers? They analyze 225 cases from the motor vehicle industry and 46 cases from the computer industry with regard to number and length of demonstrations offered and relate the findings to their theoretical model. The empirical results yield strong support for their theory. They also find that most firms offered a longer demonstration than needed and failed to use an appropriate segmentation technique for optimizing the demonstration with respect to different consumer groups.

METHOD

One of the major ways that manufacturers decrease uncertainty is through demonstrations of their new products. The authors analyze 225 cases from the motor vehicle industry and 46 cases from the computer industry with regard to number and length of demonstrations offered and relate the findings to a theoretical model. There are four basic types of demonstration, which are categorized according to the location of the demonstration and the operator of the demonstrated good:

1. Dealer's showroom/salesperson's demonstration
2. Dealer's showroom/consumer's demonstration
3. Consumer's office/salesperson's demonstration
4. Consumer's office/consumer's demonstration

The consumer tests the product in its future operating environment and directly observes whether it fits his or her particular needs and personal characteristics. One of the main advantages of this type of demonstration happens in the case of multiple users. If two persons or all family members are involved in the decision process of purchasing a new car, a demonstration would be helpful in persuading all potential users. The same holds with respect to multiple users with different needs of a new printer.

In the empirical section of the study, the authors apply their model to the fourth demonstration mode (consumer's office, consumer's demonstration), but in principle, it may be applied to any of the four categories. They describe how the different demonstrations would be employed with the different product categories. The authors formulate hypotheses of the effect of production demonstration on purchase behavior. Product classifications are developed: play products, functional products, etc. (highlighted on next pages). The statistical significance of the hypotheses are then tested by examining cases. They analyze 225 demonstrations of an Italian car to evaluate the play products category, while 46 demonstrations of Hewlett-Packard printers are used to analyze the functional products category.

EVALUATION REPORTED BY THE AUTHORS

The mathematics development and proof of the maximization model are presented. The authors found that the firms offered a longer demonstration time than needed and that they also failed to use an appropriate segmentation technique for optimizing the demonstration with respect to different consumer groups. By conducting a meaningful segmentation, based on prior knowledge and familiarity of the consumer with the product and the subject matter, the

firm can deduce the likelihood of purchase for the two segments and ascertain an optimal demonstration time for each segment.

REFERENCE

Higgins, Susan H. (John Carroll University) and William L. Shanklin (Kent State University). "Seeking Mass Market Acceptance for High-Technology Consumer Products." The Journal of Consumer Marketing, Vol. 9, No. 1, Winter 1992.

KEYWORDS

Market acceptance, mail survey, logistic regression, image factor analysis.

ABSTRACT

A deluge of breakthroughs in the world's research and development labs have made the last several decades a period of profound technological change. These technological discoveries have spawned new generations of consumer and industrial goods and services capable of performing more complex and time-saving feats than all previous high-technology offerings. Yet, the problem is that the technological sophistication of the products is often ahead of the technological sophistication of the people who are meant to use them. The authors identified four predominant types of technological fear that can act as barriers to purchase:

1. Fear of technical complexity
2. Fear of rapid obsolescence
3. Fear of social rejection
4. Fear of physical harm

METHOD

A mail questionnaire was developed to ascertain the demographic and lifestyle characteristics of high-technology consumer innovators and their attitudes toward the four types of fears. Lifestyle differences showed up as well. Manufacturers often ask recent buyers to return warranty cards that ask for personal interests and favorite leisure activities. Using many of these warranty cards as a guide, 48 diverse activities and interests were selected for a questionnaire. Subsequently, applying the statistical technique of image factor analysis, the authors were able to identify ten lifestyle groupings among the 222 respondents, and gave them names as shown below:

1. Rugged Non-Competitives
2. Gentle Introverts
3. Actives
4. Creators
5. Bluebloods
6. Yuppies
7. Purists
8. Set-in-Their-Ways
9. Wealthy Sports
10. Competitives

Further statistical analysis (using the logistic regression method) revealed that the most avid buyers of high-tech products were associated with three of the ten categories—the Creators, Purists, and Yuppies. By contrast, the people with the least inclination to buy high-technology products were associated with the Set-in-Their-Ways group.

EVALUATION REPORTED BY THE AUTHORS

In terms of demographics and attitudes, the city surveyed is considered to be typical middle America, as evidenced by its popularity for test marketing. Even so, the study needs replication in other parts of the United States and especially in other nations, where buying behavior may be different. For years, textbooks and articles have recommended separate marketing strategies for early and later purchasers of products incorporation significant technological advancements. This advice has been correct, as far as it goes.

For example, innovator groups are likely to differ in activities and interests, and to some extent in their risk tolerance for ethically troublesome technologies with potentially deleterious consequences. Accounting for such differences can lead to both more effective and more efficient marketing programs.

REFERENCE

Hill, Daniel H. (University of Michigan). "Derived Demand Estimation with Survey Experiments: Commercial Electric Vehicles." The Review of Economics and Statistics, Vol. LXIX, No. 2, May 1987.

KEYWORDS

Tobit model, electric vehicles, commercial sector, demand estimation, econometric modeling, vehicle owning companies, random sample, survey.

ABSTRACT

In this paper the author examined the demand for a hypothetical input, electric over-the-road vehicles, in the commercial sector using data from a survey experiment. This experiment is designed to allow the estimation of theoretically plausible derived demand functions from either the Translog or the CES production functions. A heteroscedasticity-corrected two-limit Tobit model is developed and estimated. The results provide evidence of considerable adaptability to new technologies and price structures on the part of firms. They evidently would be willing to cope with the limited traveling range of electric vehicles *if* these vehicles were able to provide a less costly means of doing business. In this paper is developed a methodology for empirically obtaining estimates of these elasticities and analyzing the resulting data.

METHOD

First, the investigation employs a nationally representative sample of commercial establishments. Second, by including more variation in the range treatment, more precise estimates of the relative importance of range and costs are obtained.

EVALUATION REPORTED BY THE AUTHOR

The analysis provides strong evidence that firms would be willing to cope with the limited range of electric vehicles *if* these vehicles were able to provide a less costly means of doing business.

Finally, and perhaps of greatest immediate importance to empirical economists, the survey experiment methodology appears to provide a relatively low-cost tool for investigating the likely response of firms to potential technological innovations. The estimated demand responses are plausible — both theoretically and behaviorally.

REFERENCE

Jaffee, Adam B. (Harvard University and National Bureau of Economic Research) Robert N. Stavins (Harvard University and Resources for the Future). "Energy-Efficiency Investments and Public Policy." The Energy Journal, Vol. 15, No. 2, p. 43-65, 1994.

KEYWORDS

Environmental values, regulation, housing, technology diffusion.

ABSTRACT

Concern about carbon monoxide as a greenhouse gas has focused renewed attention on energy conservation because fossil fuel combustion is a major source of CO2 emissions. Since it is generally acknowledged that energy use could be significantly reduced through broader adoption of existing technologies, policy makers need to know how effective various policy instruments might be in accelerating the diffusion of these technologies. This paper examines the factors that determine the rate of diffusion, focusing on (i) potential market failures: information problems, principal-agent slippage, and unobserved costs, and (ii) explanations that do not represent market failures: private information costs, high discount rates, and heterogeneity among potential adopters. Through a series of simulations explored are how alternative policy instruments (both economic incentives and more conventional direct regulations) could hasten the diffusion of energy-conserving technologies.

In this paper are examined two inextricably linked questions: what factors determine the rate of adoption of energy-conserving technologies and what types of public policy can accelerate their diffusion.

METHOD

As a necessary precondition for this policy analysis, the authors explore both market and non-market failures within two decision groups. The first group, requiring a decision about *whether* to incorporate a technology at a given time, may include construction of new industrial, commercial or residential structures or expansions or other modifications of existing establishments. By way of example, the authors discuss the question of whether to incorporate a potential energy-saving technology in the construction of a new home. The second group, requiring "*whether*-and-*when* determinations," includes retrofit decisions in various types of structures; here, the discussion focuses on the adoption decision faced by an individual considering the installation of an energy-saving technology in an existing home. Consider a builder who has the option of incorporating a new technology into the design of a house at a specified time, taking as given other design features of the house.

The builder's decision may be modeled as an attempt to maximize the sum of the base selling price of the house (in the absence of the energy-saving technology) and the present discounted value of the expected energy savings if the technology is adopted (that is, the capitalized value of the installed technology), minus the cost of adoption.

EVALUATION REPORTED BY THE AUTHORS

Understanding the causes of the gradual diffusion of energy-conserving technologies is key to identifying appropriate policy responses. One set of causes, labeled the "nonmarket-failure" causes—private information costs, high discount rates, and heterogeneity among potential adopters—does not provide legitimate justifications for government intervention. On the other hand, a fairly large number of potential market-failure explanations—information problems, principal-agent slippage, and unobserved costs—can provide solid arguments for government action. While this analysis indicates how alternative policy instruments—both economic incentives and direct regulations—can hasten the diffusion of energy conserving technologies, the selection of appropriate policy instruments will depend upon the relative importance of the various underlying explanations of the gradual diffusion of energy-efficiency technologies.

REFERENCE

Jamieson, Linda F. (Northeastern University) and Frank M. Bass (University of Texas at Dallas). "Adjusting Stated Intention Measures to Predict Trial Purchase of New Products: A Comparison of Models and Methods." Journal of Marketing Research, Vol. XXVI, p. 336-345, August 1989.

KEYWORDS

Telephone surveys, purchase intention, purchase behavior, new products, durable products, non-durable products.

ABSTRACT

Several of the largest marketing research suppliers estimate that 70 to 90% of their clients use purchase intention scales in some form on a regular basis. Though there have been many studies of purchase intention, relatively few researchers have tried to relate purchase intention to actual purchase behavior. Those who have attempted to relate the two often have found substantial variation between stated intention and actual behavior. The authors have collected what they believe is the largest and most comprehensive database on purchase intention and actual purchase behavior for new products yet developed. They use different models in a comparison of predictive accuracy when stated intentions data are adjusted by separate perceptions of products such as willingness to consult others before purchase, affordability, liking, and availability.

METHOD

Studies have shown a positive association between intention and purchase but have been less predictive of actual behavior than desired. The authors studied trial purchases for 10 *new products,* five durable and five nondurable. They confined their study to generic product descriptions rather than brand names.

The authors compare predictions of purchase from three alternative models. In each case, stated intentions data obtained from the 5-point scale are modified to predict trial purchase probabilities. Broadly speaking, there are two ways to modify intent scales to predict trial purchase. One is to apply weights to the fractions in the sample to indicate degrees. If the weighting scheme is constant across products, the forecasting system will require only data about intentions. Another way is to use exogenous perceptual measure of new products on such characteristics as willingness to consult others before purchase, affordability, liking, and availability, which can be done within the context of different models relating intention to trial. Within the range of the products included in the study, the authors examine the degree to which products can describe variation in intentions and purchase relationships.

Very few comparative studies have been done of the relationship between intention and behavior for new products at the individual level. This study helps fill that void. The results indicate that accurate predictions of purchase probabilities vary considerably across weighting schemes and products. However, it is possible to improve predictive accuracy by measuring and using perceptions that affect and modify the relationship between stated intentions and trial purchase for new products. The authors illustrate the approach within the context of two different models relating intention to trial: Morrison's modified beta-binomial model and the linear modified intention model.

EVALUATION REPORTED BY THE AUTHORS

Though the authors believe their results to be very good for the set of products and conditions they studied and hold promise for the prediction of trial behavior in general, the products and measures are not exhaustive. However, the results do suggest that extensions could lead to the development of modifiers of intention for use in predicting trial purchase generally. In addition, the authors think the measures they used in the study, along with the estimated relationships, could be employed successfully to predict trial purchase of other new consumer products.

This study, along with many others in which intentions are compared with actual purchase behavior, has the potential limitation that purchase measures are obtained from person who are sampled. To the extent that those sampled have been stimulated to a greater degree of awareness by the perception and intention-to-buy questions, their behavior may be different from the behavior of the population at large. Though the authors do not have firm

data on the seriousness of the contamination problem, a necessary condition for the successful prediction of purchase in the whole population is the successful prediction of the purchase that has (perhaps) been contaminated by intentions questioning. The authors believe that sufficient variation in perception, intention, and purchase over the products studied here makes possible meaningful analysis of the relationships among these measures.

REFERENCE

Juster, Thomas F. (National Bureau of Economic Research). "Consumer Buying Intentions and Purchase Probability: An Experiment in Survey Design." Journal of the American Statistical Association, Vol. 61, No. 315, September 1966.

KEYWORDS

Explicit purchase probability, survey, regression analysis, automobiles.

ABSTRACT

Surveys of consumer intentions to buy are inefficient predictors of purchase rates because they do not provide accurate estimates of mean purchase rates because they do not provide accurate estimates of mean purchase probability. This is a consequence of the fact that intention surveys cannot detect movements in mean probability among nonintenders, who account for the bulk of actual purchases and for most of the time-series variance in purchase rates.

Comparison of predictions from alternative surveys, one of subjective purchase probabilities and the other of buying intentions, indicates that purchase probabilities explain about twice as much of the cross-section variance in automobile purchase rates as buying intentions. Similar but not quite so conclusive differences are obtained from analysis of selected household durables. The probability variable predicts more accurately than the intention variable largely because it divides nonintenders, and those who report that they "don't know" about their buying intentions, into subgroups with systematically different purchase rates.

This paper discusses the accuracy of predictions based on the traditional surveys of consumer buying intentions and suggests a hypothesis to explain the unimpressive performance of these surveys. This is followed by an analysis of the results of an experimental survey designed to provide an explicit measure of consumer purchase probability.

METHOD

The experimental design involved obtaining an essentially simultaneous measure of both purchase probability and buying intentions from identical respondents. Subsequently, information on actual purchases was obtained from the same respondents.

The object of the experiment was to determine whether or not a probability survey was superior to an intentions survey. It was decided to use identical households in a direct confrontation of the competitive survey design. Hence a random sample of some 800 households that had participated in the July 1964 Quarterly Survey of Intentions (QSI) were reinterviewed a few days later with the experimental probability survey.

EVALUATION REPORTED BY THE AUTHOR

The results of the experimental survey suggest that a reasonably good proxy for household purchase probability can be obtained from a survey of subjective purchase probabilities. The data indicate that a survey of buying intentions is simply a less efficient way of getting an estimate of purchase probabilities than a survey of explicit probabilities. Intentions seem to have no informational content that a probability survey does not also have, and the probability survey is able to extract information that is not obtainable from intention surveys.

One important question that cannot yet be answered concerns the role of disturbances in the relation between ex-post purchase behavior and ex-ante purchase probability. The evidence suggests that such disturbances were of little or no consequence during the period examined in this study.

A further limitation on the experiment is that few supplementary data were obtained. There is much to be said for the proposition that probability judgments would be sharpened by making the household explicitly aware of all the considerations that ought to have some relevance to purchase prospects. Thus a survey which, prior to asking about probabilities, contains questions on the households' income, income prospects, asset holdings, stocks of durables,

repair experiences on durable stock, actual and prospective labor market participation, etc., may obtain more accurate judgements than a survey which does not.

REFERENCE

Klein, Roger (Rutgers University) and Robert Sherman (Bellcore, Morristown, NJ). "Estimating New Product Demand From Biased Survey Data." Journal of Econometrics, Vol. 76, p. 53-76, 1997.

KEYWORDS

New product demand, survey data, econometric model, tobit model, orbit model, ordered choice model, video product.

ABSTRACT

Market researchers often conduct surveys asking respondents to estimate their future demand for new products. However, projected demand may exhibit systematic bias. For example, the more respondents like a product, the more they may exaggerate their demand. The author found evidence of such exaggeration in a recent survey of demand for a potential new video product. In this paper, a computationally tractable procedure that corrects for a general form of systematic bias in demand projections is developed. This general form is characterized by a monotonic transformation of projected demand, and covers exaggeration bias as a special case.

METHOD

Many popular econometric models have the form:

$$\Lambda(Y) = (X'\beta_0 + u) \qquad (1),$$

In this paper, the following model is considered:

$$\Lambda(Y) = (X'\beta_0 + u)\{X'\beta_0 + u > c\} \qquad (2),$$

where the constant c is known and lies in the interval $(-\infty,\infty)$. This model allows a monotonic function of Y to equal a censored regression, and reduces to (1) when $c = -\infty$. *When $c = 0$,* it is argued that the above equation (2) is a useful model for new product demand based on survey data. In this context, Y denotes reported demand and $\Lambda(Y)$ denotes actual future demand. X is a vector of predictor variables, β_0 is a vector of unknown parameters, u is an error term, and Λ is a monotonic transformation. The inverse function, Λ^{-1}, may be interpreted as a reporting function mapping actual demand into reported demand, Y. The authors develop a procedure for estimating β_0, the variance of u, and Λ without making any parametric assumptions about the functional form of Λ. However, they assume that the distribution of u is known up to scale. They obtain $\sqrt{n}$-consistent estimates of the model parameters and show that the estimate of Λ converges to a Gaussian process at $\sqrt{n}$ rate. These estimates can be used to produce reliable estimates of new product demand.

The authors also present the *Orbit* procedure, so called because it borrows features from an ordered choice model and the Tobit model. It is a two-stage procedure in which they first estimate the parameters of the Tobit model, and then use these estimates to recover an estimate of the function Λ at points of interest.

EVALUATION REPORTED BY AUTHORS

In this paper the authors develop a two-stage procedure, called *Orbit,* for estimating (1) the parameters of a standard Tobit model for actual future demand, and (2) the function, Λ. They make no parametric assumptions about the functional form of Λ. Nor do they require that Λ be continuous.

To apply the *Orbit* procedure, there must exist a positive safety point at which reported quantities equal actual quantities. This point must either be known *a priori,* or if unknown, must be consistently estimable and contained in a safe open interval. The authors provide graphical and formal tests of this assumption. When a given safety point is incorrect, the graphical tests can suggest a proper choice of safety point.

The authors also apply the *Orbit* procedure to survey data on a potential new video product. Under the model assumptions, the survey respondents report demand projections that exaggerate actual future demand beyond 1.7

times the median level, corresponding to about 25% of the sample. This level of exaggeration falls somewhere between linear and quadratic exaggeration. It is possible to apply a semiparametric version of *Orbit* that does not require making any parametric assumptions about the distribution of the error term.

REFERENCE

Kling, Catherine, Quanlu Wang, and Daniel Sperling (University of California, Davis). Economic Incentives to Introduce Electric and Natural Gas Vehicles and Reduce Mobile Source Emissions. Institute of Transportation Studies. Research Report UCD-ITS-RR-92-06, May 1991.

KEYWORDS

Electric vehicles, natural gas vehicles, emissions, economic incentives.

ABSTRACT

This research project addresses the form of government intervention for introducing electric and natural gas vehicles. The primary focus of this research is the cost savings from employing a marketable permit system (MPS) relative to traditional regulatory approaches for meeting current and future emission control standards. The research project is divided into two parts. In the first part, marketable permits for the introduction of alternative fuel vehicles (AFVs) are examined. In the second part, a permit system for the adoption of alternative fuels is addressed. This document reports on the work completed to date on marketable permits for vehicles.

METHOD

To estimate the costs of emission control with a MPS, data on emission control costs for conventional gasoline vehicles were collected. A survey of car dealers for twelve vehicle manufacturers in the Sacramento area was performed from January 1991 through July 1991. Dealers were asked to provide cost information on emission control parts for a variety of engine families. These data were combined with information on manufacturer' and dealers' markup and assembly costs to estimate the total costs of emission control per vehicle. These data suggest that, on average, vehicle manufacturers spend about $840 per vehicle for emission control purposes. There is a substantial variation among manufacturers, with American producers reporting the lowest emission control costs and European reporting the highest. Total emission control costs for new cars sold in California in 1990 are estimated to be about $1.3 billion.

Cost functions relating the total cost per vehicle to emissions per vehicles were estimated using the data collected for conventional vehicles. Significant differences were found in the cost functions by manufacturer and vehicle class. A simulation model of manufacturers' behavior was built wherein manufacturers are assumed to minimize the costs of emission control subject to meeting an emission standard. The effects of emission averaging and trading on the costs are estimated in this framework.

EVALUATION REPORTED BY THE AUTHORS

Although the results presented here are preliminary, they suggest that there may be sizable cost savings associated with a permit system relative to an inflexible standard. Information on the likely cost savings of a marketable permit system can be important input into public policy debates about the form regulation of mobile source emissions should take. If a permit system can achieve sizable cost savings, industry can more easily adopt emissions reducing technologies such as electric and natural gas vehicles. As a result, a marketable permit system can be beneficial to both industry and the environment.

REFERENCE

Kostyniuk, Lidia, P., David W. Eby, Carl Christoff, Michelle L. Hopp, and Frederick M. Streff (University of Michigan). The FAST-TRAC Natural Use Leased-Car Study: An Evaluation of User Perceptions and Behaviors of Ali-Scout by Age and Gender. University of Michigan Transportation Research Institute, Ann Arbor, UMTRI-97-09, March 1997.

KEYWORDS

ITS, user survey, personal vehicles, test vehicles.

ABSTRACT

The study took place in twelve monthly cycles from October 1995 through October 1996. During each cycle, five to eleven subjects were given a project-leased, 1995 Mercury Sable equipped with the Ali-Scout system to use in their everyday driving for 28 days. During each cycle, at least one equipped vehicle was held in reserve in case a subject's vehicle needed to be replaced because of vehicle or Ali-Scout malfunction.

The following procedure was used for every subject in each cycle. Subjects passing all recruitment criteria were contacted, scheduled into a cycle, and given a day, time, and location for an orientation meeting where they would learn about Ali-Scout and get their test vehicle (i.e., the handoff meeting). To ensure that all the subjects' questions could be answered and paperwork easily completed, no more than six subjects attended a handoff meeting at one time. Therefore, on days in which a cycle was to begin, two or more handoff meetings were conducted.

After Ali-Scout training, subjects were told about the various research instruments they would be asked to complete. The first instrument was a questionnaire. Subjects were told that during their third week of participation, a questionnaire would be mailed to them. Survey questions were grouped into seven categories that focused on the characteristics of the subject and his or her attitudes towards and use of the Ali-Scout system. These categories were driving and commuting, use of technology, Ali-Scout operation and displays, the Ali-Scout system as a whole, use of the Ali-Scout system, valuation, and subject demographics. The second study instrument was driver log in which subjects kept a detailed record of driving behaviors and experiences with Ali-Scout for all 28 days of participation. Study participants were asked to keep a record of all trips in which they drove the Ali-Scout equipped vehicle.

METHOD

There were two independent variables in the study: gender (Male and Female) and age group (19-to-29, 30-to-64, and 65-to-80 years of age). The age groups were selected to represent distinct groups of potential users of in-vehicle navigation assistance systems. Drivers under the age of 19 and over the age of 80 were excluded from participation because of their elevated crash risk. Participants were given a project-leased vehicle to drive as their own for a one-month period. During this period, subjects maintained a log of their trips and completed a questionnaire.

One hundred and two subjects (i.e., 17 subjects in each of the six cells of the experiment) volunteered to participate in this study and were recruited from the general population of drivers in the Oakland County study area. In order to obtain the widest range of subject demographics as possible among licensed drivers, subjects were recruited at a Michigan Secretary of State (SOS) office in Troy, Michigan. As people stopped by the SOS office to take care of matters concerning their driver licenses or vehicles, they could stop by a booth staffed by the research team. Here they could obtain information concerning the experiment and see a video presentation that explained the FAST-TRAC project and the features of Ali-Scout. Interested persons completed a short questionnaire on the amount of driving they did in the study area and their history of crashes and convictions. Potential subjects who indicated that they either did less than one-half of their driving in the study area; had a drunk driving conviction; had a conviction related to use, distribution, or transportation of a controlled substance; more than six points on their driving record; more than one at-fault crash; or were serving a criminal/traffic sentence were excluded from participation. The driving records of the rest of the potential participants were checked through the SOS office. Again, those subjects not meeting the above criteria were excluded. Because of a lack of both younger and older people at the SOS office, the recruitment efforts were supplemented at Oakland University and Beaumont Hospital as necessary.

EVALUATION REPORTED BY THE AUTHORS

None reported in text. However, an author reports that some of the data are not as good as would be desirable because of bias in the method. Some participants, particularly young males, tried to please the study team by under-reporting problems. However, good data were obtained on people's views of the technology. Further, the subjects had the technology to test. This is different from the case with the PNGV where the technology will not be available.

REFERENCE

Kostyniuk, Lidia P., Frederick M. Streff, and David W. Eby (University of Michigan). The Older Driver and Navigation Assistance Systems. University of Michigan Transportation Research Institute, Ann Arbor, UMTRI-97-47, November 1997.

KEYWORDS

ITS, user group interviews, test vehicles, personal vehicles.

ABSTRACT

The FAST-TRAC project included tests of two in-vehicle advanced traveler information systems (ATIS) that provided drivers with in-vehicle navigation assistance. These systems, Ali-Scout and TetraStar, both made by Siemens Corporation, provided drivers with turn-by-turn route guidance through visual and auditory commands.

The authors investigated the perceptions and behaviors of users of these systems with the intent of understanding how they used these systems in their everyday driving, whether they perceived any advantages or disadvantages of the ATIS devices and whether they liked the systems well enough to consider buying them and, if so, at what price. The investigations included two natural use studies, in which subjects were given a project vehicle equipped with an in-vehicle navigation device for one month, kept detailed driver's logs of their trips, and completed a detailed survey about their perceptions and valuations of the systems.

The objectives were to gain an understanding of how older drivers use the in-vehicle navigation systems in copiloting; to identify problems that older drivers have in learning and understanding in-vehicle navigation systems; and to propose ways in which these problems can be overcome.

METHOD

People over 64 years of age who participated in the Ali-Scout and TetraStar natural use studies were invited for a group interview to discuss how they navigate in general and their experiences with learning, understanding, and using the in-vehicle navigation systems in particular. Because driving and navigating a vehicle are often team activities, their spouses were also invited to participate.

EVALUATION REPORTED BY THE AUTHORS

None reported in text. However, an author reports that some of the data are not as good as would be desirable because of bias in the method. Some participants tried to please the study team by under-reporting problems. However, good data were obtained on people's views of the technology. In addition, focus group data are not generalizable to the population. Further, the subjects had the technology to test. This is different from the case with the PNGV where the technology will not be available.

REFERENCE

Koutsopoulos, Haris, Amalia Polydoropoulou, and Moshe Ben-Akiva (Massachusetts Institute of Technology). Public Acceptance and User Response to ATIS Products and Services: The Use of Travel Simulators to Investigate the Response to Traffic Information. Cambridge MA: Massachusetts Institute of Technology. December 1993.

KEYWORDS

Simulation/simulators, workshop.

ABSTRACT

This report is one of a series of papers developed or produced by the Economic Analysis Division of the John A. Volpe National Transportation Systems Center as part of its research project looking into issues surrounding user response and market development for selected Intelligent Vehicle-Highway Systems (IVHS) products or services

The objective of the project was to better understand factors affecting the development and deployment of selected advanced traveler information products and services (ATIS). The Center addressed the objective by examining the development of markets for selected ATIS-related products and services and reviewing factors affecting the public acceptance and user response to existing traffic information services.

The Volpe Center and FHWA jointly conducted a workshop in the fall of 1992 to discuss issues involved with assessing the market for IVHS products and services. The objectives of the workshop were to help define a research program which would address measuring user acceptance and response to ATIS products and services and the role market research plays in understanding emerging markets for new or unknown products and services.

The results of the workshop are reflected in the four research tasks initiated as part of this program and the seven papers, which comprise it. The four task areas are summarized below. Copies of the papers will be provided upon request to the Volpe Center.

METHOD

The methodology for user behavior research of this nature consists of two components, data collection and data analysis and modeling. Data on user behavior should be collected using a combination of approaches. Direct observations of user acceptance and reactions to ATIS could be obtained from, simulated laboratory experiments, field operational tests, and data analysis and modeling. Methods for the analysis of the collected data range from simple explanatory data analysis to obtaining descriptive statistics and analyzing individual behavior using advanced statistical methods.

This report presents a review of existing travel simulators and ongoing data collection and modeling efforts using these simulators. The report also suggests approaches for evaluating the validity of data collected through travel simulators in general.

EVALUATION REPORTED BY THE AUTHORS

None.

REFERENCE

Kurani, Kenneth (University of California, Davis). Evaluation of Hypothetical Early Market Segments' Response to Electric Vehicles: Results of Test Drive Clinics and Focus Groups. The Institute of Transportation Studies. UCD-ITS-RR-93-19, July 1993.

KEYWORDS

Electric vehicles, drive clinics, focus groups, purchase intentions, survey, innovators, early adopters.

ABSTRACT

Drive clinics and follow-up focus groups were held with members of two hypothetical early market segments for electric vehicles — EV innovators and environmentalists. These two groups are often cited as likely initial buyers of new, original equipment manufacturer (OEM) EVs. As the first buyers, these people would be influential in setting the course of EV sales. These assumptions about early market segments raise several questions. First, can "innovator" and "green" market segments be identified prior to the existence of an EV market? Will these people actually be among the early buyers of OEM EVs? If the answers to both these questions are affirmative, then what attributes of EVs act as incentives or barriers to purchase? And, which attributes affect choices between particular EVs?

METHOD

In order to test these suppositions members of the Sacramento chapter of the Electric Automobile Association (EAA) and recruits at the Davis Whole Earth Festival (WEF) were given the opportunity to see, ride, and drive a variety of EVs. While at the drive clinic, participants completed a pre-survey, and were then conducted through a tour of the vehicles by an interviewer who recorded their responses to the vehicles. Participants then filled out a post-test drive questionnaire and scheduled a time to return for a focus group. In the focus groups, participants were guided through a series of questions on how each of the types of vehicles they had seen at the drive clinic would fit into their lives. This discussion focused on vehicle attributes and the specific travel behavior of the participants. The group then discussed in a more general way the advantages and disadvantages of EVs. Lastly, vehicle purchase intentions were explored in the context of the information base built up through the drive clinic and the group discussions. A total of 26 people completed the entire process.

Vehicles that the EAA members reviewed were as follows: City-EI, Kewet, Solectria Geo Metro conversion, Horlacher City and Sport, and Esoro. WEF recruits reviewed these same vehicles with the exception of the Kewet.

These vehicles represent a broad spectrum of performance and body styles. The City-EI represents the lowest performance level on several scales; it seats only one person, has a top speed of 30 to 35 miles per hour, a driving range of 20 to 30 miles, and a total payload capacity which was exceeded by a few of the test drivers without any other cargo. The Kewet offers two seats, a more traditional, upright driving position, a top speed of 40 miles per hour and a driving range of 40 miles. The remaining vehicles are all freeway capable, with top speeds in the range of 65 to 75 mph and driving ranges of 60 to 80 miles. All the freeway capable vehicles seat at least two people. Only the Esoro offers 2 + 2 seating. All six vehicles can charge from a standard 110-volt outlet.

EVALUATION REPORTED BY THE AUTHORS

This study asks, and attempts to answer, three questions. First, can we identify members of early market segments for electric vehicles prior to the existence of markets for vehicles? Second, if we can identify those people, do they express positive purchase intentions when presented with the opportunity to ride and drive a variety of electric vehicles? And third, what attributes of the vehicles determine choices between the vehicles?

The first question is of fundamental importance because most studies of new products are based on retrospective histories — this study differs in that it examines two hypothetical market segments for a product not yet widely available. The only definitive answer to the question is that as the terms "innovator" and "early adopter" are used in the diffusion of innovation literature, they cannot be identified *a priori* because the very definition depends on

comparisons of persons in these groups to later buyers of the product. This circular reasoning highlights the importance of the type of market analysis performed in this study. Hypothetical groups must be identified, their responses to electric vehicles assessed, and adjustments made to either or both the hypotheses or the product.

It should be noted that the group of "environmentalists" cannot be distinguished from the "EV innovators" on several attributes, most notably those characteristics which were to have identified them as environmentalists. This fact indicates that concern with air quality and the desire to do something about it has become a part of the more general social fabric of Sacramento and Davis. We may no longer be able to differentiate consumers based on this definition of "environmentalist." The search for early buyers of electric vehicles will have to find new ways to segment the market.

The answer to the second question is yes, and no. Based on their responses to the vehicles and accepting that each respondent has been correctly identified as an EV innovator or an environmentalist, the participants in this study are ambivalent with respect to choices of electric vehicles they rode and drove. Yes, there are some positive purchase intentions expressed. Fifteen of the 26 participants chose one of the vehicles they had tested in a hypothetical purchase decision. Three facts counter this positive response. First, 11 participants chose none of the vehicles. Second, 8 of the 15 who did choose a vehicle, chose the Solectria conversion. Third, the prices at which the prototype OEM vehicles were chosen represented the optimistic assumption that the prototypes would be priced similarly to gasoline vehicles of similar body styles (e.g. Honda del Sol, Mazda MX3).

With regard to the last question, the vehicle attributes which determined choices were price, top speed, driving range, and styling. Price determined both whether any EV was considered and choices between vehicles. Top speed and driving range separated the smaller, slower City-E1 and Kewet from the freeway capable Solectria, Esoro, and Horlachers. The two participants who identified that the non-freeway capable vehicles could access a large number of their activities chose these limited performance, limited range, low price vehicles. Within the group of freeway capable vehicles, respondent's choices tended to maximize either top speed or driving range, and then to select for specific styling features.

REFERENCE

Kurani, Kenneth S., Thomas Turrentine, and Daniel Sperling (University of California at Davis). "Testing Electric Vehicle Demand in 'Hybrid Households' Using a Reflexive Survey." Transportation Research, Part D, Vol. 1D, No. 2, December 1996.

KEYWORDS

Electric vehicle, hybrid, mail questionnaire, mixed mode, interviews, driver logs, economic incentives, chi-square, activity-based, gaming simulation, interactive stated response, reflexive design, multi-stage approach.

ABSTRACT

The debate over electric vehicles (EVs) pivots largely on issues of market demand: will consumers purchase a vehicle that provides substantially less driving range, yet can be refueled at home, than an otherwise comparable gasoline vehicle? Also, what roles do other unique attributes of EVs play in the purchase decision? Most previous studies find that limited driving range is a serious market barrier; many of those same studies ignore or under-value other novel attributes. To probe these future consumer decision processes deeply and robustly, the authors first devised and conducted detailed, interactive and experiment-oriented interviews. Then, incorporating what was learned, they designed an innovative mail survey and administered it to 454 multi-car households in California. The four-stage mail survey included a video of EV use and recharging and other informational material, completion of a 3-day trip diary and map of activity locations, and vehicle choice experiments. In addition to propulsion systems, respondents made choices of body styles, driving ranges, and other features. The authors formalized and tested what they call the *hybrid household hypothesis:* households who choose EVs will be purposefully diversifying their vehicle holdings to achieve the unique advantages of different propulsion systems. The hypothesis is supported, given the assumptions in the experimental design. In fact, a significantly larger number of EVs are chosen than the minimum number that would support the hypothesis. The authors find that purchases of battery-powered EVs by hybrid households would account for between 7 and 18% of annual light-duty vehicle sales in California. EVs sold to fleets and other households would be in addition to those identified by this study.

METHOD

Previous EV market studies: In the absence of data on actual sales, researchers have previously tried three methods to develop estimates of EV market potential-attitude studies, travel behavior analyses, and stated preference surveys.

The problem with attitude surveys is that they represent consumers' ideals and not their full decision processes. They tend to overstate the demand for EVs because of the vehicles' clean, progressive image. Travel behavior studies that address the role of limited range also overstate the demand. These studies identify households with daily driving patterns that match the range capabilities of EVs.

Most stated preference studies, in contrast, have produced very low estimates of EV demand, from 0 to 2%, primarily because they estimate huge average price penalties for a limited range.

The authors' approach to experimental design is built upon three areas of active research in transportation: activity-based approaches, gaming simulations, and interactive stated response methods, and a fourth new area they call reflexive design, which is not unique to this work, but which is previously not identified in the literature.

The survey instrument was divided into four parts and was designed to be completed over several days to encourage critical evaluation of the options. The four parts are summarized below.

Part 1: Initial survey of household vehicle holdings, purchase intentions for next new vehicle, demographics, and environmental attitudes.

Part 2. Three-day travel diary for two primary household vehicles, a map on which the household plotted their activity locations, and a survey of the travel and refueling behavior of the two primary drivers.

Part 3. Informational video and reprinted articles from major media that explain and demonstrate distinct refueling and recharging routines, emissions, and other new features of compressed natural gas, battery powered electric, hybrid electric and neighborhood electric vehicles.

Part 4. Choice experiments related to their next vehicle purchase.

Part 4 of the questionnaire consisted of two vehicle-choice scenarios in which respondents were asked about their next expected new vehicle transaction. Each scenario was a distinct experiment. Situation 1 was a test of the hybrid household hypothesis. It involved a choice between conventional, gasoline-fueled-vehicles and limited-ranged, home-recharged, electric vehicles. Situation 2 was designed as one plausible future market scenario, designed primarily to test a corollary of the hybrid household hypothesis — that the demand for EVs can be segmented by the demand for driving range — and to explore the lower boundary on the demand for range. Six vehicle types were offered: reformulated gasoline, compressed natural gas, hybrid electric, two types of freeway-capable battery electric, and a neighborhood battery electric.

EVALUATION REPORTED BY THE AUTHORS

The authors identified a substantial market for reduced-range, home-recharged electric vehicles among a particular group of multi-car households. Though they provide a quantitative estimate of sales to this market segment — 18% of the annual new light-duty vehicle market in California for battery-powered EVs with ranges of 40-150 miles — these numbers should be viewed as being illustrative of market responses, not as forecasts. Actual EV purchases could be far more or less, depending on prices, vehicle performance, marketing strategies, government incentives and rules, and ultimately, on whether consumers regard the EVs offered to them as affordable, viable options within a variety of transportation services.

The fundamental differences between electric and gasoline vehicles in the choice experiments were driving range, home recharging, and emissions. Purchase prices in particular were designed to overlap between vehicle types.

Studies often fail to identify markets for new technologies because researchers search among the existing inventory of consumer preferences and market segments. When potential buyers have not yet constructed preferences for the attributes of novel technologies, attempting to identify and measure market segments will surely mis-estimate future demand. The authors believe that, in order to avoid the pitfalls that they found in previous EV market studies, market research into many new transportation technologies, especially technologies with social costs and benefits, would be improved by a multi-stage, experimental and process-oriented approach such as that which they designed for this study of electric vehicles. Study lifestyle goals to evaluate the practical and symbolic values of new technologies. The answer may be a participants must be given adequate information and decision-making contexts based on their own daily life and solid market, as we found here for EVs.

REFERENCE

Mahajan, Vijay (University of Texas at Austin), Eitan Muller (Tel Aviv University), and Frank M. Bass (University of Texas at Dallas). "Diffusion of New Products: Empirical Generalizations and Managerial Uses." Marketing Science, Vol. 14, No. 3, Part 2 of 2, 1995.

KEYWORDS

Diffusion, forecasting, new product research.

ABSTRACT

The diffusion model developed by Bass (1969) constitutes an empirical generalization. It represents a pattern or regularity that has been shown to repeat over many new products and services in many countries and over variety circumstances. Applications, modifications, and extensions of the model have lead to further generalizations. In addition to the empirical generalizations that stem from the model, the authors discuss some of the managerial applications of the model.

METHOD

The authors use graphical, algebraic, and written representation of managerial applications of a diffusion model that applies to the patterns of initial purchases of a product.

Rogers has hypothesized that the adoption pattern is a normal distribution. He has suggested that there are five categories of adopters based on when adoption occurs.

1.	Innovators	2.5 %
2.	Early adopters	13.5
3.	Early majority	34
4.	Late majority	34
5.	Laggards	16

Norton and Bass estimated the parameters and examined the fits of this model for 12 product categories for products in electronics, pharmaceuticals, consumer products, and industrial product categories and found that in every instance the fits were extremely good. This model is derived from the Bass model and implies that the underlying diffusion process of this model governs the process of adoption and disadoption for successive generations of technologies.

This empirical generalization has important implications from an applied forecasting standpoint in that it is possible to estimate parameters based on data from early generations to forecast diffusion of later generations conditional on the timing of introduction of the later generations.

Forecasting adoption timing prior to product introduction will obviously require guesses of parameters:
(1) market size, (2) the time of the peak in the adoption rate, and (3) the adoption rate at the peak.

EVALUATION REPORTED BY THE AUTHORS

The Bass diffusion model constitutes an empirical generalization. In addition, other empirical generalizations have been spawned by application and extensions of the model. Early applications of the method were restricted to forecasts, but as shown here, a variety of other applications areas have emerged. The authors expect further empirical generalizations to emerge around existing and future application areas.

REFERENCE

Mahajan, Vijay (Southern Methodist University) and Yoram Wind (University of Pennsylvania). "New Product Forecasting Models, Directions for Research and Implementation." International Journal of Forecasting, Vol. 4, No. 3, p. 341-358, 1988.

KEYWORDS

New product forecasting, methods survey.

ABSTRACT

Given the importance of forecasting the performance of new products and services in the marketplace, numerous new-product-forecasting models have been developed over the years, both in industry and academia. This paper evaluates strengths and weaknesses of these models and outlines a research agenda to enhance their implementation and further development.

METHOD

New-product-forecasting models vary not only with respect to their objectives and users, but also with respect to their databases. In general, these models use one or more of the following data sources:

1. Management and expert judgments: management's or experts' subjective estimates are used to forecast new product's likely performance.
2. Analogous products: a product with similar characteristics to those of the new product under consideration is used to forecast its likely performance.
3. Consumers: based on consumer responses, likely performance of a new product is revived by estimating its awareness, trial and repeat.

The three types of forecasting models, especially the consumer-based models, vary with respect to the stage in the new-product-development process for which they are most appropriate.

EVALUATION REPORTED BY THE AUTHORS

After briefly reviewing strengths and weaknesses of the various types of currently available new product forecasting models, this paper outlined twelve areas of research and implementation that can help (a) practitioners improve the existing models to enhance their utilization in evaluating new product decisions, and (b) researchers develop models that better meet the needs of users of new-product-forecasting models.

Directions for research and implementation:

I. Improving the utility of existing models

1. A comprehensive analytical and empirical comparison of the models (like the M-competition for the time-series models).
2. External validation of the models.
3. Combination of forecasts.
4. Identification of conditions for skipping forecasts at the various stages of the new-product-development process.
5. Integration with financial criteria of product success.
6. Combination of models.

II. Broadening the scope

7. New-product models for truly innovative breakthrough products.
8. Models based on the newly available databases.
9. Development of models incorporating offensive and defensive strategies.
10. Development of forecasting expert systems.
11. Incorporation of the concept of marketing hype.
12. Models for global markets.

REFERENCE

Mander, Arthur A. (Tri-state Generation and Transmission Association, Inc.), Mark D. Rogers (Northern States Power), Martin J. Bernard III and Nancy E. Collins (Q^4 Associates). Commercial and Residential Electric Vehicle Market Size and Impacts. http://www.evs.org/evs14.

KEYWORDS

Electric vehicle, potential customers, in-person interviews, fleet, random sample, market potential, factoring (technical, economic criteria), mail questionnaire.

ABSTRACT

This analysis of electricity customers in five electric cooperatives and in a metropolitan area in the U.S. has shown that tomorrow's electric vehicles (EVs) can perform a large portion of household, farm, commercial, and governmental fleet daily vehicle usage. It was found that EVs could penetrate some commercial fleets rapidly, while for others, market penetration will be delayed until significantly better range can be achieved. For the National Rural Electric Cooperative Association (NRECA), a scientific, fully field-tested methodology was developed to determine the potential market for EVs and the impact of those EVs on load and revenue. The methodology was then refined and expanded, and applied to the Twin Cities in Minnesota metropolitan area for Northern States Power (NSP). Besides these uses intended for electric utilities, the method and its results could be used by environmental or energy organizations to determine the potential air quality or energy impacts of EVs in their region.

METHOD

First, a sample of residential customers or of a commercial subsector was drawn. (For NSP, the commercial sector was stratified into eight subsectors because vehicle-use patterns very widely by the type of business, e.g., consider the daily use of school buses compared to local delivery trucks or to rental vehicles.) A questionnaire was mailed to each customer in the sample requesting the characteristics of the household or firm and how their vehicles are used each day. Next, a set of technical and economic criteria was applied to each of the respondent's vehicles to determine their EV potential. The vehicles that meet the criteria represent the *sample* market potential. This sample market is factored up to the population of residential or commercial subsector vehicles, resulting in the *population* market potential, i.e., all the vehicles in the geographical study area having daily uses that could be EVs based solely on the criteria. Not all these vehicles will actually become EVs in the study years, so market penetration factors were applied, resulting in the vehicles in the *expected* residential or commercial subsector market. The energy, load, revenue, and local service impacts of these vehicles were then calculated and aggregated to all expected EVs in the study area.

The main technical criterion used in the NSP study concerns maximum daily mileage. For 2002, if that mileage was above 50 miles, the vehicle was not counted as an EV; for 2007, the screen was 100 miles. The only way to determine the expected markets for EVs is by analogy to the market penetration of some other product. It was decided to look at a relatively recent introduction of a new body type — minivans. Market penetration factors of 3% in 2002 and 10% in 2007 were used as a reasonable on-the-road percentage of market potential.

The NSP residential survey began with five questions about the respondent's knowledge of and attitudes toward EVs: knowledge, willingness to buy with age of respondent, household vehicle distribution by daily maximum and typical miles. Similar analysis was performed on each of the NSP commercial subsector survey results. For both the residential and commercial customers, several case studies were drawn from the data.

When the residential and commercial sector results were combined, by 2007, the number of expected EVs in the Twin Cities region is less than 3% of the regions' vehicles. By 2007, EVs will just begin penetrating the market.

EVALUATION REPORTED BY THE AUTHORS

The methodology developed and tested for NRECA and refined and expanded for NSP is a tool that can be used for any geographical area, with some of the details altered to meet local circumstances, the type of results desired, or different forecasts years. It gives very reasonable and consistent results. The cost of implementing the methodology for a given geographical area is well below the cost of developing it, thus it is a cost-effective way to learn EV potential and impacts. Besides applications of the methodology by electric utilities, it and its results could be used by environmental or energy organizations to determine the potential air quality or energy impacts of EVs in their region. Another user could be a car dealership to determine if EVs could be a viable product line. No analytical evaluation was presented.

REFERENCE

Mannering, Fred L. (Massachusetts Institute of Technology). "An Econometric Analysis of Vehicle Use in Multivehicle Households." Transportation Research, Part A, Vol. 17A, No. 3, p. 183-189, May 1983.

KEYWORDS

Household fleets, vehicle usage allocation, travel demand models, fuel consumption forecasts.

ABSTRACT

The significance of the multivehicle household in the U.S. has increased substantially in recent years to the point where over 80% of household vehicles holdings are owned by multivehicle households. Despite this fact, traditional travel demand models have not explored the determinants of individual vehicle use in such households, even though knowledge of vehicle usage allocations within household fleets is critical to subsequent fuel consumption forecasts. The objective of the current research is to overcome the weaknesses of previous research efforts by presenting a discussion and corresponding model of individual vehicle utilization in multivehicle households.

METHOD

An econometric model of individual vehicle use in multivehicle households is presented, having been estimated with national disaggregate data of two-vehicle households. The model evaluates household activity information against household vehicle allocation.

Activity choices include: type of activity; location of activity (destination); mode; route; time of day; and activity duration. Vehicle allocation variables include: number of available vehicles; type of available vehicles; bargaining among household members for access to vehicles; and within-household vehicle attachments (ownership).

The primary data source used for model estimation was the 1979-80 Household Transportation Panel collected by the Energy Information Administration of the U.S. Department of Energy. This data source contains a wealth of information relating to vehicle use including: vehicle principal driver identification with age, employment status and sex, household socioeconomic data, vehicle make and model information in coded form, vehicle vintage, and monthly vehicle usage determined from actual odometer readings.

To illustrate the potential usefulness of the model, the impacts of a doubling of fuel prices were considered. The implied price elasticity in the two-vehicle household population is -0.113 with respect to vehicle miles of travel (VMT).

It was found that:

1. Traditional aggregate and disaggregate models of VMT have virtually ignored individual vehicle use in multivehicle households, and hence their forecasting capabilities are necessarily limited.
2. Estimation of an appropriate model of individual vehicle use in multivehicle households can be achieved using a simultaneous equation approach.
3. The impacts of fuel price increases on individual vehicle use vary significantly across income groups and vehicle fuel efficiency categories, thereby underscoring the importance of household socioeconomic conditions and household fleet composition.
4. The ability of multivehicle households to substitute the use of more efficient vehicles for the use of less efficient ones should be considered in VMT-price elasticity estimates.

EVALUATION REPORTED BY THE AUTHOR

With the variables defined and a linear functional form selected, the reduced form of the equation system was solved to make certain that parameter identification problems did not exist, and in fact the system was found to be over-identified. Model estimation was then performed using three-stage least squares (3SLS) with a Davidon-Fletcher-Powell optimization algorithm. The parameters were constrained across equations. All of the variables are properly

signed as suggested by prior expectations. Moreover, all of the coefficients were found to be significant at well over the 90% confidence level (using a one-tailed t-test) with the exception of σ_6 which is significant at the 85% confidence level. The magnitudes of the estimated coefficients also seem to be quite reasonable. For example, all other factors equal: (1) principal drivers under 50 yr. of age drive their vehicles 123.51 miles more per month than those over 50, (2) urban households drive 154.44 miles less than rural ones, (3) female principal drivers operate their vehicles 130.93 miles less than males, and (4) for every 100 miles driven on a "competing" vehicle, the modeled vehicle will be driven 17.2 miles less.

The estimation produced single equation R-squared's of 0.2395 and 0.2611, which are quite satisfactory considering the amount of variance inherent in disaggregate data of the type used in this study. As a final note, it is believed that the model fit could be enhanced by data that is more detailed than that available for this study. Specifically, information relating to the type of activities the principal driver actually undertakes, such as type of work, types of leisure activities, and so on, would be of considerable value.

REFERENCE

Mannering, Fred (University of Washington) and Clifford Winston (Brookings Institution). "Automobile Air Bags in the 1990s: Market Failure or Market Efficiency?" Journal of Law and Economics. Vol. 38, p. 265-279, October 1995.

KEYWORDS

Airbags, regression, willingness to pay, consumer choice, national household panel data, multinomial logit.

ABSTRACT

This article seeks to explain the recent growth in the adoption of air bags in the new automobiles. The analysis focuses on market forces, that is, consumers' willingness to pay for air bags and automakers' responsiveness to consumers' willingness to pay.

METHOD

Since 1990 air bags have been available on enough vehicle models to permit us to infer through a statistical model what consumers *are* willing to pay for air bags. The approach taken is to estimate a model of consumer choice of which new vehicle to purchase. The coefficients that capture the effect, on this choice, of a vehicle's price and whether an air bag is available on this vehicle can be used to estimate consumers willingness to pay for an air bag.

The data set is from a national household panel administered by National Family Opinion Inc., Toledo, Ohio, and managed by Alison Fisher, Inc. The sample consisted of complete vehicle ownership histories of households that purchased a new car from 1990 through 1993. Respondents provided information to construct the brand loyalty variables, socioeconomic variables, and air bag interaction variables. The remaining vehicle attributes are from the 1990-1993 issues of the *Market Data Book* published by Automotive News. Separate new vehicle choice models were initially estimated for the years 1990, 1991, 1992, and 1993. Because statistical tests indicated that the models' parameters were not statistically significantly different during these time periods, a single model for the entire period was estimated.

EVALUATION REPORTED BY THE AUTHORS

None.

REFERENCE

Maples, John D., James S. Moore Jr., Philip D. Patterson, Vincent D. Schaper (U.S. Department of Energy). Program Analysis Methodology Office of Transportation Technologies Quality Metrics 2000. January 1999.

KEYWORDS

Emissions, gross domestic product, market penetration, vehicle size classes, discrete choice multi-attribute logit model, alternative-fuel light vehicles, fuel type, households, utility theory

ABSTRACT

"Quality Metrics" evaluations are conducted on an annual basis in the U.S. DOE. Office of Energy Efficiency and Renewable Energy (EE/RE) to assess the energy and environmental benefits potential of EE/RE programs. The Quality Metrics program of EE/RE and the preparation of the EPACT 2021 report to Congress led to the development of an impacts assessment methodology for the Office of Transportation Technologies (OTT), which is continually improved and updated. This document provides the final documentation for the Quality Metrics 2000 (QM 2000) analytical process and results, and an overview discussion of continuing work. It is named QM 2000 because the benefits are listed in the FY2000 budget to Congress.

METHOD

Vehicle choice analysis techniques were used to estimate the market penetration of technologies in five light vehicle classes, medium trucks (classes 3 through 6) and heavy trucks (classes 7 & 8). The Vehicle Size/Consumer Choice (VSCC) model was developed to define the successful introduction of technologies in light vehicles by vehicle size class. This modeling exercise acknowledges that not all technologies are applicable to all size classes and that the introduction of advanced technologies is a gradual one. The VSCC model is a discrete choice, multi-attribute logit model designed to simulate the household market for alternative-fuel light vehicles. The model forecasts, to the year 2020, the future sales of conventional and alternatively fueled light vehicles by size class, technology and fuel type. Market penetration estimates are based on consumer derived utilities related to vehicle attributes that are associated with the different alternative fuels and advanced propulsion technologies. As such, the model is "household" based. Other market sectors are considered in various "off-line" calculations.

The vehicle demand function used in this model is based on the utility-maximization theory in which the consumer demand for alternative vehicles is defined as a function of the attributes of these vehicles and the fuels they use. The total utility of each light vehicle technology and fuel makeup is determined by the sum of the attribute utilities of that vehicle for each size class. The size class market share penetration estimates of the different technologies are a function of each technology's total utility compared to the total utility of other vehicles and technologies in that size class. The technology's total utility is calculated by summing attribute-input values that have been multiplied by their corresponding coefficient. A discussion of the model structure, including the vehicle attributes and attribute coefficients considered is presented.

EVALUATION REPORTED BY THE AUTHORS

In regard to attribute coefficient values for vehicles and fuels, it is important to note that a major limitation in estimating the potential household market penetration of alternative vehicle technologies is the lack of revealed preference data. Revealed preference data is gathered from actual consumer response in the market place. Currently, there are only a limited number of alternative-fuel technologies commercially available. Although purchase and use data are being collected on these vehicles, they are primarily owned by fleet operators, reflecting the desired attribute utilities of that market.

REFERENCE

McNeil, John (Bureau of the Census). "Federal Programs to Measure Consumer Purchase Expectations, 1946-1973: A Post Mortem." Journal of Consumer Research, Vol. 1, December 1974.

KEYWORDS

Consumer expectations, consumer intentions, consumer attitudes.

ABSTRACT

In early 1973, the Bureau of the Census announced the discontinuation of the Survey of Consumer Buying Expectations. The Bureau of the Census had conducted quarterly surveys of buying plans since January 1959; first, through the Quarterly Survey of Consumer Buying Intentions (QSI) and, since 1967, through the Survey of Consumer Buying Expectations (CBE). This article describes the development of the Federal programs and summarizes the evidence that led to the decision to discontinue the program.

The sponsorship by the Federal Government of surveys to measure consumer expectations, intentions, and attitudes dates from the 1946 "National Survey of Liquid Assets." The survey was sponsored by the Federal Reserve Board and was conducted by the Division of Program Surveys of the U.S. Department of Agriculture. The purpose of the survey was to provide an indication of the probable impact on consumption of the large amount of liquid assets then being held by consumers. The survey information which was intended to be used for predictive purposes could be divided into two types: first, "objective" variables such as income, assets, and liabilities: second, "subjective" variables such as expectations, intentions, and attitudes. The objective variables could be related to each other in an effort to explain behavior, and the estimated relationship could then form the basis for predictions. The subjective variables could, hopefully, be used directly.

METHOD

This study examines the predictive value of the survey. It presents predicted purchases generated by the survey and compares them to the actual level of purchases among the same group of consumers. A discussion of the shortcomings of the predictive value of consumer expectations and the survey follow.

Examples of the questions on the National Survey concerning expectations, intentions, and attitudes include the following:

Expectations. What do you think things are going to be like for the country as a whole in the next year or so? Why do you think so? What about the prices of things you buy? In the next year or so do you expect them to go up or down or stay about as they are now? Why do you think so?
Intentions. Now we'd like to get an idea of how much money you personally are planning to put into large items that people haven't been able to get during the war. Let's take cars, for example. Do you expect to buy a car in 1946? How much do you expect to pay for it? Will it be one of the new models?
Attitudes. Now that the war is over, would you say you people are better off or worse off financially than you were while the war was still on?

This study also examines problems encountered in the survey of consumer buying expectations and the reasons for its discontinuation in 1973.

John Lansing and Stephen Withey reported that the car purchase rate of intenders was about twelve times as great as the purchase rate of nonintenders, but because the nonintender group was large relative to the intender group, about one-half of all new car purchases during a twelve month period were accounted for by those who had no plans to buy a car at the beginning of the period (Lansing and Withey, 1955).

If the Census Bureau program to measure purchase expectations must be considered a failure, it is worth asking how the program came into being and why it survived for nearly 15 years. A reading of the 1955 committee report suggests that the decision to initiate the QSI was based largely on the ability of intentions data to identify individual

purchasers. In retrospect, the warnings of Katona and Mueller about the limitations of cross-section tests were not given adequate attention. It seems clear that cross-section tests are necessary to reach judgments about the predictive value of intentions, expectations, and attitudes, but they are not sufficient. It is, of course, true that a number of years are required before time-series tests can be conducted and the results, as we have seen, are not always conclusive. In the future we would do well to pay more attention to the specification of cross-section tests and exercise the utmost caution in using cross-section results to infer time-series performance. The Census Bureau program survived for 15 years because the early part of that period was marked by a high correlation between plans and purchases. When both series lost the strong trend factors, which had been present for much of the 60's, it became apparent that aggregate purchase plans were not a good predictor of aggregate purchase behavior.

EVALUATION REPORTED BY THE AUTHOR

None.

REFERENCE

Moore, J. S. Jr. (TA Engineering, Inc.), J. D. Maples (University of Tennessee), and Philip D. Patterson (U. S. Department of Transportation). "Light-Duty Diesels, Consumer Perspectives and U.S. Energy Supply Issues." Transportation Research Record No. 1641, p. 19-26, 1998.

KEYWORDS

Discrete choice multinomial logit model, diesel, econometric telephone survey.

ABSTRACT

An assessment of the potential for diesel engine light-duty vehicles to reduce petroleum consumption and greenhouse gas emissions is presented. Historical diesel vehicle sales behavior is presented and analyzed. Future market penetration and resultant petroleum consumption and emission reductions for advanced diesel engines are projected. Results of a survey of new vehicle buyer attitudes toward improved diesel engines are presented and analyzed. Effects of increased diesel market share on diesel fuel supply and price are estimated. Overall, the outlook for diesels in light vehicles is somewhat promising if pollution issues and consumer concerns about the earlier diesels can be addressed.

METHOD

Market penetration for advanced diesel engines in light vehicle applications was estimated using the Vehicle Size/Consumer Choice (VSCC) model. The model estimates market penetration for four vehicle size classes: small car, large, car, passenger truck, and cargo truck using a discrete choice, multinomial logit structure. For each of these size classes, vehicle attributes for competing technologies (i.e., the advanced diesel) are measured against the conventional technology (gasoline spark-ignition engine) using consumer-derived utilities. The attributes include vehicle cost, fuel economy, vehicle range, trunk space, acceleration, and top speed. For this analysis, it is assumed that the advanced diesel engine will be available in each of the four size classes.

The model was developed to define the successful introduction of technologies by vehicle size class. This modeling exercise acknowledges that not all technologies fit in all size classes and that the introduction of advanced technologies is gradual. The model is a discrete choice, multiattribute logit model designed to simulate the household market for alternative-fuel light-duty vehicles. The model forecasts the sales of conventional and alternatively fueled light-duty vehicles by size class, technology, and fuel type to 2020. Market penetration estimates are based on consumer-derived utilities related to vehicle attributes that are associated with the various alternative fuels and propulsion technologies.

To help determine the interest of new vehicle buyers in diesel light vehicles, in July 1997, a short telephone survey was conducted that questioned a 1,010 person random sample of the U.S. population. The first question asked the respondent was, "Would you consider buying a diesel engine version that got 40 percent better fuel economy and cost $1,500 additional for your next new vehicle purchase?" The responses indicate that 22 percent of the sample would consider diesels; and the percentage was lower for females, older respondents, and those in the South. The percentage was higher for the young; those in the West; and persons with higher incomes, bigger households, and more education. The fact that older respondents are less interested in diesel may be due, in part, to their knowledge of diesel problems in the early 1980s. Those who would not consider purchasing a diesel were asked to list the reasons why. The major reasons for not considering a diesel are presented.

EVALUATION REPORTED BY THE AUTHORS

Responses to a survey indicated that, if the negative attributes of diesels were eliminated, the potential exists for increased use of diesels. Survey results are corroborated by market penetration analysis indicating that improved diesels can be strong competitors of gasoline engine vehicles.

REFERENCE

Morrison, Donald (Columbia University). "Purchase Intentions and Purchase Behavior." Journal of Marketing, Vol. 43, No. 2, Spring 1979.

KEYWORDS

Probability estimate, purchase intentions.

ABSTRACT

This paper provides a framework for collecting, analyzing, and interpreting purchase data, and presents a method to transform stated purchase intentions into purchase probabilities. There has been little follow-up to see if individuals surveyed actually purchased the product of interest over the specified time periods. One purpose of this paper is to stimulate such follow-up procedures. This paper is an attempt at building a formal mathematical model that establishes the intermediate links between stated purchase intentions and actual purchase behavior.

METHOD

First, a general framework for analyzing purchase intentions data is presented. This model focuses attention on three very different phenomena that often are implicitly and confusingly combined. Then within this overall framework a specific, mathematically tractable and statistically testable model is developed. The overall model uses a three-step transformation to transform stated intention, I_s, into a purchase probability estimate, p.

Step 1. Stated intention, I_s, is transformed into an estimate of the true intention, I_t, by the True Intention Model (TIM).

Step 2. The estimated true intention, I_t, is transformed into an unadjusted purchase probability estimate, p_u, by the Exogenous Events Model (EEM).

Step 3. The estimated unadjusted purchase probability, p_u, is transformed into the estimated purchase probability, p, by the Probability Adjustment Model (PAM).

The model forces the researcher to explicitly consider:

- The number of scale points on the intention scale
- The numerical value of each point on the intention scale
- The adjectives associated with each point on the scale
- Whether a direct probability response scale should be used
- The reliability of stated intentions
- The transformation from stated intentions to true intentions
- The distribution of true intentions across the population of consumers
- The appropriate time frame for the intentions
- The effect of "unexpected" events over the time frame
- Systematic discrepancies between average intentions and average purchase probabilities

Clearly, automobile intentions are more stable over time than appliance intentions.

EVALUATION REPORTED BY THE AUTHOR

The advantage of the formal three-step model is that the resulting parameters decompose the empirical slope of this linear relationship into the components due to the heterogeneity of the true purchase intentions and that due to the propensity of individual purchase intentions to change.

At the moment there is not an adequate set of purchase intentions with follow-up purchase behavior studies in the literature to make the above type of forecast. The author hopes this paper will supply a unifying framework for the design of such studies and that the researchers involved will be motivated to publish their findings. If this is done the probability is very high that empirical regularities will emerge that will make purchase intentions data much more useful to the marketing community.

REFERENCE

Moyer, C. B. and Coleman, D.A. (Acurex Environmental Corporation, Mountain View, California). "Electric Vehicle Vision 2007". http://www.evs.org.evs14.

KEYWORDS

Electric vehicles, Delphi, in-person interview, telephone interview, mail questionnaire, experts.

ABSTRACT

The purpose of the study was to assemble the survey responses, to note where responses varied so as to allow some assessment or inference of the degree of uncertainty or risk, and to note which factors the respondents felt were the most important in determining the market outcomes that they expected.

METHOD

The Electric Power Research Institute (EPRI) project titled "Electric Vehicle Vision 2007" surveyed and interviewed experts in order to define integrated visions of the electric vehicle (EV) industry in the years 1997 to 2007. The focus of the project was to identify the most important strategic issues and stakeholders, and forecast likely outcomes for EVs so that the electric utility industry can better plan their investments and like their strategies to those of other stakeholders.

The survey resembled the first pass of a Delphi format, with no interchange between the respondents. The approach included a questionnaire and, for many of the respondents, an open-ended interview, either by telephone or in person. The respondent list included about 75 key stakeholders, of which about 40 responded, consisting of manufacturers of vehicles, batteries, and vehicle components, electric utility representatives, representatives of government agencies, trade organizations, researchers and academics.

EVALUATION REPORTED BY THE AUTHORS

The number of distinct, reasonably coherent but different visions for electric vehicles suggests a number of strategic issues, especially for recharging infrastructure, that possibly call for some further interactive work involving the various stakeholders. All the respondents foresee that the EV evolution will start in the 1997-2000 time frame with a small number of limited range vehicles. It seems likely that the industry can develop a robust strategy that starts with the objective of protecting and building a limited, but viable market similar to the vision of the Moderates, and then creating infrastructure development strategies that can support a broader market if vehicle costs can be decreased or range increased.

To allow battery vehicles to move from a Moderate vision to one of greater market share will require an evolutionary matching of recharging infrastructure to the capabilities of the vehicles and the needs of customers. Even within each group of respondents, there are ranges of opinion about what kind of infrastructure is needed, how much is needed, what locations are needed, and who can be expected to fund it and operate it. The EV community needs to work carefully and continually to develop the recharging infrastructure as evidence accumulates to guide choices.

To assist in this effort, it may be useful to develop low-cost methods to get information from the EV owners about their use of the vehicles and their evolving experience with recharging. Discussions appear to be needed to develop concepts of information development that may prove effective but can avoid compromising information of competitive value to the vehicle suppliers.

Additionally, hybrid electric vehicles appear to need further research, development, and demonstration. Some respondents believe that the battery EV is highly unlikely to be able to move outside of a small market share, but that hybrid EVs have a much better opportunity. However, there exists a range of opinion on the type of hybrid that most likely will penetrate the market. Certainly, the characteristics of the various types, such as grid-connected

versus non-grid connected, ought to be studied more carefully in terms of the benefits they provide to consumers and government agency programs.

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Nakicenovic, Nebojsa (International Institute for Applied Systems Analysis IIASA, Laxenburg, Austria). "The Automobile Road to Technological Change, Diffusion of the Automobile as a Process of Technological Substitution." Technological Forecasting and Social Change, Vol. 29, No. 4, p. 309-340, July 1986.

KEYWORDS

Forecasting, technological substitution model, diffusion.

ABSTRACT

Advancement of the motor vehicle and its production methods is analyzed as a process of technological change. In a broader context, motor vehicles evolved as an integral component of road transportation through a series of interlaced substitutions of old by new technologies. Building on a large number of studies that described technological substitution processes, first it is shown how new energy forms replaced their predecessors and how the old marine-transport technologies were substituted by new ones. These examples constitute some of the oldest, empirically documented technological changes and show that many events in the dynamics of energy substitution and marine transport are related to technological changes in road transportation. It is shown that these substitution processes can be described by simple rules and that the replacement of old by new technologies in the energy and transport systems lasted about 80 years. The technological changes within road transportation, however, were more rapid. Replacement of horses by automobiles and older by newer generations of motor vehicles and production methods lasted only a few decades in the Untied States. Thus, technological substitutions within the road-transportation system were considerably shorter than the expansion of railroads, surfaced roads, all road vehicles together, and the more recent expansion of air transportation.

METHOD

Analysis of the historical replacement of old by new technologies has shown that most of these processes can be described by simple rules that are captured in the logistic-substitution model. The evolution of motor vehicles during the last 100 years can also be seen as a series of interlaced technological changes of production methods and vehicles. These changes can be captured by logistic-substitution analysis and have occurred with a high degree of regularity. Substitution processes in terms of annual production of motor vehicles and equivalent processes at the level of the whole fleet are distinguished.

EVALUATION REPORTED BY THE AUTHOR

None.

REFERENCE

Nesbitt, Kevin and Daniel Sperling (University of California, Davis). "Myths Regarding Alternative Fuel Vehicle Demand by Light-Duty Vehicle Fleets." Transportation Research, Part D, Vol. 3, No. 4, p. 259-269, 1998.

KEYWORDS

Alternative fuel vehicles, fleet, alternative fuels, focus groups, interviews, surveys, incentives.

ABSTRACT

Public and private vehicle fleets have long been targeted as an ideal initial market for alternative fuel vehicles (AFVs). The authors examine seven widely accepted hypotheses regarding the potential fleet market for AFVs. The hypotheses are tested using data and information collected from focus group sessions, one-one-one interviews with fleet operators, and a large two-part survey administered to over 2700 California fleets, as well as secondary sources. They find a large number of misconceptions by both fleet operators and policymakers that lead to distorted expectations and ineffective policies regarding the purchase and use of AFVs by fleets.

METHOD

First the authors conducted 39 one-on-one interviews and seven focus groups with 59 individuals who played major roles in the fleet management and purchase decisions of their organizations. They were specifically recruited from a variety of organizations and management positions. The authors had hypothesized, and it was confirmed in the interviews and focus groups, that most previous AFV fleet market studies were flawed in assuming that the fleet manager alone would make all decisions pertaining to the acquisition of alternative fuel vehicles. Because of the importance of such purchase decisions, in terms of the number of people affected, the resources involved, and the precedents set, they found that several individuals from the same organization generally play substantive roles in the AFV purchase decision, especially in the initial purchase.

Building upon insights gained in the focus groups and interviews, the authors helped design a two-part survey comprised a computer-aided telephone interview (CATI) administered to 2715 organizations throughout California that operated at least 10 light-duty vehicles. Of these organizations, 2131 completed a follow-up questionnaire that included detailed questions regarding the purchase and use of alternative fuel vehicles. This equates to a response rate of 78%, which is extraordinarily high for mail surveys administered to fleets.

EVALUATION REPORTED BY THE AUTHORS

Available knowledge about vehicle fleets is insufficient for producing reliable estimates of the near-term AFV fleet market. Studies attempting to assess the potential fleet market for AFV's have focused on mapping AFV attributes to fleet travel demand and operating needs forecasting AFV market size based on regulatory requirements, and predicting AFV market penetration rates based on fleet purchase patterns and stated preferences. Although necessary and useful, these studies generally have many shortcomings, including incomplete sampling frames, low response rates, failure to identify decision makers, poor grasp of organizational decision making behavior, and poor understanding of purchase behavior of new products and attributes. Furthermore, they provide little insight regarding which fleets will actually purchase AFVs, under what conditions they will purchase AFVs, and for what reasons.

The findings reported here suggest the AFV regulations are difficult to implement largely because of the diverse nature of the fleets. The only commonality is that they operate vehicles: they do not make the same product, provide the same service, or even operate their vehicles in the same manner. As a result, proposed and adopted AFV implementation strategies may produce unexpected and, in some cases, undesired outcomes.

Given fleet diversity and a rather poor understanding of decision making, it seems desirable that public policy aimed at accelerating fleet adoption of AFVs should tilt more toward flexibility, market instruments, and assuring positive experiences. Where regulatory mandates apply, marketable credits might be seriously considered. A better

understanding of fleet behavior will go a long way in helping formulate more effective AFV implementation strategies.

REFERENCE

Nowlis, Stephen M. and Itamar Simonson. Preference Reversals Between Consumer Choices and Rating of Purchase Likelihood. Stanford University, Graduate School of Business, Washington University, Department of Marketing, Research Paper No. 1339, September 1995.

KEYWORDS

Preference reversals, choice, ratings, multi-attribute decision theory.

ABSTRACT

The authors propose that consumers' preferences for brands are systematically affected by whether they make direct choices between the brands or rate them separately in terms of purchase likelihood. Specifically, preference reversals are expected such that low quality, low price brands and low quality brands are preferred more in ratings. These predictions are derived from an analysis of the differences between choice and ratings and the compatibility between these tasks and the attributes of the considered options. Binary choice often involves within-attribute comparisons and across-attribute comparisons of intervals (e.g., whether the difference between a Sony TV and a Magnavox TV is worth $100), which is expected to enhance the importance of attributes that produce precise and unambiguous differences (e.g., price) relative to more complex, qualitative attributes that are more difficult to compare (e.g., brand names). In a ratings task, on the other hand, brand names may often serve as powerful cues, and the cost of a better brand name in terms of price and features is less salient and more difficult to detect. The predicted preference reversals were supported in six studies, which also examined several rival explanations. They discuss the theoretical implications of this research and explore its consequences for the measurement of buyers' preferences and for marketers' pricing, merchandising, distribution, and communications strategies.

METHOD

The authors begin with a review of prior research regarding preference reversals, and in particular, reversals between ratings and choice. They then present the analysis that leads to the prediction of preference reversals between choice and ratings with respect to options that differ in terms of brand quality and price, and explore two alternative explanations. Next, the proposition regarding preference reversals is extended to alternatives that differ in terms of brand name and product features, and this prediction as well as another alternative explanation are examined. This is followed by a further test of their account for the preference reversals. Then the authors use think-aloud protocols to gain insights into the differences between choice and ratings in terms of the processing of brand names, prices, and features. Next they explore the impact of manipulating attribute knowledge on the observed preference reversals. Finally, they test an important implication of the proposed preference reversals, which suggests that purchase likelihood ratings are less sensitive than choices to the magnitude of price and feature differences between the considered options. The theoretical and practical implications of the findings are discussed.

EVALUATION REPORTED BY THE AUTHORS

The authors begin with a review of prior research regarding preference reversals, and in particular, reversals between ratings and choice. They then present the analysis that leads to the prediction of preference reversals between choice and ratings with respect to options that differ in terms of brand quality and price, and explore two alternative explanations. Next, the proposition regarding preference reversals is extended to alternatives that differ in terms of brand name and product features, and this prediction as well as another alternative explanation are examined. This is followed by a further test of their account for the preference reversals. Then the authors use think-aloud protocols to gain insights into the differences between choice and ratings in terms of the processing of brand names, prices, and features. Next they explore the impact of manipulating attribute knowledge on the observed preference reversals. Finally, they test an important implication of the proposed preference reversals, which suggests that purchase likelihood ratings are less sensitive than choices to the magnitude of price and feature differences between the considered options. The theoretical and practical implications of the findings are discussed.

REFERENCE

Pohl, H. (Sydkraft Konsult AB, Malmö, Sweden). Company Vehicles – A Market Study. http://www.evs.org/evs14.

KEYWORDS

Electric vehicle, questionnaire, fleet, random sample, test vehicle, vehicle-owning companies.

ABSTRACT

This study was conducted during 1996 and 1997, in order to better understand the electric vehicle (EV) market in Malmö, Sweden. First, the driving pattern of one day for a large number of light company vehicles was investigated. This study resulted in a number of companies having vehicles that were not exceeding the range of a Renault/Peugeot in electric version. These companies were then given an EV offer in the second part of the study. A three-year full service-leasing contract for an EV at the same price as a conventional vehicle was offered to them. Only a few companies contracted an EV, and the reasons were investigated through interviews.

One conclusion of these studies is that limited range is not the only obstacle when marketing EVs to companies, other questions like "Who is the buyer?" are also very important.

METHOD

Theoretical Study. An enquiry was sent to 2002 vehicle owners, randomly selected from complete list of vehicle-owning companies in Malmö. In the enquiry, the primary driver defined his working day completely regarding where and when he drove, distances covered, number of passengers and weight of load.

The reference vehicle used was the Renault Express Electrique, with an assumed range per charge of 65 km in city traffic and eight hours for a complete recharge.

Among the vehicles having performed any work during the selected day, almost four out of five could have been replaced by electric vehicles. Considering the total number of company vehicles in Malmö, the result from the theoretical study is that at least 1600 private cars and 1550 pick-ups could be replaced by EVs having performance data similar to the Renault Express.

Kilometers traveled for business during the studied week was more than 25000 km for the vehicles in the study. Half of the work (46%) could have been made by electric vehicles according to this study.

Applied Study. An invitation was sent to all these companies having vehicles which, according to the theoretical study, could be exchanged by electric one. This letter informed about EVs and the offer from the project and invited them to a lunch meeting. During this meeting they would have a further information and possibilities to drive an EV themselves. The offer to them was a three-year full service-leasing contract for a Peugeot 106 or a Renault Express. The price for this was comparable to, or slightly higher than, what an equivalent gas driven vehicle would cost.

These meetings were held three times with totally 60 persons from 35 companies. In addition almost all other companies were contracted by phone to get their point of view regarding the offer.

The findings of applied and theoretical studies were compared. According to the theoretical study, a high percentage of the companies were able to use an EV. In the following applied study, the author realized that only very few actually wanted to substitute one conventional vehicle by an EV. Reasons for this included:

- Only one working day was considered in the theoretical study.
- The range is not the only important factor.
- New technology is not adopted directly by everybody.

EVALUATION REPORTED BY THE AUTHOR

The results of the applied and theoretical studies were very different. Of the companies able to use the EV, only a few chose to do so.

REFERENCE

Pringle, Lewis G., R. Dale Wilson, and Edward I. Brody (BBDO, Inc., New York, NY). "News: A Decision-Oriented Model for New Product Analysis and Forecasting." Marketing Science, Vol. 1, No. 1, p.1-29, Winter 1982.

KEYWORDS

New product demand, marketing theory, non-durable products, telephone survey, optimization.

ABSTRACT

Modeling efforts in the area of new product introductions have had a significant impact on marketing planning and strategy. One result of these efforts, BBDO's (Batten, Barton, Durstine & Osborn) *New Product Early Warning System* (NEWS), has been used since the late 1960's to provide marketing managers with forecasts and diagnostic information regarding their new product strategies. This article presents the specification of the NEWS model, its parameter estimation methods, and its validation. A brief case history is also included which illustrates how the model is applied in a typical new product situation.

NEWS is designed to use a variety of readily obtainable input data to generate forecasts of consumer awareness, trial, repeat purchase, usage, sales, and market share for a new brand. These outputs, combined with diagnostics from the model, can then be incorporated into the marketing plan in a way that will improve the new entry's chances of success in the marketplace. The model can be used to project early test market data (NEWS/Market); or it can be used to analyze pre-test market data (NEWS/Planner).

METHOD

The NEWS model is based upon a blend of marketing theory, consumer behavior constructs, empirical evidence, and intuition.

Since NEWS models the growth of consumers' awareness of a new brand in response to the marketing program, a high degree of initial awareness interferes with the modeling process. As a result, experience has shown that a total brand awareness of 25 percent of the target market *prior* to the beginning of advertising is an appropriate upper limit.

The NEWS model first identifies the target population and then posits that the key indicators of success or failure for a new product introduction are brand awareness, trial, and repeat purchase among consumers in that population.

NEWS is designed to model behavior at the aggregate consumer level. It projects the proportions of the target market that are expected to become aware of the brand, to have tried it, to have repeated their purchase, and to have become loyal users. The NEWS parameters are concerned primarily with estimating the rate of conversion (expressed as probabilities) of brand awareness to trial purchase, trial to repeat purchase, etc. The key variables in NEWS are behavioral in nature and are measurable through the use of consumer surveys or store audits.

Successful use of NEWS requires the accurate estimation of its inputs. Secondary source materials, prior and current custom marketing research, related product experiences, and informed judgment are all necessary. One of the objectives of NEWS is to use readily available research methods to aid in the estimation of parameters. A conceptual approach such as the Bayesian philosophy is adopted. Thus, NEWS takes advantage of the best available information prior to the introduction of the brand as a source of point estimates for behavioral probabilities. These initial estimates are then modified as further information becomes available. Several data sources are used in estimating the model.

EVALUATION REPORTED BY THE AUTHORS

Except in a few cases, NEWS has been able to accurately predict sales and /or market share based upon data from either pre-test market results or early test market results. The model also provides diagnostic information that can be used by marketing managers for the purpose of revising or fine-tuning their new Product introduction plans.

The major objective of new product models is to assist marketing management in deducing the substantial risks incurred when introducing a new produce. Since its development in the late 1960's, NEWS has proven to be a major contributor to this area of marketing.

REFERENCE

Roop, David W. (Virginia Power), Dean D. Taylor and William West (Southern California Edison). Key Role of States in the Electric Vehicle Market Launch. http://www.evs.org/evs14.

KEYWORDS

Electric vehicle, incentives, public policy incentives, regulations.

ABSTRACT

This paper outlines the critical role that communities and states play in creating a supportive market environment in which electric vehicle (EV) technology can be launched and then allowed to mature. About thirty different local and state approaches to supporting the market launch of EVs are highlighted – from the adoption of appropriate building codes and standards, to the deployment of changing infrastructure.

METHOD

The primary focus of the automotive and electric utility industry for the remainder of 1997 and the majority of 1998, as defined by the EV Market Launch Framework, will be on assuring that the rollout of EVs into the ten communities is sufficient to establish "critical mass" and that once established, the "critical mass" of vehicles is supported in a way that allows the market to grow. But, some of the goals of the Market Launch Framework for calendar year 1998, and the actions that will flow from those goals, set the stage for transition from an early market launch of limited product into limited areas to an expanded launch of more types and better EVs into a growing number of markets.

By December, 1997, the Electric Transportation Coalition plans to have assessed the level of "EV Readiness" of the ten market launch communities. The findings and conclusions, which will be developed with the cooperation and active participation of EV stakeholders in each of the communities will be presented at the national gathering of market launch community leaders.

Periodically throughout calendar year 1998, the Coalition will update and report to its Board, membership, and the ten market launch communities upon the success (or lack thereof) of the various areas in achieving the to-be-agreed-upon 1998 objectives. Such assessments will allow the community leaders and interested industry advocates to revise and amend activities to assure that, ultimately, the goals are achieved.

EVALUATION REPORTED BY THE AUTHORS

None.

REFERENCE

Ryans, Adrian B. (University of Western Ontario Canada). "Estimating Consumer Preferences for a New Durable Brand in an Established Product Class." Journal of Marketing Research, Vol. 11, No. 4, p. 434-443, November 1974.

KEYWORDS

Market research, regression analysis, durable goods.

ABSTRACT

Every year many marketing managers face the critically important but difficult task of estimating the demand for a new or modified product. The object of this study was to develop and test experimentally a relatively simple model to aid managers in this task. This model is designed to estimate the level of preference consumers will exhibit toward a differentiated brand at a given price in a multibrand durable good market.

METHOD

The model developed here draws heavily on the theory of consumer demand proposed by Lancaster. In contrast to the traditional economic theory of consumer demand, which treats the product themselves as the basic units of analysis, Lancaster's theory is based on viewing products as bundles of product characteristics.

The model assumes that a consumer making a durable good purchase purchases a brand and other goods and services that together maximize his total satisfaction while meeting his budget constraint.

In the experimental test, the focus was on the estimation of the preference that subjects will exhibit toward a new product at a given price in an existing durable good product class. Four randomly assigned groups of subjects were involved in the experiment. The subjects in one of these groups, the analysis group, provided data on their perceptions of the similarity of all possible pairs of 12 existing brands. These subjects also provided information on their relative preference for the different brands. Subjects were to assume (1) that they won an amount of money greater than the price of any of the brands, (2) that they had to purchase a brand, and (3) that they could retain any change from the transaction. Similar data were gathered from the other three groups, the validation groups, for the existing brands and one additional "new" product. The price of the "new" product was different in each of the three validation groups. Using the procedure outlined in the last section, the parameters of the model can be estimated for the individuals in the analysis group from the data, which they supplied. Utilizing these estimates and data on the perceived characteristics of the new product (determined from the similarity data gathered from the validation group subjects), predictions of how the analysis group subjects would have reacted to the "new" product at the three different prices can be made.

EVALUATION REPORTED BY THE AUTHOR

From a managerial viewpoint, the most meaningful test of the model is how well it performs relative to the predictions management might make using other models or methods. Unfortunately, the author has no such information here. In this study the model was developed and its predictive ability was tested in a laboratory setting for one durable good product class. Clearly this work needs to be replicated for other durable good product classes using larger sample sizes.

REFERENCE

Segal, Robin. "Forecasting the Market for Electric Vehicles in California Using Conjoint Analysis." The Energy Journal, Vol. 16, No. 3, 1995.

KEYWORDS

Electric vehicle, conjoint analysis, mail questionnaire, multi-attribute utility model, market simulations.

ABSTRACT

Beginning in 1998 a percentage of large auto companies' sales in California must include zero-emission vehicles (ZEVs), which at this time are synonymous with electric vehicles. Data on consumer values and the level of consumer acceptance for alternative fuel vehicles are necessary to determine the practicality of the state's policy. This paper presents the results of a forecast for alternative fuel vehicle purchases in California. This forecast uses conjoint analysis, a multi-attribute utility market forecast methodology developed within the field of marketing research. The forecast yields several types of results, including market simulations of the alternative fuel vehicle market, relative preferences among vehicle attributes, and the identification of market segments most likely to purchase each type of vehicle. The research suggests a market for electric vehicles too small to support California's ZEV sales mandate, and a very large market for natural gas vehicles. This paper concludes with a discussion of automobile and electric utility industry interests with regard to these forecast market consequences.

METHOD

Three major forecasting methods have been used in alternative fuel vehicle market forecasting: hedonic tradeoff analysis, economic tradeoff analysis, and market niche analysis. Conjoint analysis represents a new electric vehicle market forecasting methodology.

The data used in this study were acquired through a mailed questionnaire using metric conjoint analysis. Conjoint analysis decomposes rated descriptions of products differing along several attributes into separate and compatible utility scales by which the original global judgments can be reconstituted. Underlying the model used in this study is the assumption that individuals can evaluate multi-attribute product profiles on category rating scale, such that their judgements may be used to simulate choices in hypothetical choice exercises.

EVALUATION REPORTED BY THE AUTHOR

This alternative-fuel-vehicle conjoint analysis provides a framework for defining the appropriate pace of electric and natural gas vehicle technology development. The elements of the framework, namely the individual attribute marginal utilities, and the revealed product preferences within specific market segments may be useful data in the formation of achievable alternative fuel vehicle policy as well.

REFERENCE

Sperling, Daniel (University of California at Davis). "Gearing Up for Electric Cars." Issues in Science and Technology, Vol. XI, No. 2, p. 33-41, Winter 1994-95.

KEYWORDS

Electric cars, environmental concerns, incentives, PNGV.

ABSTRACT

This paper suggests a government policy toward electric cars. Over the past five years, electric vehicle (EV) technology has emerged as the most promising alternative to the internal combustion engine. A wave of innovation has begun to build momentum for the widespread commercialization of electric-drive vehicles. These will include not only battery-powered cars, whose ultimate role may be modest, but vehicles powered by electric fuel cells or by hybridized combinations of internal combustion engines (ICEs) and electric motors.

It is almost inevitable that EVs will eventually supplant most, if not all, conventional cars. The challenge for public policy is to guide this transition wisely. The barriers to a wholesale change in the nation's transportation system (not only economic and technical barriers, but also institutional and structural ones) remain high. Only strong government action can level the playing field to give EV technologies a chance. At the same time, public policy must be flexible enough to permit midcourse corrections and let the market, rather than the government, pick the winners.

The most compelling feature of electric-drive vehicles is that they emit no pollutants when driven. Electric-drive vehicles are also more energy efficient than conventional automobiles. Electric motors are about 90 percent efficient, compared to less than 25 percent for ICEs. In addition, these efficiency gains are partly offset by the low efficiencies of power plants. Oil refineries are about 90 percent efficient, compared to efficiencies of about 33 percent achieved by today's power plants fired with oil, natural gas, and coal.

A technological revolution—not only in electricity storage and conversion devices, but electronic controls, software, and materials—is quietly opening up many new opportunities for electric-drive vehicles.

Government policy has a tremendous role to play in paving the road for an electric transportation strategy. But the federal government has provided few regulatory and financial incentives to develop much cleaner and more efficient vehicles and has offered virtually no direct support for EVs.

The Partnership for a New Generation of Vehicles (PNGV) initiative, however, has a fundamental weakness: It is not linked to any regulatory incentives that encourage commercialization of the technologies developed. There is plenty of evidence to suggest that as more EVs are manufactured and sold to meet the requirements of the mandate, economies of scale will be realized, engineering and production processes will improve, and the vehicles will become cheaper. The stated purpose of the initiative is to advance technology to the point where government regulation is no longer necessary. The principal need over the next 10 to 15 years is not new science or new technology, but cheap technology. That is a challenge for engineering and manufacturing, not basic science.

The government should use mechanisms such as taxes, tax credits, fees, and marketable credits to complement technology initiatives aimed at reducing or eliminating emissions. Combining technology initiatives with incentives is not only effective, it is also politically more appealing.

EVALUATION REPORTED BY THE AUTHOR

None.

REFERENCE

Train, Kenneth (Cambridge Systematics, Inc.). "Consumers' Responses to Fuel-Efficient Vehicles: A Critical Review of Econometric Studies." Transportation, Vol. 8, p. 237-258, 1979.

KEYWORDS

Automobile demand, aggregate econometric studies, disaggregate econometric studies, hedonic price analyses.

ABSTRACT

The paper reviews previous economic research on automobile demand and examines what this research can tell us about how consumers will respond to fuel-efficient vehicles. Three categories of research are reviewed, namely aggregate econometric studies, disaggregate econometric studies, and hedonic price analyses. It is shown that insufficient variation and too large covariation among automobile characteristics (such as price, weight, and length) are problems which hinder the usefulness of each type of analysis. Two methods to alleviate these problems are proposed for future research.

METHOD

The author reviews and compares existing economic models. The fundamental problem encountered in all of the previous research was insufficient variation and too large covariation among automobile characteristics. If variation both across households and across automobile types were used, then there would be more usable information than in either the disaggregate or hedonic price approaches. One method for utilizing both sources of variation is an extension of the disaggregate models of automobile class choice. Instead of considering a small number of automobile classes as alternatives among which consumers choose, each make, model, and vintage of automobile can be considered an alternative.

However, these changes can bring about another problem. This property is called the *independence from irrelevant alternatives (iia) property,* which requires that the ratio of the probabilities of two alternatives is the same independent of the characteristics or availability of other alternatives. For a small number of fairly distinct alternatives, this property might hold, but for a large number of fairly similar alternatives (such as each make, mode, and vintage of automobile) the iia property is most certainly inaccurate.

A second approach which might be profitably applied is to use various experimental methods, such as conjoint analysis, to elicit consumers' values of various automobile characteristics. Responses of each consumer would then be used in disaggregate analysis the same as if the consumer actually faced a set of automobiles like those described to him and actually chose the automobile which he stated as his preferred one.

The limitation of this approach is that consumers might not be willing or able to state which automobile they would actually choose in the situation. However, the experimenter could construct his experiment such that there is sufficient variation across consumers in each automobile characteristic and that the variation for one characteristic is independent of that for other characteristics.

These two approaches do not solve other problems that were encountered in previous research. In particular, the problem remains that characteristics, which are easy to measure, are not necessarily those which consumers value. These problems are minor, however, compared to the lack of variation in automobile characteristics.

EVALUATION REPORTED BY THE AUTHOR

The greatest numbers of studies have only estimated an equation for the total number of new automobile purchases (or number of automobiles owned) and have ignored the consumer choice of class of automobile. It is significant, however, that none of these models includes automobile characteristics other than price. Consequently, these studies tell us nothing about consumers' responses to changes in automobiles' fuel economy, weight, horsepower, and so on. Only consumers'responses to changes in price can be determined from these models.

The primary limitation of the *aggregate* econometric models is that they do not include as explanatory variables the whole array of automobile characteristics, which affect consumers' choices of number and class of automobile to be owned. The omission of these variables was due to two problems with the data.
First, the automobile characteristics do not vary substantially over time or across regions. A second problem confronting the builders of aggregate models is that, over time, automobile characteristics tend to vary together. Weight and external dimensions tend to move in tandem, with both increasing or decreasing together. Similarly, horsepower and price tend to be correlated.

The fundamental problems with disaggregate analysis is the same as in aggregate analysis: most of the automobile characteristics do not vary over the population.

The major problem with the *hedonic* price approach is that the important characteristics of automobiles tend to be correlated over makes and models. Heavy automobiles are usually larger and have more horsepower than lighter automobiles. Similarly, horsepower and engine type are correlated since eight cylinder engines are more powerful than those with six cylinders.

REFERENCE

Train, Kenneth (University of California at Berkeley). "The Potential Market for Non-Gasoline-Powered Automobiles." Transportation Research, Vol. 14A, No. 5-6, October-December 1980.

KEYWORDS

Electric vehicle, hybrid vehicle, secondary-data collection, multinomial logit, consumer preference model, personal household, forecast.

ABSTRACT

This paper presents estimates of what the market share for several non-gasoline-powered automobiles would be in the years 2000 and 2025 if no large changes occur in fuel prices, taxes, consumers' attitudes or regulations affecting the automobile market. As such, the estimates serve as "base-case" forecasts from which changes in these factors can be analyzed. Several types of non-gasoline-powered automobiles are included in the analysis: battery-powered vehicles (both nickel-zinc and high-temperature batteries); a hybrid (with both a battery motor and a gas engine in one vehicle); a hydrogen vehicle (which ignites hydrogen instead of gas); and a vehicle which is powered by the reaction of aluminum into energy and oxidation products. Engineers at Lawrence Livermore Laboratory specified the probable characteristics of the vehicles, based on "most-likely" and "optimistic" outcomes of research and development. With these characteristics of the vehicles, based on "most likely" and "optimistic" outcomes of research and development. With these characteristics as input, a model of the type of automobile which households would choose to own was used to predict the share of the auto market which each of the vehicles would capture under the "base-case" assumptions. It was forecast the nickel-zinc battery vehicle would capture very little of the market, but that the market share for high-temperature-battery vehicles would be larger. Also, the hybrid and aluminum-reaction vehicles were forecast to capture a significant share, while the hydrogen-powered vehicle was not. The forecasts for the battery-operated vehicles were compared to those obtained by SRI and Mathtech, and it was found that, while SRI's forecast are close to those obtained herein, Mathtech's forecasts are much higher. Promising avenues for future research are discussed.

METHOD

The present paper examines several specific types of non-gasoline-powered automobiles. Estimates are presented of what the market share for these vehicles would be in the years 2000 and 2025 if (a) the vehicles are available in whatever quantities are demanded in those years, (b) consumers' valuations of automobile characteristic (e.g. operating costs) remain the same over time, (c) no major changes occur in the regulations and taxes affecting the automobile market, and (d) gas and electricity are available in sufficient quantities such that their real prices do not rise over time. As such, the estimates serve as "base-case" forecasts from which changes in prices, regulations, taxes, and consumers' attitudes can be analyzed.

Unfortunately, one of the most important characteristics of battery-operated vehicles — their limited range — is not included in the model. As a result, the model was modified to account, insofar as possible, for the range characteristics.

EVALUATION REPORTED BY THE AUTHOR

Several aspects of the forecasting methodology limit the accuracy of the forecast, and, consequently, warrant further research. Perhaps the most important area in which further research could fruitfully be applied is that of determining how best to account for the limited range of battery-powered vehicles.

A second issue concerns the specification of the Lave/Train model. According to this model, the weight of an auto is very important in determining the probability that the auto will be chosen. However, as discussed above, it is doubtful that weight in itself is the attribute which consumers value. Rather, consumers are probably interested in safety, solidity of ride, roominess and other characteristics which heavier autos usually afford. This issue can be resolved by estimating a model in which the characteristics that consumers actually value enter the model rather than proxies, such as weight.

A third area in which further research could provide useful information is the question of the extent to which households' choices for a first, second, and third auto are made simultaneously.

Lastly, the methodology could be improved by incorporating dynamic effects into the model. The representative utility of the currently owned auto should be increased by the amount of the transaction costs associated with trading the car.

REFERENCE

Train, Kenneth. Qualitative Choice Analysis: Theory, Econometrics, and an Application to Automobile Demand. Cambridge MA: MIT Press, 1986.

KEYWORDS

Demand, qualitative choice analysis, simulation, regression, econometrics.

ABSTRACT

This book addresses two significant research areas in an interdependent fashion. It is first of all a comprehensive but concise text that covers the widely applicable methods of qualitative choice analysis, illustrating the general theory through simulation models of automobile demand and use. It is also a detailed study of automobile demand and use, presenting forecasts based on these techniques.

METHOD

The book develops the general principles that underlie qualitative choice models that have been applied in numerous fields in addition to transportation, such as housing, labor, energy, communications, and criminology. The general form, derivation, and estimation of qualitative choice models are explained, and the major models — logit, probit, and GEV — are discussed in detail. Also, continuous/discrete models are introduced. In these, qualitative choice methods and standard regression techniques are combined to analyze situations that neither alone can accurately forecast.

EVALUATION REPORTED BY THE AUTHOR

Summarizing previous research on auto demand, the book shows how qualitative choice methods can be used by applying them to specific auto-related decisions as the aggregate of individuals' choices. The simulation model that is constructed is a significant improvement over older models, and should prove more useful to agencies and organizations requiring accurate forecasting of auto demand and use for planning and policy development. Fluctuations in energy prices (and policies), the domestic manufacturing situation and import restrictions, air pollution, and highway congestion are among the national background considerations and concerns, and the number, age, type, fuel efficiency, and accumulated mileage of automobiles owned by individual households are among the local-impact forecasts of the model.

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Turrentine, Thomas, Daniel Sperling, and Kenneth Kurani (University of California, Davis). Market Potential of Electric and Natural Gas Vehicles. Institute of Transportation Studies. Research Report UCD-ITS-RR-92-8, April 1992.

KEYWORDS

Multi attribute decision theory, utility theory, alternative fuel vehicles, surveys, vehicle field test, interview, mail survey, panel study.

ABSTRACT

Alternative fueled vehicles are being promoted in California, especially Southern California, as a solution to air quality problems. The Clean Air Act encourages the development of AFVs, including the sale of AFVs in California, but California has moved more decisively, mandating the sales of zero emissions vehicles (ZEVs) and adopting much more stringent vehicle emission standards. While rules require producers to supply alternative fuel vehicles, it is not yet certain how consumers will respond.

The authors objective is to improve the understanding of how consumers will respond in a cultural and historical context to the introduction of AFVs and to the technical attributes of AFVs, and thus to develop a credible survey instrument which can measure the current market for AFVs and suggest policy strategies to advance the market for AFVs.

METHOD

To achieve those objectives, the authors designed a set of research activities to give a complete look at the potential of AFVs. Year 1 research activities simulate market contexts to observe consumer decision making, and evaluate primary constraints on consumer choices. Year 2 and 3 projects are surveys that rely upon the first year for insight; they were to develop and implement a credible survey instrument for testing hypotheses across the entire California population. They were to identify policy instruments that would be most effective at increasing sales of vehicles and fuels, and estimate their market penetration under different conditions and in response to various policy initiatives. They focus on electric and natural gas vehicles (including hybrid configurations), but are including methanol as well.

This project includes ten linked research activities: 1) development of a theoretical framework of consumer choice behavior; 2) test drive and interviews at the Rose Bowl in June 1991: post test-drive focus groups in June 1991; 4) constraints analysis of potential EV owners; 5) survey of refueling and other behavior of current EV owners in California; 6) survey of owners of CNG home refueling units in Ontario, Canada; 7) surveys and interviews in New Zealand to learn from that country's 1980's experiment with CNG; 8) use of gaming techniques (PIREG) in interviews of households to determine their decision processes for purchasing and using limited range vehicles; 9) Mail surveys to extrapolate findings from previous activities to the entire California population; and 10) permanent panel studies in which individual and households are monitored and periodically interviewed over time.

EVALUATION REPORTED BY THE AUTHORS

The test-drive clinic was designed to probe a market in which several types of AFVs are being sold. The authors discovered that the majority of participants were convinced that AFVs are the solution to air quality problems in Los Angeles. In the initial report on the theory of AFV purchases, they hypothesize that once a majority of the population is convinced of the inevitability of a problem and know the solution, cooperative decisions and moral choice can become a part of the decision process. If they believe they have arrived at a historical juncture in which government and industry are committed to the solutions, consumers with adequate resources and knowledge will invest in what they believe is the future.

REFERENCE

Underwood, Steven E., Kan Chen, and Robert D. Ervin (University of Michigan). "Future of Intelligent Vehicle-Highway Systems: A Delphi Forecast of Markets and Sociotechnological Determinants." Transportation Research Record No. 1305, p. 291-303, 1991.

KEYWORDS

Intelligent vehicle highway systems, Delphi forecast.

METHOD

The principal purpose of this study was to explore the future development and market penetration of selected Intelligent Vehicle-Highway Systems (IVHS) categories in light of an optimistic scenario for government support. The research would address the timing of research, system introduction, and levels of market penetration for 10 systems categories: automatic tolls and road pricing, automatic vehicle location, automatic vehicle navigation, motorist information, cooperative route guidance, collision warning, collision avoidance, speed and headway keeping, automated highway, and automated guideway.

Finally, the social and technological impacts of the systems were to be assessed; and the benefits associated with each system category were especially to be delineated.

The essential features of the Delphi are (a) remote and explicit communication, (b) statistical summary of group responses, (c) iteration and controlled feedback, and (d) anonymity among the participants. Sponsors of the project included the big three U.S. automotive companies, their electronic component suppliers, telecommunications companies, state and federal transportation agencies, and representatives of transportation user groups.

Specifically, the Delphi panelists were asked to delineate what they viewed as (a) the driving forces for implementation, (b) the barriers to market penetration, (c) constructive government policy initiatives, and (d) the expected sociotechnical impacts from adoption of the systems.

Findings of the study include the following:

Barriers to Implementation. The principal barriers to implementation of IVHS were social, economic, and institutional. Only system reliability and human factors could be considered technical. The crosscutting barriers to implementation are listed in order of importance as ranked by the panelists:

1. Cost to the consumer;
2. Reliability;
3. Lack of demand;
4. Government and manufacturer liability;
5. System effectiveness.

Driving Forces. What will lead society to adopt these new systems?

1. Increasing traffic congestion,
2. Desire for improved safety,
3. Motorists' desire for comfort and convenience,
4. Public's demand for travel information,
5. Declining technology and operating costs.

Government Policy. How will the federal, state, and local governments be able to assist in the development and implementation of IVHS?

1. Limit the liability borne by manufacturers and government,
2. Establish effective standards,
3. Federal funding or incentives for research and development.

Social Impacts. The list of social impacts is similar to the list of driving forces, except that it also includes several negative outcomes.

1. Reduced congestion,
2. Improved safety,
3. Increased comfort and convenience for motorists,
4. Driver acceptance of automated control,
5. Increased automobile commuting, and
6. Smoother flow of traffic.

The survey indicates that the turbulent institutional environment has the potential to slow, or even halt, the progress toward a comprehensive IHVS capability in the United States. In fact, the most likely and consequential near-term barriers to development and implementation of IVHS are the possible lack of consumer demand for and acceptance of these new transportation alternatives and the failure of our institutions to support the cooperative development of IVHS. Thus, the successful implementation of IVHS in North America will require a concerted effort on the part of the participating manufacturers, government agencies, and other interest groups to cooperate in resolving the issues of liability, standards, and support for research, development, and demonstrations. Cooperation among the key participants will need to continue through implementation and operation of many of the systems presented because both the vehicle and the highway elements will be fused into a unified whole. Existing institutional arrangements are unlikely to provide adequate support for these efforts, and institutional innovation must be sought. The unconventional nature of the institutional problems posed by IVHS limits the ability to predict relevant social, political, and economic events with any degree of certainty.

EVALUATION REPORTED BY THE AUTHORS

None.

REFERENCE

U.S. Department of Energy, Office of Transportation Technologies, Encouraging the Purchase and Use of Electric Motor Vehicles. Washington, DC, July 1995.

KEYWORDS

Economic incentives, electric vehicles, secondary data collection, cost analysis, incentive analysis, policy analysis, personal.

ABSTRACT

This report was prepared in response to section 615(b) of the Energy Policy Act of 1992, which requested a study of methods for encouraging the purchase and use of electric vehicles. Specific objectives of the study are to:

- Assess the potential cost of purchasing and maintaining electric vehicles, including the initial cost of the batteries and the cost of replacement batteries;
- Identify methods for reducing, subsidizing, or sharing such costs; and
- Develop recommendations for legislative and administrative measures to encourage the purchase and use of electric vehicles.

METHOD

The methodology used for this electric vehicle study included performing cost analysis, incentive analysis, and policy analysis. As part of the cost and incentive analysis, two cities were the focus of this study: Los Angeles and Washington, DC. Both cities were chosen for being in nonattainment of national ambient air quality standards, but the cities have some dissimilar situations. The Los Angeles area has the worst pollution problems in the country due to several factors, including urban sprawl, long commutes, extensive freeways, traffic congestion, limited mass transit, and unusual meteorological and geological conditions.

Costs to purchase and use electric vehicles and spark ignition vehicles were estimated using life cycle cost analysis and the net present value function. The life cycle cost analysis compares an electric vehicle minivan with a similar spark ignition vehicle minivan. This life cycle cost analysis provides a means for comparing the overall costs of purchasing and using electric vehicles with those of spark ignition vehicles.

Net present value, the cost function that is most commonly applied in life cycle cost analyses, is used in this study to provide a single measure by which electric vehicles and spark ignition vehicles can ultimately be compared for the same year. In the life cycle cost analysis, net present value cost estimates are provided both in1994 dollars and in dollars of the year of purchase (either 1998 or 2005).

Current cost data for electric vehicles and spark ignition vehicles are projected from 1994 to the assumed vehicle purchase years of 1998 and 2005. Using the study assumptions, a computer model applies a constant inflation rate and a net present value discount rate to a stream of annual cash outlays for each vehicle.

It was found that:

- Current electric vehicle purchase costs present a barrier to consumers, but projected purchase costs for the electric vehicles in this study could be competitive with spark ignition vehicles by 2005.
- Electric vehicle recurring costs will be competitive with spark ignition vehicles in Washington, DC in 1998 but will remain higher in Los Angeles, California even in 2005.
- The projected life cycle cost of the electric vehicle is projected to be at most 33 percent higher than that of the spark ignition vehicle in 1998, and 13 percent higher in 2005.
- The control-cost-based value of emissions is lower for the electric vehicle than for the spark ignition vehicle in 1998 and 2005.

- Current federal and state incentives reduce the initial purchase cost of an electric vehicle by 9 to 11 percent in some states, but many of the incentives are near-term only.
- Some electric utility companies are offering discounts for electric vehicle recharging that will reduce operating costs.

EVALUATION REPORTED BY THE AUTHOR

None.

REFERENCE

U. S. Department of Transportation , John A. Volpe National Transportation Systems Center. An Update of the Commercial ATIS Market, Cambridge, Massachusetts, March 7, 1996.

KEYWORDS

Intelligent transportation systems, demand, market research, overview.

ABSTRACT

This draft paper is the first installment updating the Volpe Center paper, *A Market Analysis of the Commercial Traffic Information Business* (March 1994). This snapshot is comprised of a narrative analysis and matrix describing consumer Automated Traffic Information System (ATIS) products available for purchase today.

METHOD

An established market can be examined from the perspective of consumers, through survey research. Where the market is just emerging and there are few products available to consumers, assessment of market response may be based on an analysis of industry behavior. While it is very unusual for industry to speak openly and honestly about consumers' response to their products, it is possible to discern some patterns through a historic review of industry and analysts statements, review of preliminary products' market positioning, and through survey of retail outlets.

As traveler information system concepts were developing in 1991-2, several truisms were frequently repeated: the price for any new in-vehicle ATIS product would need to be below that of an air conditioner, in-vehicle ATIS products will not debut as OEM equipment, and as a communications application outside of the car, traffic information would be combined with other services on a multi-purpose platform to be saleable. Current market observations support these early assertions.

EVALUATION REPORTED BY THE AUTHORS

In the absence of direct survey and sales data, it is impossible to describe ATIS consumers with any precision or reliability. What data exist are contained within some of the field test evaluations, but even this data have limited applicability. Where ATIS products are available for sale on the market, one can assume that the manufacturer is basing marketing, advertising, and retail channel choices on marketing research, and thus, infer certain consumer features from this evidence.

REFERENCE

Urban, Glen L., John R. Hauser (Massachusetts Institute of Technology), and John H. Roberts (University of South Wales, New South Wales, Australia). "Prelaunch Forecasting of New Automobiles." Management Science, Vol. 36, No. 4, April 1990.

KEYWORDS

Electric vehicle, product clinic.

ABSTRACT

The authors illustrate how a firm can face the challenge of forecasting consumer reaction for a "really-new" product. For the case of an electric vehicle, the authors describe how one firm combines managerial judgment and state-of-the-art market measurement to determine whether (1) the really-new product would be a viable business venture at its target launch date, (2) the firm should plan for improvements in technology that would reduce price and / or increase benefits enough so that the business venture would be profitable, or (3) the firm should stop development. The new market measurement system combines existing methods with a multimedia virtual-buying environment that conditions respondents for future situations, simulates user experience, and encourages consumers to actively search for information on the product. The authors comment on the advantages and disadvantages of the methodology and summarize the lessons they have learned from this application.

METHOD

To address these questions, the project sponsor, General Motors Corporation (GM), chose to combine existing forecasting methods (i.e., concept evaluation, decision-flow models, prelaunch forecasting models, and conjoint analysis) with the new information acceleration (IA) method. The basic idea behind IA is to place the consumers in a virtual buying environment that simulates the information that is available to the consumer at the time he or she makes a purchase decision.

Future conditioning, full information, user experience, user control, and active search constitute the core of IA. After the authors put respondents in the virtual future buying environment, measures were taken of their likelihood of purchase, their perceptions, and their preferences. These measures were taken after each major information exposure and then integrated in a model to predict the growth of sales of the new product on the basis of assumptions about the changes in the environment, the managerial introduction plan, and the projected competition.

EVALUATION REPORTED BY THE AUTHORS

In the EV application, the two IA studies provided valuable data on which to base managerial decisions, but these studies were not without weaknesses.

Cost. As it was implemented in the EV study, IA is expensive.

Managerial judgement. The EV forecast depends on the measures taken in the IA (judged purchase probabilities, word-of-mouth, and dealer-visit-probability), measures available from other market research data (EV consideration and target market size), and measures of competitive and product-line preference. But the forecast also depends on managerial judgements.

Order of entry. The sales of the Impact (a GM electric vehicle) depend on whether it is the first EV on the market. In the IA, the authors measured how forecasts change if there are two vehicles on the market. However, they could not simulate order-of-entry effects that might result.

REFERENCE

Urban, Glen L. (Massachusetts Institute of Technology), John S. Hulland (University of Western Ontario), and Bruce D. Weinberg (Boston University). "Premarket Forecasting for New Consumer Durable Goods: Modeling Categorization, Elimination, and Consideration Phenomena." Journal of Marketing, Vol. 57, No. 2, April 1993.

KEYWORDS

New product forecasting, automobiles product clinic.

ABSTRACT

The authors extend previous models for premarket forecasting of new durable consumer goods by including parameters that reflect consumers' categorization and consideration processes.

They propose a model and measurement methodology, which they apply to the premarket forecasting of a new automobile. They describe empirical data collection, parameter estimation, managerial implications, validation issues, and future research needs. The extended model generates new managerial insights into positioning and marketing planning effectiveness, can be used to simulate the effects of changes in positioning strategy on consideration and choice, and provides more detailed information about why consumers consider or reject a new brand. The relevance of the categorization extension for other new product models that condition choice on a consideration set is also explored.

METHOD

The objective is to extend aggregate new product forecasting models to include the important behavioral phenomena of categorization and consideration. The authors describe their modeling extension in the context of a specific durable goods new product-forecasting model developed by Urban, Hauser, and Roberts. They developed a model, measurement, and estimation methodology and then applied it empirically in the context of a new-car launch.

The new auto-forecasting model developed by Urban, Hauser, and Roberts is based on the durable goods model of Roberts and Urban. Customers are defined as being in decision process states, and they flow from one state to another as a result of their search for information and marketers' actions. Customers move from being unaware to being aware of advertising for the new model at some rate per month dependent on advertising expenditures.

Extending the model to include consideration is conceptually simple. New states representing separate categories of brand alternatives and parameters defining the fraction of brands considered in each category are added. In each application, the number of categories and their brand compositions must be determined empirically. Each consumer included in the model estimation process is assigned to one category. The model then keeps track of the proportion of individuals in a category who are in the market at the present time and the proportion who visit a dealership to see the new product. As a result, there is a one-to-one correspondence between the category, in the market, and dealer visit states.

Individual-level measures of perceived similarity and consideration are used to estimate aggregate categorization, elimination, and consideration phenomena. This information is then used to determine the new product's perceived positioning and to develop a sales forecast. By incorporating consumers' responses in the clinic setting to alternate positioning strategies (as translated into actual marketing communications), the extended model can be used to simulate the effects of these alternate strategies on consumers' brand perceptions and expected sales volume. Finally, the model should be validated by comparing its sales forecasts with actual sales.

EVALUATION REPORTED BY THE AUTORHS

The submodel and measurement methodology for understanding the consumer decision steps of categorization, elimination, and consideration is described here in the context of a specific durable goods new product model, but it can be used or adapted whenever a model is conditioned on evoking or specific brand awareness.

REFERENCE

Urban, Glen L. (Massachusetts Institute of Technology), Bruce D.Weinberg (Boston University), and John R. Hauser (Massachusetts Institute of Technology). " Premarket Forecasting of Really-New Products." Journal of Marketing, Vol. 60, p. 47-60, January 1996.

KEYWORDS

New product forecasting, automobiles product clinic.

ABSTRACT

The authors extend previous models for premarket forecasting of new durable consumer goods by including parameters that reflect consumers' categorization and consideration processes.

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EVALUATION REPORTED BY THE AUTHORS

The submodel and measurement methodology for understanding the consumer decision steps of categorization, elimination, and consideration is described here in the context of a specific durable goods new product model, but it can be used or adapted whenever a model is conditioned on evoking or specific brand awareness.

REFERENCE

Vyas, Anant D., Henry K. Ng, Danilo J. Santini, and John L. Anderson (Argonne National Laboratory). "Batteries for Electric Drive Vehicles: Evaluation of Future Characteristics and Costs Through a Delphi Study." Conference paper, SAE International Spring Fuels and Lubricants Meeting, Detroit, Michigan, May 5-7, 1997.

KEYWORDS

Electric vehicle, hybrid electric vehicle, Delphi, survey data.

ABSTRACT

Uncertainty about future costs and operating attributes of electric-drive vehicles (EVs and HEVs) has contributed to considerable debate regarding the market viability of such vehicles. One way to deal with such uncertainty, common to most emerging technologies, is to pool the judgments of experts in the field. Data from a two-stage Delphi study are used to project the future costs and operating characteristics of electric-drive vehicles. The experts projected basic vehicle characteristics for EVs and HEVs for the period 2000-2020. They projected the mean EV range at 179 km in 2000, 270 km in 2010,and 358 km in 2020. The mean HEV range on battery power was projected as 145 km in 2000, 212 km in 2010, and 244 km in 2020. Experts' opinions on 10 battery technologies are analyzed, and characteristics of initial battery packs for the mean power requirements are presented. A procedure to compute the cost of replacement battery packs is described, and the resulting replacement costs are presented. Projected vehicle purchase prices and fuel and maintenance costs are also presented. The vehicle purchase price and curb weight predictions would be difficult to achieve with the mean battery characteristics. With the battery replacement costs added to the fuel and maintenance costs, the conventional ICE vehicle is projected to have a clear advantage over electric drive vehicles through the projection period.

METHOD

In order to obtain a better understanding of the state of both EV and HEV technologies, the Office of Transportation Technologies (OTT) of the U. S. Department of Energy sponsored a two-stage Delphi study. The goal of the study was to collect information on vehicle attributes and components, evaluate their performance, and assess their market-penetration potential. The first step was to survey the experts in the field and solicit their opinions. The results of the study will help decision-makers to properly orient their research and development efforts. The survey was designed to collect information for the years 2000, 2010, and 2020. The questionnaire contained sections on vehicle, components, and system impacts. Each section contained questions seeking opinions on critical characteristics of EVs and HEVs. Some questions within the vehicles section sought experts' opinions on such vehicle attributes as range, acceleration, highest acceptable uphill grade, seating capacity, cargo capacity, curb weight, power, battery recharging time, and maintenance interval. For the HEV, an additional question was asked concerning the engine range. The authors computed the implied battery-only range by subtracting engine range from the total HEV range. Experts also provided opinions on EV and HEV price, fuel and maintenance cost, and fuel economy. Within the component section of the questionnaire, they responded to questions about 10 battery technologies. The authors analyzed the responses to all these questions to arrive at two separate estimates of EV and HEV characteristics, primary (i.e., resulting from respondents' vehicle opinions) and secondary (i.e., resulting from respondents' battery opinions).

For most of the analysis presented here, the authors used mean values of the responses. They listed several other values, such as number of valid responses, median, and mode, whenever they summarized the responses in a table. They also present *optimistic* and *pessimistic* values for the basic vehicle characteristics. These values represent means of the responses either below or at the median point or above the median point (i.e., the responses are split into two groups at the median point). A group's *optimistic/pessimistic* identity is dependent on the attribute. For example, because longer range and lower vehicle curb weight are desirable, the *optimistic* group for range will be above the median and the *optimistic* group for curb weight will be at and below the median. A good measure of the level of agreement among the respondents is the interquartile range. A narrower interquartile range represents a higher degree of agreement. The authors also present these statistics for the data summarized in tables.

Information regarding study methodology and questionnaire development has been published earlier [Ng, Anderson, and Santini, 1995; Ng et al., 1996] In all, 93 valid second-stage responses were available for analysis. Industry was the largest responding group, providing 47% of the responses. Within the industry group, original equipment manufacturers provided nearly half the responses (23% of the total). Private research organizations and potential component suppliers provided 29% of the responses, and government and academic institutions provided the remainder.

EVALUATION REPORTED BY THE AUTHORS

None.

REFERENCE

Walls, Margaret A. (Victoria University of Wellington). "Valuing the Characteristics of Natural Gas Vehicles: An Implicit Markets Approach." The Review of Economics and Statistics, Vol. LXXVIII, No. 2, pp. 266-276, May 1996.

KEYWORDS

Government mandates, natural gas substitution, consumer surplus, public policy, environmental benefits, hedonic price function.

ABSTRACT

This paper estimates the costs of a government mandate to use natural gas vehicles, focusing on the less desirable attributes that these vehicles possess. A model of producer and consumer behavior in a market for a differentiated product is constructed; a hedonic price function is estimated; and consumer surplus losses from the substitution of natural gas cars for gasoline cars are calculated. These losses are found to be significant: the average per car consumer surplus loss ranges from $1100 to $3200, with 20% to nearly 50% of the loss due to changes in vehicle characteristics. The costs of such a policy appear to be greater than the environmental benefits, but may not be too far out of line with the costs of alternative approaches for reducing vehicular pollution.

METHOD

The author describes a Lancasterian model of product differentiation where consumers get utility from the characteristics of a good — in this case, cars. They choose the amounts of these characteristics to consume so as to maximize utility subject to a fixed budget constraint, taking the "prices" of those characteristics and all other goods as given. The basic model is modified to allow consumers to jointly optimize over leisure time and miles traveled. Consumers then face a second constraint: the number of hours spent in labor, leisure, and refueling their vehicles cannot exceed the total number of hours available in a specified time frame, such as a year.

Perfectly competitive producers are assumed to choose the product characteristics and the number of products to produce so as to maximize profits, taking all factor and output prices, as well as the characteristics "prices", as given. An equilibrium bundle of characteristics is reached through this process, as well as an equilibrium quantity and price of products sold.

EVALUATION REPORTED BY THE AUTHOR

Vehicles that run on fuels other than gasoline may look and drive quite a bit differently from gasoline vehicles. Compressed natural gas vehicles are substantially heavier than gasoline vehicles and thus accelerate more slowly. In addition, their large fuel storage tanks often take up valuable cargo space, and they have lower driving ranges than gasoline-powered vehicles. Until now, no study has attempted to quantify these costs. This study does so by developing a model of consumer and producer behavior in a market for a differentiated product; estimating a hedonic price function; and using the results in combination with information about natural gas vehicle characteristics to calculate consumer surplus losses from natural gas vehicles.

The results indicate that consumer surplus losses are on the order of $1100 to $3200 per car. These losses arise because cars are more expensive — $600 to $2500 more than gasoline cars — and because consumers' utility is reduced by having to drive cars with less than optimal sets of characteristics. Because of the lack of cost and other information about natural gas vehicles, it was necessary to make some "educated guesses" about what those vehicles will look like and what costs will be. And, finally, it would be preferable to look at a more realistic partial penetration scenario, rather than a scenario where all gasoline cars are replaced with CNG cars.

The results of this paper do suggest that considering the full costs of regulation is important. When products are valued for the characteristics embodied in them, and regulation induces changes in those characteristics, consumers experience losses above and beyond the higher product prices.

REFERENCE

Weiss, Joel A. and Bruce C. Dale (Lockheed Martin Corporation). "Diffusing Against Mature Technology: Issues and Strategy." Industrial Marketing Management, Vol. 7, No. 4, July 1998.

KEYWORDS

Diffusion of innovations, consumer acceptance, demand, solar power.

ABSTRACT

The classic attributes of diffusion identified by Everett M. Rogers—relative advantage, compatibility, complexity, trialability, and observability—are a good basis for evaluating the diffusion prospects of a new technology qualitatively. This process may be simplified by evaluating just two primary factors, the relative performance advantage and the degree of operational novelty introduced by the new technology relative to its antecedent. The authors introduce the concept of operational novelty as a contraction of the innovation attributes of complexity and compatibility. Challenging a mature, established technology with a product based on new technology is risky, although the risk can be moderated by high performance advantage and low operational novelty. A product's performance advantages and operational novelties should be evaluated and compared before a strategy for market introduction is planned. An oblique rather than direct challenge to the established technology may be advised when performance advantage is marginal or operational novelty is high.

METHOD

The objective of the paper was to present a framework for evaluating the prospects for success of new products using Rogers' attributes.

Rogers identifies five attributes of innovation that affect the rate of adoption:

1. *Relative advantage:* the degree to which an innovation is perceived as being better than the idea or product it supercedes.
2. *Compatibility:* the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters.
3. *Complexity:* the degree to which an innovation is perceived as relatively difficult to understand and use.
4. *Trialability:* the degree to which an innovation may be experimented with on a limited basis.
5. *Observability:* the degree to which the results of an innovation are visible to others.

The authors examine Rogers' attributes to new product success in detail, and in relation to each other. Tradeoffs between the attributes are examined with respect to the potential of a new technology to displace or compete profitably against an established technology. Performance advantage and operational novelty are the primary attributes examined. Specific examples of solar power adoption are examined at the household and firm levels.

Challenging an established technology with a product based on a new and unfamiliar technology is difficult under the best conditions. Entrepreneurs should objectively analyze the relative performance advantages and operational novelties introduced by their product and evaluate the likely success of a direct challenge.

A more effective strategy for many products may be to challenge the incumbent technology obliquely by first establishing market acceptance in an area that has been overlooked by the dominant technology or in an emerging market need that has not yet been colonized by any single technology.

Superior technology is no guarantee of market success. Acceptance must be cultivated through establishing a customer experience base and generating familiarity and trust with the technology over a period of time. Once a new technology has established a base of acceptance, it may then be realistic to mount a direct challenge to the traditional technology in its area of dominance.

EVALUATION REPORTED BY THE AUTHORS

None.

REFERENCE

Wilton, Peter C. (University of California, Berkeley) and Edgar A. Pessemier (Purdue University). "Forecasting the Ultimate Acceptance of an Innovation: The Effects of Information." The Journal of Consumer Research, Vol. 8, No. 2, September 1981.

KEYWORDS

Electric vehicle, new product forecasting, product clinic.

ABSTRACT

Limited knowledge and purchase readiness seriously hamper attempts to predict the adoption of innovative products and the early sales of new, infrequently purchased products. Test results for electric vehicles indicate that the methods employed in this study can overcome these knowledge and readiness deficiencies.

Four basic tasks must be completed to produce an early forecast of the rate and extent of adoption: measure the current state of knowledge about the innovative new product, service, or social arrangement; artificially advance knowledge to the state normally encountered prior to an adoption decision; measure the probability of adoption by individuals whose knowledge is equivalent to what it would be at the time of making an adoption decision; predict the purchase choices of these individuals and validate against external data, where available.

METHOD

To monitor the maturation of perceptions and preferences for potential purchasers of subcompact electric vehicles, an experiment was designed in which subjects were exposed to information stimuli containing *objective* (nonevaluative) information designed to alter individual perceptual structures for the set of alternatives. Data were collected from eight groups of subjects in a 4 x 2 factorial experiment with repeated measures on individuals (pre- and postexposure to a unique information treatment). Two groups acted solely as controls and received no information about the objects. The remaining six groups each received information about the objects via a unique (i.e., cell-specific) audio-visual stimulus presented through local area cable television networks at prespecified dates and times.

EVALUATION REPORTED BY THE AUTHORS

While these results indicate that *stated* choices of individuals for an innovation can be reasonably predicted on the basis of modified perceptual and effective judgements, their validity as estimates of *actual* market behavior remains untested. As with most new products unsupported by test marketing or actual sales performance data, stated purchase intentions for the electric vehicle may provide a useful criterion for predictive validity.

Furthermore, this method of analysis appears to be an efficient approach to predicting the level of acceptance for innovative new products.

REFERENCE

Xie, Jinhong (University of Florida), X. Michael Song (Michigan State University), Marvin Sirbu and Qiong Wang (Carnegie Mellon University). "Kalman Filter Estimation of New Product Diffusion Models." Journal of Marketing Research. Vol. XXXIV, p. 378-393, August 1997.

KEYWORDS

Diffusion model, empirical evaluation, Kalman filter, Bayesian updating procedure.

ABSTRACT

The authors introduce a new estimation procedure, Augmented Kalman Filter with Continuous State and Discrete Observations (AFK(C-D)), for estimating diffusion models. This method is directly applicable to differential diffusion models without imposing constraints on the model structure or the nature of the unknown parameters. It provides a systematic way to incorporate prior knowledge about the likely values of unknown parameters and updates the estimates when new data become available. The authors compare AKF (C-D) empirically with five other estimation procedures, demonstrating AKF (C-D)'s superior prediction performance. As an extension to the basic AKF (C-D) approach, they also develop a parallel-filters procedure for estimating diffusion models when there is uncertainty about diffusion model structure or prior distributions of the unknown parameters.

METHOD

To overcome the preceding limitations of the standard Kalman filter and to make better use of the Kalman filter technique, the authors introduced an AKF (C-D) by combining two ideas recently developed in the engineering literature: (1) the Extended Kalman Filter with continuous state and discrete observations, which uses discrete observations to estimate the state of a continuous system with *known* parameters, and (2) the Augmented Filter for parameter estimation , which estimates unknown parameters in a *continuous* Kalman filter model. The AKF (C-D) model formulation for diffusion models is as follows:

(7) $$\frac{dn}{dt} = f_n\,[n(t),\ \boldsymbol{u}(t), \boldsymbol{\beta}, t] = w_n$$

(8) $$\frac{d\boldsymbol{\beta}}{dt} = f_\beta\,[\boldsymbol{\beta}, n(t), t] + \boldsymbol{w}_\beta$$

(9) $$z_k = n_k + v_k,$$

where n is the cumulative number of adopters, **u** is the marketing mix variable vector, $\boldsymbol{\beta}$ is the unknown parameter vector, w_n and w_β are the process noise, $n_k + z_k$ are the actual and observed cumulative number of adopters at time t_k , and v_k is the observation noise. It is assumed that $n(0) \sim (n_0, \sigma_{n0})$ and $\boldsymbol{\beta}(0) \sim (\boldsymbol{\beta}_0, \mathbf{P}_{\beta 0})$, $\{w_n, \mathbf{w}_\beta\}$ and $\{v_k\}$ are white noises; $\{w_n, \mathbf{w}_\beta\} \sim (0, \mathbf{Q})$, $v_k \sim (0,r)$, and $\{w_n, \mathbf{w}_\beta\}$ and $\{v_k\}$ are not correlated to one another. An augmented state vector (y) that consists of the original state (n) and the unknown parameter vector ($\boldsymbol{\beta}$) is $\mathbf{y} = [n, \boldsymbol{\beta}]^T$.

The first three equations above can be rewritten as:

$$\frac{dy}{dt} = \mathbf{f}_y\,(\mathbf{y}, \mathbf{u}, t) + w_y, \text{ where } \mathbf{f}_y = (f_n, \mathbf{f}_\beta)^T.$$

$$z_k = n_k + v_k.$$

The estimation algorithm is based on the last two equations. The AKF(C-D) algorithm is essentially a Bayesian updating procedure. In Figure 1, we provide an overview of the AKF(C-D) algorithm. The figure presents the relationships among the real market, the diffusion model, and the AKF(C-D) estimation process. To estimate a new-product diffusion process in a real market, one identifies a diffusion model with unknown parameters to describe the new product adoption process. Using prior experience or knowledge, one gives initial estimates for the unknown parameters. AKF(C-D) updates the parameter estimates of the diffusion model as new sales data become available. It estimates parameters and updates the state variables through two processes: a *time updating* process and a *measurement updating* process.

EVALUATION REPORTED BY THE AUTHORS

The predictive performance of the AKF(C-D) procedure is empirically evaluated by comparing its forecasting results with five commonly used procedures. Because most studies of the evaluation of estimation procedures use the Bass model as a basis for comparison, the Bass model has the most reported empirical results. Although one of the major advantages of AKF(C-D) is its capability to estimate more complicated diffusion models, to facilitate comparison with other estimation approaches suggested in the literature that were tested for the Bass model, the authors followed the literature and evaluated AKF(C-D) using the same Bass new-product diffusion model.