NATIONAL COOPERATIVE
HIGHWAY RESEARCH PROGRAM REPORT 329

USING MARKET RESEARCH TO IMPROVE MANAGEMENT OF TRANSPORTATION SYSTEMS

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
REPORT 329

USING MARKET RESEARCH TO IMPROVE MANAGEMENT OF TRANSPORTATION SYSTEMS

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AREAS OF INTEREST

Administration
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(Highway Transportation, Public Transit, Rail Transportation, Air Transportation, Other)

TRANSPORTATION RESEARCH BOARD
NATIONAL RESEARCH COUNCIL
WASHINGTON, D. C.
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Systematic, well-designed research provides the most effective approach to the solution of many problems facing highway administrators and engineers. Often, highway problems are of local interest and can best be studied by highway departments individually or in cooperation with their state universities and others. However, the accelerating growth of highway transportation develops increasingly complex problems of wide interest to highway authorities. These problems are best studied through a coordinated program of cooperative research.

In recognition of these needs, the highway administrators of the American Association of State Highway and Transportation Officials initiated in 1962 an objective national highway research program employing modern scientific techniques. This program is supported on a continuing basis by funds from participating member states of the Association and it receives the full cooperation and support of the Federal Highway Administration, United States Department of Transportation.

The Transportation Research Board of the National Research Council was requested by the Association to administer the research program because of the Board's recognized objectivity and understanding of modern research practices. The Board is uniquely suited for this purpose as: it maintains an extensive committee structure from which authorities on any highway transportation subject may be drawn; it possesses avenues of communications and cooperation with federal, state and local governmental agencies, universities, and industry; its relationship to the National Research Council is an insurance of objectivity; it maintains a full-time research correlation staff of specialists in highway transportation matters to bring the findings of research directly to those who are in a position to use them.

The program is developed on the basis of research needs identified by chief administrators of the highway and transportation departments and by committees of AASHTO. Each year, specific areas of research needs to be included in the program are proposed to the National Research Council and the Board by the American Association of State Highway and Transportation Officials. Research projects to fulfill these needs are defined by the Board, and qualified research agencies are selected from those that have submitted proposals. Administration and surveillance of research contracts are the responsibilities of the National Research Council and the Transportation Research Board.

The needs for highway research are many, and the National Cooperative Highway Research Program can make significant contributions to the solution of highway transportation problems of mutual concern to many responsible groups. The program, however, is intended to complement rather than to substitute for or duplicate other highway research programs.

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The members of the technical committee selected to monitor this project and to review this report were chosen for recognized scholarly competence and with due consideration for the balance of disciplines appropriate to the project. The opinions and conclusions expressed or implied are those of the research agency that performed the research, and, while they have been accepted as appropriate by the technical committee, they are not necessarily those of the Transportation Research Board, the National Research Council, the American Association of State Highway and Transportation officials, or the Federal Highway Administration, U.S. Department of Transportation.

Each report is reviewed and accepted for publication by the technical committee according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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FOREWORD

By Staff
Transportation Research Board

This report describes a broad range of market research techniques and their application to the formulation of public policy and the planning, administration, and operation of transportation programs. The report is arranged in handbook fashion, first defining the techniques for data collection and analysis and then suggesting appropriate uses. As part of the project, the research agency also conducted a focus group and a national telephone survey to demonstrate sampling and interviewing procedures as well as the use of various statistical methods. The results of this research will be of interest to many people within state and local departments of transportation and other public agencies. Top managers and program level officers will find the report to be a useful tool in devising ways to elicit public opinion and knowledge of their departments' proposed or existing policies and programs and, therefore, will be better equipped to accommodate and inform the transportation customer through new or modified activities. National transportation-oriented organizations will also find the report directly applicable to the development and evaluation of their efforts.

With increasing competition for public funds, difficult choices must be made in the provision of transportation services and facilities by federal, state, and local governments. Any wise expenditure of funds requires an understanding of the opinions and desires of the transportation customer, the general traveling public as well as commercial users. Such an understanding can then be used to help formulate policies and programs to better serve and educate the transportation customer.

Modern market research techniques (e.g., public opinion surveys and focus groups) offer a systematic way to help provide answers to a variety of questions. Private firms make considerable effort to identify their customers and their specific needs and, based on this information, design or improve a product or service.

As with other areas of modern life, marketing has become more sophisticated and technically advanced. How marketing research techniques can be adapted to help guide departments of transportation (DOTs) was the subject of the research carried out under NCHRP Project 20-24(1), "Using Market Research to Improve the Management of Transportation Systems." Apogee Research, Inc., with the assistance of Gordon S. Black Corporation, conducted the study.

The researchers reviewed several aspects of the problem: data collection and analysis procedures, previous transportation applications, and DOT functions amenable to marketing techniques. As a result, the researchers have provided detailed explanations of how to obtain and evaluate data. Guidance on potential applications to various functions of publicly funded transportation agencies has also been provided. The handbook format of the report is designed to accommodate various levels of detail based on the reader's degree of interest.

The researchers also conducted a national telephone opinion survey to demonstrate the technique. As part of the demonstration, the researchers applied various statistical techniques to illustrate the many ways data can be evaluated. However, extending any interpretations inferred from the data evaluations to the overall population was not the intent of this research and no such attempt should be made.

CONTENTS

ACKNOWLEDGMENTS

This report was prepared by Dr. Susan Jakubiak and Dr. Richard Mudge, Senior Economist and President, respectively, of Apogee Research, Inc., and Dr. Robert Hurd, formerly of Media and Opinion Research, a division of the Gordon S. Black Corporation, and now President of Apogee Market Strategies. Major contributors include Mr. Anthony Casale, formerly Vice President and General Manager of Media and Opinion Research now President of American Opinion Research, Mr. Edward Petkus, Jr. of Media and Opinion Research, and Ms. Sharon Glover and Mr. Eric Cowan of Apogee International. Ms. Lynne Abdel-Megeid, Ms. Hope Adams, Ms. Laura Novell, Mr. Neil Tender, and Ms. Anne Connolly of Apogee Research and Mr. Len Bayer of Gordon S. Black Corporation also helped with this project. Special thanks are due to Mr. John Clements for his valuable advice and assistance.

This work would not have been possible without contributions from many other individuals who participated in various ways. These include the many transportation professionals, who answered questions and provided us with copies of their market research studies, and the focus group and survey participants

Statistical analyses used *Statistical Package for the Social Sciences* (SPSS), Second Edition (McGraw-Hill Book Company, New York); 1975.

USING MARKET RESEARCH TO IMPROVE MANAGEMENT OF TRANSPORTATION SYSTEMS

SUMMARY

Today's transportation professional faces many problems that have changed little over the past decades. The more complex financial, social, and political environment of today means traditional solutions may not always be adequate, however. The resulting search for new analytic tools may also generate new ways of thinking about transportation and its relationship with the public. In this regard, modern market research offers an exciting combination of techniques as well as an approach that adapts private-sector methods to public problems and institutions.

There is more to market research than a series of simple public opinion poll questions. For example, direct questions such as "Do you favor higher motor fuel taxes?" or "Do you support better roads?" will generate predictable results. In contrast, more sophisticated techniques can identify what characteristics the public considers when they think of good transportation or what combination of transport improvements is likely to generate public support for a change in user fees.

This report, written as a handbook on market research for transportation agencies, provides a practical guide to the full range of market research techniques and how they can be applied by state DOTs and other transport agencies. It combines a description of data collection methods and analytic techniques with examples from recent public and private applications.

The handbook is designed for a wide audience covering the policy, planning, public affairs, and operating sections of state departments of transportation (DOT). Just as each group faces different problems, each will find different ways to use this handbook. For example, the chief administrative officer (CAO) and other top policy makers will need to understand what market research is, which problems it can address, and how it can help meet these problems. Managers will need to evaluate alternative ways to collect data and analyze the results, selecting those techniques that are most appropriate and cost effective. Still others within the DOT will then require more details in order to implement these approaches.

Market research has long been an important tool used by private sector firms to develop marketing strategies, to help design specific product features, and to assess their progress in a competitive market. Transportation agencies can apply these methods to a similar broad range of problems, including long-term planning, the testing and design of specific improvements, more effective communication with the public, and evaluation of progress.

Market research incorporates techniques that range from simple and low-cost approaches to sophisticated methods that require experience to implement. Some methods can be implemented with almost no formal training and most should be accessible to transportation agencies relatively easily either by building in-house skills or by calling on consultants for special facilities or experience in design or statistics. This handbook

is designed to encourage DOTs to experiment and gain experience through hands on work.

Data collection techniques covered here range from telephone interviews using computerized phone banks to mail surveys to focus groups and to public meetings or panel surveys. The advantages and disadvantages of each are described, including cost parameters and their appropriateness for helping address different problems.

While full consideration is given to qualitative analysis and simple cross tabulations, most of the attention on data analysis focuses on multivariate techniques (regression analysis, discriminant analysis, multidimensional scaling, and conjoint analysis). These approaches make it possible to understand the motivations behind public choices and to stimulate the trade-offs that the public makes in the real world. These have been very successful in the private sector and offer similar promise for transportation agencies.

The market research techniques covered in this handbook include the following:

- *Data Collection*

Focus Group—a small group (10 to 15 persons) discussion that is led by a trained leader using a prepared outline to explore issues, generate ideas, and gauge response to new policies; participants may be selected to represent population segments important to the study, but results cannot be projected or generalized to the total population. Discussions are open ended and can be invaluable for assessing reactions to new proposals and identifying overlooked issues. Focus groups are often videotaped for later reviewing.

Panel Survey—information is collected from a group of participants (the panel) selected to record data over a period of time in a set format; generally used to track personal responses or actions in response to changes in participants' environment, for example, changes in transit schedules or identify patterns over a longer period of time when recollection is considered inaccurate.

Personal Interview Survey—data are collected from interviewers who personally discuss each question with survey participants. Participants can be selected in advance from voter registration roles, census tract address lists, and telephone listings, or can be selected on the spot (intercept surveys). Personal interview surveys are the most expensive method of data collection, but allow visual materials to be used, permit interviewer probing, and usually have a high response rate.

Intercept Survey—survey data are collected from passers-by who are intercepted by interviewers in selected locations such as airports or shopping malls. Although participants usually are drawn from a fairly broad spectrum of the targeted population, selection is not truly random because interviewers may be biased unconsciously in their choice of participants and some population groups of interest may not frequent certain public places.

Mail Survey—information is collected from questionnaires distributed to a large, randomly selected, group of individuals, is filled out at leisure, and is then mailed back. Participants may be selected at random from voter registration or census lists. Questionnaires can also be handed out at selected locations, for example, at the entrance to a particular bridge or tunnel. Mail surveys are relatively inexpensive, allow visual materials such as maps to be used, but may be characterized by low rates of expense.

Telephone Survey—participants, randomly selected from population lists or with computer-based random digit dialing, are queried by telephone by skilled interviewers, often using computer programmed questionnaires. Interviews should be kept to 25 min or less and visual materials are precluded, but costs are significantly lower than personal interview surveys, probing is effective, response rates are

high, results are available quickly, and findings can be projected to the population as a whole.

- *Data Analysis*

Cross Tabulations (Crosstabs)—tabular presentation of data for two variables at a time to identify possible relationships between variables; for example, the number of respondents more than 65 years old who support increased fuel taxes.

Importance-Performance Analysis—technique to evaluate whether public perception of performance is commensurate with importance. By inference, responses can be used to prioritize expenditure on those services where performance does not match importance versus those with low performance and even lower ratings of importance.

Regression Analysis—statistical technique that is used to understand and sort out the relationships among several factors and their individual influence on a given outcome; results are usually presented with one "dependent variable" or outcome as a function of one or more "independent variables" or factors that affect the outcome. For example, is public satisfaction with DOT performance affected more by congestion, perceived sufficiency of road maintenance, or by socioeconomic characteristics such as income and age?

Factor Analysis—statistical technique that takes a large number of variables and searches for underlying forces or factors they hold in common; the procedure can be used to reduce a large number of variables down to a limited number of statistically defined factors that seem to underlie the original variables. For example, a factor called "amenities for travelers" is a common thread in respondent interest in highway signs, and rest stops and waysides. The DOT could improve public satisfaction by addressing the underlying concern—amenities—in its policies rather than each component separately on an ad hoc basis.

Discriminant Analysis—statistical technique that is used to identify the factors or combinations of variables that account for the separation of individuals into different groups. For example, what are the underlying elements that distinguish those supporting fuel tax increases from those that oppose them? **Perceptual Mapping** is a graphical presentation of the results of discriminant analysis where each graphical axis is the dimension described by a discriminant function.

Conjoint Analysis—statistical technique that identifies underlying trade-offs that are made in a difficult public policy choice. For example, what type and level of improved services are needed to generate public support for higher fuel taxes? What implicit value is assigned to different services—less congestion versus better road services or better long-range planning?

Multidimensional Scaling—statistical technique that produces a graphical mapping of products/objects; translates perceptions of objects and/or their attributes into distances used to create a single map revealing perceived relationships among objects and/or attributes simultaneously; each axis represents a dimension that is inferred from the data as important in comparisons of these objects.

Correspondence Analysis—statistical technique that is used to analyze categorical data; indicates proximity or similarity between categories and, thus, possible relationships; uses same type of categorical data as crosstabs, but more flexible, because it can deal with more than two dimensions or variables at a time.

Psychographic Market Segmentation—analytical technique that is used to classify respondents into groups representing distinct market segments; analogous to demographic grouping, but based on attitudes instead of age, income, occupation, or other demographic data.

The handbook is organized into three chapters and five appendixes. Chapter I introduces the concept of market research and provides background on the motivation for this project. Chapter II summarizes a menu of data collection methods and the analytical techniques that can be applied to these data. Chapter III provides an overview of how these tools can fit into the range of transportation problems faced by state DOTs.

Appendix A provides background on random sampling. Appendix B provides detailed technical descriptions of each of the multivariate analytic techniques summarized in Chapter II. Appendix C summarizes some of the techniques applied in the national demonstration survey conducted for AASHTO. Appendix D reviews the recent market research applications of state DOTs. And Appendix E contains a glossary of terms.

Readers are directed to Chapter I, section under "Guide to Efficient Use of the Market Research Handbook," to help them tailor additional reading in this handbook to their role in transportation market research.

CHAPTER I

INTRODUCTION

Synopsis: **Market research provides a set of tools to gather and analyze information from groups of individuals. Typically, market research has been used by businesses interested in developing new product lines and services to better appeal to their customers or in refining existing services. More recently, public agencies have used market research to facilitate communication between themselves and their customers, the public served by those agencies.**

This handbook is intended to support transportation agencies as they consider the applicability of different types of market research studies to help solve short-term as well as long-term problems. It also provides practical advice on how to design and implement a wide range of market research efforts. The need for this guide was first suggested as part of an earlier NCHRP study to identify and develop research programs to help solve problems faced by the chief administrative officers of state departments of transportation. (See NCHRP Project 20-24 Research Program Design, final report, August 1989 for details and for a description of 17 other applied research projects targeted at CAOs and other top DOT managers; see also *NCHRP Research Results Digest 170.*) The handbook is structured so that it can be used by officials at all levels within a transportation agency; a guide to use in this chapter pinpoints those sections most important to each type of reader.

BACKGROUND AND TECHNICAL APPROACH

General

The private sector has used market research for years to gain information on customer characteristics and their perceived needs, to gauge how well current products and services satisfy these wants, and to develop more effective ways to communicate with current and potential customers.

As with the private sector, public agencies also deliver "products" to customers although, in the public case, these products are often intangible services. Public sector customers may pay directly for these products—for example, highway tolls or transit fares—or they may pay indirectly through beneficiary-based taxes, such as gasoline, or general levies, such as property taxes. Despite some significant differences from private markets, transportation users are customers analogous to those who patronize private firms and their needs can be met best if they are known. Indeed, the lack of a formal price system and limited competition makes a system of market information and communication even more practical.

Because most transportation decisions involve the public and their elected representatives, analysis can be less straightforward and the decision-making process more complicated than in the market place. In the modern world, these decisions often require complex trade-offs between different goals and difficult financial choices. Market research can provide valuable insights that can help improve the design and implementation of a wide range of transportation policies.

Of course, transportation planners can identify the engineering needs of the system without input from customers; using objective criteria, they can assess bridge safety, highway congestion,

road surface quality, intermodal connections, and the like. Customer needs or latent demand for new services, however, can only be discovered by communicating with customers. Market research can provide the means of identifying these needs and, thus, more effective public sector allocation of resources and planning by providing better information to public authorities.

When resources are limited, not all needs—whether new services or upgrading of current services—can be met simultaneously. Projects must be prioritized—it is not sufficient to have a listing of all projects desired by the public. Currently, transportation agencies face increasing fiscal constraints (citizens resist general increases in taxes and even increases in user-based fees); at the same time, less support is forthcoming from the federal government. Thus, hard choices must be made and the public must be involved in selecting among the alternatives because, in the end, they pay the bills. More than ever, it is important for public officials to understand their customers, to evaluate public priorities and, where necessary, reveal the areas in which greater education and communication are required to build consensus.

Yet, in spite of this need, transportation agencies, and the public sector in general, has barely tapped the potential for market research to aid in policy decisions. Many public agencies are unfamiliar with techniques of market research, especially the newer techniques that go beyond tabulation of direct responses to reveal inferred values and trade-offs.

NCHRP Project 20-24(1), "Using Market Research to Improve the Management of Transportation Systems" was initiated to address this need. The research was divided into three phases. The first phase reviews past market research conducted by transportation organizations. Results are summarized in Appendix D. This provided the background for the second phase of this project, which was a demonstration survey for AASHTO on national transportation issues. This survey was designed to illustrate market research techniques and to test their applicability to modern transportation issues. This work is summarized in Appendix C of this report and examples are used throughout the handbook.

This third and final phase of the market research project is designed as a handbook to familiarize public agencies, particularly transportation agencies, with modern market research techniques and to help them implement market research studies in support of their planning and administrative objectives. While the focus and most examples are drawn from transportation, the techniques should find practical application for most other public agencies.

Components of Market Research

Market research is both broader in scope and more complex than simple opinion polling. Market research requires coordination of data collection and analysis with policy objectives and it utilizes inferences that are not immediately obvious in simple tabulations of the type used to present poll results. Used efficiently, market research analytical techniques, such as conjoint analysis, can even make explicit public preferences and trade-offs that are not obvious to the respondents generating the information. Instead of blindly introducing policies that may backfire, public officials can use market research to anticipate results and modify policies before politically and financially expensive errors are made.

Effective design of market research rests on two bases: (1) understanding the techniques available for collection and analysis of data—including their appropriate applications, strengths, and limitations; and (2) careful identification of research objectives and practical constraints, and the trade-offs involved in achieving balance among incompatible factors.

Accordingly, the core of this handbook is contained in two chapters. Chapter II summarizes market research techniques for data collection and analysis, noting the special characteristics and shortcomings of each approach. Chapter III begins with a discussion of the five basic areas of transportation activity and notes which market research techniques are suitable in each area and subarea. Building on the general criteria suggested in this segment, the rest of Chapter III is devoted to guidelines for designing market research studies suited to the objectives, constraints, and skills of individual transportation agencies.

The appendixes offer more detailed information in three areas: technical descriptions of market research techniques (Appendix A on sampling, Appendix B on quantitative methods of analysis), illustrations of transportation market research (Appendix C summarizing the National Demonstration Survey and Appendix D summarizing market research by selected transportation agencies), and a glossary for quick reference on technical terms (Appendix E).

GUIDE TO EFFICIENT USE OF THE MARKET RESEARCH HANDBOOK

This handbook was designed to fulfill the needs of officials in all areas of a public transportation agency. However, not all officials require information at the same level of detail. Some officials need only familiarize themselves with market research techniques and applications, so that they can supervise others implementing the research. Others need more extensive information, so that they can design studies at the detailed level. Thus, the handbook is structured as a series of modules from which officials can pick and choose the sections most appropriate to their needs and background.

The following, "Guide to Efficient Use of the Market Research Handbook," should help officials tailor their reading to their needs, a function of their role in the agency. There are three levels of technical detail in this handbook. The *Summary* is the most concise and least technical presentation. This may constitute the only reading for top administrative officials; it will serve as the introductory overview for all other officials. The *Synopsis* sections of Chapters II and III are extensions of the *Summary* and, read independently, help senior officials become familiar with market research without involving them in more detail than they need to fulfill their roles.

The main bodies of Chapters II and III are more extensive but not excessively technical; they are intended for those overseeing market research design and supervising others' implementation of data collection and analysis (whether in-house or contracted out). The second part of Chapter III focuses on designing market research and is intended for those who need to help design a research project. Appendixes C and D illustrate actual market research applications; they are presented as appendixes because they are detailed, but the discussion is at the same technical level as the main chapters. Appendixes A and B describe market research techniques in greater technical detail; these supplements are designed for those who expect to be actively involved in implementation and analysis, and, therefore, need to understand the statistical and analytical properties of these approaches.

GUIDE TO EFFICIENT USE OF THE MARKET RESEARCH (MR) HANDBOOK

PERSON AND ROLE IN AGENCY	SECTIONS THAT SHOULD BE READ
Chief Administrative Officer or other executive: Review concepts and applicability to agency	**Summary:** Overview of MR applications, methods **Chapter II,** *Market Research Techniques* **Synopsis:** Brief review of data collection and analysis techniques **Chapter III,** *Application of Market Research to Transportation Issues* **Synopsis:** Presents overview of applications, design of MR (Optional: **Appendix C,** *National Demonstration Survey: Summary of Findings*—illustrates applications of modern MR)
Senior Manager: Select areas for MR studies in transportation agency	**Summary:** Overview of MR applications, methods **Chapter I,** *Introduction*—background to study, chapter summaries **Chapter II,** *Market Research Techniques* **Synopsis:** Brief review of data collection and analysis techniques **Chapter III,** *Application of Market Research to Transportation Issues* **Synopsis:** Presents overview of applications, design of MR **Dynamics of MR Design** **Planning and Implementation Activities:** Relates specific MR techniques to transportation planning tasks **Appendix D,** *Review of Transportation Market Research*—reviews 33 case studies of transportation MR (Optional: **Appendix C,** *National Demonstration Survey: Summary of Findings*—illustrates applications of modern MR)
Manager or Public Affairs Officer: Select MR projects, suggest general MR design including level of effort and techniques	**Summary:** Presents overview of MR applications, methods **Chapter I,** *Introduction*—describes background to study, chapter summaries **Chapter II,** *Market Research Techniques* **Synopsis:** Briefly reviews data collection and analysis techniques **Chapter III,** *Application of Market Research to Transportation Issues* **Synopsis:** Presents overview of applications, design of MR **Dynamics of MR Design** **Planning and Implementation Activities:** Relates specific MR techniques to transportation planning tasks **Factors in Market Research Design:** Describes factors to consider in general MR design **Choosing a Market Research Design:** Defines decision process **Implementing Market Research:** Discusses factors that influence implementation and choice of specific forms of data collection and analysis **Appendix C,** *National Demonstration Survey: Summary of Findings*—illustrates applications of modern MR **Appendix D,** *Review of Transportation Market Research*—reviews 33 case studies of transportation MR
Public Affairs Officer or Deputy: Set up MR for agency including specification of design for data collection and analysis and supervision of others performing technical implementation	**Summary:** Presents overview of MR applications, methods **Chapter I,** *Introduction*—describes background to study, chapter summaries **Chapter II,** *Market Research Techniques* **Synopsis:** Briefly reviews data collection and analysis techniques **Data Collection Techniques:** Describes data collection for qualitative and quantitative research **Data Analysis Techniques:** Summarizes various ways to analyze data, particularly survey data **Chapter III,** *Application of Market Research to Transportation Issues* **Synopsis:** Presents overview of applications design of MR **Dynamics of MR Design** **Planning and Implementation Activities:** Relates specific MR techniques to transportation planning tasks **Factors in Market Research Design:** Describes factors to consider in general MR design **Choosing a Market Research Design:** Defines decision process **Implementing Market Research:** Discusses factors that influence implementation and choice of specific forms of data collection and analysis **Appendix C,** *National Demonstration Survey: Summary of Findings*—illustrates applications of modern MR (Optional: **Appendix D,** *Review of Transportation Market Research*—reviews 33 case studies of transportation MR)
Public Affairs Officer, Deputy or other person implementing study: Specify detailed design of agency MR and perform analysis of data from (quantitative) survey or work closely with those within agency or contractor analyzing data.	**Summary:** Presents overview of MR applications, methods **Chapter I,** *Introduction*—describes background to study, chapter summaries **Chapter II,** *Market Research Techniques* **Synopsis:** Briefly reviews data collection and analysis techniques **Data Collection Techniques:** Describes data collection for qualitative and quantitative research **Data Analysis Techniques** **Qualitative Analysis:** reviews analytical methods for qualitative studies **Qualitative Analysis, Basic Tabulations, and Cross Tabulations only:**—describes simple tabulations

GUIDE TO EFFICIENT USE OF THE MARKET RESEARCH (MR) HANDBOOK (Continued)

PERSON AND ROLE IN AGENCY	SECTIONS THAT SHOULD BE READ
	Appendix B, *Methods of Quantitative Analysis*—presents technical discussion of modern MR techniques for analysis of quantitative survey data (substituted for the less detailed explanation of the same methods summarized in Chapter II following Cross Tabulations); includes examples from National Demonstration Survey to illustrate applications of some techniques
	Chapter III, *Application of Market Research to Transportation Issues*
	Synopsis: Presents overview of applications, design of MR
	Dynamics of MR Design
	Planning and Implementation Activities: Relates specific MR techniques to transportation planning tasks
	Factors in Market Research Design: Describes factors to consider in general MR design
	Choosing a Market Research Design: Defines decision process
	Implementing Market Research: Discusses factors that influence implementation and choice of specific forms of data collection and analysis
	(Optional: **Appendix C,** *National Demonstration Survey: Summary Findings*—illustrates applications of modern MR)
	(Optional: **Appendix D,** *Review of Transportation Market Research*—reviews 33 case studies of transportation MR)

CHAPTER II

MARKET RESEARCH TECHNIQUES

Synopsis: **Market research refers to a broad array of techniques for gathering and evaluating information pertaining to the market for a given set of products or services. Data collection techniques are categorized according to the type of analysis they support: qualitative or quantitative research. The difference is that the results of quantitative research typically can be generalized to the whole population because they are based on a large sample that is a representative microcosm of the whole population of interest. Techniques for quantitative analysis include simple summations, cross tabulations (showing differences among subgroups or the possible correlation between two variables), importance-performance analysis, and a number of more complex techniques for multivariate analysis requiring statistical manipulations to extract patterns and to reveal hidden inferences from the data.**

DATA COLLECTION TECHNIQUES

Data collection techniques can be divided into two categories according to the type of analysis they will support: (1) *Qualitative analysis* is based on anecdotal evidence, comments offered, and ideas generated by participants. The sample of participants is small and not proportionally representative of the total relevant population. While the information may be collected systematically, the results are usually impressionistic in nature. (2) *Quantitative analysis* is based on data collected from a large sample of participants. Often they are proportionally representative of the total relevant population, that is, the sample is a microcosm of the full population. Data collected from the sample are evaluated statistically and may be generalized to the population at large.

Data Collection for Qualitative Analysis

Qualitative analysis is based on opinions from selected experts, nonrandom samples of target population members, case studies, and selected observations. Participants may be screened according to specified selection criteria with care taken to represent important segments of the population. For example, an analysis of airport access problems might focus on frequent flyers. However, the group of participants does not constitute a fully representative microcosm of the relevant population. Evidence may be anecdotal; opinions voiced by only one participant and not echoed by others may still constitute important data. Data for qualitative analysis may be gathered in several ways:

1. *Focus groups:* small (approximately 12 persons) groups of selected participants are led by an experienced leader using a general discussion outline; variations include *standard focus groups* (participants are drawn at random from the relevant market population) and *expert panels* (participants are selected for their expertise in the subject or their in-depth knowledge of customers and the market service under discussion).
2. *Nonrandom in-depth interviews:* a limited number of participants are selected for their expertise or on an ad hoc basis for exploration of ideas; neither the respondents nor their ideas are necessarily representative of the general population.

3. *Public Meetings:* data can be collected through observation of public attitudes, voting patterns, presentations at public meetings, or through questionnaires delivered at public meetings.

Focus Groups

Focus groups are ideal to explore concepts and generate ideas; success does not depend on agreement among participants though, in some cases, consensus may be useful for subsequent policy formulation. Participants in standard focus groups are chosen from the general population to represent themselves or a particular interest group. Members of expert panels are nominated by other experts or drawn from specialized lists such as association memberships and may represent more than their personal interests.

Focus group costs are nominal compared to full-scale surveys or extensive in-depth interviewing. (The cost of the focus group used as the first step in structuring the National Demonstration Survey was less than $4,000). Some DOTs have had success with "inhouse" focus groups, where costs are lower.

The ideas generated by focus groups may be used directly in formulating policy or in designing second stage quantitative analysis. For example, a focus group was used to identify possible new questions for the National Demonstration Survey. A typical focus group lasts 2 hours and may be videotaped for more detailed review.

Nonrandom In-Depth Interviews

In-depth interviews are also designed to explore issues and expand concepts but, in this case, on a one-to-one basis rather than in a group setting. Individual interviews are more costly, lack the interactive dynamic development of ideas possible in a group setting, but have the advantage of allowing individuals to formulate ideas independent of others' influence. Participants can be drawn from the general population or can be selected based on their expertise in a particular area.

Data Collection for Quantitative Analysis

Quantitative analysis is based on data that are systematically gathered through surveys undertaken specifically for a particular market research objective and/or from secondary sources. Typically, results are based on a large-scale representative sample.

There are explicit criteria or considerations for collecting data for quantitative analysis. These include:

1. *Sufficient number of respondents* to ensure a limited margin of error in calculating results. The number of respondents required depends on the variation among individual responses and the degree of accuracy desired—the greater the range of answers (the less the consensus), the larger the sample must be to obtain the same degree of assurance. (Appendix A on sampling shows the minimum sample size considered necessary to keep the margin of error within an acceptable range.)

2. *Inclusion of all relevant population groups* to ensure a representative sample. If there is a chance that some subgroups will be missed or seriously underrepresented, representation can be ensured by defining strata and, then, selecting participants separately from within each stratum or by "over sampling." For example, telephone surveys usually ask to speak with an older male family member because, on average, women and younger men tend to answer the phone more often.

3. *Systematic random selection of individual participants* to ensure a representative sample. Random selection requires definition of a "universe" of the relevant population and then systematic sampling within that universe (techniques for systematic sampling based on random selection are discussed in greater detail in Appendix A). This generates a group of participants that is a microcosm of the relevant population, not biased in favor of one geographic or socio-economic subgroup. In other words, individuals within each group have an equal chance of being selected.

Within the area defined by these criteria, several collection methods are possible for full-scale surveys: (1) *personal interview* where trained interviewers use printed questionnaires or discussion outlines to query respondents on their ideas and collect information; (2) *telephone interview* where trained interviewers gather information usually from some centrally located facility using either printed questionnaires/outlines or computer-assisted interviewing; (3) *mail surveys* where printed questionnaires are filled in by respondents and mailed back; and (4) *direct observation* where individual actions are observed at chosen times in representative environments.

Conventionally, interview surveys are based on samples of participants drawn at random from predetermined lists of the relevant population or by dialing randomly generated telephone numbers. Samples for direct observation are determined by the place and time(s) selected rather than from a master list of persons.

Personal Interview Surveys

Personal interview surveys are best suited for extended probing for answers to open-ended questions or when responses to particular physical printed materials are desired. Because participants' attention can be sustained longer in a personal interview, the discussion can be longer and more issues covered. In addition, interviewers can observe respondents during the survey—confusion, hesitancy, for example—and relay this feedback information about how the questionnaire is received for use in the design of subsequent studies.

However, personal interview surveys usually cost more for a given sample size. First, the costs of recruiting, training, and maintaining an interviewing staff can be quite high. Second, when door-to-door or appointment interviewing is used, the costs of transportation and "down-time" between interviews add to basic labor costs. Attempts to restrict costs by limiting the geographical area covered may seriously bias the results. Because data collection is decentralized, interviewers must be skilled enough to act without direct supervision; the researcher has less control over the process and limited ability to intervene once the study has been launched. This process also requires more time.

Telephone Interview Surveys

Telephone interview surveys permit some probing but the lack of face-to-face contact limits the interviewer's ability to respond and to hold the participant's attention; 25 min is considered the

maximum interview length unless participants are particularly interested in the issues being explored. On the other hand, the relative anonymity of the participant sometimes encourages more thoughtful or truthful answers. In addition, telephone surveys can utilize computer-assisted interviewing where branching is programmed and the appropriate follow-up questions are automatically given to the interviewers. (In branching, the choice of follow-up questions depends on answers given to earlier questions. For example, in the National Demonstration Survey, respondents working full or part-time were asked in question 15 how they commute to work. If the answer was "drive to work by myself," question 18 and several other questions dealing with their reasons for not using mass transit were asked. However, if the answer was "take mass transit to work," the computer skipped these questions and went immediately to question 21C.) Different sets of respondents can be asked different questions.

Costs can be kept down by use of WATS lines, centrally located interview sites where a few supervisors can oversee a great number of interviews, and computer-based random digit dialing to ensure random selection of households rather than more laborious research for household addresses required for most personal interview and mail surveys. Moreover, response rates can be boosted by efficient call-backs to enlist participants not available on the first try; this increases the chance that hard-to-reach groups (for example, young people, minorities, higher income individuals) will be included, thus making the sample more representative of true population parameters.

These computer-based systems offer better quality control and much faster turn-around time with summary tables and cross-tabs available the next day.

Mail Surveys

Mail surveys reach people who may not be available for telephone or in-person interviews, that is, those without phones, or who are rarely home to answer their phones or to meet interviewers. The anonymity of write-in questionnaires can encourage full and honest answers. Because they are self-administered and do not involve interviewer training or labor costs, they are also relatively inexpensive—one person can administer a whole survey. However, the rate of nonresponse tends to be very high because there is no interviewer to encourage participation. (Many respondents will simply throw the survey away; others will put it off to a more convenient time and then forget about it. The challenge for the researcher is to somehow make responding to the survey worth the respondent's time—perhaps through a carefully worded letter of explanation that outlines the importance to that respondent of the research being performed. Follow-up letters can be sent to addresses from which no responses have been received; cash inducements can also be offered. A different approach is being tried by the New York City Triborough Bridge and Tunnel Authority which is entering completed questionnaires in a raffle with cash prizes.) The absence of an interviewer also precludes probing to clarify answers. Moreover, branching may be difficult for untrained respondents to follow, and thus must be limited on mail surveys. Because they are self-administered at the respondent's leisure and mailed back, there is often a long lag time before results are received, coded, and analyzed.

Lower response rates pose two problems: (1) additional effort and expense are required to obtain desired sample sizes, and (2) more important, low response introduces systematic bias into the sample because people who do not bother to answer tend to have different opinions than those who do answer.

Furthermore, in self-administered surveys, it is more difficult to cope with open-ended questions—questions of opinion where respondents are not confined to a set of predetermined options. Because there are no interviewers to encourage participant response or to probe for clarification, answers may be omitted or unclear. Last, the low-cost element of mail surveys is partially countered by the higher cost of formulating predetermined address lists and the necessity of using cover letters, incentives and follow-up mailings. Predetermined address lists are not needed when participants are selected at intercept sites and handed printed questionnaires to fill out at leisure and mail back. This type of mail survey is similar to mall-intercept surveys in sample selection but suffers from a higher rate of nonresponse resulting in less representative samples; thus, it should be classified as data collection for quasi-quantitative analysis rather than quantitative.

Observation

Questionnaire surveys either ask respondents to recall their actions in specific circumstances or ask them to respond to hypothetical situations. Observation, on the other hand, allows researchers to see what respondents really do in given circumstances; it is an effective way to explore public response to concrete situations and it generates more accurate results than asking people to remember (and honestly describe) their reactions. Observation, of course, is only feasible in certain situations and, unless it is coupled with an interview, does not allow for people to explain why they behave as they do.

Observation sites may be purposely created as test sites, for example, a particular intersection repaved with rough pavement to slow approaching traffic with observers noting how drivers react. Or sites may be selected as environments typical of those being evaluated, for example, four-lane highway sections monitored to see what kinds of drivers litter most frequently.

The disadvantages of observation as a data collection technique include (1) sample bias, if locations and times are not selected carefully to sample all relevant population groups; (2) cost of a large-scale effort, particularly if observers are idle for long periods of time between participants; (3) cost of creating test situations, if required, to expose respondents to new products or policies; and (4) no additional data to explain behaviors.

Comparison of the Basic Methods

Table 1 summarizes the major advantages and disadvantages of each method. In general, interviewer-administered surveys (including telephone surveys) have the following advantages:

1. *Better response rates:* people generally find it more difficult to refuse an interviewer face-to-face or over the phone than to toss away a written questionnaire handed or mailed to them. In addition, skilled interviewers can often cajole a reluctant respondent into participation.
2. *Fewer ambiguous and unsure answers:* interviewers can probe the respondents to elucidate or clarify answers.
3. *Short turn-around time:* answers are received on the spot rather than several weeks later in the mail.

Table 1. Survey data collection methods.

Type of Survey	Major Advantages	Major Disadvantages
PERSONAL INTERVIEW SURVEY		
	Most effective probing Maintain participant interest for longer time Pre-coded categories hidden Can present visual materials	Costly Difficult to schedule Branching requires skilled interviewer to avoid confusion (Possibly) restricted geographically No central supervision of interviews
TELEPHONE INTERVIEW SURVEY		
All types	Easier access to respondent Pre-coded categories hidden Some probing possible Relative anonymity Centralized supervision Faster results	Maximum interview usually 25 minutes Cannot present visual materials
Computer-based	Computer controlled branching Random digit dialing Automatic computer tabulation	
MAIL SURVEY		
	Less costly Reach people not easily included in phone or personal surveys	Limited branching possible High non-response rate/sample bias Pre-coded categories cannot be hidden No probing or explanation possible Requires pre-determined address list
OBSERVATION		
	Real environment, actual reaction – no bias	Costly to generate large and representative sample No ability to probe respondent reasons

4. *Smooth branching:* interviewers are skilled in the use of branching instructions and are therefore able to move smoothly to the appropriate follow-up questions when selection is tied to preceding answers.

5. *Unbiased responses to precoded answer categories:* interviewers can ask questions as open-ended inquiries and, keeping the coded lists of alternative answers hidden, use the precoded answers only for their own record-keeping. This allows quick data collection without prejudicing participants' answers.

Other Surveys

There are several specialized forms of surveys that are used to suit particular constraints or situations. These include:

1. *Mall-intercept and street-intercept interview surveys:* specific geographic sites are selected (typically, shopping malls) and interviewers intercept passers-by for questioning.

2. *Public meetings:* openly advertised meetings are called to discuss a particular issue and data are collected by observation of individual responses (voting) or through questionnaires distributed at the meetings.

3. *Panel surveys:* panels or groups of participants are selected to record their responses, actions or activities over a stated period of time, sometimes using a diary format specifically designed for the study; data can also be collected by phone.

The first two examples differ from conventional personal interview and mail surveys because samples are not drawn from predetermined lists but on an encounter basis. This is especially useful when the target population is characterized by a unique trait, for example, people who commute over the Golden Gate bridge in their own cars or people who are concerned about a new highway alignment. Sample selection by encounter is much less expensive than, for example, calling everyone in the geographic region on the telephone and screening them to include only those who meet the criterion (commute via the Golden Gate, etc.). However, it is very difficult to devise procedures that ensure truly random sample selection.

Intercept Surveys

In mall-intercept surveys, one or more commercial areas are selected and interviewers with printed questionnaires select participants on an ad hoc basis for short interviews. Street-intercept surveys are analogous except streets rather than shopping centers are used. In addition to the advantages of encounter sampling, intercept surveys have all the advantages of other types of personal interview surveys—higher response rate, ability to probe, and the ability to use visual aids.

The disadvantage of intercept surveys is sample bias; samples usually do not include all strata of the relevant population because (1) not all types of commercial sites are included, (2)

participant selection is limited to those appearing at the site, thus excluding that portion of the population that does not take care of their shopping needs in person (that is, persons who shop by phone or catalogue, or whose needs are tended by others). Street-intercept surveys similarly are limited because they exclude persons who drive directly from origin to destination, and again, selection of respondents at the site is typically haphazard and subject to unconscious bias.

Public Meetings

Because public meetings draw significant groups of people already interested in a given issue, they are often used to gather more detailed information for market research. Data can be collected with personal interviews or with self-administered questionnaires distributed to those attending the meetings (with the associated advantages and disadvantages of each). Like intercept surveys, selection of participants is administratively easy and inexpensive because it does not require use of predetermined phone or address lists. However, samples are generally biased because public meetings draw only that segment of the population with significant interest in the issue at hand, that is, the sample is self-selected rather than randomly selected. As a result, it is not safe to project these results to the population as a whole.

Panel Surveys

Panel surveys are used to collect longitudinal data to reveal patterns of behavior or to explore reactions to changes in participants' environments such as altered transit schedules, new solutions to congestion and so forth. Like observation, panel surveys often focus on participants' reactions to real situations or stimuli (safety advertisements, directional signs, traffic restrictions) rather than hypothesized situations. Panelists are asked to record certain data for relevant activities during specified time periods, for example, the destination, times, and routing of all the trips they make on public transit during a certain time period. When researchers are interested in alterations in behavior in response to new policies or situations, the periods are selected by the researcher to include at least one period before and one after the changes being evaluated; panelists, however, are not explicitly advised of the timing or nature of the proposed changes.

Panel surveys blend characteristics found in other data collection techniques. For example, participant selection can be from predetermined phone or address lists of specified population strata. On the other hand, participants can be selected by encounter as with intercept surveys (for example, at a given bus stop for a panel survey on mass transit). Participants may be chosen from a very limited group (residents near one transit route, a particular intersection) or selected from the population at large.

Like mail surveys, panel surveys often utilize self-administered questionnaires or diaries. However, because panelists must spend more time than would be the case for a one-time interview and must be consistent in their recording, they are generally monitored with periodic follow-up telephone contact to answer questions, to probe for clarification, and to encourage continued participation.

Data for Quasi-Quantitative Analysis

Sometimes, data collected by these various techniques do not satisfy all the criteria specified for quantitative analysis; perhaps sample size is small, was drawn from only a few strata or population groups, or selection was not random. Analysis based on these data might best be termed "quasi-quantitative" analysis, or a "grey" area between obviously quantitative and clearly qualitative research.

Data for quasi-guantitative analysis fall along a continuous line from nearly qualitative to nearly quantitative, depending on the size and representativeness of the sample selected. The more population groups (demographic, geographic) that are sampled, and the larger and more random the sample drawn from each group, the more the data approach those suitable for quantitative analysis. Data collected by these means can be subjected to the same analytical techniques as other survey data; the difference is that results should be recognized as more approximate and less precise than those from surveys based on large, scientifically selected, random samples.

DATA ANALYSIS TECHNIQUES

Qualitative Analysis

Qualitative data analysis is confined to written (rather than numerical) summaries, narrative descriptions of opinions, and lists of factors and ideas generated. When larger number of participants are involved (for example, questionnaires from public meetings), numerical tabulations can be generated, however, the number of respondents in agreement should be viewed as a barometer of general opinion only if there is a great deal of consensus among respondents and if respondents represent a broad spectrum of the general public. Although it cannot be used to develop generalizations or projections, qualitative analysis provides useful inputs to general policy planning and can offer new insights in solving problems.

Quantitative Analysis

Traditionally, transportation market research has relied on basic percentage tabulations of answers and simple cross-tabulations for quantitative analysis, even when data collection satisfied all criteria for more complex quantitative analyses. Market research for private commercial (nonpublic) interests has incorporated newer, more sophisticated techniques for quantitative analysis that are now gaining wider acceptance in the public sector. These techniques are characterized by their ability to handle several variables simultaneously, that is, multivariate analysis.

Multivariate techniques can be used singly or in combination to probe underlying relationships and reveal factors not explicitly discussed in the interviews. Multivariate techniques for quantitative analysis can reduce large amounts of data to manageable levels; evaluate complex relationships and correlations to allow researchers to analyze any interdependence among questions, attributes, and other factors, and to use these relationships to predict or project public relations; and show these relationships in easily understood graphic displays.

This section provides a brief description of techniques for quantitative analysis to introduce these concepts and familiarize the reader with their structure and application. Thus, the information is limited to a basic description of each technique, how it is used and those situations in which it would be most effective; a more detailed discussion of multivariate techniques is included in Appendix B.

Table 2. Example of marginals.

National Demonstration Survey Responses: Biggest Local Transportation Problem	
Traffic congestion	29%
Poor road conditions	13
Lack of mass transit	12
Bad drivers	7
Construction problems	3
Traffic lights	1
Other	9
Don't know/refused	7
No real problem	19

Basic Tabulations

The basic tabulations evaluate the responses to one question at a time. They are the first step in evaluation and, in many studies, the only numerical presentation. In these methods, data are presented as marginals (simple percentage or numerical responses to each question) and banner and stub output (percentages for each question by population subgroups).

Marginals simply show the frequencies of each response to a question. The marginals or frequencies for the National Demonstration Survey question—"In your opinion, what is the biggest transportation problem in your local area today?"—are presented in Table 2. Of the 1013 respondents, 29 percent answered traffic congestion, 19 percent noted no real problem, 13 percent answered poor road conditions, and so forth.

During the study design phase, the researcher often decides that comparing certain key groups within the sample may provide interesting or significant results. Banner and stub tables compare the key groups based on responses to individual questions. The groups can be defined according to demographic data collected during the survey, for example, type of community (rural, central city, suburb, small city) or according to sampling strata used in selecting respondents (geographic region).

Table 3 shows a banner and stub table for the National Demonstration Survey question on biggest local transportation problem. The "stubs" are the response categories—the types of transportation problems—and the "banners" are the population subgroups. For example, traffic congestion was most noted by suburban residents (45 percent) and least by rural residents (15 percent); most by people from the west (33 percent) and least by midwesterns (23 percent). Regions correspond to AASHTO regions.

Cross Tabulation

Cross-tabulation is a simple tabular or statistical presentation of data to identify possible relationships between variables. Taking the answers to two questions at a time, data are disaggregated into the frequencies for each possible combination of answers from the two questions. In tabular form, the data are usually organized into a grid. Table 4 shows the cross tabulations ("crosstabs") from a pair of questions in the National Demonstration Survey: income versus most important local transportation problem.

Two sets of information are presented. First, the numbers outside brackets indicate the actual frequencies—29 persons with incomes under $15,000 said that congestion was their biggest problem with local transportation. The total on the far right of each row is the number of respondents in that income group and the percentage that represents the total respondents. Thus, overall, there were 159 respondents with incomes less than $15,000; or 17.0 percent of the sample. (The total sample size shown (938) is less than the sample size of previous tables (1013) because not all respondents would reveal income levels.)

Second, the numbers within brackets are the frequencies that would be expected if respondents in each income group answered in much the same way as respondents overall. In other words, since persons with incomes under $15,000 constitute 17.0 percent of the total sample, one would expect low-income respondents to constitute 17.0 percent of those answering that congestion was their biggest problem—17.0 percent of the 274 answering congestion is 47 persons, the "expected" frequency in brackets. Clearly, low-income respondents were less concerned with congestion than on average. High-income people, on the other hand, complained about congestion more than the average.

This table indicates the relationship, if any, between income group and perception of local transportation problems. It is clear that respondents in the highest income group are more concerned with congestion and less with road conditions than the average. Middle income groups are more troubled by road conditions. High income people are also more likely to have a strong opinion (that is, few "don't knows' "). (Whether these differences are considered statistically significant or just due to error and chance can be evaluated using statistical measures such as the chi-squared test. In a chi-squared test, the squared differences between the actual and expected frequencies are summed and compared to those presented in tables of chi-squared statistics for each example size, number of variables, and confidence limits or acceptable margins of error. These tables, with directions for their use, are readily available in standard statistics textbooks.)

Importance-Performance Analysis

Respondents of a survey are likely to find that more than one service or factor provided by the DOT is lacking in quality. However, it is of greater concern when a service or factor that is considered very important falls far short of a desirable level of performance than when a peripheral service or factor is unsatisfactory. Importance-performance analysis provides a way to prioritize service quality shortfalls by comparing the importance of a specific service with how well the DOT provides it.

This technique requires a specific question design in which survey respondents are asked to: (1) "grade" or rate the *importance* to them of a series of services or attributes; and then "grade" the quality or *performance* of that service or attribute as they perceive it.

Respondents' ratings for both questions are based on a numerical scale (1 to 10, for example). The importance-performance analysis compares these two ratings for each service listed in the survey.

This type of analysis requires only basic computational skills to tabulate individual responses and compute mean (average) values and standard deviations (a measure of variability). Successful importance-performance analysis, however, does require a basic consensus among the surveyed population on the importance and quality of each item evaluated. The importance of different services may vary widely between different groups, for

Table 3. Example of banner and stub.

National Demonstration Survey: Biggest Local Transportation Problem

		Region				Community Type			
	Total	North-East	South-East	Mid-West	West	Central City	Suburb	Small Town	Rural
	1013	234	244	268	268	154	267	350	240
Traffic congestion	29%	30%	30%	23%	33%	33%	45%	25%	15%
Poor road conditions	13	13	13	14	11	5	9	13	22
Lack of mass transit	12	16	9	11	13	15	12	13	9
Bad drivers	7	6	8	8	7	11	5	8	6
Construction problems	3	2	2	3	2	4	3	2	2
Traffic lights	1	1	–	1	1	1	1	1	–
Other	9	12	10	8	8	13	7	9	10
Don't know/refused	7	7	8	8	7	5	5	9	10
No real problem	1	13	20	24	18	13	13	20	26

Table 4. Example of cross tabulation.

National Demonstration Survey:
Relationship Between Income Group and Biggest Local Transportation Problem

	Biggest Local Transportation Problem					
Income Group	Congestion	Road Conditions	All Other Problems	No Problems	Do Not Know	Total
Income less than $15,000	29 [47]	14 [21]	67 [52]	30 [29]	19 [11]	159 = 17.0%
Income $15,000-30,000	77 [84]	43 [37]	78 [93]	63 [52]	26 [21]	287 = 30.6%
Income $30,000-50,000	93 [90]	46 [40]	105 [101]	49 [56]	16 [22]	309 = 32.9%
Income over $50,000	75 [53]	18 [24]	56 [60]	28 [33]	6 [13]	183 = 19.5%
Total	274	121	306	170	67	938 = 100 %

example, transit and HOV lanes will have a low importance for most rural residents. Appendix B presents a more detailed description of importance-performance analysis as well as the multivariate statistical techniques.

Regression Analysis

Regression is used to understand the relationships among a larger number of factors simultaneously. It is especially useful when more than one factor is suspected to "cause" a particular effect. Regression analysis can also show the relative importance of various factors in influencing a given outcome.

In the simplest case of regression, a model is formulated that specifies an outcome or dependent variable as the function of one independent variable. Such a model can be used to measure the degree of influence of one factor on another, for example, how important is average income in explaining the degree of support for higher motor fuel taxes?

More complex models would use several variables simultaneously. This would make it possible to compare the relative importance of different variables—income versus residential location, for example. Next, the techniques can be used to predict future behavior; given a certain distribution of income and pattern of residential location, what kind of support can be expected for increased fuel taxes?

As discussed in Appendix C, a regression analysis from the National Demonstration Survey was used to identify which elements were most important in explaining overall satisfaction with the highway system (for example, safety ranked number two).

Factor Analysis

Factor analysis is a procedure that takes a large number of variables and searches to see whether they have a smaller number of underlying factors in common. Factor analysis is especially useful for condensing a mass of data to a manageable level by reducing many attributes down to a smaller number of key factors that underlie the attributes. For instance, with factor analysis, a group of 20 variables could be compressed into five sum-

mary factors. Factor analysis probes beyond the straightforward questionnaire answers to uncover more basic underlying elements that determine participant responses. It can also be an efficient way to summarize a large number of variables or characteristics.

Data used in factor analysis is often in the form of interval level ratings along a scale. Consumers might be asked, "How likely is it, on a scale of 1 to 10, that you would support a new toll road?" Factor analysis would be used to extract common themes in answer patterns.

For example, respondents might be asked to rate the importance of having restaurants, gas stations, and rest areas on highways. If respondents seemed to assign similar importance ratings for restaurants and highway rest areas, it would indicate that there is a common factor that, in part, determined their answers to both questions. Similarly, factor analysis can identify those characteristics that the public associates with a safe road. These examples are presented in the technical appendix (Appendix B).

Discriminant Analysis

Discriminant analysis is a technique used to identify the key characteristics that distinguish one group of respondents from another. For example, it has been used to identify the characteristics that separate likely Democrats from Republicans, buyers of one brand from another, and supporters of motor fuel tax increases from those opposed.

The results can be used either for analysis or prediction. They allow the researcher to identify the key operating factors that attract supporters or adherents, or act as obstacles to support or compliance. In many cases, discriminant analysis may identify public misconceptions about a particular program or issue. This information can also be useful in designing communications campaigns to reach special population groups, for example, those who have never used mass transit, litterers, or those who refuse to use seatbelts, and so forth.

Conjoint Analysis

Many difficult public decisions involve complex trade-offs. Conjoint analysis can help evaluate the relative importance of one factor or attribute as opposed to another when not all desirable factors can be achieved together. As such, it can be a valuable predictive and explanatory tool in the "real world" of conflicting goals. For example, budgetary limits mean that not all consumer preferences can be satisfied at once. Conjoint analysis can reveal implicit policy trade-offs and, thus, identify the most attractive combination of policies to fit within the cost limitations. For example, the conjoint analysis that was part of the National Demonstration Survey developed a set of trade-offs between individual policies and fuel tax increases, thus indicating the optimal policy combinations for each proposed tax increase (see Appendix C).

Consumers are not always able to give a direct value for each factor or even to specify the underlying terms of the trade-offs they make when evaluating the alternatives presented to them. However, they are generally able to state the extent to which they support various combinations of attributes or policy components. Conjoint analysis collects data on survey respondents' support for various hypothetical combinations of factors in hypothesized "packages." These data, in the form of ratings for each package, are used to derive the implicit system of trade-offs being used and, thus, the relative importance or value of each component taken alone. In this way, conjoint analysis seeks to understand the implicit trade-offs that underlie preferences, and to disaggregate the value of each component in complex combinations and comparisons.

Multidimensional Scaling

Multidimensional scaling (MDS) is a set of mathematical techniques that enables a researcher to uncover the "hidden structure" of respondents' perceptions of objects. These analytical techniques can be used to study consumer attitudes and, in particular, the factors that influence perceptions and preferences. These techniques attempt to identify the product or service attributes that are important to customers and to measure their relative importance, in some cases without asking them directly.

Multidimensional scaling techniques can reveal the principal dimensions along which people make comparisons, and can reveal what guides their perceptions and makes one object stand out above the rest. MDS could be used to identify the ideal combination of attributes desired by transportation users, thus revealing how to position a service or program to capitalize on its perceived strengths and desires.

The technical aspects of MDS, perhaps, can best be understood by visualizing a hypothetical example. Picture a map showing the locations of several cities in the United States. Each city would be positioned a certain number of miles north or south and east or west of every other city shown on the map. It would be a fairly easy task to construct a table of direct distances between each pair of cities using a ruler to measure the distances and recording the results according to the scale of the map.

Now suppose that there was no map, but simply a table showing distances between each pair of cities. This table would not show longitude or latitude, only air distances. Using data from the table, it would be possible to construct a map that positioned each city correctly. However, considerably more effort would be required to work backwards from the table of distances to the map than to work from the map to the table. In essence, MDS is a method for solving this second task—constructing a map from the distance grid.

Perceptual Mapping

Like multidimensional scaling, perceptual mapping provides a graphical representation of public perceptions of items or objects based on a set of attributes. But instead of mapping these perceived attributes directly or inferring them from relationships among plotted objects, perceptual mapping seeks to identify dimensions or characteristics that maximize the respondent's ability to distinguish among objects, that is, what characteristics allow us to discriminate between choices.

For this reason, perceptual maps are based on the results of discriminant analysis, and enable the researcher to focus attention on the dimensions or attributes most important in influencing consumer choice or preference. (This discriminant analysis is performed to distinguish among objects, however, and not among groups or respondents as is the classic use of discrimant analysis.)

Multidimensional scaling is often preferred when the goal is to map the image of an object and understand its position relative to other objects or competitors, and its strengths and weaknesses in terms of its attributes. Perceptual mapping, on the other hand, is often preferred when the goal is to understand the features that best distinguish an object from other competing objects (funding for new expressways versus bridge reconstruction, for example). Multidimensional scaling emphasizes the strengths and weaknesses of each option. A perceptual map, however, will ignore information that may be important to an object's image and desirability, but does not contribute to its differentiation or preference over other objects.

Correspondence Analysis

Correspondence analysis is a relatively new market research technique developed to graphically display and simplify large amounts of tabulated data in a single, easy-to-read multidimensional map. It can often be applied when other types of analysis cannot be used, that is, when answers to questions are given as characteristics or qualitative features rather than numerical values.

Correspondence analysis can be used to (1) identify groups of individuals with similar behaviors and attitudes; (2) analyze product position by tabulating the frequency with which individuals assign certain attributes to certain products or services and plotting these relationships among products and attributes; (3) compare changes in attitudes among groups of respondents before and after a communication or marketing campaign, assessing the impact on product or service position; and (4) evaluate policy options by examining how different groups perceive the attributes of these options and which options they prefer.

Correspondence analysis differs from perceptual mapping, which uses numerical ratings as data, by using frequency data, that is, data on the number of times or frequency with which each answer category was selected. Technically, it has been described as both principal components analysis and discriminant analysis of categorical data.

Psychographic Market Segmentation

Psychographic market segmentation, sometimes called "values and lifestyles research," is a relatively new approach in market research. It is analogous to the use of demographics to identify and describe different population segments; it differs in the variables used to classify individuals (individuals are classified with respect to activities, attitudes, interests, beliefs, and opinions rather than only the more traditional demographic variables of age, gender, income, and education). In other words, "psychographics" measures psychological and lifestyle or behavioral variables in the same way that demographics measures such characteristics as sex, age, income, and education. Often psychographic market segmentation uses both behavioral, psychological and demographic data.

Psychographic market segmentation is a useful method for identifying and describing population segments when the traditional means of segmentation (age, income, education) do not adequately discriminate among individuals with similar reactions. For example, the needs and reactions of business travelers are likely to be very different from recreational travelers, even when they are similar in age, income, or other demographic characteristics. In other words, people who are demographically similar may have very different attitudes, values, and lifestyles that greatly influence how they behave in particular situations, respond to policy, service or product developments, and react to marketing and communication efforts.

Psychographic market segmentation can be used to (1) identify key population segments or constituents based on combinations of characteristics including attitudes and behavior; (2) identify the key characteristics that distinguish one segment from another; (3) estimate each segment's relative importance or market share; (4) assess the implications of psychographic differences on product or service requirements; and (5) determine the most effective way to reach and inform individuals within these segments.

CHAPTER III

APPLICATION OF MARKET RESEARCH TO TRANSPORTATION ISSUES

Synopsis: **Market research can support a wide range of transportation planning, policy development, and implementation activities. For simplicity, these activities have been grouped into five basic areas: (1) Long-Term Planning—develop long-term transport system options in light of expected economic and demographic changes; (2) Specification of Objectives—identify directions of change, determine areas of emphasis, and establish levels of effort; (3) Service Improvement and Project Implementation—implement specific actions both for system expansion and system modification to better meet transportation demands; (4) Communication—identify gaps in public understanding and misperceptions, rectify public misunderstanding through education, alter public behavior through outreach, market transportation projects and services, and build public consensus; and (5) Policy Evaluation and Project Monitoring—monitor responses to specific policies, perform follow-up evaluations, and modify policy in response to these evaluations.**

Merging transportation activities with market research techniques, this chapter describes the factors and steps in designing appropriate market research. Although almost all techniques can be used in

market research and policy development for at least a segment of each topical area, some techniques are better suited than others for each type of problem.

As an aid in designing market research programs, three research approaches are identified: exploratory, descriptive, and causal. In turn, these are loosely aligned with two categories of analysis: qualitative and quantitative. Each analytical category is associated with certain criteria for data collection. Given the various data collection and analysis techniques identified as appropriate to the research objectives, design also includes administrative decisions on data gathering—the medium used, sample size and approach, and questionnaire design (or discussion outline, where appropriate).

The more sophisticated analytical methods produce a wealth of information important to planning but also cost more because they require broad-based surveys among a representative sample. Thus, the final choice of data collection and analytical methods is a function of research objective tempered by considerations of administrative burden, cost, and time relative to benefits of research.

DYNAMICS OF MARKET RESEARCH DESIGN

Market research can help provide the means to more effective allocation of resources by providing better information to transportation decision-makers. Using information gained from well-designed market research, these officials are better able to formulate policy that efficiently addresses public (perceived) needs because it reflects public priorities and combines features that are most important to potential and actual customers, yet balances financing with perceived value.

Market research is both broader in scope and more complex than simple opinion polling. It requires coordination of data collection and analysis with policy objectives and it uses sophisticated analytical techniques, where appropriate, to reveal inferences not immediately obvious in simple tabulations. Market research design, however, is not a lock-step progression through levels of decision with clearly marked directions at each juncture. It requires a balancing of objectives and constraints.

The purpose of this chapter is to help design market research projects appropriate to transportation activities. To this end, the general activity "transportation planning and implementation" is divided into five activities so that the potential for market research can be addressed more concretely. Market research should be considered a tool box rather than a structured machine. The tools are varied and often more than one tool can be used for a given task. Selection of the appropriate tools, however, requires a delineation of the tasks that need to be addressed. For each subject or task in transportation planning, a range of analytical and supporting data collection techniques could be used, while others can probably be ruled out as inappropriate. Specifying the planning task or question to be addressed thus narrows the methodological choices. The set of methodological options is overlaid with research purpose or approach—a function of intended applications—which, in turn, suggests the level of statistical precision required. This directs the researcher to either qualitative or quantitative analysis.

Given these methodological choices, cost and administrative considerations may further restrict the acceptable options. Although data collection methods must always be appropriate for the analytical techniques, there is flexibility in the exact market research design created. Some parameters such as interview length, interview mode, and sample size are variable within bounds set by other considerations.

Throughout the whole process of design and implementation, the researcher must always refer back to the original tasks and research purpose to make sure that choices made along the way to the final design do not undermine the usefulness of the research effort.

This chapter contains three segments. The first defines five basic activities or topical areas in transportation and briefly indicates which market research techniques appear most appropriate for each of these. The second segment discusses design of transportation market research—guidelines for selecting data collection and analysis techniques, the interplay between cost and design factors, and the need to consider in-house technical capabilities. The third segment reviews factors in implementing market research projects. These considerations affect the final profile or administrative details of the market research plan. This chapter focuses on design of market research for transportation; a review of market research actually undertaken in transportation is included in Appendix D.

PLANNING AND IMPLEMENTATION ACTIVITIES

Transportation policy planning, implementation, and administration can be supported by some form of market research at all levels. Five basic activities have been identified which form the basis for discussion of application of market research to transportation issues:

1. *Long-Term Planning:* develop long-term transport system in light of expected economic and demographic changes.
2. *Specification of Objectives:* identify directions of change, determine areas of emphasis, and establish levels of effort.
3. *Service Improvement and Project Implementation:* implement specific actions both for system expansion and system modification to better meet transportation demands.
4. *Communication:* identify gaps in public understanding and correct misperceptions, alter public behavior through outreach, market transportation services, and develop public consensus.
5. *Policy Evaluation and Project Monitoring:* pretest policies and monitor responses to specific policies, perform follow-up evaluations, and modify policy in response to these evaluations.

Tables have been developed for each activity area to point out those market research techniques that are probably most effective in supporting the general tasks described. Most techniques, however, are flexible and can be used in more instances than listed here; this is not an exhaustive listing, particularly because the tasks are described in very broad terms and specialized subtasks may very well call for use of a different technique.

Market research methods are not mutually exclusive but, rather, can be implemented simultaneously or in sequence to complement each other. For example, qualitative research can be used to "pretest" ideas, and reveal new views, that will be subsequently incorporated in more extensive quantitative research. Moreover, a single questionnaire survey can be used to generate information for several types of quantitative analysis, each addressing a different aspect of transportation.

Furthermore, techniques can be combined to more efficiently evaluate data. For example, factor analysis can be used to condense data into fewer variables and, then, regression analysis can be employed using the derived factors as independent variables.

Long-Term Planning

Long-term planning requires standing back from the current transportation problems and structures and momentarily relaxing all constraints on system development. The objective is to develop alternative long-term system configurations that will be efficient, given the economic and social environment projected for the future. A critical first step is, thus, the projection of economic activity, expected demographic and social structures, and the values that the traveling public is likely to place on the characteristics of different transport solutions. Development of a long-term plan to deliver the required service also builds upon the following components: (1) project future transportation demand; (2) describe characteristics of each transportation mode or policy (for example, ecological impact, energy consumption, capital and operating costs, and the relative importance attached to each of these by the public); (3) identify and evaluate qualitative factors important to customers (speed, reliability, comfort, flexibility, cost, safety); (4) delineate the "Alternative System," described in terms of system characteristics considered important to the general public and to transportation customers; and (5) identify transportation customers (business: travelers, goods shipments; personal: job commuting, leisure and vacation, support).

Long-term planning is based on projection of future needs and evaluation of various means to satisfy those needs. Satisfaction, however, implies customer satisfaction with the level and quality of delivery. Not all options are equally efficient nor do they all have the same qualitative attributes; transportation users are not indifferent to these distinctions. Market research can be employed to describe future needs, probable customers, and the traits or criteria considered most important by these users. Table 5 describes the market research approaches most appropriate to these tasks. Both qualitative and quantitative analyses yield important data for long-range planning, as indicated.

Specification of Objectives

Long-term planning sets out general goals and guidelines; these must be translated into a more detailed, functional, plan for transportation development. Specification of objectives entails a breakdown of general policy goals into the more discrete components required to satisfy transportation demand. To accomplish this effectively, more detailed information is required to assess the gap between long-term needs and current ability to supply services with respect to specific types of transportation demand and by geographic regions. Moreover, public support for objectives must be evaluated and public priorities investigated because not all shortfalls can be solved simultaneously or instantaneously.

At this level, objectives are stated in terms of problems to be addressed and shortfalls in service delivery to be rectified, for example, commuter congestion between Downtown and Uptown. Individual projects are not identified, that is, the objectives specified do not name specific road segments to be widened, highway interchanges to be added, connectors to be built, or mass transit alternatives to be introduced. In Specification of Objectives, the DOT determines the areas to be emphasized, the relative focus of investment, and the level of effort involved. Components include the following: (1) evaluate the current service base—describe service attributes, assess current performance and potential performance with current capital, and evaluate DOT performance; (2) determine direction for change—analyze perceived gap between importance and performance, describe the attributes to be emphasized and the modes and structures possessing those attributes; and (3) establish supportable level of effort—estimate the available financial base and prioritize general policy objectives, including consideration of public trade-offs among objectives.

Table 6 presents those market research techniques most useful in supporting such analyses. Although both qualitative and quantitative methods are useful in prioritizing single options and establishing level of effort, quantitative analysis will most likely be needed to effectively ascertain public attitudes and trade-offs among policy options.

Service Improvement and Project Implementation

In service improvement and project implementation, qualitative descriptors and policy objectives are translated into specific actions and projects. These can include both overall system development, requiring substantial capital investment, and system refinement or modification using the existing capital base for the most part. It also includes management of short term or sporadic local disruptions to minimize customer dissatisfaction.

Activities in service improvement and project implementation are quite specific, involving delineation of engineering projects, alterations in service delivery, and explicit policy modifications. Although objectives may have been ranked in order of importance in the previous planning stage, for example, emphasizing the need to reduce travel congestion between Uptown and Downtown, these objectives must be translated into specific solutions, for example, widen main arterials, new limited access raised roadway, enhanced bus service on reserved bus lanes, subway construction, and so on. It is important to assess public attitudes correctly because not only does the public pass on capital funding, it must support the decisions by actual participation. Areas of analysis include: (1) identify specific alternatives to achieve general objectives outlined previously; (2) evaluate each alternative, including public perception and assessment of proposed options; (3) rank order or prioritize individual proposed projects, unless this was done indirectly by prioritizing problem areas in Specification of Objectives; (4) identify and evaluate policy modifications or refinements that do not require radical changes in physical structure (including both permanent long-term policies and temporary short-term or local management issues); and (5) anticipate public response and assess likely support/use by various population groups.

Table 5. Market research for long-term planning.

Task	Market Research Method
PROJECT FUTURE TRANSPORTATION DEMAND	**QUALITATIVE METHODS:** Focus Groups: composed of business and community leaders, private individuals; randomly selected and self-selected or targeted; Non-random Surveys: among targeted groups of business leaders, private individuals. Used to: (1) gauge future magnitudes of demand for transportation services directly, (2) identify underlying factors determining total transportation demand by category (travel, commuting, goods movement); useful as self-contained effort and to identify parameters for (quantitative) predictive models of demand using regression analysis, risk assessment, and the like. **QUANTITATIVE METHODS:** Regression Analysis: predicting demand for transportation services (dependent variable) as function of business and personal economic factors; useful if other data sources do not exist for state economy (e.g., regional input-output tables) or these other data do not include information on mitigating factors or behaviorial/attitudinal variables that impinge on demand.
IDENTIFY IMPORTANT FACTORS, DESCRIBE IDEAL SYSTEM, NOTE TRADE-OFFS	**QUALITATIVE METHODS:** Focus Groups, Non-random Surveys, Quasi-random Surveys: identify side-effects and indirect impacts considered important (e.g., ecological impact, social repercussions, resource consumption), and qualitative factors important to users (speed, flexibility, safety); evaluate approximate importance attached to each by each segment of paying and using public; infer factors that determine user choice among modes and demand for transportation services. Used as sole source of information or as aid in designing quantitative survey research. **QUANTITATIVE METHODS:** Regression Analysis, Factor Analysis: with information on evaluation of current performance or satisfaction with various components of current systems and overall satisfaction, can discern relative importance of factors that are important in satisfying users. Perceptual Mapping, Multi-dimensional Scaling: by collecting information on qualitative traits, comparison between alternative modes or systems, evaluation of Ideal System and its distance from known systems, can infer the relative importance of qualitative characteristics and the ability of different alternatives to satisfy the public. Conjoint Analysis: explicitly deals with trade-offs among factors when there are constraints on achieving everything at once; calculates relative values/priorities and trade-offs.
IDENTIFY CUSTOMERS	**QUALITATIVE METHODS:** Focus Groups, Non-random Surveys, Quasi-random Surveys (mall intercept): delineate different groups of future users and the factors that distinguish them from each other (objective characteristics, attitudinal factors); identify components of demand (distance, frequency, etc.). **QUANTITATIVE METHODS:** Discriminant Analysis: identify factors that distinguish population subgroups that are clearly defined in advance (e.g., different age groups, geographically distinct such as suburban/urban/rural, behaviorally distinct such as auto commuters/transit commuters). Correspondence Analysis, Psychographic Market Segmentation: distinguish groups of users by demographic and/or attitudinal characteristics when groups are not segregated prior to the analysis according to some objective characteristic -- that is, searching to define meaningful subgroups and identify the factors that differentiate among them.

Table 6. Market research for specification of objectives.

Task	Market Research Method
EVALUATE CURRENT SERVICE BASE -- PERFORMANCE, ATTRIBUTES	**QUALITATIVE METHODS:** Focus Groups, Non-random Surveys, Quasi-random Surveys: solicit opinions on performance of components of current transportation system (general adequacy, specific advantages and disadvantages, relative importance of strengths and weaknesses); ranking of problems to be solved. May be adequate in itself or used as aid in designing larger scale quantitative survey.
AND	**QUANTITATIVE METHODS:**
DETERMINE DIRECTION OF CHANGE	Importance/Performance Analyis: indicate factors or services considered most important and those areas in which performance falls short thus candidate for improvement. Regression Analysis, Factor Analysis: assess relative importance of factors contributing to satisfaction with transportation service with respect to specific need (commute, goods shipment, leisure travel) or even with respect to specific service (travel on particular corridor, or by single mode). Correspondence Analysis, Psychographic Market Segmentation: discover population sub-groups that have different evaluations of system performance and attributes. Perceptual Mapping, Multidimensional Scaling: compare alternative means to achieve same service or alternative providers; indicates proximity of current service to "Ideal" and dimensions of shortfall. Conjoint Analysis: establish trade-offs public is willing to make in general factors, for example, balance between pollution and letting everyone drive in single-person autos for all needs.
PRIORITIZE OPTIONS	**QUALITATIVE METHODS:** Focus Groups, Non-random Surveys, Quasi-random Surveys: gauge level of public financial support for policies, elements in particular policies that elicit support, discover conditions considered onerous and factors regarded as critical to satisfaction.
AND	If consensus strong, may be sufficient by itself; otherwise may be used as precursor to broader quantitative research.
ESTABLISH LEVEL OF EFFORT	**QUANTITATIVE METHODS:** Conjoint Analysis: establish relative value of alternative options (general factors, objectives, service components); prioritize problems in order of importance to public and establish degree of (financial) support for solution of each problem area; estimate trade-offs among options (can do separate conjoint analysis for defined population subgroups, e.g., suburban/urban/rural so that more localized concerns can be identified and priortized individually for each). Discriminant Analysis: analyze defined population subgroups to see if their priorities, perceived needs, desired level of effort and direction differ significantly from other subgroups.

Two kinds of choice are encountered in Service Improvement and Project Implementation: (1) evaluation of alternatives: selection among different means to a single end (e.g., the way to solve congestion in Area A), and (2) prioritization of projects: selection among various projects or expenditures that, although addressing different problems, nonetheless compete for limited funds, such as determining whether investment in road-widening to solve congestion in Area A is more or less important than investment in a widened bridge in Area B.

Table 7 summarizes the market research methods appropriate to the general tasks of service improvement and project implementation, noting the type of information yielded by each research method. Some of the analytical components can be addressed simultaneously in a single market research effort. For example, research to reveal public perceptions, rank projects, and anticipate public response can be combined in analyses based on interproject comparisons and trade-offs.

Qualitative research may be sufficient in some cases, but not in others. For example, if there is significant public agreement on priorities, qualitative research may be sufficient to prioritize projects, perhaps just to confirm what DOT officials already felt to be true. However, if projects are fairly competitive with one another and there are no clear front runners, or if ranking is done indirectly, such as by identifying the underlying factors important to the "customers" and their perceptions of different projects, quantitative research is necessary to make subtle distinctions and to extract information by inference. Moreover, criteria inferred from quantitative research could be used to formulate a more generalized evaluation system for future planning.

Anticipation of public response can be estimated using some of the same data, and techniques, used for other tasks. Information on the number and characteristics of respondents in favor of a given project, e.g., a new transit service, can generate projections of transit riders as long as the questions were carefully phrased to sort out the users from those supporting the project for others but not themselves. In addition to these inferential techniques, public response can be anticipated by pretesting projects and recording public response in these test situations.

Communication

Communication is a two-way channel, relaying important information to the public but also incorporating the public into DOT processes as participant rather than as passive respondent. Market research is a required first step for effective communication to the public—it provides information that allows the DOT to design messages more efficiently for the population as a whole and to target messages to selected subgroups.

Communication can be an activity in itself or in support of another DOT undertaking. In either case, effective communication is based on prior information elicited from the targeted audience. Objectives include: (1) identify and correct public misperceptions about DOT policies, transportation funding, service constraints, and the like; (2) alter public behavior, such as driver practices, to increase road safety and attitudes to reduce littering, or to encourage use of alternative routes during highway construction; (3) market specific transportation services, such as transit off-peak or peak use, carpooling, etc.; and (4) develop public consensus for DOT programs and/or funding proposals.

Table 8 summarizes some of the communications tasks that can be supported with market research and indicates which market research approaches are most appropriate. Qualitative analysis is effective in generating ideas and creative approaches to communication; quantitative analysis is critical in identifying population subgroups that may be singled out for specially designed communication efforts.

Often, the public misinterprets the information it has or has insufficient information with which to judge performance or transportation policies. Communication can rectify this, using qualitative and quantitative market research to pinpoint these informational gaps by population groups.

Communication can be employed to alter behavior to achieve policy objectives as, for example, to make drivers more aware of safe driving practices (using seat belts, not tail-gating), to reduce highway litter, or to minimize aggravation due to construction projects. It can also be used to market services or increase public participation as, for example, in the use of mass transit. Market research supports these efforts with data on customer preferences, media effectiveness, and basis for appeal (for example, the service factors most important to potential customers).

Market research is also used to identify target subgroups within the general population, to design communications particularly appropriate to these subgroups, given their characteristics and interests, and to pretest communication materials.

Communication can also be employed in conjunction with other tasks to achieve a consensus in support of transportation authority policies. More specifically, information gained through market research on areas of concern, public prioritization of goals, trade-offs among specific transportation projects, and importance of service qualities can be incorporated in DOT funding plans and policy modifications, then communicated back to the public to elicit their support—voter approval of proposed funding methods or increased use of mass transit.

Policy Evaluation and Project Monitoring

Market research is used not only to gauge public opinion and anticipate public response, but also to monitor and evaluate transportation projects and policies to ensure that they are, in fact, achieving the goals intended. Effective management requires that the choices made are efficient in their use of resources and in satisfying customer needs. In this, delivery of transportation services is no different from any other consumer "product," and transportation executives have the same data needs as any executive concerned with customer satisfaction. This applies both to major investment projects, for example, highway interchanges and transit equipment; and to policy fine-tuning, for example, campaigns to enhance safety or increase transit ridership in off-peak hours.

Policy evaluation and project monitoring should not be considered a discrete activity, separate from other DOT activities, but one that is undertaken in conjunction with service improvement, project implementation, and communication. Activities include: (1) on-going monitoring of project to help in project refinement; and (2) post-investment evaluation of project effectiveness in achieving goals and alleviating problems.

Table 9 summarizes the modern market research methods that can support policy evaluation and project monitoring. In many cases, evaluation requires baseline market research data gathered prior to program implementation that are then compared to post-program market research data. Such baseline information

Table 7. Market research for service improvement and project implementation.

Task	Market Research Method
IDENTIFY SPECIFIC ALTERNATIVES TO ACHIEVE GENERAL OBJECTIVES	**QUALITATIVE METHODS:** Focus Groups: among general public, selected professionals, or business and community leaders, to brain-storm alternative means to solve generally-stated problems. **QUANTATIVE METHODS:** Probably not appropriate; though interview survey could be helpful if interviewer skilled at probing.
EVALUATE ALTERNATIVE MEANS TO GIVEN END **AND** **PRIORITIZE INDIVIDUAL PROJECTS**	**QUALITATIVE METHODS:** Focus Groups, Non-random and Quasi-random Surveys: give a sense of public reaction assessment of strong and weak aspects and preferences or relative ranking among alternatives and/or proposals. If strong consensus and large enough sample, may be sufficient data without quantitative research. Otherwise, use qualitative research as foundation for subsequent quantitative research. **QUANTITATIVE METHODS:** Conjoint Analysis: by presenting public with various program packages, establish rank ordering of alternative options to solve a given problem or a combination of problems. Perceptual Mapping: identify traits associated with various options, importance attached to those traits; used to select among projects or to modify a project to improve traits considered important and move actual project closer to "Ideal."
MODIFY SERVICE TO ENHANCE DELIVERY, INCREASE PUBLIC SATISFACTION	**QUALITATIVE METHODS:** Focus Groups, Non-random and Quasi-random Surveys: used to sense public assessment of strong and weak aspects of mode or service, the relative importance of each factor, and potential reaction to changes in service delivery. If strong consensus and large enough sample, may be sufficient data without quantitative research. Otherwise, use qualitative research as foundation for subsequent quantitative research. **QUANTITATIVE METHODS:** Perceptual Mapping: identify traits associated with various options, importance attached to those traits; used to select among projects or to modify a project to improve traits considered important and move actual project closer to "Ideal." Conjoint Analysis: assess value of improvements when traded off against costs or sacrifice in other areas (other services or service traits such as convenience, comfort). Multi-dimensional Scaling: compare competing providers to gauge strengths and weaknesses of each vis-a-vis ideal or relative position of a single focal service with regard to alternative services in terms of specific traits and characteristics. Correspondence Analysis, Perceptual Mapping: distinguish subgroups in population according to demographic and attitudinal characteristics or views in order to better respond to sub-group perceived needs (that is, to target improvements to sub-groups rather than full population if this is more efficient). Regression Analysis: predict response to change as a function of demographic, attitudinal, and service policy variables. Factor Analysis: determine if there are more basic, underlying elements impacting customer satisfaction and response to service changes that could become subject of policy or service modifications.
ANTICIPATE PUBLIC RESPONSE	**QUALITATIVE METHODS AND QUANTITATIVE METHODS:** All of the methods described above can be used to gauge probable public reaction by presenting participants with hypothetical situations and recording their considered responses. Pre-test materials, policy and service changes, and proposed projects: construct test cases for selected population or area and record actual responses -- service or policy change in segmented area, construct infrastructure in one area and record response by population subgroups so that results can be extrapolated to include other areas.

Table 8. Market research for communication.

Task	Market Research Method
REDRESS PUBLIC MISPERCEPTIONS, MISINFORMATION	**QUALITATIVE METHODS:** Focus Groups: assess response to specific points, introduce new misperceptions not realized by DOT. Non-random and Quasi-random Surveys: assess response to specific points but not reveal misperceptions unrealized by DOT unless interview is loosely structured and interviewer skilled at probing. **QUANTITATIVE METHODS:** Discriminant Analysis, Correspondence Analysis, Psychographic Market Segmentation: investigate possibility that misperceptions/misinformation prevalent in population subgroups rather than randomly across full population so can better target communications efforts.
ALTER PUBLIC BEHAVIOR	**QUALITATIVE METHODS:** Focus Groups: investigate factors motivating behavior and susceptible to change, identify population sub-groups to be targeted for communications, discover and assess approaches most likely to induce changes, pre-test communications materials. Non-random and Quasi-random surveys: same as focus groups but more restrictive in generation of new ideas, relies more on pre-conceived DOT concepts; personal interviews (e.g., mall-intercept surveys) useful in pre-testing communications materials; phone surveys useful in pre-testing audio materials. **QUANTITATIVE METHODS:** Correspondence Analysis, Psychographic Market Segmentation: delineate population subgroups by demographic and attitudinal attributes to better target communications materials, note whether some subgroups' behavior already within acceptable bounds. Discriminant Analysis: when behavior is split into two distinct groups (desirable, undesirable) rather than a range from poor to good, use discriminant analysis to see if two population groups defined by behavior differ significantly in other characteristics, thus better design communications efforts. Correspondence Analysis, Psychographic Market Segmentation: delineate population subgroups by demographic and attitudinal attributes to better target communication efforts.
MARKET SERVICE	**QUALITATIVE METHODS:** Focus Groups: investigate factors motivating behavior, identify service characteristics important to potential customers and their perceptions of current service attributes, identify population sub-groups (potential customers) to be targeted for communications, discover and assess approaches most likely to induce changes, pre-test communications materials. Non-random and Quasi-random surveys: same as focus groups but more restrictive in generation of new ideas, relies more on pre-conceived DOT concepts; personal interviews (e.g., mall-intercept surveys) useful in pre-testing communications materials; phone surveys useful in pre-testing audio materials. **QUANTITATIVE METHODS:** Conjoint Analysis: evaluate relative importance of service attributes, gear communications to emphasize those attributes most important to targeted group. Multidimensional Scaling, Perceptual Mapping: identify perceived service strengths and weaknesses and market strong points, correct misperceptions where exist. Correspondence Analysis, Psychographic Market Segmentation: delineate population subgroups that are potential customers by demographic and attitudinal attributes to better target marketing efforts.
DEVELOP CONSENSUS, SUPPORT FOR DOT PROGRAMS	**QUALITATIVE METHODS:** Focus Groups, Non-random and Quasi-random Surveys: assess services and factors most important to public, incorporate this information by emphasizing important positive elements in developing support (perhaps also modify policies to improve negative ones), tie proposals to public's felt needs; pre-test communications materials. **QUANTITATIVE METHODS:** Conjoint Analysis: ascertain public priorities for specific projects, project components, or qualitative elements, and use this to structure program and presentation that incorporates these priorities. Regression and Factor Analyses: investigate factors that impinge on support, address those factors or population groups characterized by those factors to increase consensus. Correspondence Analysis, Psychographic Market Segmentation: delineate population subgroups to target for communications. Multi-dimensional Scaling: assess program or project characteristics that appeal to population, and evaluate shortfalls in current system that must be acknowledged and addressed to elicit popular support for programs.

Table 9. Market research for policy evaluation and project monitoring.

Task	Market Research Method
MONITOR AND EVALUATE COMMUNICATIONS PROJECTS	**QUALITATIVE METHODS:** Focus Groups, Non-random and Quasi-random Surveys: discuss campaign, note positive and negative aspects, which components recognized, and response to communications in terms of opinions, actions taken. Panel Surveys (Quasi-random or random but small-scale): monitor participants' behavior in response to communications by comparing responses before campaign to those during and after campaign (track actual actions or attitudes without alerting participants to communications campaign). **QUANTITATIVE METHODS:** Perceptual Mapping, Multi-dimensional Scaling: by performing pre-communications and post-communications surveys,[1] note change in position of targeting service or attitudes in response to communications project. Conjoint Analysis: based on pre-campaign and post-campaign survey data,[1] evaluate shifts in prioritization of projects or factors targeted in communications. Regression Analysis: based on data from pre- and post-communications surveys,[1] assess relative contribution of various factors to change in attitudes or behavior over the course of the communications effort; note which factors are associated with a weakened impact of communications. Correspondence Analysis: using pre- and post-communications survey data,[1] note whether some groups' positions altered more than others, indicating group-related variations in response.
MONITOR AND EVALUATE CONSTRUCTION PROJECTS, POLICY CHANGES	**QUALITATIVE METHODS:** Focus Groups, Non-random and Quasi-random Surveys: discuss project or policy changes, note positive and negative aspects, response to projects or policies in terms of opinions, actions taken. Panel Surveys (Quasi-random or random but small-scale): monitor participants' behavior in response to projects or policy policy changes by recording behavior or attitudes before changes and comparing them to those during and after changes. **QUANTITATIVE METHODS:** Perceptual Mapping, Multi-dimensional Scaling: by performing pre- and post-project or policy change surveys,[1] note change in position of perception of targeted service in response to project, particularly with respect to "Ideal Service." Conjoint Analysis: based on responses from pre- and post-project or policy change surveys,[1] evaluate shifts in prioritization of felt needs or factors targeted in projects or policy changes (for example, did relative importance of "reduce congestion between Uptown and Downtown" change after express bus lane was introduced?). Regression Analysis: based on data from pre- and post-surveys,[1] assess relative contribution of various factors to change in evaluation of targeted transportation services due to project or policy changes being evaluated; note which factors are associated with a weakened impact of project (either perceived impact or actual change in behavior). Correspondence Analysis: using data from pre- and post-communications surveys,[1] note whether some groups' positions altered more than others, indicating group-based variations in response or impact.

[1] In lieu of pre- and post-activity surveys, it is possible to conduct a single survey in which respondents are asked to recall their attitudes and/or actions prior to a certain event or date and use this information as the "pre-activity" survey data. This, however, produces a less accurate baseline than pre-activity surveys as recollections can be biased or clouded by subsequent events.

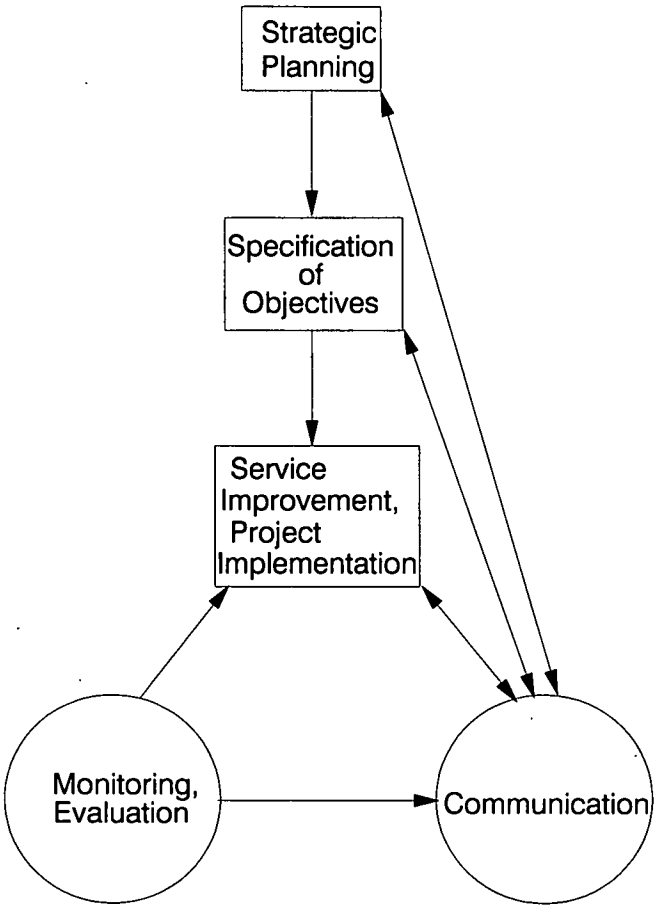


Figure 1. Flow of information.

may be incorporated in market research conducted for another activity (for example, as part of Specification of Objectives); in some cases, particularly communications efforts, baseline market research may be an explicit part of the evaluation program.

Market research for evaluation can be based on survey participants' recollections of their reaction to particular actions or services, their satisfaction with a project or policy changes, and how the project or policy affected their behavior. Or, more accurately, evaluation can be based on before-and-after surveys of large groups of respondents (quantitative analysis) that generate numerical estimates of a general shift in attitude, behavior, and response. Market research can also be based on longitudinal studies of the same individuals—panel surveys that track selected respondents over time during the impact period.

In summary, each of the five planning/implementation activities is a distinct component in the full transportation policy planning, implementation, and administration process; the activities move from the very general to the more specific. These activities can all be supported by market research. Moreover, the information gathered for one activity contributes to other activities as well. Figure 1 summarizes the flow of information. Communication receives from and feeds into the other four activities; monitoring/evaluation stands by itself to the side as an input into service improvement and project implementation. Of course, information gained through market research at each planning stage is used not only as an input at that level but also in structuring policy at the next level of specificity.

FACTORS IN MARKET RESEARCH DESIGN

It is clear that there are a number of ways to collect market research data and a wealth of analytical techniques for evaluating them. But not all collection and analytical techniques are appropriate to all goals or in all circumstances. Nor is there a one-to-one relationship between techniques and circumstances—there is almost always a choice.

There are a number of factors that influence the choice among techniques including: general research approach, importance of visual aids, administrative and budgetary considerations, cost of data collection and analysis, in-house technical capabilities; and specific research applications.

General Research Approach

Market research can be broad and open-ended in its approach or very focused on a particular question; it can identify broad concepts and generate new ideas, or it can produce statistically valid projections. Basically, there are three general approaches in market research; they are delineated as follows:

1. *Exploratory research*—undertaken to gain insights into the general nature of a problem, to generate new ideas or inventories of more specific alternatives, to develop lists of factors considered relevant to the issue, and to reveal preliminary reactions.
2. *Descriptive research*—used to provide more specific information on some aspect of the market or service environment. This requires prior knowledge of the types of information desired, the attributes that are considered relevant, or characteristics and alternatives that are considered important.
3. *Causal research*—employed to show the direction and strength of a relationship between variables (not just an association among them without a sense of causality).

The choice among the three general approaches depends on the market research objectives and intended applications. These approaches are loosely affiliated with the three categories of data collection: (1) data for quantitative analysis; (2) data for qualitative analysis; and (3) data for quasi-quantitative analysis.

The relationship is approximate: market research objectives suggest the appropriate research approach and, at the same time, point to the one or more data collection techniques that are appropriate.

Exploratory research, by definition, is not geared to precise statistical projections or descriptions and, thus, does not mandate the use of quantitative analysis. Analytical precision is probably not a primary concern. Qualitative analysis is sufficient to elucidate concepts, suggest new approaches, explore a topic, and generate new ideas, although it cannot be used to indicate the degree of likely public support for any concept or idea. It may be used to clarify issues for subsequent quantitative research, particularly if the initial exploratory research indicates a wide range of public opinion and no clear direction for public policy. Exploratory research can use quantitative analysis, but it is not mandated.

On the other hand, descriptive and causal research generally demand greater analytical precision to generalize results or to explore the strength of relationships among various factors. This, in turn, means quantitative analysis. Any research objective that requires projection of public response, calculation of degree of support, prioritization of needs and projects based on public

preferences, and accurate descriptions of a target population group's characteristics also requires quantitative analysis that is based on scientifically selected random samples. Thus, descriptive and causal research are usually based on quantitative analysis. If qualitative analysis is used (e.g., a limited number of focus groups) in descriptive or causal research, it is usually as a preface to more quantitative analysis.

Quasi-quantitative analysis is an approximation of quantitative analysis; it falls short by not meeting all the criteria for quantitative analysis and, thus, it cannot be used to predict precise proportions of the general population that will respond in a similar fashion. Quasi-quantitative analysis, however, can be used for descriptive and causal research when there is a great deal of public agreement (for example, almost everyone agreed that road alignment A was preferable to B) and/or approximate results are sufficient (for example, between 50 and 75 percent of participants would support a new interchange at I95).

Importance of Visual Aids

Some transportation market research is concerned with public reaction to media materials, directional signs, or physical configurations. In these cases, effective research requires the use of visual aids or even having respondents situated in a specified environment. In quantitative analysis, this restriction essentially precludes the use of telephone interviews and suggests the use of personal interviews, group discussions, mail surveys, or observation of respondents in the targeted situation.

Cost

Cost is, of course, always an important consideration. However, cost must be balanced against quality considerations because lower cost options usually do not yield as rich results as higher cost options. Cost is affected by number of participants, time spent with each participant, method of sample selection, and mode of data collection.

Overall, both cost and quality increase as the number of participants increases. Thus, qualitative research is less expensive than quasi-quantitative and quantitative research because many fewer participants are involved. For the same reason, quasi-quantitative is less costly than quantitative research. Quantitative research is based on large numbers of participants and, therefore, is generally most expensive.

Clearly, the more time spent with each participant, the greater the data collection costs and the fuller the data collected (more issues explored and more detailed responses). Number of participants and time spent with each can be traded off against each other to satisfy cost constraints. Table 10 shows the cost ranges for telephone interview surveys of varying lengths and sample size and, thus, the trade-offs that are possible between sample size and interview length for telephone surveys.

Method of sample selection affects costs because of the labor time involved. Selecting participants from predetermined population lists (census tract address lists, telephone books) requires (1) formulation or existence of such lists, (2) selection of potential participants, and (3) in some cases, such as personal interviews, prior contact to set appointments. Random telephone dialing for telephone surveys, on the other hand, requires no prior lists or formal selection. The least costly method of sample selection for personal interviews is encounter sampling, that is, intercepting potential participants at shopping malls, on the street, or at a public meeting and asking them to participate in a short interview.

Mode of data collection also affects cost. Gathering information from participants together in a group (some forms of qualitative and quasi-quantitative research) is less expensive per participant than working with each participant individually. However, group situations have their own dynamic (responses reflect more than individual opinion) and some segments of the population may not be represented.

Costs also vary among methods for collection of data from participants on an individual basis. Personal interviewing is most expensive per participant but yields the fullest results when interviewers skilled in probing are used. Mail surveys are considered

Table 10. Estimated cost ranges, telephone survey of general population.

Sample Size (completed interviews)	Length of Interview			
	5 min.	10 min.	15 min.	20 min.
500	$10,000-20,000	$10,000-25,000	$15,000-25,000	$15,000-30,000
1,000	$20,000-30,000	$25,000-35,000	$25,000-40,000	$30,000-45,000
1,500	$25,000-35,000	$30,000-40,000	$35,000-45,000	$40,000-55,000

Note: These costs are estimated ranges, including interviewing and basic data processing. Costs will vary considerably depending on the expected refusal rate and incidence rate (percent of respondents on list who are actually qualified to participate) and differences in study goals and objectives that may require different methodologies, types of design, and analysis. Costs will also vary due to the type of report or presentation that is desired.

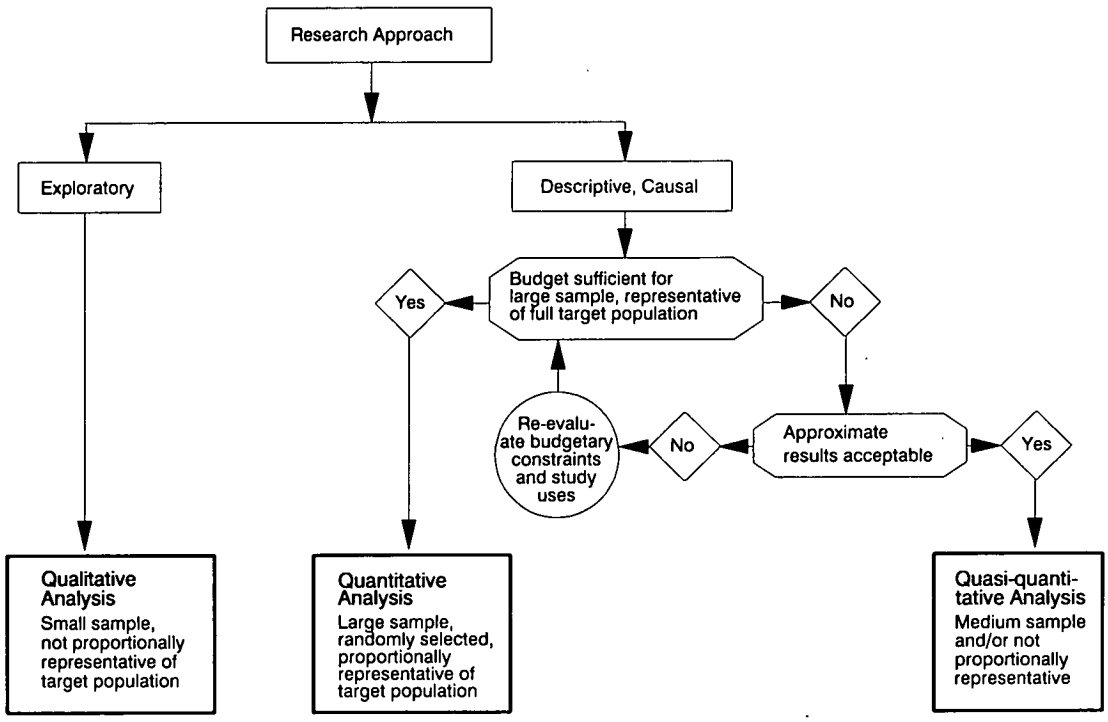


Figure 2. Decision tree—selection of type of analysis.

least expensive, but the high rate of nonresponse characterizing most mail surveys can lead to seriously biased results. Telephone interviews can be administered more easily than self-administered mail surveys, allow probing, but do cost more because of the labor costs for interviewers.

Each reduction in interview length limits the number of issues that can be explored; each reduction in sample size or increase in nonresponse increases the error in survey analysis (for example, tabulations may have a margin of error of plus or minus 20 percent rather than 5 percent in predicting response of the population, in general, to the issues reviewed).

Level of In-house Technical Capabilities

Limited in-house technical capabilities may restrict use of some techniques unless outside help is added. This, in turn, affects cost, although it does not always result in higher costs. The net financial impact of using outside expertise is the result of three factors:

1. Does outside help substitute for in-house labor or is it added onto in-house labor that must be included in cost anyway?
2. Is outside labor more expensive per person-hour than in-house labor?
3. Does outside labor have lower *unit* costs because of economies of scale and the efficiencies inherent in an organization specifically designed for such market research? The greater efficiency brought to the project by outside experts may more than outweigh any additional costs associated with the use of market research specialists.

CHOOSING A MARKET RESEARCH DESIGN

Unfortunately, there is no simple road map that dictates which way to turn at each fork or juncture in designing market research. Each of the factors described earlier enters into the design process; some choices are incompatible (for example, low cost and large sample for statistical precision); some choices are unrelated (for example, use of visual aids and expenditure). The challenge in designing market research is to select the most cost-effective and analytically efficient techniques appropriate to the objectives delineated.

Type of Analysis

Figure 2 graphically illustrates one decision process in designing a market research project. General research approaches are indicated at the top. Exploratory research is basically qualitative; personal preference and/or cost considerations will influence the choice among the alternatives and the number of participants included. The more focused the issue and/or the greater the degree of public agreement, the easier it is to rely on only one or a few focus groups, polls taken at a few public meetings, and nonrandom in-depth interviews in designing policy. Focus groups, including expert panels, are the best forum for generating new ideas and innovative approaches to problems such as dealing with construction delays. Because they are not rigidly confined to predetermined questions, focus groups are particularly useful in uncovering basic issues that concern the public (as opposed to specific projects or proposals), for example, distrust of DOT criteria in choosing projects or feelings of alienation.

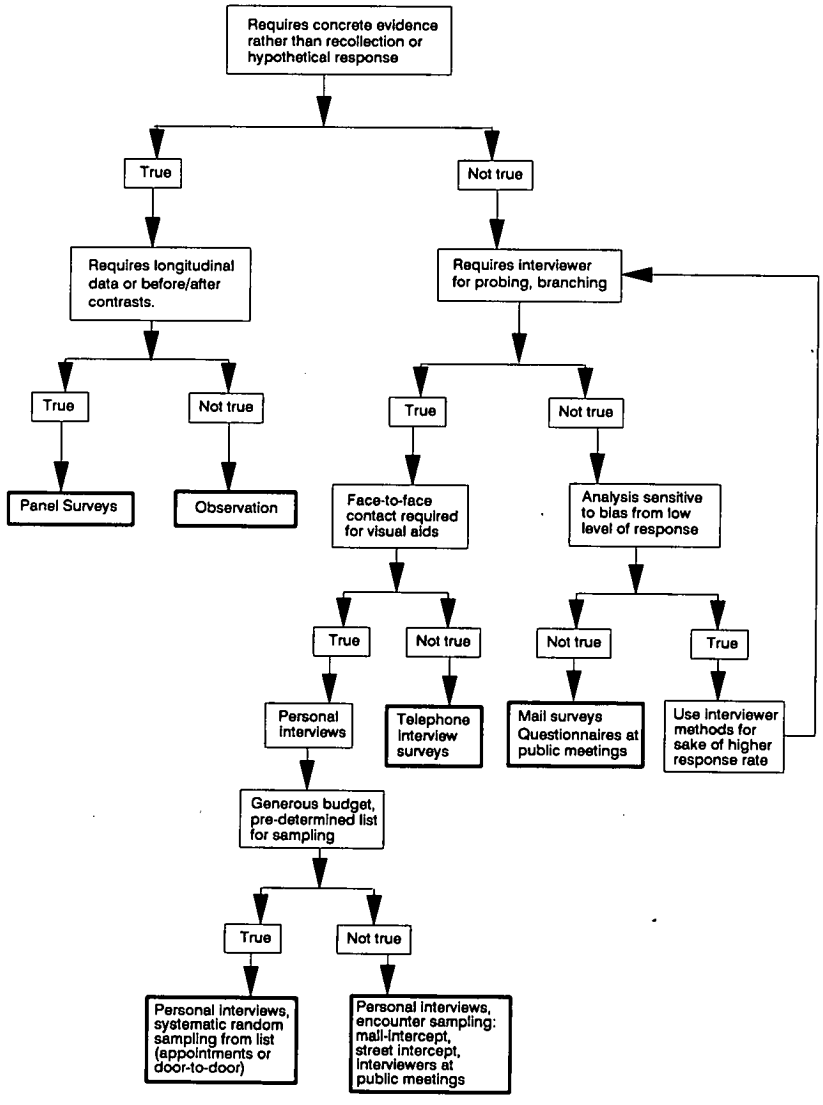


Figure 3. Decision tree—determining method of data collection for quantitative analysis.

Data Collection Method, Quantitative Analysis

Quantitative analysis is best used when the issues are more clearly delineated and when more statistically precise estimates are required. Quantitative analysis is undertaken to support descriptive and causal studies; quasi-quantitative analysis is an offshoot undertaken to reduce costs.

Figure 3 illustrates a decision path in choosing a survey form for quantitative analysis. Choices are based on a number of factors including the preference for actual reactions (rather than recalled or hypothesized), sensitivity of results to nonresponse, need to use interviewers for probing and branching, use of visual aids, and existence of predetermined population lists for sample selection. For example, the complexity of the questions necessary to elicit useful data may preclude any form of self-administered questionnaire. Thus, data collection requires interviewers, and mail surveys are ruled out. If questions are straightforward and easy to answer without help, mail surveys should be considered. However, if results are sensitive to bias caused by nonresponse, mail surveys would be inappropriate unless effective follow-up can be implemented and the path turns back to interviewer-administered surveys.

It is noted that the criteria and the end-choices illustrated in Figure 3 are not the only ones that are possible. Certainly, intercept surveys can be chosen instead of telephone surveys even if face-to-face contact is not required; they might be chosen for other reasons (for example, if it is easier to reach a certain group of suburban transit users that way). If other criteria are important, a new decision tree should be created and used to screen the various techniques, keeping in mind the characteristic advantages and disadvantages of each discussed above.

In each data gathering environment—intercept surveys, panel surveys, telephone surveys, and so forth—respondents can be selected according to the strict criteria for true quantitative research; or, by relaxing some of the criteria, data gathering can fall into the quasi-quantitative category. The choice between truly quantitative and quasi-quantitative analysis is a function of research objectives tempered by cost considerations, essentially cost minimization subject to constraints imposed by the need for numerically useful results. Quasi-quantitative analysis

will yield approximate results; they will approach statistically significant results as the sample more closely conforms to standards for true quantitative analysis. However, as the sample becomes larger and more representative, costs increase.

Data Analysis for Surveys

The design process extends to Figure 4 where methods of quantitative analysis are selected to fit the purpose of the study. These analytical methods are often applied to data collected for quasi-quantitative analysis, and the results look like statistically valid conclusions. However, it is misleading to imply that the results are as precise as those based on true random survey data. The choice of analytical technique or techniques depends on the uses to which the results will be put, such as, defining a population segment and substantiating a hypothesis about correlation between attitudes and personal factors. In many cases, answers to the same sets of questions can generate data that can be evaluated with several different types of techniques—importance-performance, discriminant, and factor analysis were all used on attribute ratings in the National Demonstration Survey. Moreover, a single survey can contain several sections each geared to data collection for a particular analytical method. The particular uses of each technique were described in Chapter II; they are briefly noted here to complete the decision tree for the primary structural elements in market research design.

Simple tabulations are sufficient when issues are straightforward—how many people in each group support toll roads? and so forth. More complex methods are required to discover underlying relationships among the factors that influence behavior. Cross tabulations can indicate possible relationships between any two variables, but multivariate analysis is needed when more than two factors are involved.

Trade-offs and prioritization in virtually all contexts can be evaluated with importance-performance analysis or, at a more sophisticated but more revealing level, conjoint analysis. Perceptions, implicit criteria for evaluation, preferences can be revealed with multidimensional scaling and perceptual mapping. Group characteristics, the elements distinguishing one group from another, can be identified with psychographic market segmentation and, to a limited degree, with cross-tabulations. If the groups are already defined, discriminant analysis can be used to reveal the below-the-surface factors that distinguish the previously defined segments.

Regression analysis is important in assessing the importance of certain variables in explaining interpersonal variations in behavior or attitudes. When individual variables seem to group together in explaining behavior, perhaps being different facets of the same underlying element, factor analysis can be employed to define the variable groups. In turn, the newly defined factors can be used in regression analysis to explore the relationships between a dependent (behavioral) variable and groups of explanatory factors.

IMPLEMENTING MARKET RESEARCH

Implementation encompasses all the activities that support data collection and analysis. There are two basic activities: selection of participants and design of the information instrument (questionnaire, etc.).

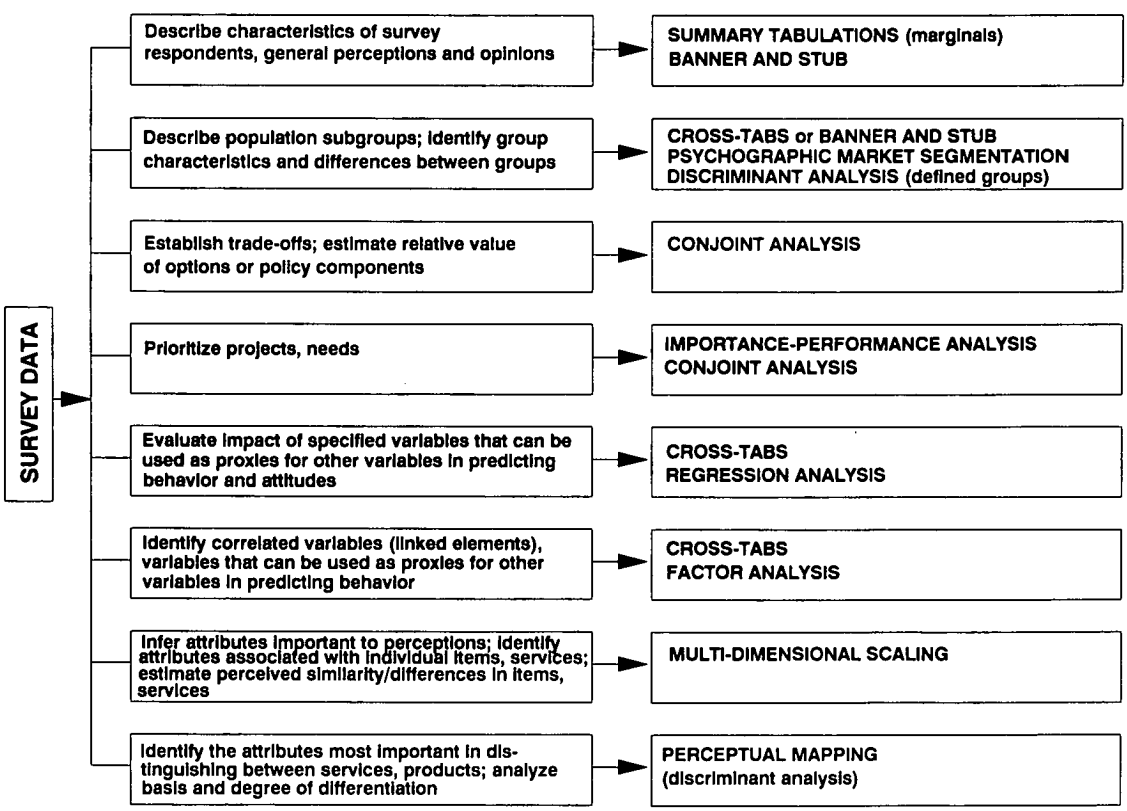


Figure 4. Decision tree—selection of analytical techniques.

Selection of Market Research Participants

All data collection techniques entail some form of sample selection. Data collection for quantitative analysis requires a more structured and systematic approach than that for qualitative analysis, but the latter still requires selection of market research participants.

Qualitative Research

Participants for focus groups and public meetings can be selected in the following ways:

1. *Self-selection:* notices are posted inviting all interested persons to attend.
2. *Targeted invitations:* persons known for their special expertise or demonstrated interest in a particular topic are invited to attend "expert groups" to brainstorm ideas and comment on selected issues.
3. *Random selection with screening:* individuals belonging to certain population strata (e.g., all local businessmen) or the general public are selected randomly, screened according to some criteria to ensure representation of all relevant population subgroups (gender, age, racial diversity), and invited to attend a focus group. Screening can also include more restrictive criteria, such as frequency of travel and car ownership.

Self-selected participants are usually composed only of individuals with a direct stake in the issue under consideration; they are not representative of the full population. This, however, does not in any way invalidate the ideas they generate; it ensures their interest even if they do not speak for the rest of the population.

Participants selected for their expertise do not represent the general population but, rather, are constituted as a one-session "think tank" to generate ideas and comments to help hone policies for a large public population; their ideas represent a broader base than those of participants drawn from the population at large.

Participants chosen randomly usually represent a broad spectrum of the targeted population. Generally, they are contacted by telephone using general population lists or specialized lists and screened through a short telephone interview. The composition of the focus group is *not* identical to that of the general (or targeted) population; it is structured so that all significant groups are represented but not necessarily in proportion to their numbers in the population.

Very often, outside firms specialized in market research are employed to contact and screen focus group participants and to conduct the sessions in accordance with client objectives. Clients often observe the proceedings from behind one-way glass in adjacent rooms.

Persons enlisted for in-depth personal interviews can be chosen in much the same way using posted notices, telephone contacts, and, in addition, street encounters (quasi-random selection).

Quantitative Research

Quantitative research requires scientifically designed selection of participants. In essence, this means random sampling of the general population or a specifically defined subgroup or subgroups (strata) within the general population. The sample thus derived is essentially a microcosm of the targeted population (though some groups may be intentionally overrepresented to ensure sufficient observations). Appendix A discusses the variables that determine sample size and the methods of ensuring randomness in selection. In brief, selection of participants for quantitative analysis requires: (1) definition of the relevant population to be included; (2) definition of strata that will be sampled separately to ensure representation of important subgroups (rural/urban, geographic regions) or, in encounter sampling, definition of sites that ensure selection of a representative total sample; and (3) random selection of a "significant number" of individual participants within each stratum or, in encounter sampling, at each site; the desired sample size is a function of expected variance.

For surveys using participants selected in advance, random selection of individuals can be achieved by random digit telephone dialing with each stratum defined by area code and telephone prefix, by systematic random selection from lists (for example, every fourth household), or by other techniques that preclude selection bias. Sample selection by encounter should be based on objective rules if possible, for example, every fifth adult that passes. Of course, it is harder than sample selection from predetermined lists where people are fixed in place.

Quasi-Quantitative Research

Quasi-quantitative research involves some randomness in participant selection but is not as broad nor as systematic as true quantitative research. That is, although substantial numbers of participants may be involved, one or more of the requirements for true quantitative analysis is not met—the sample is not selected randomly, not all strata are represented, or the number of participants is too small to permit statistically precise conclusions.

Data collection based on encounter sampling has a built-in tendency to nonrepresentativeness, thus, often restricting its use to quasi-quantitative analysis. For example, mall-intercept surveys do not sample the population that shuns mall shopping altogether. On the other hand, these methods easily satisfy the criteria for quantitative analysis if the targeted population includes only those people frequenting the selected sites, for example, those driving to shopping malls for a study of mall access routes.

Questionnaire and Discussion Design

All data collection techniques are organized around a previously defined set of questions, some more flexible and loosely structured than others. Group discussions are based on topical outlines if not specifically worded questions; surveys, of course, require more tightly structured questions and even precoded answers. In many instances, surveys are preceded by group discussions or focus groups to flesh-out the list of alternatives to be considered and to draw up lists of precoded responses to facilitate rapid recording of answers during full-scale survey interviews.

Several factors must be kept in mind in designing data collection instruments: amount of time available, unintended bias, and difficulty of administration.

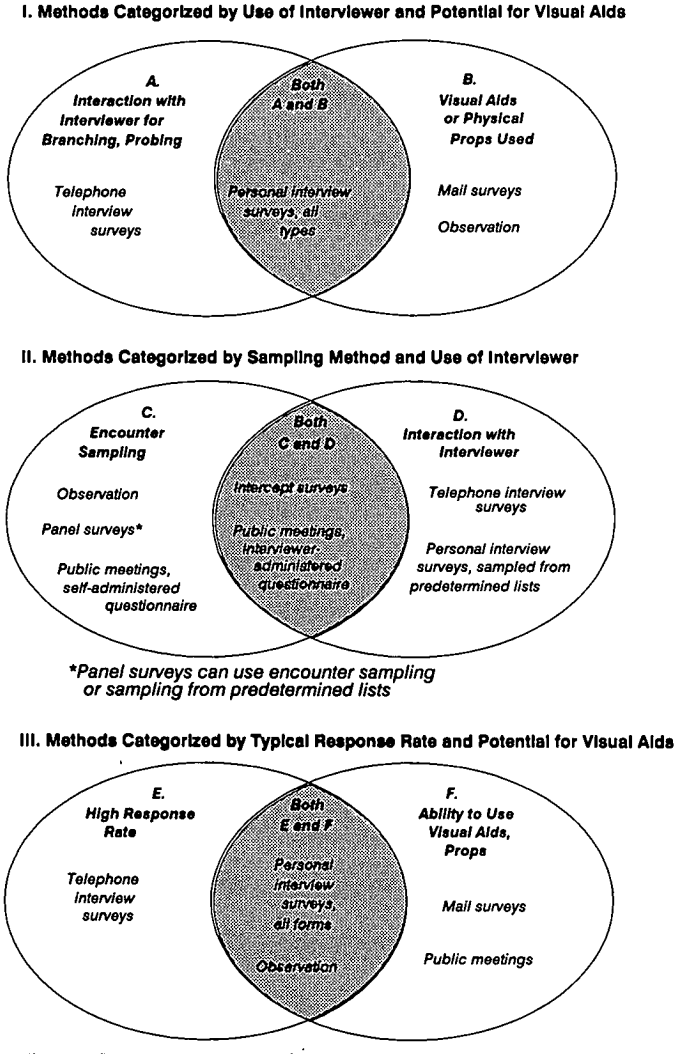


Figure 5. Categorization of data collection methods.

Amount of Time Available

Focus groups typically last 2 hours; telephone survey interviews should not exceed 25 min unless participants are selected because they are especially interested in the topic of discussion. Mall-intercept interviews are often limited by the fact that people are rushed to finish their errands or they have children with them. Observation, of course, has no limit except the time involved in the action under observation.

Unintended Bias

The way questions are phrased or the names given to certain topics or responses can often carry unintended overtones that bias respondents to one answer or another. In fact, even listing the alternative selections in mail surveys or telephone interviews biases the responses because it tends to cut off consideration of unlisted options ("other" is often given little attention in opinion questions). The wording and structure of all questions and descriptive introductions should be reviewed critically to purge them of any unintended biases or hidden pressures.

Difficulty of Administration

Questionnaires or discussions that require a lot of "branching," such as selection of subsequent topics/questions based on earlier answers, are more difficult to administer. They are often too difficult for self-administered written questionnaires and they require skilled interviewers for face-to-face interviews. They are, however, easy to administer when computer-based interviewing is used for telephone surveys (the computer is programmed to select the proper follow-up questions when answers are entered).

CONCLUSION

There is a loose interaction among all factors influencing market research design and implementation; the final design is the result of balancing these elements. It is analogous to working within the boundaries of the intersection of multiple sets or circles where each circle represents a factor or constraint taken into consideration and the final market research program must be selected from within the overlap area—methods that satisfy *all* sets of characteristics.

Figure 5 illustrates this approach using two factors at a time for three pairs of factors. In the first pair, Circle A contains all data collection methods that use interviewers, a requirement for complex branching and probing. Circle B contains all data collection methods that permit the use of visual aids or props. The area where Circle A and Circle B overlap—the shaded area—contains the methods that belong to both circles, that is, they use interviewers and visual aids can be used (i.e., all types of personal interviews). The area to the left in the crescent Circle A segment lists those methods that belong *only* in Circle A—use interviewers, but no allowance for visual aids (telephone interview surveys); the crescent area to the right lists those methods acceptable for the use of visual aids or props but which do not employ interviewers (mail surveys, observation).

The second pair of circles classifies methods by interaction with interviewer and whether encounter sampling is used. The third pair classifies data collection methods by typical response rate and the ability to employ visual aids or props.

No single research design is best for all circumstances; this chapter described options and general rules for selecting options but, in the end, each transportation market research project must be designed as a unique project by persons conversant with the available methods, the research objectives, and the cost and technical constraints.

REFERENCES

1. AIKER, D.A. and DAY, G.S., *Marketing Research.* John Wiley and Sons (1986).
2. BABBIE, E., *Survey Research Methods.* Wadsworth Publishing Company, Inc., Belmont, California (1973).
3. NIE, N.H., HULL, C.H., JENKINS, J.G., STEINBRENNER, K., and BENT, D.H., *Statistical Package for the Social Sciences* (SPSS). Second Edition, McGraw-Hill Book Company, New York (1975).

APPENDIX A

FUNDAMENTALS OF RANDOM SAMPLING

INTRODUCTION

The general goal of quantitative analysis in market research is to predict behavior or describe the characteristics of a population. Ideally, everyone in the target population would be surveyed and the results would then certainly be descriptive of that population. Such an undertaking is, in most cases, not cost-effective. Even the United States Census does not ask everyone to complete the long form of the census questionnaire. Fortunately, it is usually not necessary to survey each member of the targeted population -- a properly obtained sample can yield results that are adequately representative of the population within some estimable margin of error.

The best approach to obtaining a representative sample is to use a random sample. A random sample is one in which each member of the population has an equal probability of being included in the sample; there is no systematic tendency to exclude people from one segment or tendency to oversample people from another segment.

A random sample has the following advantages over a non-random sample:

- Allows the researcher to define the amount of variation that is directly attributable to the size of the sample;
- Allows the researcher to demonstrate that the sample is representative of the target population;
- Permits the researcher to better identify any biases.

BASIC STEPS IN RANDOM SAMPLING

There are three main steps in obtaining a random sample: defining the target population, determining the sample size, and selecting the random sample.

DEFINING THE TARGET POPULATION

The target population is the population segment or segments that are being investigated in the study, or the group to which one wants to generalize. It is the group of people whose opinions and ideas are important to the researchers. Thus, the research objectives are the most important factor in defining the target population. Once the research objectives are clearly stated, the appropriate target population will often be quite obvious. Even so, it is a good practice to consider some alternative populations and then determine which one best accommodates the research needs.

When defining the target population, it is important to avoid being overly restrictive. For example, a population restricted to males aged 35-50 with incomes over $50,000 would (1) definitely comprise only a small portion of persons involved with transportation issues, thus leaving out a lot of information useful to policy planning and (2) be excessively costly because so many people would have to be contacted in order to obtain enough participants in that category. Researchers would have to ask themselves whether there were sound reasons for collecting information only from this group and not from all adults or all males in general.

DETERMINING THE SAMPLE SIZE

There are three main factors taken into consideration in determining sample size: cost, the nature and number of subgroups that the researcher wishes to examine within the sample, and the required degree of accuracy for the results.

Cost constraints are an important consideration because the size of the sample is a major driving factor in the cost of the research project. In some cases, restrictive budgets may limit sample size. The cost ranges involved in a telephone interview survey of varying lengths are shown in Table A-1.

If the researcher is interested in examining several subgroups of the population separately, the sample size must be large enough to ensure inclusion of enough members in each subgroup. In turn, the number of subgroup members needed is a function of the margin of error that the researcher considers acceptable for that subgroup.

The larger the sample size, the smaller will be the margin of error on the results. That is, larger samples produce results that are more accurate in describing the population because more of that population is represented in the sample. However, there is a point of diminishing returns. Thus, further increases result in diminishing impacts on accuracy. At the other end, a slight change in sample size for a small sample has a great effect on the margin of error.

Table A-1: Estimated Cost Ranges, Telephone Survey of General Population

Sample Size (completed interviews)	Length of Interview			
	5 min.	10 min.	15 min.	20 min.
500	$10,000-20,000	$10,000-25,000	$15,000-25,000	$15,000-30,000
1,000	$20,000-30,000	$25,000-35,000	$25,000-40,000	$30,000-45,000
1,500	$25,000-35,000	$30,000-40,000	$35,000-45,000	$40,000-55,000

Note: These costs are estimated ranges, including interviewing and basic data processing. Costs will vary considerably depending on the expected refusal rate and incidence rate (percent of respondents on list who are actually qualified to participate) and differences in study goals and objectives that may require different methodologies, types of design, and analysis. Costs will also vary due to the type of report or presentation that is desired.

Table A-2 shows the relationship between sample size (or subsample size) and the margin of error in results for that sample(or subsample examined separately). For a sample of 100 persons, the margin of error is nearly 10 percent -- that is, the "true" value for the whole population of a given variable could be as much as 10 percent below or 10 percent above the average value calculated for the sample.

Table A-2: Sampling Size and Corresponding Margin of Error

Sample Size	100	200	300	400	500	600	700	800	900	1000	1100	1200	1500	2000
Margin of Error (%)*	9.8	6.9	5.7	4.9	4.4	4.0	3.7	3.5	3.3	3.1	3.0	2.8	2.5	2.2

*Margin of error at the 95% confidence level.

Increasing the sample by 100 persons to a total sample of 200 reduces the error by almost two percentage points -- to 6.9 percent. At the other end of the range, increasing the sample by 500 persons from 1,500 to 2,000 reduces the margin of error by only 0.3 percent (from 2.5 to 2.2 percent).

The final decision on sample size amounts to a cost/benefit analysis. The researcher will choose a sample size that is large enough for thorough subgroup analysis with an acceptable level of accuracy, yet is acceptable in terms of cost.

SELECTING THE RANDOM SAMPLE

In its simplest form, random sampling is nothing more than "pulling names out of a hat." As long as all names are entered and the slips of paper in the hat are mixed well enough that each one has an equal probability of being chosen, and no names are entered more than once, a random sample will result.

When obtaining a pre-selected random sample for a research project, the first step is to assign all members of the target population a unique identifying number. This is analogous to writing each name on a separate sheet of paper in the "names out of the hat" example. Of course, in many cases (such as telephone interviewing) the population will have some inherent identifying number and none will have to be assigned -- a telephone number, a street address, a license number.

The next step is to select from among these identifying numbers. Some researchers use lists and select identifying numbers at spaced intervals -- every tenth telephone number, every fifth house, etc. This systematic selection will result in a random sample if the list itself is in random order and contains no systematic order bias or "periodicity." In other cases, researchers use computer-generated lists of random numbers to pinpoint the identifying numbers selected from the general population. This is analogous to thoroughly mixing the names in the hat before they are drawn. In this case, the numbers in the list have no intrinsic pattern to them.[1] In modern telephone interviewing, the computerized Random Digit Dialing system automatically generates randomized telephone numbers.

In encounter sampling, participants are chosen on the spot by interviewers who intercept them as they pass by. There is no pre-selection from lists or identifying numbers. These samples can also be random -- "drawn from a hat" -- if (1) the intercept locations are selected carefully so that, as a group, they draw passers-by that fully represent the target population and (2) participants are truly intercepted at random by the interviewers. This means that interviewers cannot systematically ignore fathers with crying babies or people who look like they are late for appointments. This is very difficult.

Once the random sample has been selected, the researcher should always compare the sample characteristics to known characteristics of the target population. This is a check to ensure that the sample is adequately representative of the target population. It is important to remember that a random sample will produce results that are accurate within some known margin of error, but these error margins are typically calculated at the 95% level of confidence. As a result, one sample in 20 may be unrepresentative and produce results outside the margin of error due purely to random chance.

STRATIFIED SAMPLING AND OVERSAMPLING

There are two reasons given for defining strata and sampling separately within each defined stratum: (1) ensure adequate representation of each stratum or (2) sample more heavily or differently within a given stratum. It is a common misperception in research that it is necessary to stratify or separate subgroups of a population for sampling to ensure their adequate representation in a random sample. If true random sampling is used and the sample is not too small, the proportion of people in each subgroup will automatically reflect the actual proportion of the groups in the total population.

[1] Samples selected at set intervals from telephone lists have an alphabetical pattern -- one tenth of the Jones and Smiths will be selected. Samples selected from household address lists that are organized by geographical districts have a geographic pattern. These patterns are not necessarily bad. In some cases, they may be desirable in ensuring, for example, a proportional representation of all area neighborhoods. However, if true random sampling is used, this proportional representation will be achieved anyway; see section on Stratified Sampling and Oversampling.

However, researchers often want to make inferences about specific population subgroups. They are then concerned with obtaining enough people in the subgroup or stratum to keep the margin of error acceptably low. If the subgroup is a small proportion of the total target population, they may want to obtain more participants than they would normally get in a population-wide random sample. To ensure adequate sample size in the subgroup, the researcher can stratify the population and oversample the subgroup. Statistical weighting procedures are then used to correct for any bias due to this overrepresentation when the total sample is analyzed.

Sometimes researchers are interested only in particular subgroups or a restricted sample -- for example, transit riders from a particular geographic area, commuters who cross a particular bridge, etc. Restricted samples can be obtained by encounter sampling at the target site -- on the bridge -- or by screening respondents early in the questionnaire to see if they fit the criteria. Screening as each person is contacted can be costly, particularly if the target population is only a small part of the total population. If geographic region is a criterion, sampling can be done by randomly selecting people within the desired area using address lists, telephone number area codes and prefixes, etc.

APPENDIX B

METHODS OF QUANTITATIVE ANALYSIS

This appendix presents a more detailed technical discussion of the more sophisticated methods of quantitative analysis for market research. The methods included in this appendix are:

IMPORTANCE-PERFORMANCE ANALYSIS

SUMMARY

Importance-performance analysis is a way to assess priorities for projects affecting delivery of services. These priorities are not derived directly but, rather, are inferred from rankings assigned by survey respondents to a series of specific services or service attributes. This technique requires a specific question design in which survey respondents are asked to, first, "grade" or rate the importance to them of a series of services or attributes and, second, "grade" the quality or performance of that service or attribute as they perceive it. Importance-performance analysis utilizes only basic computer analysis to tabulate individual responses.

PURPOSES

Importance-performance analysis was designed to take into consideration the fact that not all shortfalls in service quality are of equal concern. When a service or factor that is considered to be of primary importance falls far short of a desirable level of performance, that is a greater concern than when a peripheral service or factor is unsatisfactory. By inference, projects to address shortfalls in a critical area (rated as high in importance) would be given higher priority by the public than projects proposed to rectify shortfalls in areas of marginal importance (rated as low in importance).

This type of analysis can be used to compare and prioritize transportation projects in dissimilar areas. For example, if performance were graded as 8 on a scale of 1 to 10 for both highway rest stops and highway directional signs but signs were rated as 9 in importance and rest stops as 3, we could safely assume that the public interviewed would rather have funds spent on signs than rest stops.

TECHNICAL METHODOLOGY

Importance-performance analysis is based on answers to questions asking survey respondents to assign numerical values (within a prescribed range, say 1 to 10 or 1 to 5) to the importance of each item in a list of services, traits, or abstract factors. Survey participants are then asked to grade the quality of delivery or performance of the same items, using the same numerical scale.

The items in the list must be elements that can vary in performance or quality. To be an effective tool, these items should also be ones that can be affected by DOT policies to consciously alter quality (or, perhaps, by offering acceptable substitutes addressing the same needs).

For each item in the list, the mean importance score and the mean performance score are computed as a simple summation of individual scores divided by the number of respondents. (Variance or standard deviation should also be calculated.) The mean importance and performance scores are then compared for each item to illustrate the gap -- if any -- between importance and performance. Although it is quite possible for performance to be rated higher than importance for a given item (that is, "over" achievement), usually performance ratings are lower than importance.

Results of importance-performance analysis can be presented in several ways. The gap between performance and importance can be shown as the numerical difference between the two scores for each item -- performance minus importance, thus a negative value indicates a shortfall and a positive value indicates over-achievement relative to public perception of need. Alternatively, the gap can be computed as a percentage of achievement -- performance score divided by importance score, to indicate the proportion of the goal achieved. In this case, values less than 100 percent indicate a gap or shortfall and values greater than 100 percent indicate overachievement.

The results can also be presented graphically in an "action grid" with each item represented by a point located in the grid according to the mean importance score (the vertical or y-axis distance) and the mean performance score (the horizontal or x-axis distance).

The origin of the graph (where the two axes cross) is not zero, as in a conventional graph, but a value within the rating range. The values selected as the center of the grid can be chosen as (1) the mid-points in the scale used (3 when a scale of 1 to 5 is used), (2) the mean scores for all items in the list, or (3) the median scores for all items in the list.

When either means or medians are used as the center of the grid, items placed in the upper right quadrant score above "average" in both importance and performance;[1] items in the lower right quadrant score below average in importance but above average in performance -- these would be low priorities for future investment. Items in the lower left quadrant score low in both importance and performance -- also low priority for investment since they are considered relatively lower in importance. Items in the upper left quadrant, however, rank high in importance yet are scored as below average in performance. These are the services/factors/attributes that presumably are of highest priority for new investment.

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

Successful importance-performance analysis is dependent upon basic consensus among the surveyed population on the importance and quality of each item in the list evaluated. If there is a wide divergence in individual ratings, this will show up in the variance or standard deviation computed; a high variance will undermine the validity of the results since the scores are computed as average opinions.

If differences in individual ratings follow a pattern, for example, according to residential location, the analysis could be done separately for the identified groups -- separate analysis for rural, urban, and suburban respondents. This may reduce the inter-personal variation within each subgroup to an acceptable level for importance-performance analysis.

Moreover, analytical interpretation may require arbitrary value judgements on the part of the analysts. Although we can say with certainty that items in the upper left quadrant of the graphical analysis have higher investment priority than those in the upper right quadrant or that an item with a performance/importance score of 2/10 has higher priority than one with a score of 8/10, we have no way to evaluate and compare items that are not so clearly differentiated. How can you choose between an item with a 7.5/10 score and one with a 3/5 score? The first has a greater numerical gap (2.5 compared to 2.0) but the second falls shorter on a proportional scale (60 percent achievement versus 75 percent). There is no categorical answer to this dilemma and prioritization may depend on value judgements by transportation analysts.

There are also some problems in data collection itself. Respondents tend to rate performance as the middle value in the scale range -- they tend to rate items as a neutral "not bad, not good" 3 on a scale of 1 to 5. This can be overcome by eliminating a precise middle score -- using a scale of 1 to 10 where 5.5 is exact middle -- but answers may still cluster overwhelmingly in the middle range. Moreover, some respondents fail to distinguish among items in importance -- everything from rest stops to ice removal tend to be rated as important, so it is often difficult to determine which are most important. Comparing a list of items all rated as top in importance and mid-range in performance yields no conclusions since the shortfall is the same for all.

SPECIAL CONSIDERATIONS

Importance-performance analysis requires special question structure in which specified items are evaluated with regard to both importance and performance, using a numerical scale or scoring system. The system can be explicitly numerical or can be phrased as verbal ratings (poor, fair, good, excellent is comparable to a numerical scale of 1 to 4). Ranking cannot be used since each rank can be assigned only once but importance-performance ratings can be the same for more than one item. Questions should be neutral in structure, not biased to downgrade or inflate the importance of a single item (for example, a question on snow removal should only name the service, not append the purpose as "snow and ice removal to reduce the chance of fatal collisions on curves").

[1]When median values are used to define the center of the grid, each quadrant will contain one fourth of the services or attributes. By definition, half of the services will rank above the line (drawn at the median importance value) and half below. Moreover, since the vertical division is drawn along the median performance score, half will be placed to the left and the other half to the right.

EXAMPLE

In the National Demonstration Survey,[2] the 1013 respondents were asked to rate the importance and quality of service for the following features on highways on which they travel:

- Highway signs giving information on directions and mileage;
- Services such as restaurants and gas stations along the highway;
- Rest areas and waysides;
- Four-lanes on highways;
- Highway border areas that are well-landscaped and litter-free;
- Bridges with breakdown lanes;
- More frequent safety inspections of vehicles;
- Traffic kept moving at normal speeds;
- Safe road conditions; and
- Warnings of when to expect traffic delays and road closings due to construction.

Respondents were asked to use a scale of 1 to 5 with 5 meaning extremely important and excellent respectively for importance and performance ratings.

Table B-1 shows the survey results in tabular form. Looking at performance-importance differences, bridges with breakdown lanes has the largest numerical gap (-0.9) and safe road conditions is second (-0.8).

Table B-1: Example of Importance-Performance Analysis

National Demonstration Survey: Highway Features

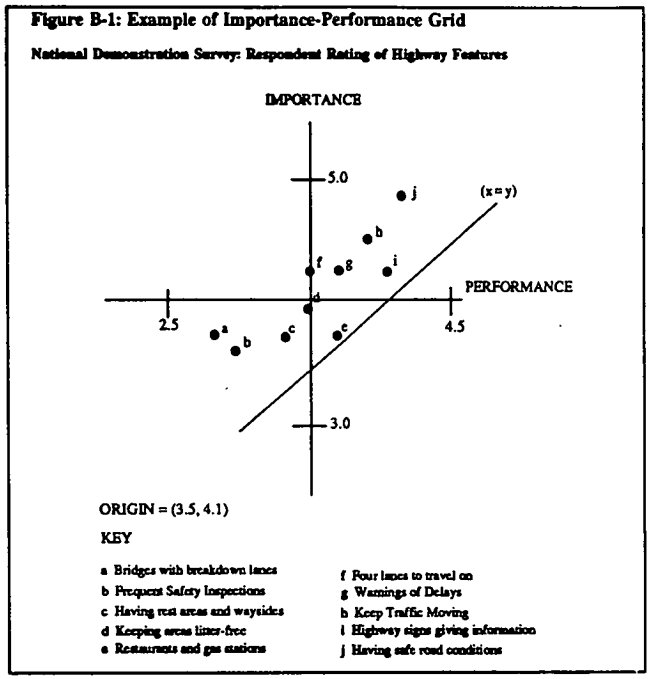
Highway Feature	Respondents' Average Importance Rating (1-5) (Col.1)	Respondents' Average Performance Rating (1-5) (Col.2)	Difference (Col.2-Col.1)	Ratio (Col.2/Col.1)
Safe road conditions	4.7	3.9	-0.8	0.830
Keeping traffic moving	4.4	3.7	-0.7	0.841
Highway signs with information	4.2	3.8	-0.4	0.905
Warnings of delays	4.2	3.6	-0.6	0.857
Four lanes for travel	4.2	3.5	-0.7	0.833
Litter-free roadside	4.0	3.5	-0.5	0.875
Bridges with breakdown lanes	3.8	2.9	-0.9	0.763
Restaurants and gas stations	3.8	3.6	-0.2	0.947
Rest areas and waysides	3.8	3.3	-0.5	0.868
Frequent safety inspections	3.7	3.0	-0.7	0.811

[2]The National Demonstration Survey is described in Appendix C of this report.

Looking at the ratio of performance to importance, bridges with breakdown lanes still has the greatest shortfall (a ratio of 0.76) but the second greatest shortfall is in frequent safety inspections (ratio of 0.81), thus the rank ordering of "priority for investment" is slightly different. Warnings of delays is sixth in shortfall by both ranking methods, and restaurants and gas stations is last by both.

The results are presented graphically in Figure B-1. The two axes intersect at the overall mean ratings of 4.1 for importance and 3.5 for performance. Thus the lower right quadrant contains features that respondents rated as having importance ratings below the overall average but performance ratings above the overall average (for example, restaurants and gas stations). These would be the features with the lowest priority for future investment according to graphical interpretation of survey responses -- they are below average in importance yet above average in performance in the opinion of the participants.

Figure B-1: Example of Importance-Performance Grid



If features had appeared in the upper left quadrant, they would be candidates for increased investment as this position would indicate that respondents assigned a higher than average importance to these features yet felt that performance was below average. In this survey, no features were placed here.

The upper left and lower right quadrants in importance-performance analysis single out high priority and low priority investments respectively. Features appearing in the upper right and lower left quadrants, however, are all candidates for investment IF importance ratings exceed performance ratings, that is, if they are placed graphically above the diagonal line indicating equal importance and performance values. (This corresponds to a negative value in column 3 of Table B-1.) It is up to those making policy and investment decisions whether or not to invest in features that are in the lower left quadrant (below average importance) yet above the diagonal "balance" line; it is also their decision on what criteria are appropriate for selecting among those features in the upper right quadrant.

Overall, importance-performance analysis can help to prioritize investments in an approximate sense, even if fine distinctions in priorities cannot be supported.

MULTIPLE REGRESSION

SUMMARY

Multiple regression is a method of data analysis that allows the researcher to examine the relationship of a number of variables simultaneously when it is suspected that a number of influences are responsible for a specific outcome. Computer analysis is used for multiple regression, with the researcher specifying in the regression model the independent variables he suspects influence the dependent variable. The computer then assesses the relative strength of these independent variables when taken together, as well as the relationship between the dependent variable and the entire set of independent variables combined.

PURPOSE

Multiple regression is used to understand the relationships among a large number of factors or variables simultaneously. It is especially useful when it is suspected that there is more than one factor which "causes" a particular effect. In this technique, the outcome or "dependent variable" is predicted or explained by causative factors or "independent variables." Regression analysis can also reveal the order of importance of factors which affect a variable.

TECHNICAL METHODOLOGY

In the simplest case of regression, a model is formulated which specifies the dependent variable -- the outcome -- as the function of one independent variable -- the factor that presumably affects the outcome. Suppose that we are interested in finding out the impact of advertising on mass transit use. More specifically, we are curious about the number of people who used mass transit each day as a result of heavy advertising the day before.

The regression model on which we would base our predictions would be written as:

$$Y = B_0 + B_1X + E$$

where:

- Y = the dependent variable: the number of people that used mass transit on each day observed;
- X = the independent variable: the amount of money that was spent advertising the preceding day;
- E = the error term: unexplained daily fluctuations in Y due to influences other than advertising that cause variations in transit ridership;
- B_0 = the intercept: the core number of transit riders that does not vary from day to day in response to advertising;
- B_1 = the coefficient of advertising expenditure: numerically represents the proportional effect of advertising expenditure on next day ridership. This also represents the slope of the line $Y = B_0 + B_1X$.

The computer would then evaluate and standardize data in the form of X's and Y's for each case, and then solve for B_0 and B_1.

In reality, the use of mass transit is affected by many variables, such as proximity to riders' homes, cost, speed, and so on. Even if the advertising expenditure were known and our hypothesized relationship between ridership and advertising expenditures were correct, it would not be possible to predict transit use exactly. There would still be a margin of error, measured by the error term.

One of the goals of regression analysis is to determine the value of the equation parameters -- B_0 and B_1 in our hypothetical example, which characterize the relationship between mass transit users and advertising. In order to do this, a random sample might be taken of a number of different bus routes, for example. For each bus route, the number of people travelling on the bus would be documented and the advertising spent the day before would also documented. Next, these points could be plotted on a scatter diagram with transit riders measured along the vertical or y axis and advertising expenditures measured along the horizontal or x axis.

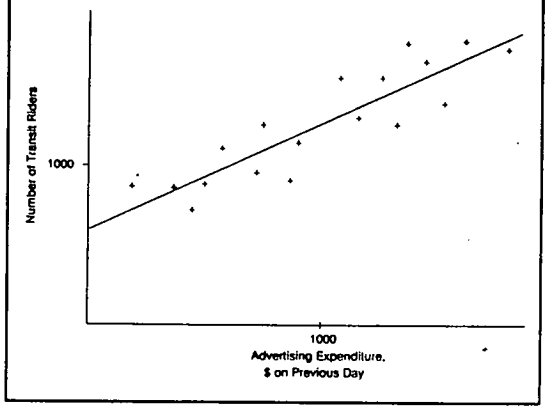
In a graphical analysis, the next step in the process would be to draw the line that best fits the points on the scatter diagram. The fitted line can be viewed as a predictor line, in the sense that it predicts mass transit traffic and various levels of advertising expenditures. The computer program used to run regression generates the equation for the line that minimizes the squared deviations from the line across all the cases. The line is called the least squares line. The computer program computes the regression coefficients that are estimates of the two equation parameters. The parameter B_0 is the intercept or point where the line crosses the y axis, interpreted as the core number of transit riders, and the parameter B_1 is the slope of the line or the change in ridership expected for every change in advertising.

Figure B-2 illustrates a hypothetical scatter diagram with the least squares line drawn in. The computer output from regression might look as follows:

$$Y = 600 + 0.66X$$

Thus, given this estimated relationship, we could say that if expenditures of $450 were planned for advertising, then we would expect the total mass transit users to be 897 the following day.

Figure B-2: Hypothetical Scatter Diagram and Least Squares Line



Frequently, data gathered in a field study or survey include a number of independent variables, such as age, education, income, etc. Researchers may believe that all of these factors have an effect on mass transit use. When two or more independent variables are used in a linear regression analysis, it is called multiple regression. The equation used for multiple regression is:

$$Y = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + \ldots$$

where Y is the dependent variable and the X terms are the independent variables with their respective coefficients. In this equation, the B terms associated with each X term represent partial slopes, since they represent the amount of change in the dependent variable associated with each independent variable, holding all other independent variables constant.

The partial slope of each independent variable generated through regression is interpreted as the amount of expected change in the dependent variable (Y) associated with a one unit change in the independent variable, holding constant all other independent variables. The regression equation represents our best estimate of the value of the dependent variable associated with any combination of values of the independent variables.

The partial slopes also allow us to compare the importance of the independent variables. The higher in value the partial slope, the more important is that variable in explaining the dependent variable for the particular subpopulation.[3]

[3]More specifically, to assess the relative importance of each predictive variable in a single regression equation, we must standardize all the variables so they are comparable in the range of values they cover. Age probably ranges from 18 to 80, but income can range from 0 to over $100,000; these would be multiplied by different coefficients even if they had equal impact on transit ridership just because the numbers are so different in scale. Standardizing them, in essence expressing each observation as a percentage of the average value for that variable, allows us to use the same scale for both and thus compare their coefficients -- compare the relative impact of

The measure of the regression model's ability to explain is the correlation coefficient (called R-squared) that measures how closely the regression line fits the data. It represents the proportion of the variance in the dependent variable explained by all of the independent variables. R-squared lies between 0 and +1. The closer the fit, the higher the correlation coefficient (that is, closer to +1) and more confident we can be in predicting the values of the dependant variable based on values of the independent variables. If the value of the correlation coefficient is 0.8 or larger, there is a very strong or high relationship between variables. If is between 0.4 and 0.8 the relationship between the variables is considered moderate to high. Significance is much more than a matter of magnitude -- large correlations can be insignificant in a small sample, and small correlations can be significant in a large sample.

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

A major limitation of regression analysis is that if an important variable is omitted from the regression equation, and the omitted variable is correlated with one particular independent variable, the regression coefficient for the independent variable included in the analysis will also incorporate the effect of the omitted variable -- it will be "assigned" the influence of the omitted variable to some degree and it will appear to be more influential than it really is in fact.

Although regression analysis is used to explain the degree and strength of relationships between the dependent variable or outcome and each independent variable, it cannot "prove" causality or the existence of a cause-effect relationship. Regression analysis indicates the strength of the correlation or coincidence among variables; arguments demonstrating a functional tie between outcome and independent influences must be based on sound theoretical principles.

The data for regression analysis usually consist of measures of two or more continuous variables although adjustments can be made for other types of data. The larger the number of observations related to the number of variables (termed degrees of freedom), the greater the confidence that can be placed in the results.

SPECIAL CONSIDERATIONS

Regression analysis is generally based on numerical data that reflect values. That is, data must be interval measures -- measures in which properties of a variable not only can be ranked or ordered, but where the distance between those rankings is exact and constant. Interval measures not only position and categorize phenomena, they indicate the extent of difference between values. Income, education, temperature, and age are all examples of interval measures.

Interval level data permit a degree of precision in stating relationships that is not possible with rankings or ordinal data. Statistical techniques designed for use with interval data indicate the magnitude and the directions (positive or negative) of the relationship between two variables. These techniques also permit the mathematical expression of one variable (the dependent variable) as a function of the others (the independent variables). These techniques allow us to predict, with a certain degree of accuracy, the effect of unit changes in the independent variable on changes in the dependent variable.

Independent variables that are categories rather than numerical values (rich/poor rather than dollar income) can be used in regression analysis by transforming category codes into "dummy variables" where every category is represented by a yes answer (entered as a 1) to a yes-no question. Regression analysis can also use ranks, rather than interval data, by relaxing the assumptions and assuming that the distances between each rank are approximately equal -- that is, that the ranks are almost the same as values.

change in the independent variables associated with changes in each dependent variable.

EXAMPLE

One of the goals of the 1989 National Demonstration Study was to determine what factors most influence public satisfaction with highways. This information is important for policy development and for public information efforts.

Included in the questionnaire were 30 factors later identified as plausible predictors of satisfaction with highways. These factors included perceptions of road conditions and safety, highway performance ratings, and demographics such as age, region, etc. Using a standard computer program for regression analysis, each of the 30 factors or "independent variables" was analyzed to determine which one had the most impact on the "dependent variable" -- respondent satisfaction with highways. The analysis identified five significant predictors of respondent satisfaction with highways. The results are shown in Table B-2.

These results show that while highway performance factors and the lack of traffic congestion all contribute significantly to satisfaction among survey respondents, the most important predictor of respondent satisfaction with highways is the perceived efficiency of the DOT.

The negative sign of the coefficient for "commuting time added by congestion" reflects the fact that commuting time wasted in traffic results in decreased satisfaction among those surveyed.

The other coefficients were positive, indicating that higher the rating, the more satisfied respondents were with the highways they used.

Overall, these five variables explained 20 percent of the variation in highway satisfaction among survey respondents. Such "low" explanatory power (low R^2) is not uncommon in cross-sectional analysis using large diverse data bases.

Table B-2: Example of Regression Analysis

National Demonstration Survey: Relationship Between Various Factors and Respondent Satisfaction with Highways

Factor	Importance*
Perceived efficiency of state DOT	+0.31
Performance rating: safe road conditions	+0.16
Commuting time added by congestion	-0.13
Believe DOT spending is wiser than state government in general	+0.10
Performance rating: highway signs giving information	+0.07

Altogether, these factors explained 20 percent of the variation among respondents in highway satisfaction.

*Based on standardized multiple regression coefficients.

FACTOR ANALYSIS

SUMMARY

The primary use of factor analysis is that of data reduction. Because factor analysis identifies underlying constructs of variables, it can determine if two or more variables measure essentially the same attributes. Many data analysis techniques begin with factor analysis in order to condense a large number of variables into fewer factors and to make the information more meaningful, easier to interpret, and amenable to other analytic techniques.

PURPOSE

Factor analysis is a procedure that takes a large number of variables and searches to see whether they have a smaller number of factors in common which account for their intercorrelation. Factor analysis is especially useful for reducing a mass of data to a manageable level by condensing many attributes down to a smaller number of key factors that underlie the attributes. For instance, with factor analysis, a group of twenty variables could be reduced down to five underlying factors. Factor analysis probes beyond the straightforward questionnaire answers to uncover more basic underlying elements that determine participant responses.

Factor analysis can be very useful in the early stages of a major transportation study. For example, consider a study of the impact of proposed changes in a subway system on commuter use. Commuters, when

surveyed, will have a wide variety of perceptions, each individually contributing to a whole that determines how they would respond as consumers. However, the entire set of responses can prove to be too disparate or unwieldy for further statistical analysis to be applied to it.

Factor analysis would allow the researcher to reduce these complex perceptions to the key elements which underlie them. This would permit further, more in-depth, statistical analysis to be better defined and more focused on the most significant elements of the entire set of consumer responses.

Existing data from previously performed transportation studies can also be re-analyzed using factor analysis. This would serve to clarify results and to focus the analysis on issues of particular concern that have arisen after the original study was completed.

Factor analysis is also useful for questionnaire development. When a questionnaire is first written and pretested, it can contain a great many questions, some of which might contain unintentional redundancy. Factor analysis can be used on answers collected from questionnaire pre-testing to identify those specific questions which are representative of a group of questions in the pattern of answers given. These key questions are then used in the final questionnaire -- the result is a questionnaire that provides much of the same information as the original, but is shorter and less costly.

Many advanced analytical techniques begin with factor analysis. A study will often involve a great number of variables. Factor analysis procedures can reduce the number of variables while retaining the necessary information. Further statistical analysis is then better defined and more focused on the most significant elements of the set of variables.

TECHNICAL METHODOLOGY

Factor analysis assumes that the observed variables are linear combinations of some underlying (unobservable) factors. Some of these factors are assumed to be common to two or more variables and some are assumed to be unique to each variable. The unique factors are assumed to be parallel to each other, and it is only the common factors which contribute to the covariations among the observed variables.

Data used in factor analysis are numerical values (interval level data rather than, for example, categories). They are often in the form of ratings along a defined scale. For example, respondents might be asked to give importance rankings to having restaurants, gas stations, and rest areas on highways, or consumers may be asked, "How likely is it that, on a scale of 1-10, you would support a new toll road?" Factor analysis would be used to extract common themes in answer patterns. For example, if respondents seem to assign similar importance rankings for restaurants and highway rest areas (people who rate restaurants as 2-3 also tend to rate rest areas below 5), it would indicate that there is a common factor that determines their answers to both questions.

Raw data, with ratings on various questions, are input into a computer program. The computer manipulates that data and identifies variables that seem to have a common thread. It then creates a smaller number of independent factors by forming unique linear combinations of the variables. In order to help interpret each factor defined by the analysis, the analysis also generates factor loadings, which are the correlations between each composite factor and the original variables. If the factor loading is close to zero, then there is little or no association between the variable and the factor. When the factor loading is close to -1 or +1, then there is a clear, strong association between the variable and the factor.

The computer program provides factor loadings but it does not give names to the new composite factors; they are presented as Factor 1, Factor 2, etc. It is up to the researcher to determine from the factor loadings which original variables tend to group together and what each composite factor represents. If, for example, a composite factor seems to be strongly correlated with importance of restaurants and importance of rest stops, the researcher could term the underlying factor "amenities for travelers." In some cases, the combination of original variables in a factor makes no intuitive sense -- it is not possible to interpret the composite factor as having a meaningful theme or common element.

The results of factor analysis can be viewed from two angles. The factor loadings indicate how much the underlying factor or common element influences the value of each original variable. The statistically-derived factor is considered the hidden communality which comprises a portion of each original variable. By inference, it also shows which variables move together -- reflecting their ties to the common factor.

From another view, the factor loadings can be used to construct a scale or index for estimating the value of the underlying dimension in individual cases; the factor loadings provide the weighting scheme for combining the contributing variables in a weighted composite value called a "factor score" representing the value of the underlying factor.

In turn, these estimates of the value of the underlying factor can be used as data in other statistical analyses. For example, rather than using several independent variables that are somewhat correlated with each other in a regression analysis, the factor that underlies those variables can be used as a single independent variable in regression. By combining observations on the several initial variables in a weighted composite estimate of the underlying common factor, problems of multicolinearity (correlations among independent variables that can lead to spurious results) are avoided.

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

The most important assumptions made in factor analysis is that there are factors underlying the variables and that the variables indeed completely and adequately represent these factors. In practical terms, this assumption means that the list of variables should be complete.

The greatest limitation of this method of data analysis is that factor analysis is a highly subjective process. The determination of the number of factors and the interpretation of the factors are subjective decisions. The results are largely dependent on the variables included in the analysis and the particular method chosen for factoring. Moreover, there is no clear test of statistical validity, thus it is often difficult to know if the results are merely due to chance or do indeed reflect meaningful patterns of results.

SPECIAL CONSIDERATIONS

Factor analysis can be performed on data which has been previously collected and does not require specially structured questions.

EXAMPLE

One of the questions in the National Demonstration Survey was designed to identify the transportation components most important to the public. The question read as follows:

> "I am going to read you a list of features that might be desirable in major highways. For each, please tell me how important it is to you when you travel, on a scale from 1 to 5 where 1 means not at all important and 5 means extremely important."
>
> What about highway signs giving information on directions and mileage?
>
> Having services such as restaurants and gas stations along the highway?
>
> Having rest areas and waysides?
>
> Having four-lane highways to travel on?
>
> Keeping the areas bordering highways well-landscaped and litter-free?
>
> Having bridges with breakdown lanes?
>
> Having more frequent safety inspections of vehicles?

> Keeping traffic moving at normal speeds?
>
> Having safe road conditions?
>
> Having warnings of when to expect traffic delays and road closings due to construction?

In each of these ten questions, respondents "graded" the importance of that feature on the 1-5 scale. The researchers used factor analysis to determine whether the importance assigned to these ten features reflected a smaller number of factors underlying them. Such groupings would focus the results into a few key transportation components. Decision-makers could then use these key factors as focal points for prioritizing projects and setting policies.

Factor analysis began with the computer taking the twelve variables and finding the ones that were most strongly interrelated. It then mathematically combined these interrelated variables into a new variable, a single "factor." Results of the factor analysis on National Demonstration Survey data are presented in Table B-3.

To label and interpret these factors, the researchers looked at the variables that were most strongly related to the factor by examining the factor loadings. The variables with loadings closest to +1 and -1 were considered the strongest components of the group. Their apparent common theme was then given a name by the researcher.

The two most important factors in this study were named "Providing Amenities for Travelers" and "Keeping Highway Traffic Moving Safely;" these labels reflect the variables that grouped together as the most important reflectors of the underlying themes for this survey. A third factor, not shown in the table, also resulted from the factor analysis. It was composed of two safety-related and one aesthetic feature -- frequent safety inspections, bridges with breakdown lanes, and litter-free highways -- that did not fit together as naturally as the components of the first two factors, and accounted for less variance.

Table B-3: Example of Factor Analysis

National Demonstration Survey:
Key Factors Behind Respondent Importance Ratings for Highway Features

Factor 1: Providing Amenities for Travelers

	Importance*
Having restaurants, gas stations	0.83
Having rest areas and waysides	0.72
Having highway signs giving information	0.67

Explains 33 percent of all respondent variation in importance ratings.

Factor 2: Keeping Traffic Moving Safely

	Importance*
Having safe road conditions	0.77
Keeping traffic moving at normal speeds	0.67
Having warning of construction delays and closings	0.61
Having four-lane highways for travel	0.54

Explains 12 percent of respondent variation in importance ratings.

*Based on the factor loadings for each factor; these can be interpreted as the correlation between each item and the factor, ranging from 0.00 for no correlation to 1.00 for perfect correlation.

DISCRIMINANT ANALYSIS

SUMMARY

Discriminant analysis is used to identify the factors that best distinguish one group of survey respondents from another. The characteristics that are associated with each group are revealed by computer analysis applied to a set of variables on which the respondents might be expected to differ.

PURPOSE

Discriminant analysis is a statistical technique used to identify the key factors that distinguish one group of respondents from another. For example, it has been used to identify the characteristics that separate Democrats from Republicans and buyers of one brand from another.

The results can be used for either analysis or prediction. They allow the researcher to identify the key operating factors that attract supporters/adherents or act as obstacles to support/compliance. In turn, this allows communications to be fine-tuned to reach specific population segments.

The researcher can also predict how uncommitted people are likely to respond by understanding the characteristics that distinguish one group of committed respondents from another. The researcher can identify target populations because the discriminant analysis describes the factors that distinguish among groups of respondents and seem to be characteristic of group membership or classification.

In a sense, the researcher uses statistically-derived stereotyping to predict how people will react, based on observed characteristics of the people in question. This information is then used to understand the basis for support and the sources of opposition, to predict which types of people are most likely to be swayed by what kinds of information, and thus to tailor communications and fine-tune policies.

TECHNICAL METHODOLOGY

The first step in discriminant analysis is to define the population groups in terms of the discriminating dimension or characteristic relevant to policy formulation. It could be mass transit users and non-users, people who support or oppose a proposition, or people exposed to an information campaign and those who have not been exposed. The goal of discriminant analysis is to create an equation or function that defines a line or dimension on which the two groups are located as far apart as possible.

For example, respondents to the National Demonstration Survey could be classified into one of two groups based on whether or not they were willing to pay higher motor fuel taxes to improve the transportation system. In this case, discriminant analysis was used to identify the key factors that distinguish willing respondents from those who are unwilling to pay higher motor fuel taxes (see below, Example).

To distinguish between previously-defined groups of respondents, the researcher selects from the questionnaire a set of variables on which the two groups also might be expected to differ. The computer-based discriminant analysis examines these variables and then selects the set that can be weighted and combined to form a linear equation or "function" that maximizes the separation between the two groups, making them as statistically distinct as possible. This linear combination is called a "discriminant function;" it defines a single line or axis in space and contains a series of coefficients that provide the weighting for each of the discriminating variables that are combined in the equation.

The discriminant function also computes a single discriminant score for each respondent, indicating their location on that dimension or scale, by taking the numeric value for that respondent on each of the discriminating variables, standardizing that value, multiplying it by the corresponding coefficient for that variable and then adding the resulting products (that is, forming a linear combination).

The discriminant function's standardized coefficients or weights can be interpreted in essentially the same way as in multiple regression or factor analysis -- they indicate how much each variable contributes to the differentiation of the groups along the respective dimension or function.

The coefficients range from 0 to 1.0, both positive and negative, and the larger the magnitude of the coefficient, the greater its relative strength or contribution. Negative coefficients indicate an inverse relationship between the discriminating variable and the dependent variable represented by the groups. Positive coefficients indicate a relationship in which the values of each variable increase monitonically.

Methodologically, the researcher can enter all the discriminating variables simultaneously, or allow the computer to enter them in a "stepwise" or hierarchical fashion, selecting the best discriminator first followed by other variables that increase the predictive ability of the model or function until the best model is created -- the equation that maximizes the separation with the least number of discriminating variables.

No single variable will perfectly differentiate between the two groups but, by taking several discriminating factors and combining them mathematically, it is often possible to find a single dimension on which the members of one group are clustered at one end and the members of the second group are clustered at the opposite end.

The spatial relationships of the two groups can be graphically displayed and/or summarized statistically -- showing the distance between the two groups and how well they have been differentiated from one another.

Discriminant analysis also computes statistics that indicate how well the discriminant function has distinguished the two groups -- does the function make the two groups significantly different? There are many such statistics that can be used to evaluate the success of the discriminant analysis, but most common are Wilks lambda and the canonical correlation.

A very high degree of separation will result in a small Wilks lambda (which ranges from 0 to 1.0) and a large canonical correlation (which ranges from -1.0 to 1.0). A corresponding chi-square statistic is provided to evaluate whether the observed separation is statistically significant, or could be due to mere chance (sampling error).

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

The major limitation of discriminant analysis is that it ignores the relative importance of individual attributes to consumers. It assumes that respondents reflect the attitudinal or behavioral characteristics of a group and that individual deviations from group patterns are of lesser importance. The statistics used to evaluate the discriminant function will point out whether or not individual uniqueness is more important than group patterns.

SPECIAL CONSIDERATIONS

Discriminant analysis can be carried out on data which has previously collected, provided the data is in ordinal form. Special questions are not necessary but the groups must be defined so that respondents cannot belong to both groups simultaneously (voters that either support or reject a transportation bond issue, but not voters that are indifferent).

EXAMPLE

As mentioned earlier, respondents in the National Demonstration Survey could be classified into two groups based on their answer to the following question on motor fuel taxes:

> "Would you be willing to pay more in motor fuel taxes to significantly improve our transportation and highway system?"

Of the nearly 1,000 respondents answering this question, 62 percent were willing to pay higher motor fuel taxes to significantly improve the highway and transportation system and 34 percent were not.

Researchers wanted to identify the primary differences between these groups of survey respondents to understand the factors that might influence people to support or oppose a motor fuel tax hike. They suspected a number of variables might account for or, at least, be associated with these differences, including:

- Demographic differences such as age, income, the size of their community and whether it is urban, suburban or rural;
- Transportation factors such as whether their job requires them to drive, their daily commuting distances, and their perceptions of traffic congestion;
- Congestion-avoidance measures -- the number of things they themselves have done to avoid traffic congestion;

- Level of satisfaction with highways on which they travel;
- Attitude toward government spending for specific highway improvements; and
- Perceptions of state DOT efficiency and how wisely it currently spends their tax money.

Each of these variables was included in the discriminant analysis. The computer program then selected the best combination of variables, given the responses in the survey, and assigned weights to them in a way that resulted in the greatest differentiation between those who favored and those respondents opposed to raising the motor fuel tax.

It proved difficult, however, to clearly differentiate between the two survey groups, even with the best discriminant function that could be created from these variables. The weakness of the analysis was apparent from the low canonical correlation ($r = 0.28$). The canonical correlation measures the overall strength of the relationship between the discriminant function as a whole and each of the discriminating variables that comprise it. This value when squared indicates that the two groups account for about 8 percent of the variance in the scores along the dimension created by the discriminant function.

This lack of a clear separation in this case was also indicated by the large Wilks lambda (0.92) that was obtained for the discriminant function. In other words, it would be difficult to predict whether a survey respondent would favor or oppose an increase in motor fuel taxes, even if we knew their responses to all the above questions.

The large sample size, however, enabled us to detect that this separation, however small, was statistically significant for this survey and not due to chance. Statistically, there is less than 1 in 100 probability that these respondent group distinctions are due to pure chance. In other words, we can be very confident that there is a small -- but real -- difference between supporters and opponents of the hypothesized tax hike in the group surveyed. To understand the factors that contribute to this small, but real, difference, it was necessary to examine the individual coefficients of the discriminating variables. Table B-4 summarizes the results of the analysis.

Table B-4: Example of Discriminant Analysis

National Demonstration Survey:
Variables Distinguishing Between Respondents Supporting and Respondents Opposing Increased Motor Fuel Taxes

Factor	Impact on Support*
Household income	0.47
Favor government spending to improve roads	0.41
Favor government providing special HOV lanes	0.34
Favor widening highways to add more lanes	0.32
Favor improving mass transit	0.29
Live in central city	0.29
Job requires driving	0.25

*Based on standardized canonical discriminant function coefficients, ranging from 0.00 to 1.00, indicating how powerful each factor is in differentiating between respondents who are willing and not willing to pay a higher fuel tax to significantly improve the highway and transportation system.

From these values we would conclude that the most important factors that differentiated supporters of the tax hike from opponents in the survey was their generally higher household incomes and their support for government spending on specific transportation improvements.

Respondents supporting the tax increase were also slightly more likely to live in the central city and have jobs that required driving during the workday. But the impact of the latter variable (0.25) was only about half of the contribution made by income (0.47) in differentiating the two respondent groups.

Also worth noting were the factors that, although included in the analysis, did not effectively differentiate the two respondent groups - satisfaction with the highways and the perceived efficiency of the state DOT.

CONJOINT ANALYSIS

SUMMARY

Conjoint analysis is used to evaluate the relative importance of one feature or attribute as opposed to another when not all desirable features can be achieved together. For example, when budgetary constraints mean that not all consumer preferences can be satisfied at once and, therefore, trade-offs are necessary, conjoint analysis can be used to derive the optimal combination of factors subject to the cost limitations. The analysis is based on survey participants' preference or degree of support for various combinations of features in hypothesized "packages."

PURPOSE

Consumers are not always able to give a direct value to each feature in combinations of features or even to specify the underlying terms of the trade-offs they make when evaluating the alternatives presented to them. However, they are generally able to rate their support for various combinations of attributes or policy components.

Conjoint analysis is based on respondents' support for various hypothetical combinations of factors. It uses these data to derive the relative value of each attribute when compared to others, the trade-offs between attributes, and the ideal combination of attributes when not all desirable attributes can be achieved together.

Conjoint analysis is used frequently in product development in the private sector when trade-offs must be made in product attributes. It can readily be adapted to the development of public sector programs, policies, and services that are responsive to public needs and demand. In general, conjoint analysis allows the researcher to:

- Assess the individual impact of each attribute on the decision to buy, use, participate, or support; and
- Ascertain the impact of various combinations of attributes or policy components and identify the optimal combination.

For example, conjoint analysis can be used to determine the characteristics of an optimal transportation system where speed, comfort, flexibility, and cost must be balanced to gain public approval if the system is going to be supported both politically and financially. It could be used to develop a transit fare system, enjoying public approval, where fares were varied according to time of day, travel time, and comfort. It could be used also to delineate a transportation project package that would elicit sufficient public support to pass a bond issue funding that set of projects.

TECHNICAL METHODOLOGY

Conjoint analysis applies a complex form of analysis of variance to respondents' ratings of various combinations of attributes or policy components. The analysis calculates a utility for each level or feature of each attribute, based on respondents' reactions to the addition and subtraction of attributes in the packages presented. These are basically index numbers that reflect the relative value or desirability to a respondent of a particular feature.

Features that respondents are reluctant to give up from one package to another (shown by their high rating of packages containing the desired feature) are judged to be of high utility to respondents. For example, an attribute that barely affects the ratings given to packages when it is added and subtracted is judged to be relatively unimportant -- its presence does not greatly affect the respondents' views -- and it is given a lower utility. An attribute that is always found in high-rated packages and never in low-rated packages is considered important -- its presence boosts the package's rating -- and it is assigned a higher utility.

The utilities calculated in the analysis are useful in two ways. First, they identify the more important attributes. Second, utilities are used to rank attributes relative to each other, achieving a finer distinction than just "important" and "less important." Moreover, utilities are additive. That is, a series of positive attributes with positive utilities can be combined to balance combinations of negative attributes with negative utilities, thus achieving combinations that are considered acceptable overall.

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

To be fully effective, conjoint analysis must include the factors that are truly important in the public's mind and that can, in fact, be traded off against other features in constructing policies or services. The analysis could be ambiguous if the features chosen for the analysis do not properly reflect the elements in respondents' decision-making. Results are dependent on the features considered, however, and can be misleading if important features are omitted.

The analysis depends on a degree of public consensus since it calculates the average utility and a typical trade-off structure. If the public does not agree, or if subgroups of the population have widely divergent value systems, the analysis may not be meaningful. In that case, it would be more effective to segregate respondents and analyze each subgroup separately.

Finally, there are no statistical tests to determine validity. This is primarily a descriptive technique. Also, respondents are not allowed to choose "none of the above." So a high rating does not necessarily mean they will buy a support a program or policy, nor does a low rating preclude them from doing so. In other words, the results are all relative to the other packages or alternatives.

SPECIAL CONSIDERATIONS

Conjoint analysis requires specially designed questions that present respondents with varying combinations of features or attributes in a randomized order. The exact number of items in each package, and the selection of factors for each package, is carefully designed. The question is generally in the form "Tell me how likely you are to support a package that contains the following elements..." with the respondent indicating on a set scale (0-5, 0-10 etc.) the strength of his/her support. Conjoint analysis can also be performed on data that ranks the packages from most desirable to least, or simple preference data.

The number of factors that can be considered, the number of questions that have to be asked of each respondent, and the number of respondents in the sample are traded off against each other. The more factors considered, the more packages that must be asked of each respondent in a given sample and the more components in the average package.

Conjoint analysis can be performed with a wide range of attributes and features or levels, but there are some practical limitations. While a special experimental design must be tailor-made to meet the particular requirements of each study, there are some useful guidelines that can be followed.

Generally no more than 12 to 16 questions or alternative packages should be presented over the phone. Each package can contain up to 4 or 5 component features. Respondents can handle up to 24 questions in person or by mail. In general, the number of questions required for conjoint analysis is indicated by the following:

- A design with five attributes of three levels each requires 16 questions. (An attribute is analogous to a variable and can have several levels.)
- A design with eight to 11 attributes, each with two levels, requires 12 questions.
- A design with 12 to 15 attributes, each with two levels, requires 16 questions.

The appropriate sample size is determined in the same way as other studies.

EXAMPLE

Part of the National Demonstration Survey was designed to investigate respondent reaction to various improvements in highway and transportation systems. The goal was to determine what types of improvements survey participants considered most desirable and how much they would be willing to pay for these improvements. The improvements, therefore, were coupled with a "sacrifice" in the form of hypothesized increases in motor fuel taxes.

The researchers examined respondent acceptance of various combinations of costs (increased fuel taxes) and benefits (various highway and transportation improvements). The following sequence was used:

> "Now I am going to read some improvements that might be made in our highway and transportation system. Each of the programs I describe will include a different combination of the following features: raise the motor fuel tax, reduce accidents, reduce traffic congestion, reduce pollution, reduce the federal deficit, increase research on high technology, improve the physical condition of the roads, and make mass transit more available.
>
> For each program I describe, please tell me how likely you are to vote for these changes, using a scale from 0 to 10 with 0 meaning not at all likely and 10 meaning very likely to vote for it.
>
> How likely are you to vote for a program that would: raise the motor fuel tax 25 cents a gallon, reduce accidents and traffic congestion, and improve the physical condition of the roads?"

This question was repeated for many different combinations of features chosen systematically according to a pre-specified experimental design. Four hypothesized tax increases were used in alternation: 5 cents, 10 cents, 25 cents, and 50 cents.

The results of the conjoint analysis are shown in Table B-5. The analysis indicated that hypothesized tax increase was the most important determinant of respondent support for the various policy packages -- the higher the tax, the lower the support for the package. Among the "benefits" in each package presented to survey participants, improved physical condition of the roads was the most valued component -- that is, its absence or presence caused the greatest fluctuation in respondent support or variance among the program expenditures, thus it was the hypothesized improvement most valued by survey respondents.

Table B-5: Example of Conjoint Analysis

National Demonstration Survey:
Relative Value of Transportation and Highway Improvements to Survey Respondents

Factor	Units of Importance*	Utility
Amount of motor fuel tax increase (5, 10, 25, 50 cents)	59	—
Improved physical condition of roads	13	4.9
Increased research on high technology	8	2.9
Reduced traffic congestion	6	2.3
Reduced accidents	6	2.1
Greater mass transit availability	5	1.9
Reduced pollution	3	1.0
Reduced federal deficit	1	0.6
Total	100	15.7

*Based on a 0-100 scale of importance derived from a percent of respondent variance accounted for by the variable.

The analysis shows that the group surveyed in the National Demonstration Survey would probably be willing to pay a maximum tax increase of 15.7 cents per gallon to receive all of the benefits. Moreover, this group would be unwilling to support a tax increase of this magnitude unless all the benefits were included. On the other hand, if a 7 cent increase were instituted, this group of respondents would probably settle for less. Most likely, it would be sufficient to construct some combination of benefits for which the sum of utilities was 7 or greater -- for example,

increased research on high technology and improved physical condition of the roads. A program to reduce traffic congestion, reduce accidents, and reduce pollution would support a fuel tax increase of only 5.4 cents (2.3 + 2.1 + 1.0) or less among the survey respondents.

Reduction of the federal deficit was the weakest policy component; overall, survey respondents would support a tax increase of only 0.6 cents for deficit reduction. This agrees with respondents' answers to the direct question on fuel taxes for deficit reduction.

MULTIDIMENSIONAL SCALING

SUMMARY

Multidimensional scaling (MDS) is a measurement and statistical technique used to map and identify the dimensions along which respondents compare objects, to position the objects with respect to those dimensions, and to position objects with respect to each other.

PURPOSE

Multidimensional scaling (MDS) is a set of mathematical techniques that enable a researcher to uncover the "hidden structure" of respondents' perceptions of objects. These analytical techniques can be used to study consumer attitudes and, in particular, the factors that influence perceptions and preferences. These techniques attempt to identify the product or service attributes that are important to customers and to measure their relative importance, in some cases without asking them directly.

Multidimensional scaling techniques can reveal the principal dimensions along which people make comparisons, and can reveal what guides their perceptions and makes one object stand out above the rest. MDS can also identify the combination and relative importance of attributes desired by transportation users, thus revealing how to position a product, service or program to capitalize on perceived strengths and desires of the respondents.

MDS is both a measurement and statistical technique that attempts to measure people's perceptions of the similarities and dissimilarities among objects and produce a map that graphically portrays these relationships among objects, their relative positions and infer the principal dimensions along which these comparisons are made.

TECHNICAL METHODOLOGY

The technical aspects of MDS can perhaps best be understood by visualizing a hypothetical example based on data that are well known. Picture a map showing the locations of several cities in the United States. Each city would be positioned a certain number of miles north or south and east or west of every other city shown on the map. It would be a fairly easy task to construct a table of direct distances between each pair of cities using a ruler to measure the distances between cities and recording the distance according to the scale of the map.

Now suppose that there was no map, but that there was a table showing distances between each pair of cities. This table does not show longitude or latitude, only air distances. Using data from the table, it would be possible to construct a map that positioned each city correctly. However, considerably more effort would be required to work backwards from the distance grid to a spatially correct map than to work from the map to a table of distances. In essence, MDS is a method for solving this second task.

MDS refers to a class of techniques that use proximities among any kind of objects as input. That is, input data are numbers that indicate the perceived similarity or differences between pairs of objects. Data collection for this method involves asking people to directly judge the "psychological distance" or closeness of the objects. Although the words similarity and dissimilarity are most frequently used to elicit opinions, words such as relatedness, dependence, association, complementarity, substitutability, and so on are also used.

In order to discover rather than impose the dimension or set of attributes used for judgement, the attributes on which the stimuli are to be judged are usually not specified.[4] That is, respondents may be asked to rate the similarity of countries or transportation modes to each other, but the respondents would not be told on what basis to compare "similarity." Objects are compared two at a time such that all objects are compared with each other once.

For example, respondents might be asked how similarly they perceive Norway and Sweden and, subsequently, how similarly they perceive Sweden and Germany, Germany and Norway, and each of these vis-a-vis France. If a scale of 1 to 10 were used, 10 would mean that pair of countries were perceived as extremely different from each other; a score of 1 would mean great similarity. This would yield a grid of "distances" between each of the four countries and the rest. The more objects or items involved, the greater is the number of comparisons that must be made to produce a complete grid of perceived distances.

The chief output of MDS is a spatial representation, consisting of a geometric configuration of points, as on a map. Each point in the configuration corresponds to one of the objects. The configuration reflects the "hidden structure" in the data, and often makes the data much easier to comprehend. The larger the dissimilarity between the two objects, as shown by their proximity value, the further apart they should be in the spatial map. The computer constructs a map based on dimensions that best preserve the perceived interrelationships among objects, while minimizing the discrepancy or deviation among respondents. In other words, it seeks to produce the "best fit" map.

The factors represented by the x and y axes of the spatial map are not inherent in the analysis; they are inferred by the researcher using what he/she knows about the objects rated and the patterns that result from the mapping. For example, in rating the countries, if France and Germany were close together in one dimension and far from the two Scandinavian countries, the researcher might infer that this axis represented "production of wine." Other standard questionnaire items can sometimes be used to help interpret the dimensions -- by knowing how the various objects rate on certain independent scales.

In addition to using tangible items, known services, or recognizable institutions as objects in MDS, researchers can include the "ideal" in the analysis. Respondents then specify the proximity between their ideal and each item in the analysis. The resultant spatial map includes "ideal" as a point on the map, indicating the proximity of each item in relation to the ideal and the position of the ideal with respect to the two dimensions or implicit criteria. The ideal point can be calculated as the average for all respondents or, if there are distinct clusters of opinions, one ideal for each population subgroup. This would show, for example, how different population groups would describe the ideal transit system, the ideal solution to local congestion, the ideal funding package, etc.

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

In MDS, the spatial location of each object on the resulting map is based upon the "average" distances assigned to each pair. That is, the final distance grid presents the averages of all scores given by the survey respondents. Thus, the technique assumes that there is basic consensus among individuals in their perceptions of the distances between objects in each paired set -- that most survey participants would agree with the computed spatial distances. The extent of this potential problem can be assessed by examining the standard deviation. If half the participants think Sweden and Germany are very similar and half think these two are far apart, the average score is not really meaningful. In this circumstance, however, analysis could be performed separately for individual population subgroups defined by demographics or psychographics.

When the spatial dimensions are not explicitly named in the survey, MDS is limited by the fact that the underlying attributes have to be identified by the researcher; these are not always obvious from the analysis. There is the danger that the perceptions and preconceptions of the researcher are interjected, leading him/her

[4]See the next section on "Multidimensional Scaling with Explicit Attributes" for a discussion of MDS that explicitly includes attributes in the analysis.

to name attributes or dimensions that are different from those actually underlying the respondents' answers. However, this may be less problematic than allowing the researcher to assume the dimensions to be measured a priori and producing misleading results on the relative positions of the objects.

The technique also assumes that the underlying data represent valid measures, that respondents have the ability to compare objects with respect to similarity or preference or attributes, and that these distances not only have conceptual meaning. The latter is not answered. There is no guarantee that the dimensions that define the map are the attributes that most influence preference choice or actual behavior.

SPECIAL CONSIDERATIONS

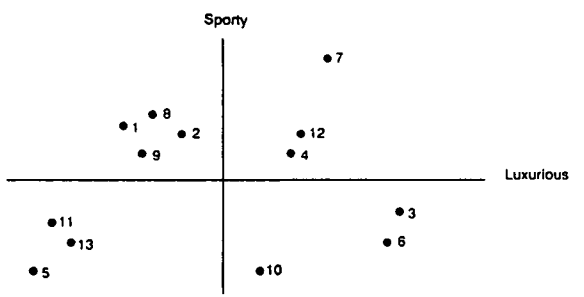
The use of MDS requires specially constructed questionnaire segments that ask for rated comparisons between paired items. The researcher must know in advance what items are going to be included in the spatial map, and restrict that number to an amount that can be paired in all possible combinations in the time allowed. The number of combinations of "n" items is [(n-1)n]/2. Thus, to construct a spatial map with 10 items, a series of 45 questions must be asked.

EXAMPLES

An example of a spatial map used to evaluate different makes and models of cars is shown in Figure B-3. The attributes sporty and luxurious were determined by the researcher after the computer generated the map, given his knowledge of the cars used in the survey. In this example, the respondents were asked to rate the similarity of each named pair of cars. Thus, from the spatial map, it can be seen that a Lincoln Continental V8 and a Chrysler Imperial V8 were considered fairly similar to each other and that both of these were considered similar to a Jaguar sedan in one dimension (the horizontal value) but quite different in terms of the other implicit criteria (value along the vertical axis).

In addition to positioning cars in the spatial map, this particular study also positioned two groups of respondents. Respondents in groups I and J were asked the similarity between their ideal cars and each of the named models. Respondent Group I's ideal car was slightly up and to the right of a Ford Thunderbird V8. In terms of the criteria inferred by the researcher, Group I's ideal car would be slightly more luxurious and slightly sportier than a Thunderbird, but not as luxurious or sporty as a Jaguar sedan.

Figure B-3: Example of Multi-dimensional Scaling – Evaluation of Different Cars



KEY

1. Ford Mustang 6
2. Mercury Cougar V8
3. Lincoln Continental V8
4. Ford Tunderbird V8
5. Ford Falcon 6
6. Chrysler Imperial V8
7. Jaguar Sedan
8. AMC Javelin V8
9. Plymouth Barracuda V8
10. Buick Le Sabre V8
11. Chevrolet Corvair
12. "Ideal" location, Group I
13. "Ideal" location, Group J

Source: D.A. Aiker and G.S. Day, Marketing Research (John Wiley & Sons, 1986)

In another example, administrators at a state university in the Southeast wanted to know how their university was perceived by various constituent groups (taxpayers, parents, potential students, etc.). They were

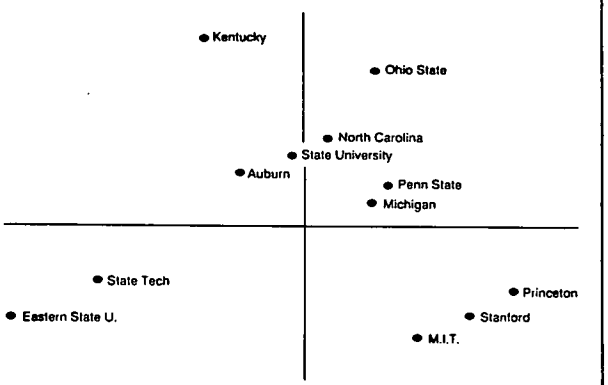
interested in using this information to formulate a communication strategy to maintain and enhance their public image.

They chose MDS as a primary methodology. In one phase, a random sample of students was asked to compare their university with other well-known universities, including some potential competitors and others that served as convenient references. The list of universities included two smaller in-state colleges, several large Southeastern state universities, two Midwestern state universities and several "prestige" schools.

Students were given a scale and asked to assess the difference between pairs of universities in a series of questions that included each possible pairing of schools. They were instructed to say "0" if they perceived no difference at all between the two schools in a given pair and a large number if they perceived the two universities were very different. In this case, there was no upper bound on the scale. However, researchers frequently use a 1-7 or 1-10 scale. Students were free to use any criteria of their own choosing to make comparisons. The result was the map shown in Figure B-4.

The perceived differences were treated as distances between the universities and were averaged across the respondents. The average distances between each pair of schools were then used to plot the schools as points on a map, using a computer program to arrange the schools in the minimum number of dimensions necessary to describe the data while also minimizing the "error" in their interpoint distances.

Figure B-4: Example of Multi-dimensional Scaling – Student Perceptions of Selected Universities



Source: Dr. M. Mark Miller and Dr. Robert E. Hurd, Media and Opinion Research, a division of the Gordon S. Black Corporation.

The two dimensions portrayed in the map accounted for more than 65 percent of the response variance. From this map, researchers were able to see that "State University" was perceived as most similar to North Carolina and Auburn, and very different from the smaller state colleges or the prestige schools.

The administrators were also interested in identifying the two principal dimensions along which the perceptions were arranged. The "east-west" or x-axis dimension was the longest -- explaining the most variance. It was interpreted to represent "academic prestige" because it was bounded by the smaller state colleges at one end and the prestige schools like Princeton at the other extreme. Students located their own State University in the middle, and perceived that the other large state universities had better academic reputations.

On the "north-south" or y-axis distances, Kentucky and Ohio State were ranked highest. At the other extreme were both the smaller state schools and the prestige universities. Researchers labelled this dimension

"athletic prowess" and noted that neither the prestigious schools nor the smaller local colleges had the reputation for strong athletics that characterized schools at the other end of the scale. State University was better than average.

Administrators were able to see that:

- Students appeared to assess universities on both academics and athletic reputations;
- State University was perceived to be average academically and better than average in terms of athletics;
- Academics was apparently more important than athletics in distinguishing among schools; and
- State University would have to improve its academic image if it intended to compete with large state schools such as Michigan and Ohio State.

Although it was not attempted in this study, researchers could have included "The Ideal University" as a school in the group of schools compared. MDS would have located Ideal in the same way as existing universities. It would then have been possible to see how students compared State University to their ideal, to see in which direction students would like to see their school head.

MULTIDIMENSIONAL SCALING WITH EXPLICIT ATTRIBUTES

SUMMARY

Attribute-based MDS is a specific application of MDS which measures and "maps" the extent to which various, explicit attributes are associated with an object. An object's location is determined in relation to its perceived attributes, and not necessarily relative to other objects. Respondents are asked how well various attributes describe an object; attributes strongly associated with the object will appear as points on the map located near the object. Some applications combine both multiple objects and multiple attributes, as well as an ideal point or self-referent.

PURPOSE

The goal of MDS in general is to provide an easy-to-interpret graphic portrayal of the image that respondents have of an object. This image can be measured and constructed in terms of an object's position relative to other objects, as noted in the previous section, or in terms of the explicit attributes with which it is associated. Attribute-based MDS focuses more on the precise nature of that image and the attributes that contribute or detract from it, rather than the relative position of a policy, program or institute.

TECHNICAL METHODOLOGY

MDS can also be used to "map" a wide variety of explicit attributes that may be associated with a particular object. Essentially the same techniques are used as above, but in this case respondents are not asked to compare or evaluate the perceived similarity/dissimilarity between objects two at a time. Instead, they are asked to evaluate how well a particular attribute describes an object, or how closely an attribute is associated with the object. These perceptions are measured for each in a series of descriptive attributes.

These evaluations or perceptions are then converted into distances by the computer in the same way that distances or perceived similarities among objects were calculated. the computer then locates each item on a map that best preserves these aggregate perceptions, while minimizing any discrepancies in the perceived distances among respondents.

Attributes that describe an object very well appear as points on the map that are located very close to the object. Attributes perceived to not describe the object well will be located further away. Distance estimates

between attributes can be obtained based on their perceived similarities.

Thus, attribute-based MDS procedures produce an easily-interpreted map on the aggregate image that respondents have of an object. In this case, however, the researcher interprets and orients him/her self to the map by using the attributes instead of the perceived relationship among the objects themselves. Nor is it necessary to interpret the X and Y axes or dimensions, because the attributes themselves provide rich descriptions and substantive interpretations.

Some researchers have also combined the two applications to produce maps showing interrelationships among MULTIPLE objects and MULTIPLE attributes simultaneously. This requires only a minor change in the instructions for the respondent. They are asked to assess the psychological similarity or closeness between objects and attributes, between objects themselves, and between pairs of attributes. Each of these assessments is treated as an interpoint distance between items to be plotted on the MDS map.

Returning to the previous automobile example, respondents would essentially be asked how luxurious each car was, how sporty each car was, how similar one car was to the other, and how similar or different the two concepts "luxurious" and "sporty" were.

The resulting spatial map would have points representing each of the cars and each of the attributes included in the analysis. The similarity or degree of relationship between each of these concepts -- each attribute and each item -- could be evaluated with respect to every other concept. Any two concepts close to each other would be considered related or similar; this means two attributes, one attribute and one car, or two cars.

ASSUMPTIONS, CONSTRAINTS, AND LIMITATIONS

The assumptions, constraints, and limitations are the same as those for MDS in general. That is, the technique assumes a consensus among respondents and interpretation is somewhat subjective. However, MDS with explicit attributes is perhaps less subjective since named attributes are shown on the spatial map, thus indicating the attributes most important in public evaluation. Nonetheless, if important attributes are overlooked, researchers can erroneously interpret the implicit values to be confined to the ones included in the analysis.

SPECIAL CONSIDERATIONS

Questions must be specifically structured for all MDS analysis and, in this case, the attributes must be chosen carefully to reflect the criteria probably used by respondents.

EXAMPLE

In the second phase of State University's project to analyze its image (the example described above in the section on Multidimensional Scaling), researchers wanted to get a more detailed view of the university and attributes perceived as key strengths and weaknesses. One aspect of this focused on a random sample of college-bound high school seniors. The goal was to map their perceptions of the university and develop an effective communication strategy for recruitment.

Open-ended interviewing was first used to develop a list of attributes that most students thought about when considering which university to attend. Three more concepts were added to this list of attributes for evaluation; these concepts represented the State University, the respondent himself, and the university the respondent would most like to attend. This latter concept is similar to the "ideal" university.

A random sample of students was asked to evaluate the similarities and differences among these concepts, assigning a low value to things that seemed similar or related and a high value to pairs that were perceived as unrelated or very different. The responses were treated as interpoint distances between concepts and averaged across respondents to create a multidimensional map of student perceptions. These revealed the relationship among the key attributes and objects representing the universities.

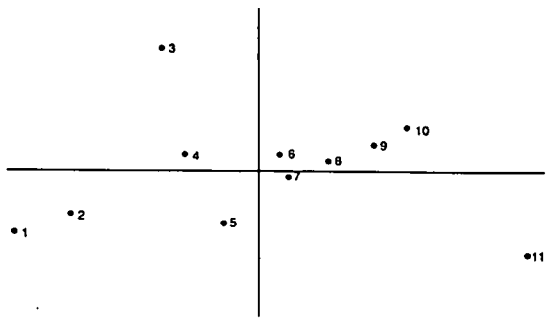
Attributes located closest to "yourself" and "your first choice college" were interpreted as desirable and

valued by students. Attributes located further away were taken to be less valued. It was also assumed that attributes associated with the university would be located closer to State University; those not describing the university very well would be located further away.

Figure B-5 shows the results of this study. Researchers interpreted this map to suggest that the attributes most important to students included strong courses in your field, chance for personal independence, and pleasant surroundings. Moreover, these same attributes described the college of their choice.

State University was rated highly on two of these factors -- personal independence and pleasant surroundings. On the other hand, it was rated lower on strong courses in your field and academic standards in general. It was rated fairly high in two concepts not as important to potential students -- extracurricular activities and meeting new people. State University was also perceived as more closely associated with athletics than academics, while the reverse was true for their first choice university.

Figure B-5: Example of Multi-dimensional Scaling with Explicit Attributes -- Student Perceptions of a State University and Its Attributes



KEY

1. High academic standards
2. Strong courses in your chosen field
3. Variety of classes
4. Yourself
5. Your first college choice
6. Opportunity for personal independence
7. Pleasant surroundings
8. State University
9. Meeting new people
10. Lots of extracurricular activities
11. Athletics

Source: Dr. M. Mark Miller and Dr. Robert E. Hurd, Media and Opinion Research, a division of the Gordon S. Black Corporation.

The practical conclusion of this study was that State University's recruiting campaign would emphasize academic standards and career preparation so as to better appeal to prospective students.

PERCEPTUAL MAPPING

SUMMARY

Perceptual mapping is essentially a graphic display of discriminant analysis results, producing a map that appears similar to MDS, but based on the dimensions or attributes that most clearly differentiate one object from another and contribute most to perceptions that influence actual choice or preference.

PURPOSE

Like multidimensional scaling, perceptual mapping provides a graphical representation of the perceptions of items or objects based on a set of attributes. But instead of mapping these perceived attributes directly or inferring them from interrelations among plotted objects, perceptual mapping seeks to identify the dimensions that maximize respondent discrimination -- the ability to distinguish among objects.

For this reason, perceptual maps are based on the results of discriminant analysis instead of similarity data, and enable the researcher to focus attention on the dimensions or attributes most important in shaping consumer choice or preference. (In this application, discriminant analysis is performed to distinguish among objects, however, and not among groups of respondents as is often the case.)

Multidimensional scaling is often preferred when the goal is to map the image of an object to understand its position relative to other objects or competitors and to analyze its strengths and weaknesses in terms of its attributes. Perceptual mapping, on the other hand, is often preferred when the goal is to understand the features that best distinguish an object from its competitors and the attributes it must emphasize to improve that image. (However, because perceptual mapping ignores information that does not contribute to an object's differentiation or preference over other objects, it may ignore information that is important to an object's image and desirability.)

TECHNICAL METHODOLOGY

Instead of directly plotting objects and attributes based on similarity/dissimilarity data, objects are evaluated along a series of attributes and multiple discriminant analysis is used to reduce their dimensionality while maximizing their separation or "discriminant." Each object (product, service, program. etc.) occupies a specific point on the resulting perceptual map; the location of each point is determined by plotting the output of the discriminant analysis.

Functionally, the computer combines and weights individual attribute variables and creates a "discriminant function" that is analogous to a regression equation or a factor in factor analysis, except that the discriminant function maximizes the separation among objects being evaluated. The first function is the one that best separates the objects, the second function is second best, and so on.

The first two functions are used to draw the right-angle dimensions of the perceptual map because they are uncorrelated and account for the most variability in the attributes. The exact location of the objects is then determined by evaluating the discriminant functions at the mean of each attribute that has been weighted and combined to form that function. These "discriminant scores" are then plotted along these two dimensions.

The individual attributes can then be overlayed on this map to help interpret the dimensions and the location of the objects. Each attribute is treated as a vector whose direction from the origin is determined by its correlation with the discriminant function. Attributes that contribute highly to a discriminant function will be located at a smaller angle from the function or axis. The higher the rating of an item on an attribute, the farther out from the center that item will be placed along that attribute's vector.

Objects that are perceived as very different from each other will be located further apart on the map, and those perceived to be similar will be close together. The perceptual map also allows the researcher to identify how an object is associated with an attribute, and which attributes contribute most toward these perceived similarities and differences.

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

It should be kept in mind that, unlike MDS, these perceptions are distorted to the extent that they maximize differences where only small differences may exist. On the other hand, these perceptual maps provide information that can be very valuable in determining which attributes are most important in influencing consumer preferences, choices or behavior -- information not provided by MDS.

Generally, perceptual mapping has the same underlying assumptions and limitations of discriminant analysis, the method that provides the basis for the mapping procedures.

SPECIAL CONSIDERATIONS

Perceptual mapping relies on discriminant analysis and thus utilizes interval data rather than categorical data.

EXAMPLE

Hypothetical data is used here to provide an easy to understand example of perceptual mapping. This example deals with the attractiveness or appeal of five cities; it illustrates techniques that could be used to evaluate different aspects of various transportation programs or services or funding approaches.

Five cities were evaluated in this hypothetical example -- San Francisco, Washington, D.C., Seattle, Miami, and Minneapolis. Respondents were asked to rate each city on the extent to which each has the following criteria or attributes:

- Historic landmarks;
- Beautiful scenery;
- Good weather;
- Good places for walking; and
- A reputation for liking tourists.

For each criterion, they were asked to rate the cities using a five point scale where "1" means the statement is not at all true and "5" means the statement is very true.

Although not required for perceptual mapping, in this example the respondents were also asked to rate the "ideal" city on each attribute -- not choosing any particular city, but an imaginary place they would most like to visit.

After the respondents had rated the five cities on each of the five attributes, the first step in the analysis was the calculation of average scores so that the perceived strengths and weaknesses of the cities could be compared. The results are shown in Table B-6.

Table B-6: Average City Ratings for Perceptual Mapping Example

	Attribute				
City	Landmarks	Scenery	Weather	Walking	Reputation
San Francisco	2.7	3.9	3.2	3.9	2.4
Washington, DC	4.5	1.7	2.7	3.5	2.6
Seattle	1.0	3.4	0.9	3.1	2.8
Miami	0.2	2.6	2.7	1.3	2.7
Minneapolis	0.8	2.6	1.0	2.2	2.7
Ideal City	4.8	4.9	4.9	4.9	4.9

We can tell from these mean ratings, for example:

- Washington, D.C. is rated high for having historic landmarks (4.5) and being a good place to walk (3.5), but is rated low for its scenery (1.7) and medium for its weather (2.7).
- Respondents perceived few differences among the five cities when it came to having a reputation for liking tourists -- these ratings only ranged form 2.4 to 2.8.
- Respondents perceived the cities to be very different in terms of historic landmarks; Washington was ranked at the top with a 4.5 and Miami was rated lowest with only 0.2.

- The ideal city would have all of these attributes because each of them is rated high -- about 4.9 on a 5 point scale.
- And, as often is the case, each of these attributes appears to be equally desirable because each attribute is rated as high as the next for the ideal city.

In the next phase, a discriminant analysis was performed to identify the attributes that maximize the differences between the five cities. This produced a discriminant function that weighted more heavily the attributes on which the cities differ, thus maximizing the perceived differences among cities. (If multidimensional scaling were used here, we might plot these perceptions directly. But instead, perceptual mapping and discriminant analysis were used to identify the attributes that best distinguish one city from another in the eyes of respondents -- these are the factors that could be emphasized to maximum effect in a marketing or promotion campaign.)

The first two discriminant functions are uncorrelated with each other and represent the two dimensions that best separate respondents' perceptions of the five cities in this hypothetical example. The function is defined by coefficients that determine the weight given to each attribute in the function. They are also analagous to the coefficients in a regression equation.

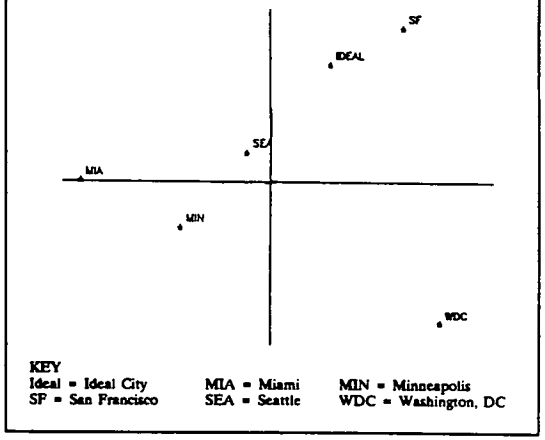
These discriminant functions define the horizontal and vertical dimensions of the perceptual map created in the next phase of analysis. The location of these cities on the two dimensions is also determined by calculating a function "score" much in the same way a factor score is created in factor analysis. Coordinates can be calculated for each city on the map by taking the mean for that city on a given attribute and multiplying it by the coefficient and then summing across attributes. These scores must be standardized before calculating or plotting.

Once the two dimensions have been defined and cities have been plotted, the resulting "map" (Figure B-6) graphically displays much of the discriminant analysis results.

For example, one can see from this map that:

- San Francisco and Washington are given high ratings on the landmark/walking dimension (East-West), and that is the most influential dimension because it is the longest one -- it does a better job of separating one city from another.
- San Francisco also rates high on the scenery dimension (North-South), while Washington rates low.
- San Francisco is also more similar to the Ideal than the other cities in terms of these distinguishing characteristics.

Figure B-6: Example of Perceptual Mapping for Selected Cities



These attributes can also be correlated with the function scores, to determine the relative location on the map of the attributes themselves (Table B-7). These correlations indicate that:

Table B-7: Discriminant Functions for City Rating Example

Attribute	Function 1	Function 2
Landmarks	0.63	-0.04
Scenery	0.00	0.52
Weather	0.13	0.14
Reputation	-0.04	-0.03
Walking	0.26	-0.12

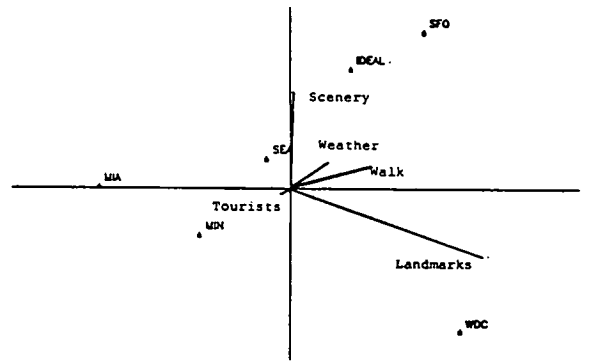
- Having historic landmarks (0.63) is the characteristic that is most important in distinguishing among these five cities. Walking is also important (0.26) and apparently perceived as related to landmarks because they load on the same factor or function.

- Having good scenery is perceived as being different from historic landmarks because they don't load on the same function. Because it is the strongest loading (0.52) on the second best function, scenery appears to be an attribute that helps distinguish one city from another.

- Weather and reputation are not strongly related to either discriminant function, indicating these attributes are not important in discriminating among cities.

Finally, the individual attributes can be overlaid on the perceptual map by plotting the correlation between each attribute and each of the two dimensions (Figure B-7).

Figure B-7: Perceptual Map with Attribute Vectors



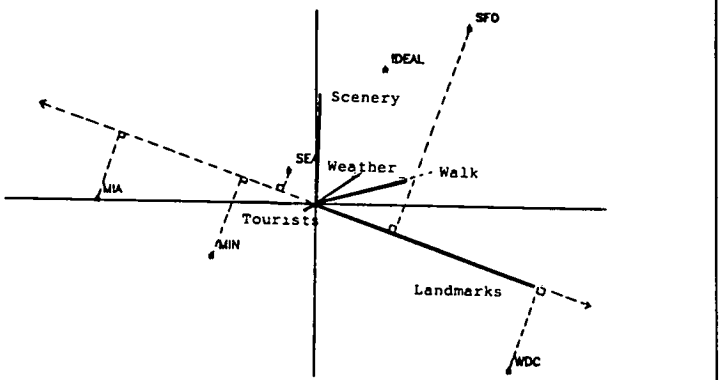
KEY
Ideal = Ideal City MIA = Miami MIN = Minneapolis
SF = San Francisco SEA = Seattle WDC = Washington, DC

These relationships are represented by a vector whose length indicates the relative magnitude of the contribution to each function and the angle indicates the degree of correlation with that function or dimension -- a perfect correlation would result in a vector that coincides with the dimension.

The original ratings of each city on that attribute can be reconstructed by drawing perpendicular lines from each city to the attribute vector that passes through the origin.

Thus, in the final map (Figure B-8), Washington rates high on landmarks, followed by San Francisco, Seattle, Minneapolis and Miami.[5]

Figure B-8: Perceptual Map Showing City Relationship to Attribute Vectors



KEY
Ideal = Ideal City MIA = Miami MIN = Minneapolis
SF = San Francisco SEA = Seattle WDC = Washington, DC

CORRESPONDENCE ANALYSIS

SUMMARY

Correspondence analysis is a relatively new market research technique developed to graphically display and simplify large amounts of tabulated data in a single, easy-to-read multidimensional map, looking much like those produced by MDS or perceptual mapping. This is a valuable tool for researchers who need to perform multivariate analysis with categorical data -- that is, data that record categories rather than intervals or values.

PURPOSE

Correspondence analysis was designed to produce analytical maps using the most common form of market research data -- simple tabulations of categorical variables. Few multivariate techniques previously existed for such data, forcing researchers to simply "eye-ball" frequency data to find patterns and trends among subgroups. This method was cumbersome, time-consuming, inefficient and often misleading.

[5]Please note again that the purpose of perceptual mapping is NOT to plot the perceptions and relative locations of the cities directly, as would be the case in multidimensional scaling, but instead to identify the combination of characteristics that maximize the perceived differences among the cities and, then, locate the cities and their attributes on THOSE dimensions.

By displaying the frequency data as distinct points representing response categories on a two-dimensional map, correspondence analysis can clarify the patterns, structures, trends and relationships in data, allowing the researcher to draw conclusions and make predictions.

It also allows the researcher to approach categorical data analytically in a manner similar to other multivariate techniques requiring ordinal or interval level data. Because it is a multivariate technique, correspondence analysis provides for a better understanding of the interrelationships in the data, revealing results that are impossible to detect by simply comparing variables two at a time.

Correspondence analysis can be used to:

- Perform market segmentation and identify groups of individuals who have similar behaviors and attitudes;
- Analyze product position by tabulating the frequency with which individuals assign certain attributes to certain products or services and plotting these relationships among products and attributes;
- Compare changes in attitudes among groups of respondents before and after a communication or marketing campaign, assessing the impact on product or service position; and
- Evaluate policy options by examining how different groups perceive the attributes of these options and which options they prefer.

TECHNICAL METHODOLOGY

Correspondence analysis has been described as both principal components analysis and discriminant analysis of categorical data. It differs from perceptual mapping, which uses numerical ratings as data, by using frequency data -- data on the number of times or frequency with which each answer was selected.

In some ways correspondence analysis is also similar to multidimensional scaling because it treats each row and column response category as an object to be plotted on a two-dimensional map, and transforms the frequency counts in each row-by-column intersection into an estimate of the "distance" between the row category and the column category.

One method accomplishes this by taking the product of the square roots of the row and column percentages in that cell, and then performing a series of transformations. The final result is a data matrix representing the spatial distance between each response category and other categories.

From this matrix, a map is constructed by defining the dimensions that best fit the data and then plotting each of the categories from the original frequency table onto these dimensions. Once the original frequency counts are entered from the original data, the computer program will analyze each variable's variance across all respondents and perform the necessary transformation.

The response category with the greatest overall variance is then loaded onto the first graphical dimension, which is represented by the horizontal axis on the map. The program then selects the category will the second most variance. If the variable to which the second category belongs is significantly correlated with the first category, it is then loaded on the horizontal dimension.. If the variables are uncorrelated, the second category is loaded on the vertical dimension, i.e. it becomes the first contributor to the second dimension. The fact that these variables are uncorrelated is represented by the perpendicularity of the axes.

The computer continues this process for each response category, loading them on one of the two dimensions that account for most of the overall variance. The location of each category is determined by both its contribution to the axes and its association with other categories.

Categories with high contribution to an axis will appear close to that axis on the map, and those with

a low contribution will appear further away.

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

In order for the correspondence analysis to work properly, the variables in the frequency table must be correlated, that is, their chi-square must be statistically significant. In other words, correspondence analysis is appropriate only when statistical tests indicate that population characteristics for one variable are related to the characteristics for another variable as, for example, the relationship among income, age, and education.

SPECIAL CONSIDERATIONS

Correspondence analysis requires only that data be presented as category frequencies rather than as intervals; no special questions are required. Thus, analysis can be performed on data collected previously.

EXAMPLE

The example of correspondence analysis used here is taken from the benchmark research study on attitudes toward drug abuse conducted by the Gordon S. Black Corporation for the Media-Advertising Partnership for a Drug-Free America. This analysis could be conducted just as easily on attitudes toward any transportation problem, program, or services.

In this case, adults were asked how attitudes had changed about the use of marijuana in the past 12 months among people they knew -- was there much more approval, somewhat more approval, somewhat more disapproval, much more disapproval or were attitudes about the same?

The raw frequency counts were tabulated for all respondents and then for different groups of people based on their age and religious service attendance (Table B-8; Table B-9 indicates the percentage distribution of answers).

Table B-8: Respondences for Correspondence Analysis Example: Frequencies

	Adults 18 Years and Older						
		Age			Attend Religious Services		
	Total	18-25	26-34	Over 34	Seldom	Occasionally	Regularly
Much More Approval	219	90	46	69	85	39	82
Somewhat More Approval	370	172	58	115	157	68	126
About The Same	2531	995	545	910	1300	412	738
Somewhat More Disapproval	808	270	134	374	333	153	300
Much More Disapproval	565	130	79	331	190	92	251
Total	4493	1657	862	1977	2065	764	1497

Most people (56 percent) said that the attitudes of people they know have stayed about the same. About one-third said there is more disapproval, and only 13 percent said there is more approval of marijuana use now. People over the age of 34 were more likely to sense growing disapproval, as were people who attend religious

services regularly.

Table B-9: Responses for Correspondence Analysis Example: Percentages

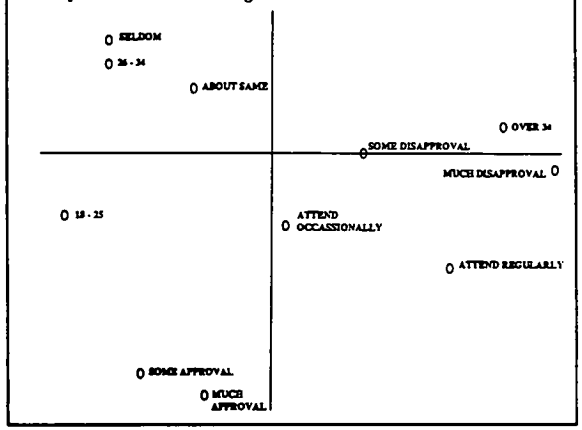
	Adults 18 Years & Older						
		Age			Attend Religious Services		
	Total %	18-25 %	26-34 %	Over 34 %	Seldom %	Occasionally %	Regularly %
Much More Approval	5	5	5	4	4	5	5
Somewhat More Approval	8	10	7	6	8	9	8
About The Same	56	60	63	51	63	54	49
Somewhat More Disapproval	18	16	16	21	16	20	20
Much More Disapproval	13	8	9	18	9	12	17
Total*	100	100	100	100	100	100	100

*Due to rounding, columns may not add to 100.

This is not difficult to see when examining only one or two crosstabulations at a time. But when categorical data analysis must be more detailed and complex, correspondence analysis becomes a useful tool because it simplifies complex relationships and presents them in a single easy-to-read display.

In correspondence analysis, the data are transformed and the response categories are plotted as points on a map, separated by "distances" derived from the variance in row and column percentages. Correspondence analysis creates dimensions that minimize the distance between these categories, so that similarities and relationships can be observed directly.

Figure B-9: Example of Spatial Map Using Correspondence Analysis: Attitudes on Drug Abuse



Thus, from the map created with correspondence analysis on attitudes toward drug abuse (Figure B-9), we can see that:

- Older people have very different perceptions than people under 34 years old about current changes in attitudes toward marijuana use -- because they are located at the opposite end of the map from younger respondents.
- People over 34 are most likely to sense growing disapproval -- they are located closest to the "disapproval" concepts.
- Regular attendance at religions service is related to perceptions of growing disapproval.
- Older people are also more likely to attend religious services regularly.

PSYCHOGRAPHIC MARKET SEGMENTATION

SUMMARY

Psychographic market segmentation is a way of identifying and describing groups within the general population. It is analogous to demographic segmentation which also groups respondents by certain characteristics. The difference between the two is in the descriptive variables used: demographic segmentation utilizes socio-economic and other demographic variables; psychographic segmentation utilizes variables that measure attitudes, lifestyle, and behavior -- factors that may greatly influence how people respond to product and policy developments or communication and marketing efforts.

PURPOSE

Psychographic market segmentation, sometimes called "values and lifestyles research," is a relatively new approach in market research. It is analogous to the use of demographics to identify and describe different population segments; it differs in the variables used to classify individuals -- individuals are classified with respect to activities, attitudes, interests, beliefs, and opinions rather than the more traditional demographic variables of age, gender, income, education, etc.

Psychographic market segmentation recognizes that:

- Today's market or population is increasingly fragmented, and composed of many different market segments;
- Each market segment tends to have its own product or service requirements, information needs and communication patterns, and may require its own distinct marketing strategy;
- These market segments cannot usually be defined by a single variable or characteristic - they typically represent a combination of factors; and
- These segments typically cannot be identified adequately by traditional demographics alone - they have unique attitudes, perceptions, habits and behavior.

Psychographic marketing recognizes that a single policy, product or service may not satisfy the diverse needs of the segmented constituency or consumer market and that the same strategy or message may not be equally effective for all groups or market segments. Thus, satisfying customers (including transportation users) effectively requires an understanding of the important differences in attitudes and behavior that may exist within market segments -- differences that transcend traditional demographic groups.

Some psychographic variables have special importance in marketing, such as attitudes toward a product, service or institution, how a product or service is actually used, the motivations for its use, and the benefits derived from its use. These factors are often more important than demographic characteristics, and will typically vary widely within one demographic group.

Psychographic market segmentation can be used to:

- Identify key population segments or constituents based on combinations of characteristics including attitudes and behavior;
- Identify the key characteristics that distinguish one segment from another;
- Estimate each segment's relative importance or share of market;
- Assess the implications of psychographic differences on product or service requirements; and
- Determine the most effective way to reach and inform individuals within these segments.

TECHNICAL METHODOLOGY

In psychographic market segmentation, survey respondents are asked about their attitudes and behavior in addition to demographic characteristics. Often, questions are posed as a series of statements and respondents are asked to indicate the extent to which they agree or disagree with each statement (typically on a three, four, five, six or ten point scale). The statements are listed in random order on the questionnaire so that, when they are read, the respondents are not likely to discern any meaningful pattern. Categorical questions can also be used, applying techniques similar to those used in "dummy" regression for analysis.

Typically, cluster analysis or a similar technique is used on the collected data to classify respondents into one of several groups -- representing market segments -- based on their answers to these questions. These groups are formed statistically, so that people within a group share many of the same attitudes and behaviors while at the same time they differ from members of other groups on the same basis. The responses are analyzed (1) to identify groups of consumers who demonstrate different activities, attitudes, interests and opinions, and (2) to identify how these groups differ with respect to their product, service, and media usage.

Once the respondents have been classified, it is possible to identify which variables or characteristics were most important or influential in determining group membership and thus provide the basis for market segmentation. Further analysis can be performed on these groups in the same way that simple demographic groups might be analyzed.

This first step in the initial cluster analysis is the selection of several variables that could provide the basis for a segmented market. These typically include differences in how people use a product or service, why they use a product or service, and their attitudes toward it. The researcher will probably summarize all the different types of product/service users or constituents that might exist in the market, and then make a list of all the variables that define those groups. These are called "clustering variables."

The list of clustering variables is then entered into one of the many computer software programs that perform cluster analysis. The program will first standardize[6] each respondent's answers on each of the clustering variables, so that scaling differences (difference in the units of measurement) do not cause distortions when variables are compared.

Next, the program will calculate the "similarity" between each pair of respondents across the entire set of clustering variables simultaneously. This similarity is defined as a spatial distance, typically the squared distance between two points that represent a pair of respondents. The squared distance between two respondents is calculated by taking the sum of the squared differences between the values given by the respondents on each variable:

[6]That is, each respondent's answer is expressed in terms of its deviation from the average value for that variable. Thus answers given in dollars and answers given on a scale of 1 to 10 can be expressed in comparable scales since they are translated into an index of "difference from the group average."

$$D = (x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2 + \ldots .$$

where x_1 is the first respondent's standardized response on variable x and x_2 is the second respondent's response on the same variable.

In other words, one respondent's answer is subtracted from the other respondent's answer. Then this difference is squared and summed across the entire set of clustering variables to produce a single number that represents the total distance between the two. This can be thought of as an average of their differences across all of the clustering variables. The smaller the distance between two respondents, the more similar they are presumed to be.

The computer program will produce a matrix of the distances between all respondents, and will use this matrix to form discrete clusters of respondents that are similar to one another.

The precise procedures for forming these clusters vary from program to program, but typically they involve a step-by-step process in which the most similar pair of respondents are grouped together, followed by the second most similar pair, and so forth until all respondents are classified into a small number of clusters.

So in step zero, there are as many number clusters as there are respondents -- each respondent represents his own cluster. At step one, the computer examines the distance matrix and combines into a single cluster the two respondents who are most similar and have the smallest distance between them. At the second step, the computer either combines two other respondents or adds a third respondent to the first cluster.

This process continues until all respondents belong to a cluster, and eventually all clusters are combined into a single cluster. The researcher then examines the computer output detailing these step-by-step decisions and chooses the number of clusters he or she feels sufficiently describe the data.

Once the clusters and their members have been defined, the researcher can begin to examine the factors most important in segmenting the market, assess the size of each cluster and identify important differences in their product requirements/perceptions or communicate habits/needs and ultimately design an appropriate marketing effort.

CONSTRAINTS, ASSUMPTIONS, AND LIMITATIONS

Similar to factor analysis, the results of psychographic segmentation are largely dependent on the researcher's choice of clustering variables and the particular method of classification. The classification process can also seem fairly arbitrary, and the determination of the appropriate number of clusters is somewhat subjective.

As a result, cluster analysis in general and psychographic market segmentation in particular are used primarily as exploratory techniques requiring replication over time; they are often described as being as much "art" as science. Nevertheless, they can provide useful insights into market differentiation that cannot be derived from other methods or from demographic segmentation alone.

Most important, psychographic market segmentation allows the researcher to "cut the data" in a different way -- one that combines several variables simultaneously and includes important attitudinal and behavioral differences that may be more influential than traditional demographics.

SPECIAL CONSIDERATIONS

Cluster analysis can be performed on most types of survey data, including categorical responses or interval level scales. Prior planning can be helpful in identifying potential clustering variables, but it is not necessary.

EXAMPLE

One situation in which this type of segmentation might be useful would be in the design of an anti-littering campaign. DOT officials may want to launch an advertising campaign to combat the littering problem but may not be sure how to spend their advertising dollars effectively.

The prior use of psychographic market segmentation on survey data from the area might reveal that the people who litter most often are characterized by a certain lifestyle, types of jobs, entertainment preferences, etc. The communication campaign could be tailored to each heavy-littering group identified -- by using certain character types most likely to be admired by each group, by delivering these messages through media most used by each group, and fine-tuning the message content to appeal to the value systems or ideas most characteristic of each group.

In planning highway safety innovations or communication strategies, psychographics could be used to identify different types of motorists who respond very differently to the same situation. Factors evaluated might include:

- Reason for driving -- pleasure, business, or personal needs;
- Driving frequency;
- Driving destinations, average trip length; and
- Attitudes toward other drivers, speed limits, unmarked police cars, sobriety checkpoints, etc.

Factors such as these may be much more important than demographics in understanding motorists -- understanding the differences among them, their reactions, and the means for effective communication.

APPENDIX C

NATIONAL DEMONSTRATION SURVEY

SURVEY PLANNING

The National Demonstration Survey was designed to illustrate some of the techniques explored in this NCHRP research project. As presented in this NCHRP report, survey data are used solely for the purpose of demonstrating applications of each individual statistical technique. The NCHRP research described in this report was not intended to provide conclusions concerning overall public attitudes or opinions on transportation issues and policies, and the report should not be used to make any such inferences.[1] Survey planning centered on discussions of the appropriate topics and issues to be included and decisions on the statistical techniques to demonstrate. Four planning phases preceded the actual survey:

- Selection of topics and techniques for evaluation;
- Creation of a questionnaire incorporating questions on the relevant topics and in the formats appropriate to the statistical techniques chosen;
- Conduct of a focus group in Missouri to see what other topical areas were important to the general public and, in part, to generate lists of possible answers to various questions to aid in precoding answers for the survey (a videotape of the focus group is available from NCHRP);
- Questionnaire pre-test, done by regular interviewers in a telephone survey performed exactly as planned for the full survey.

The questionnaire went through several revisions, to purge it of biases in question wording and to pare down the length of the interview. These revisions were done before the focus group session and before changes suggested by the pre-testing.

The focus group was conducted as a loosely structured two-hour discussion on transportation issues. An outline was used but participants were allowed to range over all issues in an open-ended discussion rather than being queried in direct questioning. Participants were selected by a market research group in Kansas City and were screened to ensure that there was a mix of ages, a balance between males and females, a few professional drivers, several persons not employed full-time, and a few minority group members. The questionnaire was modified to include issues raised by the focus group, such as DOT efficiency and credibility, and the concern with other drivers' poor driving habits and manners.

The questionnaire pre-test indicated that some questions were confusing to respondents over the telephone and these were clarified. Answers given to open-ended questions during the pre-test were used to add pre-coded response categories for interviewers to use in recording answers.

[1] Under a separate contract and for its membership, the American Association of State Highway and Transportation Officials (AASHTO) had a summary interpretation of the survey data prepared in a report titled The National Transportation Demonstration Survey: Implications for National Policy.

FOCUS GROUP

In general, the focus group felt that the following were major problems in transportation:

- Congestion;
- Planning efficiency;
- Safety;
- Pollution; and
- Funding.

One of the most surprising results of the focus group was the degree of mistrust over how transportation (highway) dollars were spent and the perception that DOT planning was inefficient. Comments indicated that a number of participants shared the feeling that there was:

- Poor planning of construction sites;
- Lack of coordination;
- Excessive time spent building/implementing projects;
- Inattention to long-term highway needs -- that is, failure to adequately predict traffic growth, location decisions;
- Lack of concern for needs/problems of average citizens; and
- Project selection often based on special interests or political needs (that is, they felt a need for greater accountability of decision-makers including possibly an elected head of DOT or an elected board).

In this same vein of criticism, participants felt that dollars were being wasted, that expenditure was inefficient. There was resistance to any increase in taxes because they felt that increased efficiency should produce the needed funds. They would be willing to spend more IF they could be sure it was spent wisely and would really result in their saving 20 minutes a day in commuting time. Indirect taxes were preferred to motor fuel taxes, and tolls were acceptable if they were kept separate from state DOT general funds (that is, if they were earmarked).

Participants were aware of externalities -- pollution, for example -- and the interactions with job and home location decisions. Thus, they were supportive of long-term solutions such as new sources of energy and new transit modes (maglev, monorail) and saw rail as the only attractive transit alternative. However, there was only limited interest in carpools or HOV (high occupancy vehicle) lanes to encourage shared vehicles. There was little concern about destroying neighborhoods in the process of building highways (but, there were no inner city residents in the group).

Participants were also concerned with safety, particularly with human factors such as discourteous and unsafe practices (cutting others off, too slow) and drunk drivers. They were concerned to a lesser degree with trucks and truck drivers and small autos posing hazards. They mentioned that many roads were designed for a period 20 years ago and that better signs and road markings were needed. Surprisingly, there was no mention of poor physical conditions on roads as a safety concern.

Although congestion was explicitly mentioned as a problem, participants felt that this was true only at certain times of day and that they were willing to shift driving times and routes or even relocate jobs/homes to avoid congestion. There was some interest in truck lanes, but many discounted the idea as impractical.

SURVEY MECHANICS

More than 1,000 respondents aged 18 years and older were polled by telephone in late December, 1988. The 48-state sample was designed to reflect national population distributions by region and by population density (urban, rural, suburban). Within each geographic and density stratum, survey participants were selected by random digit dialing of phones with telephone prefixes appropriate to that stratum.

The survey was conducted using a computer-based questionnaire that was programmed to select follow-up questions appropriate to answers given in previous questions. The interviews themselves lasted 20-25 minutes.[2] Answers to open-ended questions were recorded verbatim and grouped according to several criteria. Because the original survey responses have been retained in machine readable format, other groupings and/or cross-tabulations are straightforward.

Analysis of survey results was in two stages. The first stage was based on a straightforward tabulation of answers for selected strata. The second stage involved more sophisticated statistical analysis of responses including regression, factor, discriminant, and conjoint analyses.

The distribution of survey respondents by driver type and selected demographic characteristics is shown

Table C-1: Demographic Profile of Respondents, National Demonstration Survey

	Total	Commuters	Profess'l	Recrea'l	Nondrivers
Weighted Base	1013	503	99	379	102
Gender					
Male	48%	52%	70%	39%	36%
Female	52	48	30	61	64
Employed					
Full-time	57	81	74	32	27
Part-time	13	13	18	13	12
Not at all	30	6	8	55	62
Community Type					
Central city	15	16	15	13	18
Suburb	26	28	26	25	24
Small city/town	35	32	28	38	40
Rural	24	23	31	24	16
Age					
18-29 years	25	27	22	21	35
30-49	45	54	48	36	27
50-64	19	16	19	23	16
65 and over	12	3	1	20	21
Race					
White	85	85	88	87	73
Black	11	11	1	8	22
Hispanic	5	3	4	6	9
Other	3	3	9	5	6
Income					
Less than $15,000	16	11	15	16	41
$15,000 - $30,000	28	31	26	30	18
$30,000 - $50,000	30	36	31	25	16
$50,000 and over	18	19	23	19	9

[2]A copy of the questionnaire is presented at the end of this appendix.

in Table C-1 (professional refers to truck drivers, taxi drivers and others who drive as part of earning their living). Fifty-seven percent of the sample was employed full time, 48 percent were male, 15 percent lived in the central city and 26 percent in suburbs, and 45 percent were aged 30 to 49 years.

NUMERICAL ANALYSES

TABULATION OF RESPONSES

Responses were broken out by objective characteristics (the four AASHTO regions, community type, type of driving, gender, family income, employment status, and age of respondent). Preliminary analysis also included separate tabulations for respondents classified as "willing to pay" and "not willing to pay" a higher motor fuel tax to support transportation.

Of those survey respondents commuting to work by car, more than half considered roads to be somewhat or very congested. The proportion describing conditions as congested was higher for those living in central cities and suburbs, and residents in the southeastern AASHTO district. Interestingly, those respondents willing to pay a higher fuel tax describe the congestion they face with much the same pattern as those unwilling to pay, indicating that willingness to pay is not strictly a function of local commuting congestion.

When asked if they would be willing to pay a premium of some kind to reduce congestion and get to work in less time each day, nearly 75 percent of the 400 respondents experiencing time losses from congestion answered yes. In turn, approximately 150 respondents (that is, nearly half of those willing to pay to eliminate congestion time losses) would be willing to pay $2 or more each day to reduce travel time. Consistent with other results, respondents in the southeastern region were more willing than others to pay the higher premium. As would be expected, those with higher family income (over $50,000) were also much more willing to pay the higher amount.

Asked to list the most important transportation problems, slightly over 28 percent of those responding mentioned unsafe drivers as number one; poorly maintained and damaged roads was second with nearly 20 percent of respondents. Combining respondents' views on the first and second most critical problems in transportation, the issues of unsafe drivers, poorly maintained and damaged roads, and congestion stand out as clearly the most pressing issues for the population as a whole.

In terms of possible solutions, respondents endorsed government-mandated flexible work hours to relieve congestion (53 percent support); this was supported to a greater than average degree by those in the western region, people who drive as part of their livelihood, part-time workers, and young middle-aged respondents. Respondents also endorsed restrictions on new business location to a much lesser extent (37 percent). There was virtually no support for restrictions on residential location or programs to increase what people pay to commute by car during rush hours (though 9 percent of those in the 30-49 age group were amenable to this idea).

Almost all respondents supported increased government expenditure to improve the overall transportation system in some fashion. A number of expenditures were endorsed by more than half of the respondents, particularly those affecting congestion. In order of declining support, these were: coordination of traffic lights, widened highways to include more lanes, improvement of mass transit, addition of more four-lane divided highways, and the creation of separate highway lanes for trucks.

Respondents in the southeast were most emphatically behind coordination of traffic lights and widened highways with additional stronger than average support for an increase in four-lane divided highways. In addition to traffic light coordination, respondents in the western region strongly supported improvements in mass transit and widened highways whereas those in the northeast ranked the creation of separate lanes for trucks on par with mass transit and coordination of lights. In the midwest, traffic light coordination was a primary focus by a significant margin.

Financial issues were brought up in several different questions and there are inconsistencies in participants' replies. Asked if they would be willing to pay higher fuel taxes to "significantly improve our transportation and highway system," 62 percent said yes; the percentage was higher in the southeast and lower

in the midwest, and higher among males and those in the higher income groups. However, when queried on a series of alternative financing approaches to fund improvements, a minority of respondents were willing to shoulder the burden directly. The most popular single measure was fees levied on builders and developers (almost 44 percent of respondents) with higher taxes on large trucks a close second (nearly 41 percent). With regard to those fund-raising approaches that affected respondents more directly, nearly 32 percent sanctioned increased motor fuel taxes and more tolls on highways, and almost 24 percent would support increased vehicle registration fees.

When asked directly about motor fuel taxes for deficit reduction, survey respondents overall very soundly rejected the idea (73 percent were against any use of fuel tax revenues for deficit reduction; somewhat less than 21 percent would support allocation of a portion of increased fuel tax revenues for deficit reduction). Those in central cities and nondrivers were more amenable than the average to fuel revenues use for deficit reduction. Those in the older middle age group (50-64 years) were more adamantly against the use of fuel revenues for anything other than highway projects (nearly 83 percent).

IMPORTANCE-PERFORMANCE ANALYSIS

In the National Demonstration Survey, the 1013 respondents were asked to rate the importance and quality of service for the following features on highways on which they travel:

- Highway signs giving information on directions and mileage;
- Services such as restaurants and gas stations along the highway;
- Rest areas and waysides;
- Four-lanes on highways;
- Highway border areas that are well-landscaped and litter-free;
- Bridges with breakdown lanes;
- More frequent safety inspections of vehicles;
- Traffic kept moving at normal speeds;
- Safe road conditions; and
- Warnings of when to expect traffic delays and road closings due to construction.

Respondents were asked to use a scale of 1 to 5 with 5 meaning extremely important and excellent respectively for importance and performance ratings. The data were analyzed in an importance-performance framework in which mean values are compared in an attempt to evaluate needs. The basic assumption is that features that are rated high in importance but low in performance should be addressed before features rated low in both or high in both.

Table C-2 presents the National Demonstration Survey results in tabular form. Looking at performance-importance differences, bridges with breakdown lanes has the largest numerical gap (-0.9) and safe road conditions is second (-0.8). Looking at the ratio of performance to importance, bridges with breakdown lanes still has the greatest shortfall (a ratio of 0.71) but the second greatest shortfall is in frequent safety inspections (ratio of 0.81), thus the rank ordering of "priority for investment" is slightly different. Warnings of delays is sixth in shortfall by both ranking methods, and restaurants and gas stations is last by both.

The results are presented graphically in Figure C-1. The two axes intersect at the overall mean ratings of 4.1 for importance and 3.5 for performance. Thus the lower right quadrant contains features that have importance ratings below the overall average but performance ratings above the overall average (in this case,

Table C-2: Comparing Highway Features by Importance and Performance

Importance-Performance Analysis, National Demonstration Survey

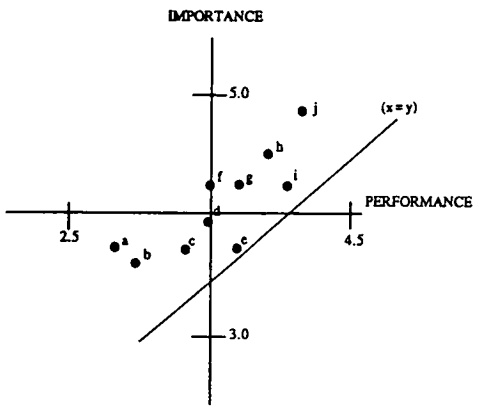
Highway Feature	Respondents' Average Importance Rating (1-5) (Col.1)	Respondents' Average Performance Rating (1-5) (Col.2)	Difference (Col.2-Col.1)	Ratio (Col.2/Col.1)
Safe road conditions	4.7	3.9	-0.8	0.830
Keeping traffic moving	4.4	3.7	-0.7	0.841
Highway signs with information	4.2	3.8	-0.4	0.905
Warnings of delays	4.2	3.6	-0.6	0.857
Four lanes for travel	4.2	3.5	-0.7	0.833
Litter-free roadside	4.0	3.5	-0.5	0.875
Bridges with breakdown lanes	3.8	2.9	-0.9	0.763
Restaurants and gas stations	3.8	3.6	-0.2	0.947
Rest areas and waysides	3.8	3.3	-0.5	0.868
Frequent safety inspections	3.7	3.0	-0.7	0.811

restaurants and gas stations). These would be the features with the lowest priority for future investment according to graphical interpretation of survey respondents opinions -- they are below average in importance yet above average in performance.

If features had appeared in the upper left quadrant, they would be candidates for increased investment as this position would indicate that respondents assigned a higher than average importance to these features yet felt that performance was below average. In this survey, no features were placed here. Features in the lower left quadrant were assigned below average importance and rated as below average in performance by the survey respondents. Thus, in the opinion of those surveyed, performance was somewhat in line with importance for bridges with breakdown lanes, frequent safety inspections, and rest areas and waysides. Features in the upper right quadrant were rated by survey respondents as both high in importance and high in performance. Thus, these, too, are somewhat in balance as far as survey respondents were concerned.

Figure C-1: Comparison of Highway Features by Importance and Performance

Importance-Performance Grid, National Demonstration Survey



ORIGIN = (3.5, 4.1)

KEY

a Bridges with breakdown lanes
b Frequent Safety Inspections
c Having rest areas and waysides
d Keeping areas litter-free
e Restaurants and gas stations
f Four lanes to travel on
g Warnings of Delays
h Keep Traffic Moving
i Highway signs giving information
j Having safe road conditions

The diagonal line in the graph indicates numerical balance between importance and performance -- that is, an equal rating. This forms the link between the numerical and graphical interpretations -- features with importance substantially exceeding performance (Table C-2, column 3) appear farther above the diagonal line in the graph. Thus, although it is in the lower left quadrant, bridges with breakdown lanes nonetheless has importance significantly above performance in the eyes of the respondents. Among those features rated high in both importance and performance, having safe road conditions would be a candidate for increased investment in the opinion of survey respondents.

Nonetheless, the graphical and numerical evaluations derived from the survey do not generate a precise prioritization of investments. The only feature placed by respondents in the lower right quadrant -- below average importance but above average performance -- was restaurants and gas stations. Presumably, survey respondents would not support public investment in this area. Survey results did not highlight any features that would be obvious candidates for increased investment -- that is, placed in the upper right quadrant with above average importance and below average performance.

STATISTICAL ANALYSIS

Basic numerical tabulations of answers to the survey questions and computation of mean values provided useful information on respondent characteristics, evaluation of public services, identification of transportation concerns, and the like. In addition, more sophisticated statistical techniques were used to gain insight into relationships that were not directly revealed by these conventional tabulations. Techniques included:

- Basic multivariate (regression and correlation) analysis;
- Discriminant analysis;
- Factor analysis; and
- Conjoint analysis.

BASIC MULTIVARIATE ANALYSIS

All techniques for multivariate analysis assess the closeness of the relationship among several variables. It indicates the extent to which an "independent" variable or influence contributes to the value of another "dependent" variable or outcome.

Regression analysis was used to sort out the relative influence of several criteria on respondent satisfaction with highways. As can be seen in Table C-3, the variables most closely correlated with overall respondent satisfaction were perceived efficiency of the state DOT, performance rating on safe road conditions,

Table C-3: Variables Affecting Satisfaction with Highways

Regression Analysis, National Demonstration Survey

Variable	Importance*
Perceived efficiency of state DOT	0.31
Safe road conditions	0.16
Performance rating on commuting time saved if no traffic	-0.13
Believe DOT spending is wiser than state government in general	0.10
Performance rating on highway signs giving information	0.07

Altogether, these factors explain 20 percent of the variation in highway satisfaction among survey respondents.

*Based on standardized multiple regression coefficients.

and the amount of commuting time that could be saved if there was no traffic (which was inversely correlated with satisfaction, that is, the more time wasted in congestion, the less satisfied the respondents were). It is interesting that perceived efficiency of the state DOT had a weight nearly double that of safety performance rating in its impact on respondent satisfaction with highways.

These elements did not account for all the variation among survey participants in their satisfaction with highways. Nonetheless, the importance of the relationship between perceived efficiency and satisfaction could have significant policy implications if it were true for large segments of the population. It could indicate the need for clearer communication between transportation agencies and the public of the financial and political constraints that determine road conditions independent of agency efficiency. The focus group found similar results.

DISCRIMINANT ANALYSIS

Discriminant analysis is a form of multivariate analysis that is used to determine what characteristics distinguish one group of respondents from another and thus which characteristics might be used as predictors of behavior. For example, discriminant analysis was used to identify the objective variables that might best distinguish survey respondents willing to support higher motor fuel taxes to improve transportation from those unwilling to support such taxes. Respondents were classified according to their answers to the following question on motor fuel taxes:

> "Would you be willing to pay more in motor fuel taxes to significantly improve our transportation and highway system?"

Of the nearly 1,000 respondents answering this question, 62 percent were willing to pay higher motor fuel taxes to significantly improve the highway and transportation system and 34 percent were not.

Researchers wanted to identify the primary differences between these groups to understand the variables that might influence people to support or oppose a motor fuel tax hike. They suspected a number of variables might account for or, at least, be associated with these differences and data on each of these variables was included in the discriminant analysis.

It proved difficult, however, to clearly differentiate between the two respondent groups, even with the best discriminant function that could be created from these variables. The weakness of the analysis was apparent from the low statistical measures of correlation. In other words, it would be difficult to predict whether someone not in the survey sample would favor or oppose an increase in motor fuel taxes, even if we data for them on all the variables used in the analysis.

The large sample size, however, enabled us to detect that this separation, however small, was statistically significant and not due to chance. Statistically, there is less than 1 in 100 probability that these distinctions between groups of survey respondents are due to pure chance. In other words, we can be very confident that there is a small -- but real -- difference between supporters and opponents of the hypothesized tax hike among those surveyed. Results indicated that respondents that live in central cities, had jobs requiring driving, wasted greater commuting time to congestion, favor widened highways, and had higher household incomes were more likely to be members of the group supporting such taxes. Table C-4 summarizes the results of the analysis.

From these values we see that the most important variables that differentiated supporters of the tax hike from opponents among those surveyed was their generally higher household incomes and their support for government spending on specific transportation improvements.

The data indicated that, though significant, the impact of having jobs that require driving during the workday (0.25) was only about half of the contribution made by income (0.47) in differentiating the two survey groups. Also worth noting were the variables that, although included in the analysis, did not effectively differentiate the two respondent groups -- satisfaction with the highways and the perceived efficiency of the state DOT.

If such results can be generalized to the population at large, it could be used to project the likely support for increased motor fuel taxes from specific population groups, and thus to formulate education campaigns and policies to build popular support for motor fuel tax proposals.

Table C-4: Variables Distinguishing Between Respondents Supporting and Those Opposing Increased Motor Fuel Taxes

Discriminant Analysis, National Demonstration Survey

Variables	Impact on Respondent Support*
Household income	0.47
Favor government spending to improve roads	0.41
Favor government providing special HOV lanes	0.34
Favor widening highways to add more lanes	0.32
Favor improving mass transit	0.29
Live in central city	0.29
Job requires driving	0.25

*Based on standardized canonical discriminant function coefficients, ranging from 0.00 to 1.00, indicating how powerful each factor is in differentiating between respondents who are willing and not willing to pay a higher fuel tax to significantly improve the highway and transportation system.

FACTOR ANALYSIS

Factor analysis is another technique in multivariate analysis. It is a way to probe beyond the straightforward questionnaire answers to uncover more basic underlying elements that determine participant responses. Using participants' responses to a variety of questions, some of which may touch on the same issues in different form, factor analysis indicates when opinions on one issue parallel opinions on another seemingly different issue -- as though there were an underlying common factor that determined participants' answers to several different questions.

Factor analysis performed on data from the survey indicated that respondents tended to give similar importance ratings to having restaurants and gas stations, rest areas and waysides, and having highway signs giving information. This can be seen in Table C-5. The importance assigned to any one of these by individual survey respondents tended to mirror the ratings assigned to the others, and thus it might be concluded that all of these are different facets of a more basic factor underlying respondents' answers that the researchers named "providing amenities for travelers." In policy terms, the factor analysis would indicate that, among survey participants, highway users emphasizing the need for restaurants and gas stations would also emphasize the importance of highway signs giving information.

Factor analysis revealed a second grouping of elements related to importance ratings that could be termed "keeping traffic moving safely." This group included having safe road conditions, keeping traffic moving at normal speeds, having warning of construction delays and closings, and having four-lane highways for travel. Thus factor analysis would indicate that highway users among survey respondents that stress safe road conditions would also stress the need for warnings of construction delays and closings. It is important to note that respondents linked traffic flow to safety -- they wanted traffic to keep moving, but not at the expense of safety.

Applying factor analysis to evaluate proposed solutions to congestion indicated that respondents grouped remedies into five basic approaches. Listed in order of decreasing importance to support for congestion-reducing policy options, these were: increasing highway capacity (widening highways, increase in four-lane divided highways), decreasing volume from other drivers (separate lanes and highways for trucks, car pool lanes, flexible work hours, and improved mass transit), voluntary lifestyle adjustment (changed residential location, altered commuting time), voluntary move to mass transit, and required adherence to new government regulations.

Factor analysis was also employed to identify basic elements in respondents' evaluation of transportation problems. Three composite factors were distinguished that, together, explained 45 percent of the variation in perceived seriousness of transportation problems among survey respondents. These are listed in Table C-6. The first factor was termed "Infrastructure and Management Problems" and includes not only elements of physical condition but also perceptions of DOT management. This confirms the importance of public perception of DOT performance revealed by the multivariate analysis.

CONJOINT ANALYSIS

Conjoint analysis is perhaps one of the most exciting new tools in market analysis. It is used to reveal

the trade-offs that people make among competing alternatives and the prioritization of individual programs or components when not everything can be achieved at once. Although individual respondents might have a difficult time explicitly assigning a value to individual features or program components, they have much less trouble stating the strength of their support for combinations of elements.

Designing the survey to include conjoint analysis required careful structuring of questions specifically designed for that purpose. Respondents were asked to indicate how likely they were to support each of a series of policy packages that included a hypothesized increase in motor fuel taxes, and two to four uses of such funds including improved physical condition of roads, high technology research, reduced traffic congestion, reduced accidents, more mass transit, reduced federal deficit, and reduced pollution. Individuals did not rank their preferences explicitly; conjoint analysis was used to infer rankings -- and even the relative values or fiscal support generated by each -- by statistically evaluating the effect each policy substitution had on willingness to support tax increases.

Table C-5: Key Factors Behind Respondents' Perceptions of Transportation Problems

Factor Analysis, National Demonstration Survey

Factor 1 -- "Infrastructure and Management Problems"
Poorly maintained and damaged roads.
Poor management of highway funds.
Unsafe bridges.
Poorly designed roads.
Poor coordination and planning.

Explains 26 percent of all variation in perceived seriousness of problems among survey respondents.

Factor 2 -- "Problems of Access"
Hard to drive to recreation areas.
Hard to drive to areas with job opportunities.
Not enough four-lane divided highways.
Lack of mass transit.

Explains 11 percent of all variation in perceived seriousness of problems among survey respondents.

Factor 3 -- "By-products of Highway Use"
Pollution.
Traffic congestion.
Unsafe drivers.

Explains 8 percent of all variation in perceived seriousness of problems among survey respondents.

Conjoint analysis revealed that the most important determinant of support for a policy package among survey participants was the level of the proposed tax, which ranged from $0.05 to $0.50 per gallon; there was no single policy option so important that its inclusion would immediately generate respondents' support for a high tax. Among the policy options, improved physical condition was the most important in generating support among survey respondents for increased motor fuel taxes; increased research on high technology was second most important and reducing the federal deficit was clearly of minor importance (ranked last; see Table C-7).

The analysis also revealed that a package composed of all the hypothesized programs could probably generate support for a $0.15 per gallon fuel tax increase -- but no more -- among those participating in the survey. An expenditure package including only improved physical condition of roads and increased research on high technology -- the two expenditure items ranked highest by the group surveyed -- would muster support for a fuel tax increase of $0.077 at most among survey participants. A $0.05 increase in the fuel tax would be supported by a majority of the survey respondents if the proceeds were allocated to one of the following programs: improving the physical condition of the roads and reducing pollution; reducing accidents and, simultaneously, increasing research on high technology; or reducing traffic congestion, making mass transit more available, and reducing pollution.

Table C-6: Prioritization and Relative Value of Transportation Programs to Survey Respondents

Conjoint Analysis, National Demonstration Survey

Program	Respondents' Inferred Value
Improve physical condition of the roads	$0.049
Increase research on high technology	0.029
Reduce traffic congestion	0.023
Reduce accidents	0.021
Make mass transit more available	0.019
Reduce pollution	0.010
Reduce the federal deficit	0.006
TOTAL	0.157

SURVEY QUESTIONNAIRE

Survey interviewers used a computer-based questionnaire that was programmed automatically to follow the appropriate branching pattern. Thus, for example, if the interviewer entered a "No" response to question 3, the computer automatically skipped to question 6D without further instructions from the interviewer. The full questionnaire is reprinted here, including all branching and skip instructions.

TRANSPORTATION TODAY AND TOMORROW
QUESTIONNAIRE

Q1. Hello! My name is _____ from the Gordon S. Black Corporation, the national public opinion polling firm. We are conducting a research study on how the nation's transportation system can be improved. I'm not trying to sell you anything. (BECAUSE WE MUST INTERVIEW AN EQUAL NUMBER OF ADULT MALES AND ADULT FEMALES, MAY I SPEAK WITH AN ADULT MALE IN YOUR HOUSEHOLD? IF NOT AVAILABLE CONDUCT INTERVIEW WITH ADULT FEMALE.)

Male
Female

Q2. (INTERVIEWER: RECORD RESPONDENT'S STATE OF RESIDENCE)

Q3. Are you a licensed driver?

Yes
No
DK/Ref

(ASK Q3B IF YES TO Q3; OTHERWISE SKIP TO Q6D)

Q3B. Did you drive a motor vehicle in the past week?

Yes
No
DK/REF

(ASK Q4 IF YES TO Q3B; OTHERWISE SKIP TO Q6D)

Q4. During a typical week, about how much of your driving is local? (READ LIST)

More than half
Less than half
About half
None at all
Don't know
Refused

(IF NONE TO Q4, SKIP TO Q6D)

Q6A. For which of the following reasons is most of your LOCAL driving? Is MOST of it for: (READ LIST -- MULTIPLE RESPONSE)

Commuting to and from work or school
Work or business other than driving to and from your workplace
Shopping and errands
Recreation, or visiting family and friends

(ALL RESPONDENTS)

Q8D. In your opinion, what is the biggest transportation problem in your local area today? (OPEN-ENDED, DON'T READ LIST)

Traffic congestion/crowding
Poor road conditions
Lack of mass transit
Construction causes problems
Bad drivers
No real problem
Other (specify)
DK/REF

(ASK Q7 IF YES TO Q3 AND YES TO Q3B; OTHERWISE SKIP TO Q11)

Q7. About how often do you make long distance trips, that is, driving more than 100 miles in one direction? (DO NOT READ LIST; PROMPT IF NECESSARY)

More than once a week
Once a week/ 4 times a month
2- 4 times a month
Once a month
Several times a year
Once a year
Less than once a year
Never
DK/REF

(IF NEVER IN Q7, SKIP TO Q11)

Q9. For which of the following reasons are most of these trips? Are they MOST often for: (READ LIST -- MULTIPLE RESPONSE)

Commuting to and from work or school
Work or business other than driving to and from your workplace
Shopping
Recreation, or visiting family and friends (one day)
Vacation (Multi-day trips)

(ALL RESPONDENTS)

Q11. What is the biggest problem with long distance transportation today? (OPEN-ENDED, DEVELOP PRE-CODED LIST)

Traffic congestion/crowding
Poor road conditions
Lack of good train system
Construction causes problems
Bad drivers
Hard to get to some places
No real problem
Other (specify)
DK/REF

Q12. Are you employed full time, part time or not at all?

Full time
Part time
Not at all

(ASK Q13A IF EMPLOYED FULL OR PART TIME IN Q12; OTHERWISE SKIP TO Q13B)

Q13A. Does your job require that you drive during the normal workday, other than to and from your workplace?

Yes
No

(ALL RESPONDENTS:)

Q13B. Which of the following best describes the type of community in which you live: The central city of a metropolitan area, a suburb of a metropolitan area, a small city or town or a rural area?

The central city
A suburb
A small city or town
A rural area
Other
Don't know
Refused

(ASK Q14 THRU Q25C IF EMPLOYED FULL OR PART TIME IN Q12; OTHERWISE SKIP TO Q25D)

Q11. About how many miles is your workplace from your home? (IF RESPONDENT SAYS IT VARIES, PROBE FOR AVERAGE DISTANCE)

_____ miles
Work at home
DK/REF

(ASK Q14C IF CENTRAL CITY IN Q13B; OTHERWISE SKIP TO Q14E)

Q14C. Do you work in the central city, the suburbs, a different city, or somewhere else?

Central city
The suburbs
Different city
Somewhere else

(ASK Q14E IF SUBURB IN Q13B; OTHERWISE SKIP TO Q14G)

Q14E. Do you work downtown in the city, in the same suburb where you live, another suburb, or somewhere else?

City
Same suburb
Another suburb
Somewhere else

(ASK Q14G IF SMALL TOWN OR RURAL IN Q13B; OTHERWISE SKIP TO Q15)

Q14G. Do you work in your local area, in another town, the central city of a metropolitan area, or in the suburbs of a metropolitan area?

Local area
Another town
Central city
Suburbs
DK/REF

Q15. How do you usually travel to and from work each day? (DON'T READ LIST)

Drive by yourself
Car pool/ride with someone else
Use mass transit
Walk
Bicycle
Work at home
Other (specify)
Don't know
Refused

(ASK Q17 IF THEY DON'T DRIVE IN Q15; OTHERWISE SKIP TO Q18)

Q17. What is your main reason for travelling this way? (DON'T READ LIST)

Less costly
Takes less time than driving
Don't own a car
Less aggravating
Other (specify)
Don't know
Refused

(ASK Q18 IF THEY DRIVE BY THEMSELVES IN Q15; OTHERWISE SKIP TO Q19B)

Q18. What is your main reason for NOT using mass transit? (DON'T READ LIST)

Not available
Takes too much time
Not close to work/home
Doesn't run often enough
Not reliable
Not comfortable
Not safe
Other (specify)
DK/REF

(ASK Q19B IF THEY DON'T USE MASS TRANSIT IN Q15; OTHERWISE SKIP TO Q21C)

Q19B. What features would make you MOST likely to use mass transit? (DON'T READ LIST)

Low cost
Close to work/home
Safe
Clean
Few transfers
Reliable
Other (specify)
Would Never Use It
DK/REF

Q21C. How would you describe the traffic when you go to and from work? Is it: (READ LIST)

Very congested
Somewhat congested
Not very congested
Not at all congested
DK/REF

(ASK Q22 IF DRIVE OR CAR POOL IN Q15; OTHERWISE SKIP TO Q25D)

Q22. On the average, how long does it usually take for you to drive to work each day? (RECORD ANSWER IN MINUTES)

Q23. How long would it take to drive to work if there were no traffic at all? (RECORD ANSWER IN MINUTES)

Q24A. Would you be willing to pay ONE DOLLAR per day if you could get to work in (Answer from Q23) _____ minutes each day?

Yes (Continue)
No (Skip to Q24C)
DK/REF (Skip to Q25A)

(ASK Q24B IF YES TO Q24A; OTHERWISE SKIP TO Q24C)

Q24B. Would you be willing to pay TWO DOLLARS per day if you could get to work in (Answer from Q23) _____ minutes each day?

Yes (Skip to Q25A)
No (Skip to Q25A)
DK/REF (Skip to Q25A)

Q24C. Would you be willing to pay 50 CENTS per day if you could get to work in (Answer from Q23) _____ minutes each day?

Yes
No
DK/REF

Q25A. Which of the following things have you done to avoid traffic to and from work. Have you ever: (READ LIST – CHECK ALL THAT APPLY)

Changed the time you leave for work
Changed the route you take to work
Changed where you live
Changed where you work
Used special car pool lanes
Used mass transit or car pool

Q25B. Is there anything else you have done to avoid traffic to and from work?

Yes
No
DK/REF

Q25C. What was that? (OPEN-ENDED)

Q25D. I am going to read some things that might be done to reduce traffic congestion in your area. For each one, please tell me whether you think the government should spend more money on it. (READ LIST; CHECK ALL THAT APPLY)

Improve mass transit
Provide special lanes for car pools and buses only
Coordinate traffic lights
Widen highways to include more lanes
Add more four-lane divided highways
Creat separate lanes or highways for trucks
DK/REF

Q25E. Please tell me which of the following government actions you would support to reduce traffic congestion. (READ LIST; CHECK ALL THAT APPLY)

Require flexible work hours
Restrict where people can live
Restrict where new businesses can locate
Make people pay more to drive during rush hour
DK/REF

Q25F. Should the government spend more money to maintain and improve the physical condition of the highways and roads you use?

Yes
No
DK/REF

Q26. I am going to read you a list of transportation issues facing Americans today. For each one, please tell me whether you consider it is a major problem in your area. (READ AND ROTATE; CHECK EACH THAT APPLY)

Traffic congestion
Unsafe drivers
Poorly designed roads
Pollution
Poorly maintained and damaged roads
Lack of mass transit
Poor coordination and planning
Poor management of highway funds
Unsafe bridges
Not enough four-lane divided highways
Hard to drive to recreation areas
Hard to drive to areas where there are job opportunities

Q28. Which of these transportation problems is the single most important to you personally? (INTERVIEWER READ ONLY ITEMS MARKED "MAJOR PROBLEM" IN Q26 and Q27)

Q29. What's the second most important? (LIST REMAINING "MAJOR" PROBLEMS)

Q29B. What's the best thing about the highway and transportation system in your area? (OPEN-ENDED, DON'T READ LIST)

Convenient access to highways
Roads are well maintained
Not too congested/crowded
It's fine when not under construction
Other (specify)
DK/REF

Q29F. What is the most important benefit your area could receive from improving the highway and transportation system? (OPEN-ENDED, DON'T READ LIST)

Increase tourism/business
Reduce traffic congestion
Reduce accidents
Reduce pollution
Make travel easier/more convenient
Other (specify)
DK/REF

Q30. Which ONE of the following changes would you MOST like to see made to the national system of highways? (READ LIST and RECORD ONE RESPONSE)

Extend major highways to more small and medium-sized cities?
Widen major highways to include more lanes?
Improve the physical condition of major highways?
Build more beltway highways around major cities?
Or, none of the above
DK/REF

Q31. Please tell me how satisfied you are with the highways on which you normally travel, using a scale of 0 to 10 with 0 meaning not at all satisfied and 10 meaning extremely satisfied with the highways.

10 Extremely satisfied
9
8
7
6
5
4
3
2
1
0 Not at all satisfied

Q32. I am going to read to you a list of features that might be desirable in major highways. For each, please tell me how important it is to you when you travel, on a scale from 1 to 5 where 1 means not at all important and 5 means extremely important. (ROTATE ITEMS)

Q32A. What about highway signs giving information on directions and mileage?

Q32B. Having services such as restaurants and gas stations along the highway?

Q32C. Having rest areas and waysides.

Q32D. Having four-lane highways to travel on?

Q32E. Keeping the areas bordering highways well-landscaped and litter-free?

Q32G. Having bridges with breakdown lanes?

Q32I. Having more frequent safety inspections of vehicles?

Q32J. Keeping traffic moving at normal speeds?

Q32K. Having safe road conditions?

Q32L. Having warnings of when to expect traffic delays and road closings due to construction?

(ASK Q33 FOR EACH ITEM IN Q32A THRU Q32L)

Q33. Please rate this feature for the highways on which you normally travel, using a scale from 1 to 5 with 1 meaning poor and 5 meaning excellent.

5 -- Excellent
4
3
2
1 -- Poor
Don't Know
Refused

Q37. What do you think is the most important factor in highway safety? (DON'T READ LIST)

Physical condition of the road
Speed of the vehicle
Safety of the vehicle
Weather
Driver error

Q39. If the highway and transportation system were improved, how should these improvements be paid for? Should the government: (READ AND ROTATE LIST; CHECK ALL THAT APPLY)

Increase motor fuel taxes
Raise non-highway taxes
Raise taxes on large trucks
Apply more tolls on highways
Increase vehicle registration fees
Charge fees for builders and developers
Other (specify)

Q40A. Do you think that revenues from motor fuel taxes should be used exclusively for highway and transportation projects, or should they also be used to help reduce the federal deficit?

Highway projects exclusively
Reduce the deficit
Other
Don't know
Refused

Q40B. Which level of government pays for most of the highway construction and repair in your state? (READ LIST)

Federal government
State Department of Transportation
City & county highway departments
DK/REF

Q40C. Which level of government SHOULD PAY for most of the highway construction and repair in your state? (READ LIST)

Federal government
State Department of Transportation
City & county highway departments
DK/REF

Q40D. How efficient is your state Department of Transportation? Would you say it is: (READ LIST)

Very efficient
Somewhat efficient
Not very efficient
Not at all efficient
DK/REF

Q40E. Compared with the state government in general, do you think the state Department of Transportation spends your tax money more wisely, less wisely, or about the same as the rest of state government?

More wisely
Less wisely
About the same
DK/REF

Q41. Would you be willing to pay more in motor fuel taxes to significantly improve our transportation and highway system?

Yes
No
DK/Ref

Q42. Now I am going to read some improvements that might be made in our highway and transportation system. For each program I describe, please tell me how likely you are to vote for those changes, on a scale from 0 meaning not at all likely to 10 meaning very likely to vote for it.

Q42A. How likely are you to vote for a program that would: raise the motor fuel tax 25 cents a gallon, maintain local roads better, reduce traffic congestion, and reduce accidents.

10	Very likely
9	
8	
7	
6	
5	
4	
3	
2	
1	
0	Not at all likely

Raise motor fuel tax 5c, 10c, 25c, 50c
Reduce accidents
Reduce traffic congestion
Improve physical condition of roads
Reduce the federal deficit
Reduce pollution
Make mass transit more available
Increase research on high technology

(OTHER COMBINATIONS BASED ON ABOVE LIST TO FOLLOW)

Q43A. How much do you think you currently pay PER GALLON for motor fuel taxes? (RECORD IN CENTS)

Q43B. For classification purposes only ... In which age category may I place you? Are you between:

18 and 29
30 and 49
50 and 64
Or, 65 and older
Don't know
Refused

Q44A. What is your occupation?
(DO NOT READ)

Professional	[01]
Manager	[02]
Proprietor (small business)	[03]
Clerical Worker	[04]
Salesman	[05]
Skilled craftsman, foreman	[06]
Operative	[07]
Unskilled laborer, except farmer	[08]
Farmer, farm manager	[09]
Farm laborer	[10]
Student	[11]
Housewife	[12]
Military Service	[13]
Unemployed	[14]
Retired	[15]
Welfare	[16]
Other	[21]
Don't know	
Refused	

Q44B. To which racial group do you belong -- Black, White, Oriental/Asian or some other?

Black
White
Oriental/Asian
Some other
Don't Know
Refused

Q44C. Are you of Hispanic origin?

Yes
No
DK/REF

Q45. In 1987 was your total household income over $30,000?

Yes	(CONTINUE)
No	(SKIP TO Q47)
Don't know	(SKIP TO Q48)
Refused	(SKIP TO Q48)

Q46. Was it over $50,000?

Yes	(SKIP TO Q48)
No	(SKIP TO Q48)
Don't know	(SKIP TO Q48)
Refused	(SKIP TO Q48)

Q47. Was it over $15,000?

Yes
No
Don't know
Refused

Q48. Thank you and terminate.

APPENDIX D

REVIEW OF TRANSPORTATION MARKET RESEARCH

SUMMARY

Transportation market research can be categorized by several characteristics:

- Method of collecting information;
- Research objective; and
- Type of questions asked.

Most of the 33 market research studies reviewed here served several objectives and included more than one type of question. A singie survey, for example, can be designed to gather public input for strategic planning and, at the same time, for the evaluation of alternative solutions to a specific local problem. Several studies utilized more than one technique to gather information. For example, the Golden Gate Bridge, Highway, and Transportation District study used focus groups and mail and telephone surveys, and the Minnesota State Department of Transportation study on construction inconvenience combined personal interviews with local leaders, focus groups, and a random telephone survey.

This report describes the components of each dimension -- method, objective and type of questions -- and gives examples drawn from our review of transportation market research.

METHOD OF COLLECTING INFORMATION

There are two types of market research techniques -- techniques for collection of information and techniques for information analysis. Techniques for collecting information -- surveys and focus groups/meetings -- are well known to transportation professionals. However, the range of sophisticated information analysis techniques used by decision-makers in other areas have not been widely applied to transportation studies; such techniques are described elsewhere in this handbook. This review is intended only as a summary of information collection techniques used in transportation market research and a description of how they have been implemented in the transportation sector.

Information used in market research is collected through surveys and focus groups or public meetings. Surveys, and to a degree public meetings, are suitable for gathering quantitative and qualitative information. Focus groups, because of the small number of participants, are used more often to gauge attitudes and opinions.

Participation can be open to the general public or involve selection of participants. Participants can be selected to target particular groups based on factors such as residential location, use of transportation facilities or personal characteristics including age and income. Or, they may be chosen from the population at large. Moreover, participants may be sampled on a random basis to be representative of the full group or may be selected to ensure sample breadth or simply for expediency.

Approaching data collection schematically, the techniques can be described in terms of the environment in which information is collected (that is, individual response, or group environment), whether respondents were invited to participate or whether they volunteered, whether invited participants were selected at random or not, and according to the form of contact (written response, telephone survey, personal interview). Classifications include the following:

- Group Environment

  Invited Participation: focus groups (both random and non-random selection)

  Open Participation: exhibits, public meetings, and hearings

- Individual Responses or Surveys

  Invited Participation: personal interviews, telephone interviews, and written responses (both random and non-random selection)

  Open Participation: personal interviews, telephone interviews (for example, call-in radio shows), and written responses (for example, questionnaires and comments filled out by people attending public hearings)

Focus groups have been used to gauge opinions of government officials, experts, and interest groups as well as small samples of the general public. Because the number of participants is so limited, focus groups are not used to generate quantitative data but, rather, as brain-storming sessions to develop concepts or as preludes to larger scale market research surveys.

Public meetings have been directed to collecting quantitative and qualitative information from the general public. Meetings are arranged through exhibits in public places such as malls and public hearings. Although the number of participants may be substantial, care must be exercised in extrapolating data from such meetings since they are self-selected and do not necessarily constitute a microcosm of the general public.

In a group environment, individual answers may be recorded but the respondent participates in a group discussion and may be influenced by others present at the meeting or focus group. Information collected from open participation responses cannot be considered strictly representative of the population as a whole since usually only those intensely interested in the issue choose to participate. Focus groups, even though participants are usually randomly selected, are not large enough in size to offer statistically valid estimates for the population as a whole. However, in both cases, a sense of public attitudes can be gained and individual suggestions or criticism -- though perhaps nonrepresentative -- can be of great help in formulating policies.

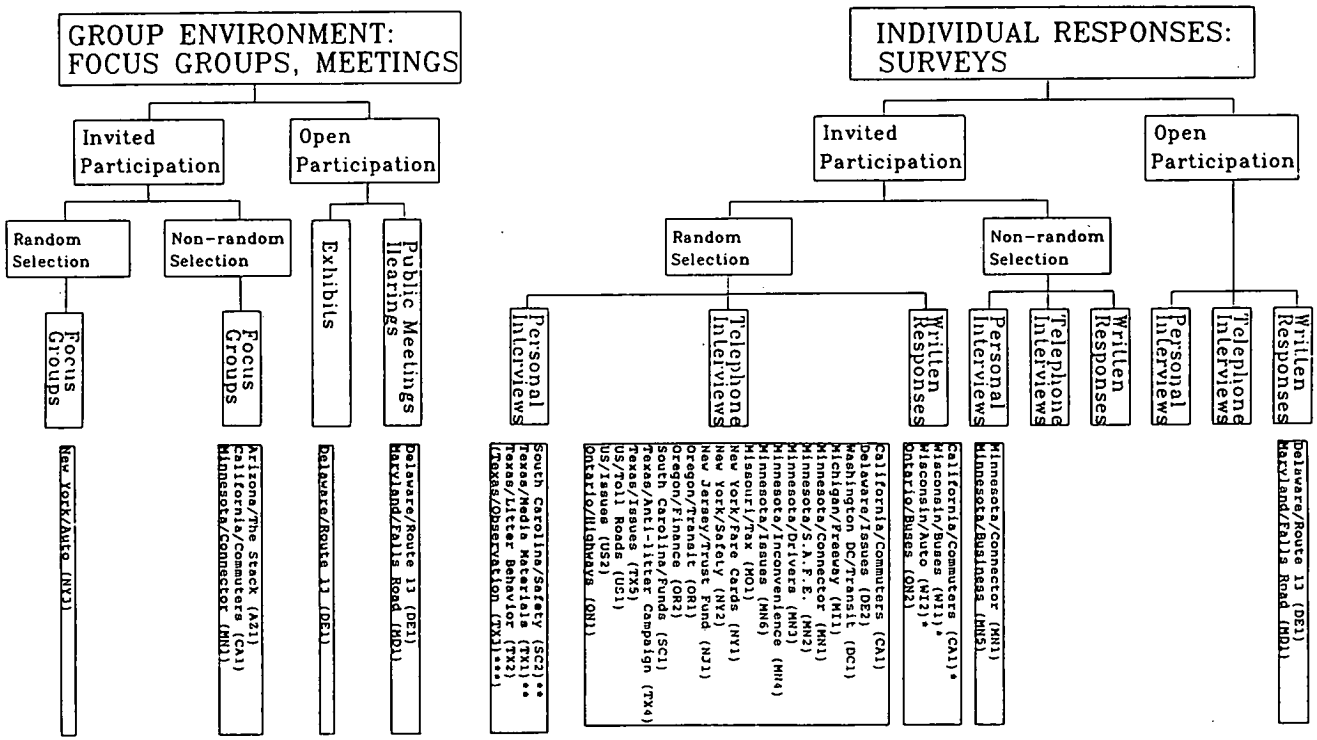
Statistical extrapolation of market research results to the population overall -- for example, prediction of public response to new policies -- requires collecting information from a relatively large cross section of the relevant population. This means either a series of focus groups with participants selected at random or a survey of some kind.

Surveys are conducted in three ways: personal interviews, telephone interviews or written reponses to questions. They are useful for collecting both qualitative and quantitative information because they can involve a large sample of people and consist of a set of pre-designated questions.

Figure D-1 categorizes the 33 market research studies reviewed here by method of obtaining information; each study is identified by state or country, short title, and reference code.[1] Telephone interview surveys of randomly selected participants predominate: they are broad enough to allow statistical analysis yet are less expensive than personal interviews and have a better response rate than written surveys. However, other

[1]The three digit letter-number code is the reference number assigned to that study; the two letters identify the state or country and the number indicates the specific study undertaken in that jurisdiction.

Figure D-1: Method of Obtaining Information



* Selection of participants was random for the written component of the California survey. However, like most mailback surveys, it was characterized by a lower rate of participation than telephone surveys, indicating that self-selection was involved that presumably introduced some non-randomness into the final sample.

** Selection of participants was quasi-random. That is, participants were not systematically selected using an objective (probabilistic) method to sample from a full population but, rather, were chosen an ad hoc basis without apparent or intended bias.

*** The "interviews" were really personal observations of participants' behavior.

methods have been successful for a wide variety of objectives. In some cases -- for example, dealing with construction disruption -- different jurisdictions relied on different methods for the same objective (compare AZ1 with MN1, MN4, and MI1).

The data collection method that is selected may limit the analytical methods that can be used. Information collected in focus groups and other small sample or non-random studies cannot be used for precise statistical analysis; they are best used to generate ideas and to develop a feeling for general trends in public opinion. Data from broader-based systematic surveys, however, can be analyzed using a variety of techniques ranging from simple tabulation of answers to more sophisticated statistical analysis. These methods are described elsewhere in this handbook.

MARKET RESEARCH OBJECTIVES

Market research can also be described in terms of the objectives of each study. However, these are not mutually exclusive categories and, as noted above, many of the studies reviewed seemed designed to satisfy more than one objective. Thus, in this section, studies may be mentioned under several alternative headings.

Five basic activities in transportation policy planning and implementation, described in the handbook, form the basis of discussion in this section. There are:

- Long-term planning,
- Specification of objectives,
- Service improvement and project implementation,
- Communication, and
- Policy evaluation and project monitoring.

LONG-TERM PLANNING

Effective long-term planning requires stepping out of the current situation, composing a picture of the most desirable future structure, and comparing it to the current structure. It entails forecasting the future economic and social environment and relating this back to public needs. Translating this into transportation requirements is based on long-term market analysis -- that is, identification of system users and definition of the components that are important to them. Market research studies supporting this objective include those designed to provide the following:

- Estimates of future demand for transportation in general;[2]
- Description of transportation's role and importance in the general economic context and to individuals;
- Identification of socio-economic and environmental factors to be considered in evaluating transportation policies, including public perception of these characteristics and their importance to the public (e.g., safety, ecological impact, energy consumption, costs);
- Identification of transportation service components that are most important to public satisfaction (expressed as qualitative variables such as speed, cost, safety, etc. or as more concrete factors such as smooth pavement, highway signs, and the like); and

[2]None of the studies reviewed projected demand for transportation in general or related transportation demand to economic activity.

- Profile of transportation customers.

Among the 33 studies reviewed the survey on intercity bus travel in Wisconsin (WI1) was the only study oriented primarily toward description of the role and importance of transportation, though, in this case, a specific mode rather than the full network was the focus of the market research undertaken. The Wisconsin bus survey gathered information on passenger background (thus providing a profile of customers), access to auto transportation, and probable action if no intercity bus systems were available. By inference, this provided information on the importance of intercity bus services to individual segments of the population. The Missouri survey (MO1), concerned primarily with information to help design a campaign for a fuel tax increase, asked respondents to comment on the importance of good roads for maintaining and expanding tourism, the connection between good roads and traffic accidents, and the potential impact on Missouri's economy of an increase in four-lane highways.

Only one study reviewed was explicitly concerned with public perception of socio-economic and environmental factors in evaluating transportation. The Delaware project to determine the Route 13 relief route (DE1) specifically included public concerns on environmental, agricultural, business, and residential impacts in evaluating route alternatives. A 1984-5 Minnesota survey (MN6) approached these factors indirectly by querying respondents on their preferences among alternative treatments to achieve a given end (e.g., weed control); results indicated a strong leaning toward practices with reduced environmental side effects.

A number of studies collected information on the components of a good transportation system and the criteria that should be used to evaluate effectiveness. For example, participants in the Washington, DC transit system survey (DC1) were asked to rate the importance to them of factors such as time spent in transit, cost, stress avoidance, flexibility, safety, comfort, and reliability. As part of research to determine the best way to handle construction inconvenience, the Minnesota Department of Transportation queried respondents on their trade-offs between duration and intensity of inconvenience, on the one hand, and between saving money and saving time/reducing inconvenience on the other (MN4).

Other studies couched their questions in terms of factors as they applied to particular modes. The Portland, Oregon transit survey (OR1) investigated the conditions or factors that would affect transit use by the general population. Indirectly, therefore, the survey evaluated factors considered most important to riders and potential riders. In a similar vein, the tri-partite study by the Golden Gate Bridge, Highway, and Transportation District (CA1) investigated the service factors that influence commuter use of mass transit and ride-sharing programs, including cost, scheduling, and distance to and from mass transit routes. A study by the New York Metropolitan Transportation Authority (NY3) investigated the factors important to auto commuters in their choice of mode. Prior screening eliminated drivers who did not have access to public transit and used private autos by default.

Minnesota (MN3) and Ontario (ON1) highway users were asked to evaluate the importance of a number of highway factors including physical features (number of lanes, pavement condition) and associated amenities and services. In a more restricted approach, the survey undertaken by The Road Information Program (TRIP -- US2) assumed that road safety was an important factor and asked respondents to identify the elements they considered important in preventing accidents.

Although all studies collected some demographic information from respondents, several efforts attempted a more detailed profile of transportation users with respect to specific modes. Objectives of the Golden Gate Authority study (CA1) included identification of the travel patterns of peak period commuters and determination of the demographic characteristics of each of the several attitudinal and travel-pattern population sub-groups. The Wisconsin bus study (WI1) analyzed demographic characteristics of inter-city bus travelers and the New York study on auto commuters (NY3) described these drivers in terms of attitudinal characteristics.

SPECIFICATION OF OBJECTIVES

Long-term planning establishes future goals and guidelines; these must be specified in greater detail and related to transportation elements. The appropriate transportation authority needs to pinpoint areas for

emphasis, define the level of effort and funding magnitudes involved, and narrow down the types of activities in which it will engage. The general information collected and used to support long-term planning can also be used to support more specific program objectives. For example, general information on the importance of transportation can be used to help design education campaigns where the general population is not aware of the close relationship between transportation and the efficient delivery of both inputs and finished products on a timely basis. Many of the studies reviewed were concerned with public perception in several of these areas. They were designed to gather information on several fronts and to aid in designing educational campaigns and service improvements as well as defining long-term goals and financial plans.

Additional market research can support specification of objectives by providing data for the following activities:

- Evaluate the current service base -- both transportation performance and agency effectiveness;
- Estimate (perceived) gap between importance and performance, determine direction of change and future focus important to the public; and
- Establish the supportable level of effort.

At this stage, analysis is in general terms -- shortfalls, general needs. It may include area-specific evaluations but it is not detailed to the level of individual projects.

A number of studies reviewed either focused on or included **evaluation of the current service base**. For example, the 1987 Texas telephone survey (TX5) dealt primarily with performance of the highway department and the condition of roads, highways, and related facilities. Respondents rated Texas highways overall and within specific contexts on a scale of 1 to 10 with respect to condition and appearance; they compared Texas highways with those in other states; they indicated what services they thought were state highway department responsibilities; and they evaluated the state's performance both directly with respect to departmental response to personal communication and indirectly by rating roadside rest areas, highway litter control, public information, highway signs, and overall perception of departmental efficiency.

A 1987 Delaware telephone survey (DE2) gathered information on the public's perception of system adequacy with questions on the ability of the road and highway system to handle congestion, physical condition of Delaware roads and highways by category and with respect to an extensive list of specific (named) roads, changes in system adequacy over the preceding two to three years, and effectiveness of the Department of Transportation in carrying out various responsibilities. In gathering information on funding sources and burden, the 1986 Missouri telephone survey (MO1) also included questions on perceived quality of the roads, highway department performance, and current (unsolved) problems. The New York Metropolitan Transit Authority survey on crime in the subways (NY2) focused on a narrower component of system performance: public perceptions about crime in the subway system and, thus, the transit authority's (perceived) effectiveness in maintaining a safe environment.

Several studies went a step further than basic "report cards" on transportation delivery. The analyses **estimated the perceived gap between performance and importance** of current service components, thus helping to **determine the direction and focus of change**. For example, Minnesota DOT's informal "Listen to Business" interviews (MN5) queried selected business persons on their transportation needs so that DOT could better evaluate the importance to business of specific transportation services. An earlier Minnesota telephone survey (MN6) asked respondents to evaluate the degree of improvement or deterioration in highway conditions in the preceding five years and the quality of current services in selected areas.

Both 1987 Minnesota DOT surveys (MN2 and MN3) asked respondents to numerically rate the importance and quality of specific services provided by the state such as new road construction, repair, snow removal, and reduction of congestion.

Market research aids in estimating the **supportable level of effort** by providing data on the likely financial base, willingness to pay or financial trade-offs, preferred funding sources in general and with respect to specific

needs, and any conditions requisite for project and/or funding support. The highway services study (MN2) queried respondents on their trade-off between increased congestion and increased taxes, and on the amount they would be willing to pay to shorten the road replacement cycle. In an earlier Minnesota survey (MN6, 1984-5), respondents indicated how much more they would be willing to pay if less corrosive chemicals were substituted for salt in ice removal and whether public funds should be used to develop-build-operate high speed rail systems. The multi-objective 1987 Delaware survey (DE2) also investigated the public's support for increased expenditure on roads and highways to combat congestion. The TRIP national survey (US2) explored public reaction to user fees and other revenue sources, probable support for hypothesized increases in the fuel tax and the form such an increase, if enacted, should take.

SERVICE IMPROVEMENT AND PROJECT IMPLEMENTATION

The general goals delineated in Specification of Objectives must be translated into specific DOT policies and projects. Some of these will involve significant capital expenditure on new facilities; some will entail only changes in the way business is carried out. In most cases, the public needs to make a choice among alternatives -- alternative investments to service the same need, investments addressing different needs that compete for the same funds, mutually exclusive policy options, or between doing something and doing nothing in a particular circumstance. Market research helps establish priorities and determine the choices most in line with public preferences by providing information for the following activities:

- Identify alternative means to achieve general objectives;
- Assess relative efficiency, and public perception and evaluation of proposed options;
- Select among alternatives to achieve same goal;
- Set expenditure priorities among proposed projects that compete for limited funds;
- Identify and evaluate policy modifications or refinements that do not require radical changes in physical structure, including both long-term policies and temporary short-term or local management issues; and
- Anticipate public response to projects, policies or service options, and assess likely support/use by various population groups.

Public reaction to hypothesized policies, financial alternatives, and proposed revenue sources, and information indicating preferences among competing investments can then be utilized in formulating more detailed funding and investment plans.

Market research techniques allowing open-ended responses (rather than restricted to multiple choice answers) can be effectively utilized to **identify alternative means** to achieve a given end. For example, Montgomery County, Maryland (MD1) used a non-random questionnaire survey (printed in local newspapers) coupled with public meetings to solicit public input on how to deal with an important local road considered by many to be unsafe. The County DOT has reserved judgement on the need for more statistically reliable market research until it can judge the degree of concurrence manifest in the survey and public meetings. Various alternatives, including acceptance of the status quo, were identified and discussed for individual segments of the two-lane road.

After having identified the alternative means to achieve a given objective, Delaware DOT used a variety of qualitative and quasi-quantitative means to assess **public perception and evaluation of proposed options** to revamp Route 13 (DE1). The public was invited to decide whether reconstruction, realignment, or development of totally independent segments was most appropriate for each of several road sections and, where new construction was appropriate, which of several alignments was preferred. Opinion was solicited through focus groups, public meetings and exhibits, and questionnaires distributed at meetings. Although results were not amenable to statistically valid generalization (since respondents were not necessarily representative of the entire

population), Delaware felt that the citizens with strong opinions were sufficiently involved that the results were an adequate basis for planning.

The 1987 Minnesota "S.A.F.E." survey (MN2) was initiated by the state DOT to help set expenditure priorities in anticipation of budgetary constraints. It elicited public opinion on those services and expenditures considered most vital, by asking respondents to estimate the cutbacks they would tolerate in certain services if economizing became necessary, so the department could better determine where cuts might be effected. A more recent telephone survey (September 1988, OR2) by Oregon's Transportation Financing Task Force, composed of several political jurisdictions in the Portland area, the transit authority, and the state DOT, was designed to help set priorities for transportation projects scheduled for implementation in the next 10-15 years.

In several notable cases, market research helped the transportation authority to identify and evaluate policy modifications or refinements preferred by the public. A number of surveys solicited respondents' opinions on the speed limit, rules and regulations on large trucks, etc., for example, the Wisconsin mailback questionnaire surveys on transportation-related issues (WI2). But several studies focused almost entirely on fairly narrow management and policy issues requiring specific decisions that had to be made in the near future.

Three studies focused on policy modifications to minimize driver aggravation caused by planned road construction and reconstruction (AZ1, MN1, MN4). The options considered in the market research did not extend to the investment decision itself or engineering specifications; these had already been determined. The options concerned only ways of timing construction components and ways of handling public notification, thus enhancing customer satisfaction with DOT management of the specific projects. Because there was no need for statistically-generalized conclusions, Arizona relied on focus groups and conversations with eight individuals professionally involved with transportation to generate ideas and to give them an indication of probable public response to several options. So long as there was basic consensus among participants, there was no need to know the precise percentage of each type of auto commuter in favor of each option.

Although Minnesota could probably have achieved much of its objective with qualitative market research, the DOT launched a more extensive market research effort. Their first effort concerned explicitly with construction inconvenience was a two-stage telephone survey (MN4) of rush hour commuters in the Minneapolis-St. Paul metropolitan area. The initial survey polled drivers on their preferences for handling disruption due to construction and then, after policies based on the survey results were enacted, the DOT followed up with a second telephone survey to confirm the efficacy of the policies enacted to minimize driver aggravation.

In their second construction-oriented market research effort (MN1), the Minnesota DOT approached the problem of minimizing the reconstruction disruption on a specific major St. Paul-Minneapolis connector with a broader-based research design that included interviews with local and DOT officials, focus groups with business owners, and a telephone survey of area residents. The research identified drivers' preferences among alternative construction scenarios, e.g., short, concentrated inconvenience versus longer term but less intense inconvenience, and gathered information to help design more effective communications campaigns to keep commuters informed each week on the bottlenecks to be expected. Like Arizona, MnDOT construction plans were not subject to discussion; market research dealt only with limited scheduling and communications options in implementing these plans.

Market research was also used to anticipate public response and assess likely support/use for both investment projects and policy changes. Techniques included questionnaire surveys describing hypothetical situations, questionnaire surveys presenting more site- or policy-specific options, and even a working pre-test of one option. The TIAG survey (US1) was designed to explore the likelihood of public support for toll roads in certain contexts. It was not site-specific enough to be considered a survey of specific issues -- although several parameters for each alternative route were presented, specific locations were not identified. Rather, it aimed to establish the approximate (potential) political support and public use of tolls roads described in generic terms. In a more project-specific context, the Portland, Oregon transit system survey (OR1) of area residents was geared toward analysis of the feasibility and justification of a second light rail line, based on evaluation of probable public response and support. The survey included a number of general policy questions but the core of the questionnaire was a series of questions on transit use, support of the light rail line recently completed, factors

that would encourage greater use of transit in general and light rail in particular, and on likely financial support for a second light rail line.

In several cases, market research was designed to project public response to proposed operational changes or new policies rather than investment projects. The New York Transit Authority used a city-wide survey to judge public acceptance and potential use of transit farecards and/or passes (NY1). The surveys were quite specific in price per ride, time period, and total cost. The results, therefore, can be used to project sales by demographic group and to estimate the revenue implications of each alternative. One of the most realistic studies to anticipate public response was based on a test case (pre-test) of one option. The Toronto Transit Commission undertook a limited panel survey (ON2) to gauge public response to schedule changes. However, as the sample was small and limited to one bus route, this study was considered the first stage of more extensive research; results could not be used to predict public response to changes in other parts of the transit system.

COMMUNICATION

Communication can be an independent activity -- making sure the "customers" are adequately informed -- or can be used to aid other undertakings, e.g., developing viable investment or funding programs that enjoy public support. Market research provides background information on public perceptions that are requisite for effective communication. More specifically, information collected through market research can be used in communication for the following:

- Correct public misperceptions about transportation authority policies, transportation funding, service constraints, etc., based on information to pinpoint these informational gaps;
- Market specific transportation services such as transit off-peak or peak use, carpooling, etc., based on identification of potential users, the factors that are likely to appeal to these individuals or groups, and the medium most effective in conveying the information;
- Develop public consensus for transportation programs and/or funding proposals, based on knowledge of public program/project priorities, areas of concern, and revealed trade-offs; and
- Alter public behavior such as safety-related driving practices and littering, or choice of alternative routes and transportation modes during periods of disruption.

One of the primary objectives of the Minnesota "Listen to Business" interviews (MN5) was correction of misperceptions concerning transportation or departmental functioning. In face-to-face interviews, selected businessmen discussed their concerns and raised questions in a number of areas; DOT spokespeople then responded. This market research thus addressed the existing informational gaps and laid the groundwork for better communication and mutual understanding in the future. One of the objectives of a 1987 Texas general-issue study was identification of the information gap on transportation funding and DOT responsibilities. A New Jersey telephone survey (NJ1) focused on public knowledge of financial issues, dealing primarily with the state transportation fund and a potential increase in fuel taxes. Among other things, the survey indicated the kinds of information the public lacked and the probable public response to educational campaigns concerning the structure and use of the trust fund, and the fuel tax burden in New Jersey relative to other states. The 1981-2 national TRIP survey (US1) gathered information on public awareness of the highway trust fund, gasoline tax levels and uses, the impact of road conditions on fuel consumption and vehicle maintenance, and the factors affecting road safety; these data were used to design an educational program to address areas in which the public was ill-informed.

Market research is often the first stage in programs to market specific transportation services. Information gathered is used to design marketing communications as well as to revise service structure and other operational factors. The study by the Golden Gate Authority noted above (CA1) generated recommendations to increase transit ridership. These included improved communication on transit benefits, schedule changes and other relevant service information transmitted through media pinpointed by the survey as most likely to be effective. Market research by Washington, DC's public transportation authority (DC1) indicated the demographic

characteristics and transportation criteria of a population group that might be converted to transit use; this will be used to design marketing future communications.

Often, it is essential to **mobilize public consensus and support** to effect implementation of a viable solution to transportation problems, for example, voter approval of a tax increase for transportation investment. In such circumstances, proposals incorporating expressed public priorities and answering felt needs have a greater chance of passing than those not responsive to these needs. Qualitative research can be sufficient to highlight areas of agreement, particularly if there is overwhelming consensus. However, in most cases, researchers used quantitative research to more accurately predict (likely public support.

Some public and private organizations used market research to pinpoint public preferences and, based on the results, to formulate campaigns for increased funding. For example, market research in Missouri (MO1) helped identify those transportation expenditures that would enjoy sufficient public support to overcome any initial resistance to tax increases for transportation projects. The research pinpointed areas of public concern, extent of public knowledge, and thus the basis for appealing to the public for support for an increase in the state fuel tax. The survey[3] also queried respondents on the likelihood of their supporting specified increases in the fuel tax. After a communications campaign that incorporated the market research results, the tax increase was approved.[4] A non-governmental organization in South Carolina used the results of a systematic telephone survey (SC1) on highway issues and funding to campaign for public support of a program to increase the state's highway funding.

Several communications campaigns designed to **change transportation-related behavior** began with market research to help design the campaign materials and evaluate the (probable) relative effectiveness of several options. Thus South Carolina relied on focus groups to help design safety campaign materials and then implemented mall intercept surveys, using prototype materials, to confirm the effectiveness of the media campaign materials (SC2). Texas used 30 in-depth interviews (TX2) to find out why people litter and which types of highway users were most likely to litter; they also used mall intercept interviews to help design the final anti-litter media materials (TX1). Also, the projects in Arizona and Minnesota to minimize construction disruption used market research to design publicity encouraging commuters to use alternative routes and to be more tolerant of such temporary inconveniences for the sake of the long-term good.

POLICY EVALUATION AND PROJECT MONITORING

Efficient management requires periodic evaluation of projects and policy decisions to ensure efficient allocation of resources and maximum customer satisfaction. Many of the market research studies cited above also provided information for policy evaluation and project monitoring by either providing benchmarks with which future results could be compared to measure project impacts or by querying respondents on their reactions to past or ongoing transportation activities. Market research supports the two types of evaluation:

- Ongoing monitoring of projects or policy changes to help in further refinement; and
- Post-project analysis of effectiveness in achieving goals and alleviating problems.

[3]A series of focus groups was also held in the state but the report describing their composition, extent, and subject content is not available.

[4]In San Diego, a public opinion poll apparently helped local leaders construct a list of suggested transportation projects that would appeal to a large segment of area voters. The San Diego Area Governments (SANDAG) sponsored an unusual survey designed to help prioritize transportation projects to be linked to an incremental sales tax to be levied in the San Diego area. Public preferences, revealed in a local public opinion survey, were included in the proposed legislation to raise the sale tax so that passage of the referendum tied the incremental revenues to expenditure on specific projects as part of a unified revenue-expenditure package. Unfortunately, in spite of repeated attempts, information on the survey was unavailable.

Several transportation authorities used random surveys for **ongoing monitoring of projects** to help them modify activities during the course of project. The Texas Department of Highways and Public Transportation used two types of market research to evaluate its anti-litter campaign. First, Texas retained a private firm to collect information by periodically sampling litter along selected highways and observing acts of littering (TX3). The baseline information helped to identify target groups and design the anti-litter campaign; information from subsequent surveys allowed evaluation of effectiveness and suggested mid-campaign revisions. Specifically, analyses showed not only a reduction in litter during the campaign but also a shift in the profile of litterers from younger (predominantly male) motorists and pedestrians deliberately littering to older persons accidentally littering, resulting in a change in focus during the campaign from the former to the latter group.

Second, Texas conducted three waves of random telephone surveys (TX4) to evaluate the effectiveness of the anti-litter campaign during the course of the campaign. Data collected included information on respondent recall of media messages including, changes in attitudes toward littering, and changes in (admitted) littering behavior. Results indicated awareness of media communication, especially television. However, respondent admissions of continued littering actually contradicted data from the observation survey.

Michigan conducted two telephone surveys as part of its campaign to alleviate the disruption caused by Phase I of the reconstruction of the Lodge Freeway (MI1). The first survey contributed to communication and management design. The second survey generated information for the **post-project evaluation** of the communications and management actions undertaken. Results indicated that the efforts had indeed minimized driver inconvenience; nonetheless, data indicated there was room for improvement and this information was used in designing policies for Phase II of the reconstruction effort.

SUMMARY -- MARKET RESEARCH OBJECTIVES

In many of the studies reviewed, market research was used to satisfy more than one objective simultaneously. Certainly, once the method of obtaining information has been determined, it is tempting and relatively easy to add a few more questions focusing on another transportation issue. The only argument against such piggy-backing is the increase in respondent time required which may discourage participation; the choice between longer, multiple-objective research and more frequent, single-objective market research sessions is a strategic decision of the agency in charge. The agencies in charge of the 33 studies described above usually decided in favor of expanded research, particularly since questions posed for one objective could be applied to analyses of other objectives as well when coupled with a few additional inquiries. Thus, a survey to help plan a communications campaign also served as the benchmark for subsequent project monitoring; a survey focusing on the feasibility of a light rail line also pinpointed the general factors important to transit customers and, thus, the direction needed in new marketing efforts, and so on. Transportation planning is an ongoing, integrated activity; the market research undertaken reflects this continuity.

QUESTIONS ASKED

There is a mutual interdependence among market research study goals or objectives, techniques, and questions asked. Analytic techniques are closely linked to question form and structure: some analytic techniques such as conjoint analysis require questions to be structured in very specific ways while others are more flexible. Study goals or objectives delineate the range of analytic techniques that are appropriate and the topics covered. Thus the specific questions included in any market research study reflect the other two dimensions; they do not comprise an independent descriptive dimension.

The questions included in transportation market research can be grouped into the following categories:

- General Policies,
- Specific Policies,
- Local, Short-term Situations,

- Financial Matters,
- Department of Transportation Services, and
- Empirical Data.

GENERAL POLICIES

General policy questions are broad in scope and focus on public perception of the components of a good system, the importance of a road system and its contribution to state and personal welfare, overall policy and expenditure priorities by function and not by specific projects, and means of evaluating the adequacy of the total system and its components. These questions are not restricted to specific (named) transportation components or narrowly defined issues but, rather, are designed to explore public attitudes on the transportation system in relation to other public services, its general configuration, and future direction.

For example, the 1987 Delaware telephone survey (DE1) asked respondents to assess the physical condition of the state's roads and highways, their ability to handle traffic, and to evaluate the adequacy of public transportation. Delaware's market research questionnaire on the realignment and reconstruction of Route 13 (DE2) also included questions on the criteria that respondents considered most important in evaluating alignment alternatives in general.

Minnesota's "Listen to Business" (MN5) series of interviews covered a number of general policy issues including the importance of the transportation system, convenience, and access by users. Similarly, a survey conducted by Portland, Oregon's transit authority (OR1) included questions on the importance of transit and adequate transportation in general. Several surveys including one by the Ontario, Canada, Ministry of Transportation (ON1) asked respondents to rate the importance of a number of highway features and to identify policies they considered most important in promoting highway safety.

SPECIFIC POLICIES

Questions on specific policies focus on the effective achievement of discrete goals or selection among alternative approaches to achieve these objectives. These might include speed limits, truck size limits, safety and pollution inspections, snow plowing, directional signs, driver eye and ability examinations, driver's license constraints for the elderly, curfews, drunk driving penalties -- all specific policy components of safer transportation. Examples include the South Carolina focus groups on highway safety (SC2) and the 1987 Minnesota telephone survey on various specific policies (MN3).

Specific policy questions can also query the public on an individual component of a functioning system or attempt to project public reaction to the introduction of specific policies. Questions posed in the survey by the New York Metropolitan Transit Authority centered on the form of farecards and/or passes that would be most effective for the transit system (NY1). In other NY-MTA market research, focus groups were used to explore the possible reaction of auto drivers to specific policies designed to inhibit auto use in the central city (NY3).

The questions included in Toronto's survey of selected transit users were concerned only with participants' reaction to changes in bus frequency (ON2). In this case, rather than asking respondents to anticipate their reactions to changed frequency, the transit authority actually implemented these changes on a test route and monitored participants' travel patterns before and after the changes as a way to gauge public reaction to specific policies.

LOCAL SHORT-TERM SITUATIONS

Questions on local short-term situations are a subcategory of specific policy questions. These question are phrased with reference to a particular transportation component (a particular road or interchange, transit station), and relate to a short-term situation. In many cases, such questions yield information that is too situation-specific to be of use elsewhere. Examples include market research on the alignment of specific road segments and individual local road options in Delaware (DE1) and Montgomery County, Maryland (MD1).

Even when posed as relating only to local short-term situations, results often can be generalized to other similar situations and thus elevated to a specific policy. For example, suggestions for handling disruptions due to construction and reconstruction in specific local situations, such as in Minnesota (MN1, MN4) and in Arizona in anticipation of construction on "The Stack" interchange (AZ1), can be extended to other construction projects. Survey results indicating public preference for more aggravation over a short time period compared to less aggravation stretched over a longer time period can be generalized, as can their strong request for timely advance information on specific lane and ramp closings. In this sense, questions on local short-term situations shade over into specific policy questions.

FINANCIAL MATTERS

Although many of the issues broached in general and specific policy questions have financial impacts, these can also be dealt with in questions structured specifically to gauge expenditure priorities and willingness to pay. Questions in the financial issues category include those concerned with the transportation trust funds and the level of fuel taxes (NJ1), other additional taxes,[5] and other sources of funding to meet transportation needs (in numerous studies including NY1, MN4, MN5, OR1 and OR2, TX5), reaction to expenditure constraints such as in Minnesota's S.A.F.E. survey questions on the tradeoff between congestion and increased taxes (MN2), and willingness to pay for improvements such as questions in surveys done by Missouri (MO1) and The Road Information Program (US2) that posed hypothesized increases in the gasoline tax.

Questions on financial matters can be based on very specific hypothetical situations with proposed tax or toll levels such as the questions constructed on toll road alternatives by the Transportation Infrastructure Advisory Group (US1). Or, questions can be more general and rely on ranking or scaled answers to evaluate probable public reaction to broadly defined financial policies such as Missouri's questions asking respondents the degree to which they agreed with the statement "I would support a fuel tax increase if more money were spent for road and bridge projects in my area of the state..." (MO1).

DEPARTMENT OF TRANSPORTATION SERVICES

Questions requiring public prioritization of services or evaluation of service importance could be considered policy questions as well as service-oriented inquiries. However, questions regarding department of transportation (DOT) or transportation agency performance in these areas and the quality of service delivered belong in the service-based category. Many of the public opinion polls reviewed for Task 1 included "report cards" on provision of services by the state Departments of Transportation or the transit authority sponsoring the analysis. Even those studies primarily concerned with specific policy options included questions on service performance such as the surveys by Missouri (MO1) and New Jersey (NJ1).

Often, respondents were asked to use a scale to rate performance -- a four-point scale from poor to excellent in rating Missouri DOT overall, a five-point scale from very poor to excellent in Minnesota's S.A.F.E. survey (MN2) to rate several specific aspects of Minnesota DOT's (MnDOT) performance such as provision of signs, road maintenance, and the like. Transit authority surveys queried users directly about quality of service (OR1, DC1, WI1) and asked nonusers what discouraged them from using the system (CA1, NY1, DC1).

In the case of Michigan's survey concerning construction on the Lodge Freeway (MI1), questions focused on DOT performance in a very specific situation -- the department's handling of disruption and distribution of information during the construction period.

EMPIRICAL DATA

Market research implies analysis of the market or customer base and thus the need for empirical data characterizing those customers. Such information is necessary to accurately extend survey results to the

[5]San Diego's SANDAG survey, described in a previous footnote, dealt with an incremental sales tax for transportation funding.

population at large, to identify target groups by their objective characteristics, and to gauge transportation use patterns for future planning.

Virtually all of the transportation market research reviewed here included basic demographic information on respondents -- sex, race, age and income groups. Several, however, gathered more information to be used in analyzing survey results and projecting future market response. For example, the Wisconsin survey of inter-city bus riders (WI) included a number of questions on trip origin, destination, other modes used on the same trip, frequency of bus use, auto availability, and the like, to provide a complete profile of bus users. Wisconsin's periodic mail surveys (WI2), based on questionnaires inserted with license renewal notices, included questions eliciting empirical data on travel patterns, car size, and other factors.

SUMMARY -- QUESTIONS ASKED

None of the market research projects reviewed were confined to only one type of question. At a minimum, all included some empirical information to allow generalization of the study's results; almost all the studies exemplified even greater breadth. Table D-1 lists the studies containing questions in each of the several categories defined. For example, a number of surveys focusing on solutions to very specific problems or policy issues also included general questions on departmental performance or broad policy issues that were added on to the primary questions and inquiries designed to evaluate public attitudes on financial issues also included questions on DOT performance or general policy priorities.

Table D-1: Questions Asked in Studies Reviewed

General Policies	California/Commuters (CA1), Delaware/Route 13 (DE1), Delaware/Issues (DE2), Washington DC/Transit (DC1), Minnesota/S.A.F.E. (MN2), Minnesota/Drivers (MN3), Minnesota/Issues (MN6), Missouri/Tax (MO1), New Jersey/Trust Fund (NJ1), New York/Auto (NY3), Oregon/Transit (OR1), South Carolina/Funds (SC1), US/Issues (US2), Ontario/Highways (ON1)
Specific Policies	Washington DC/Transit (DC1), Minnesota/S.A.F.E. (MN2), Minnesota/Drivers (MN3), Minnesota/Inconvenience (MN4), Minnesota/Business (MN5), Minnesota/Issues (MN6), Missouri/Tax (MO1), New York/Fare Cards (NY1), New York/Safety (NY2), New York/Auto (NY3), South Carolina/Funds (SC1), South Carolina/Safety (SC2), Texas/Media Materials (TX1), Texas/Litter Behavior (TX2), Texas/Anti-litter Campaign (TX4), Wisconsin/Auto (WI2), US/Toll Roads (US1), Ontario/Highways (ON1), Ontario/Buses (ON2)
Local Situations	Arizona/The Stack (AZ1), Delaware/Route 13 (DE1), Maryland/Falls Road (MD1), Michigan/Freeway (MI1), Minnesota/Connector (MN1), Minnesota/Inconvenience (MN4), Minnesota/Business (MN5)
Financial Matters	Minnesota/S.A.F.E. (MN2), Minnesota/Inconvenience (MN4), Minnesota/Business (MN5), Missouri/Tax (MO1), New Jersey/Trust Fund (NJ1), New York/Fare Cards (NY1), Oregon/Transit (OR1), Oregon/Finance (OR2), South Carolina/Funds (SC1), Texas/Issues (TX5), US/Toll Roads (US1), US/Issues (US2)
DOT Services	Delaware/Issues (DE2), Washington DC/Transit (DC1), Minnesota/S.A.F.E. (MN2), Minnesota/Drivers (MN3), Minnesota/Business (MN5), Minnesota/Issues (MN6), Missouri/Tax (MO1), New Jersey/Trust Fund (NJ1), New York/Fare Cards (NY1), New York/Safety (NY2), New York/Auto (NY3), Oregon/Transit (OR1), South Carolina/Funds (SC1), Texas/Issues (TX5), Wisconsin/Buses (WI1), Wisconsin/Auto (WI2), Ontario/Highways (ON1)
Empirical Data	Delaware/Route 13 (DE1), Delaware/Issues (DE2), Washington DC/Transit (DC1), Minnesota/Connector (MN1), Minnesota/Drivers (MN3), Minnesota/Inconvenience (MN4), Missouri/Tax (MO1), New Jersey/Trust Fund (NJ1), New York/Fare Cards (NY1), New York/Auto (NY3), Oregon/Transit (OR1), South Carolina/Safety (SC2), Wisconsin/Buses (WI1), Wisconsin/Auto (WI2), US/Toll Roads (US1), US/Issues (US2), Ontario/Highways (ON1)

SUMMARY -- TRANSPORTATION MARKET RESEARCH STUDIES

Our review of transportation market research indicates a wide range of issues covered and questions used, from very general policy to very specific road segments; there is an awareness of the usefulness of market research in addressing a variety of transportation policy problems. However, in spite of the range of information collection methods available, a preponderance of studies were based on random telephone surveys. Such surveys -- usually the least expensive of the full-scale surveys, but not the least expensive data collection technique -- are amenable to very sophisticated analysis using such statistical techniques as regression and conjoint analysis to probe for underlying relationships.

Nonetheless, these opportunities for refined statistical inference and evaluation were not utilized; most studies based their conclusions on simple tabulation of answers and cross-tabulation of responses by socio-economic characteristics using such divisions as commuters/noncommuters, male/female, and the like (although a few studies, undertaken by transit authorities, went beyond this and included multi-variate statistical analysis of responses to reveal the more subtle relationships involved). For example, several studies were concerned with prioritization of options and project selection, and were based on large-scale telephone surveys of randomly-selected participants; in these circumstances, conjoint analysis would have been an ideal analytical tool to explore the trade-offs in policy choices. Although questions geared for such analysis could easily have been incorporated in the surveys (for example, Minnesota's S.A.F.E. Survey or Oregon's analysis of investment priorities), evaluation was confined to simple summations and cross-tabulations of responses.

Our review reveals that transportation market research has been used in transportation but its use has been limited; there is a great potential for market research to better support transportation agencies in achieving the full range of departmental objectives involving interaction with the general public.

PRECIS OF MARKET RESEARCH REVIEWED

Reference: AZ1
Jurisdiction: Arizona
Subject: Freeway and interchange construction
Method: Focus groups and telephone discussions
Date: July, 1986
Number of respondents: 10 in focus groups, 8 telephone discussions
Sponsor: Arizona Department of Transportation
Contact: Paul J. McGonigle, Director, Community Relations (602-255-7355)
Reports and other written materials:
"The Stack," Phoenix, Arizona -- Public Information for Traffic System Management, Arizona Department of Transportation.
Chris Karis, "Freeway Steering Committee Research Results," report by Winward, Moody, Garvy, Gatesh, Inc., Phoenix, Arizona (July 25, 1986).

Reference: CA1
Jurisdiction: San Francisco area, California
Subject: Commuter characteristics and patterns
Method: Mailback and telephone surveys, focus groups
Date: 1985
Number of respondents: 1,900 mailback survey questionnaires received; 8 focus groups; 500 telephone interviews
Sponsor: Golden Gate Bridge, Highway, and Transportation District
Contact: Bruce H. Selby, Marketing Director (415-457-3110)
Reports and other written materials:
"A Study of Travel Patterns, Demographic and Motivational Characteristics of Commuters in the Golden Gate Corridor," report by Research Alliance, San Francisco, CA (December 1985).

Reference: DE1
Jurisdiction: Delaware
Subject: U.S. Route 13 Relief Route
Method: Focus groups, public exhibits, unsystematic questionnaire survey
Date: began January, 1984
Number of respondents: Different for each component of the planning process
Sponsor: Delaware Department of Transportation
Contact: Paul A. Welsh, Manager, Community Relations (302-736-4313)
Reports and other written materials:
U.S. Route 13 News, Relief Route Planning, Killinger Kise Franks Straw, Philadelphia, PA (various issues 1984-88).

Reference: DE2
Jurisdiction: Delaware
Subject: Transportation issues and departmental performance
Method: Telephone interview survey
Date: Winter 1987
Number of respondents: 300
Sponsor: Delaware Department of Transportation
Contact: Paula Lehrer, Administrative Assistant to Secretary of Transportation Kermit Justice (302-736-4303)
Reports and other written materials:
Internal memorandum from Larry Klepner to Paula Lehrer (September 19, 1988)

Reference: DC1
Jurisdiction: Washington, D.C.
Subject: Transit system ridership patterns
Method: Telephone survey
Date: October, 1987
Number of respondents: 1,200
Sponsor: Washington Metropolitan Area Transit Authority
Contact: Ingrid J. McCrary, Market Research Analyst (202-962-1326)
Reports and other written materials:
"Market Segmentation Study," Research Report by the Consumer Research Division of the Office of Marketing, Washington Metropolitan Area Transit Authority (April 1988).

Reference: MD1
Jurisdiction: Montgomery County, Maryland
Subject: Modifications on major local north-south road (Falls Road)
Method: Newspaper clip-out questionnaire
Date: September, 1988
Number of respondents: approximately 750
Sponsor: Falls Road Citizens Advisory Committee, appointed by Montgomery County Department of Transportation
Contact: Aileen Rappaport, County Coordinator for Falls Road Citizens Advisory Group (301-217-2145)
Reports and other written materials:
"Response is large on Falls Road survey," Potomac Almanac (September 21, 1988), and other articles in the Potomac Almanac and the Potomac Gazette.

Reference: MI1
Jurisdiction: Detroit, Michigan
Subject: Lodge Freeway reconstruction
Method: Telephone survey
Date: First survey: early 1986, second survey: late 1987
Number of respondents: 800 each survey
Sponsor: Michigan Department of Transportation
Contact: Brenda Redhead, Media Relations (313-569-3993)
Reports and other written materials:
"Rebuilding The Lodge: The Role of Communication in Rebuilding Detroit's John C. Lodge Freeway (A Final Report on the Lodge-ability Public Information Program)," prepared by the Southeast Michigan Council of Governments (SEMCOG) (1988).

Reference: MN1
Jurisdiction: Minnesota
Subject: Reconstruction of major Minneapolis-St. Paul connector
Method: Interviews, focus groups, and telephone survey
Date: Began July, 1988; telephone survey October, 1988
Number of respondents: Dependent on method
Sponsor: Minnesota State Department of Transportation
Contact: Michael S. Sobolewski, Special Projects Coordinator (612-297-3532)
Reports and other written materials:
"I-94 REMAP: Phase I - Personal Interviews, Summary of Results," prepared by Colle and McVoy, Minneapolis, MN (July 1988).
"I-94 REMAP: Phase I - Focus Groups, Summary of Results," prepared by Colle and McVoy, Minneapolis, MN (August 1988).
"I-94 Resident/User Telephone Study, Summary of Results," prepared by Colle and McVoy, Minneapolis, MN (October 1988).
"Minnesota Department of Transportation, Interstate-94, 1989 Marketing Communications Proposal," prepared by Colle and McVoy, Minneapolis, MN (October 26, 1988).

Reference: MN2
Jurisdiction: Minnesota
Subject: Highway services (S.A.F.E. Survey)
Method: Telephone survey
Date: Spring, 1987
Number of respondents: 800
Sponsor: Minnesota State Department of Transportation
Contact: Michael S. Sobolewski, Special Projects Coordinator (612-297-3532)
Reports and other written materials:
Draft report and tabulations prepared by Mid-Continent Research, Minneapolis, MN (1987?).

Reference: MN3
Jurisdiction: Minnesota
Subject: Driver survey on various issues
Method: Telephone survey
Date: February-March, 1987
Number of respondents: 3,551
Sponsor: Minnesota State Department of Transportation
Contact: Michael S. Sobolewski, Special Projects Coordinator (612-297-3532)
Reports and other written materials:
Rossana Rae Armson and Nacy Davenport-Sis, "Final Report and Codebook, Minnesota Driver Survey," Center for Survey Research, University of Minnesota, Minneapolis, MN (April 27, 1987).

Reference: MN4
Jurisdiction: Minnesota
Subject: Construction inconvenience
Method: Telephone survey
Date: January, 1986 and follow-up December, 1986
Number of respondents: 600 and 602 respectively
Sponsor: Mid-Continent Research for Minnesota State Department of Transportation
Contact: Michael S. Sobolewski, Special Projects Coordinator (612-297-3532)
Reports and other written materials:
Mary Jane Davis and Gail E. Lorenz, "Using Public Opinion Research for Highway Construction Decision Support," Minnesota Department of Transportation (August 1987).
Julie A. Frank and Paul L. Riedesel, "Survey of Attitudes About Metropolitan Highway Construction, Phase II," Mid-Continent Research Inc., Minneapolis, MN (February 1987).
"Survey Probes Attitudes on State Highway Construction," news release from Minnesota Department of Transportation (May 5, 1986).
Julie A. Frank, "Survey of Attitudes About Metropolitan Highway Construction," Mid-Continent Research, Inc., Minneapolis, MN (February 1986).

Reference: MN5
Jurisdiction: Minnesota
Subject: Business concerns in transportation ("Listen to Business" program)
Method: Personal on-site interviews
Date: Initiated July, 1985 (report dated January, 1986)
Number of respondents: 277
Sponsor: Minnesota State Department of Transportation
Contact: Michael S. Sobolewski, Special Projects Coordinator (612-297-3532)
Reports and other written materials:
"The Mn/DOT LISTEN TO BUSINESS Program," report by Minnesota Department of Transportation (January 1986).

Reference: MN6
Jurisdiction: Minnesota
Subject: Transportation issues
Method: Telephone survey
Date: probably 1985, possibly 1984
Number of respondents: approximately 2,000
Sponsor: Minnesota State Department of Transportation
Contact: Michael S. Sobolewski, Special Projects Coordinator (612-297-3532)
Reports and other written materials:
Unpublished tabulation of responses.

Reference: MO1
Jurisdiction: Missouri
Subject: Missouri fuel tax and transportation finance
Method: Telephone survey
Date: July, 1986
Number of respondents: 600
Sponsor: Associated General Contractors
Contact: Art Taylor, Public Affairs Officer (314-751-2840)
Reports and other written materials:
"Missouri Fuel Tax Survey Report," report prepared for Associated General Contractors by Targeting Systems, Inc., Arlington, VA (August 1986)

Reference: NJ1
Jurisdiction: New Jersey
Subject: New Jersey Transportation Trust Fund
Method: Telephone survey
Date: September 8th and 14th, 1986
Number of respondents: 802
Sponsor: New Jersey Alliance for Action
Contact: Ellis S. Vieser, New Jersey Alliance for Action (201-225-1180)
Reports and other written materials:
Draft questionnaire.
"Gallup Reports Strong Support to Continue Transportation Fund," New Jersey Alliance for Action Press Release (October 29, 1986).
"New Jersey Transportation Trust Fund: A Survey of Public Opinion," prepared for New Jersey Alliance for Action by The Gallup Organization,, Inc., Princeton, NJ (October 1986).

Reference: NY1
Jurisdiction: New York, New York
Subject: New York City transit fare cards and passes
Method: Telephone survey
Date: City sample: first wave - May 5-27, 1983, second wave - June 7-20, 1983; suburban sample: June 7-26, 1983.
Number of respondents: City: 2500; suburbs: 500.
Sponsor: New York City Transit Authority
Contact: David Jordan, Deputy Director, Fare Structure Analysis (718-330-3479)
Reports and other written materials:
"Transit Pass Marketing Study," draft final report prepared for Metropolitan Transportation Authority by Charles River Associates, Boston, MA; CRA Report No. 732 (August 5, 1983).

Reference: NY2
Jurisdiction: New York, New York
Subject: Perception of subway safety
Method: Telephone survey
Date: 1988
Number of respondents: 996
Sponsor: New York Metropolitan Transit Authority
Contact: Peter Harris, Marketing Research Director (212-878-7181)
Reports and other written materials:
Andrew C. Hyde, "Crime and PersonalSecurity in the Subway: New Yorkers' Perceptions," MTA Marketing Research report (September 20, 1988).

Reference: NY3
Jurisdiction: New York, New York
Subject: Decision to drive in center city
Method: Focus groups
Date: April-May 1987
Number of respondents: 171
Sponsor: New York Metropolitan Transportation Authority
Contact: Michael J. Rossmy, Project Manager (212-878-7258)
Reports and other written materials:
"Manhattan Auto Use Decision Study - Report on Qualitative Research," prepared for Planning Department, New York Metropolitan Transportation Authority by Decision Research Corporation, Lexington, MA (March 1988).

Reference: OR1
Jurisdiction: Portland, Oregon
Subject: Public transit system
Method: Telephone survey
Date: November 6-20, 1987
Number of respondents: 2,000
Sponsor: Tri-Met (Portland area transit authority)
Contact: Catherine Koppel, Strategic Research Coordinator (503-239-6465)
Reports and other written materials:
"Attitude and Awareness Study," prepared for Tri-Met by Moore Information, Portland OR (November 1987)

Reference: OR2
Jurisdiction: Portland, Oregon
Subject: Transportation investment and funding
Method: Telephone survey
Date: September, 1988
Number of respondents: 1,000
Sponsor: Transportation Financing Task Force
Contact: Carol Pedersen, Strategic Research Assistant (503-239-6435)
Reports and other written materials:
Unpublished tabulation of responses to telephone interview.

Reference: SC1
Jurisdiction: South Carolina
Subject: Transportation issues and highway funding
Method: Telephone survey
Date: January 9-13, 1987
Number of respondents: 303
Sponsor: South Carolinians for Better Transportation
Contact: Norma U. Bryce, Executive Director (803-252-8442)
Reports and other written materials:
David Reed, "Survey: Residents support major highway expansion," The Sun News, Myrtle Beach SC (March 29, 1987).
Unpublished summary of most significant survey findings.

Reference: SC2
Jurisdiction: South Carolina
Subject: Highway safety
Method: Focus groups and mall intercept surveys
Date: Spring, 1988
Number of respondents: focus groups - 60, survey - 300
Sponsor: South Carolina Highway Department
Contact: Sam McCuen/Brian Ellison, South Carolina Department of Highways and Public Transportation (803-737-1270); Kevin Fisher, Newman, Sallory and Gregory (803-254-8158)
Reports and other written materials:
"Focus Groups Summary Report," prepared for South Carolina Department of Highways and Public Transportation by Newman, Saylor and Gregory, Columbia SC (May 9, 1988).
Highway Driving Habits Focus Group Discussion Guide, prepared by Market Search Corporation, Columbia SC

Reference: TX1
Jurisdiction: Texas
Subject: Anti-litter media materials
Method: Mall-intercept interview survey
Date: June 14-15, 1985
Number of respondents: 88
Sponsor: Texas Department of Highways and Public Transportation
Contact: John Cagle, Manager of Public Information Branch (512-463-8954)
Reports and other written materials:
Questionnaire used in mall intercept interviews.

Reference: TX2
Jurisdiction: Texas
Subject: Highway littering behavior
Method: In-depth interviews
Dates: August 27-8, 1985
Number of respondents: 30
Sponsor: Texas Department of Highways and Public Transportation
Contact: John Cagle, Manager of Public Information Branch (512-463-8954)
Reports and other written materials:
"A Motivational Study About Litter and Littering," Decision Analyst, Inc., Arlington TX (September 1985).

Reference: TX3
Jurisdiction: Texas
Subject: Highway litter
Method: Observation
Dates: Selected periods August 1985-July 1988
Number of respondents: (Not applicable)
Sponsor: Texas Department of Highways and Public Transportation
Contact: John Cagle, Manager of Public Information Branch (512-463-8954)
Reports and other written materials:

Daniel B. Syrek, Director, Institute for Applied Research, Sacramento CA, report to G.S.D. & M. Advertising on findings of previous litter surveys (September 3, 1985).

Daniel B. Syrek, "Texas Litter: 1985-1986, The Change in Visible Litter Rates at 100 State Highway Locations," report to The Texas Department of Highways and Public Transportation and G.S.D. & M. Advertising (August 15, 1986).

Daniel B. Syrek, "Texas Litter: 1987, Part Two," report to The Texas Department of Highways and Public Transportation and G.S.D. & M. Advertising (August 15, 1987).

Daniel B. Syrek, "Texas Litter: 1988 -- A Report on a Visible Litter Survey Conducted During July 1988," report to The Texas Department of Highways and Public Transportation and G.S.D. & M. Advertising (August 13, 1988).

Reference: TX4
Jurisdiction: Texas
Subject: Anti-litter advertising campaign
Method: Telephone survey
Dates: October 1985, August 1986 and July 1987
Number of respondents: 400 each survey
Sponsor: Texas Department of Highways and Public Transportation
Contact: John Cagle, Manager of Public Information Branch (512-463-8954)
Reports and other written materials:

"Pre-Wave Awareness Tracking," prepared for the Texas Department of Highways and Public Transportation by G.S.D. & M. Research, Dallas TX (October 9, 1985).

"Litter Advertising Tracking Study -- Wave II," Study #86-151 and #85-162, and accompanying statistical tables, prepared by Decision Analyst, Inc., Arlington TX (August 1986).

"Litter Advertising Tracking Study -- Wave 3," Study #87-168, Statistical Tables, prepared by Decision Analyst, Inc., Arlington TX (July 1987).

Reference: TX5
Jurisdiction: Texas
Subject: Transportation issues
Method: Telephone survey
Date: September 1-November 15, 1987
Number of respondents: 9,714
Sponsor: Texas Transportation Institute
Contact: John Cagle, Manager of Public Information Branch (512-463-8954)
Reports and other written materials:

Draft summary of tabulations by question prepared by Texas Transportation Institute and the Texas Poll at Texas A&M University (no date).

Reference: WI1
Jurisdiction: Wisconsin
Subject: Intercity bus travel
Method: Written questionnaire survey
Date: November 11-17, 1985 and January 6-12, 1986
Number of respondents: 994
Sponsor: Wisconsin Department of Transportation
Contact: Don Chatfield (608-266-3973)
Reports and other written materials:

Gati Grundmanis, "The 1986 Wisconsin Intercity Bus Passenger: A Profile of Trips, Socioeconomic Characteristics and Transportation Alternatives," Wisconsin Department of Transportation report (February 1987).

Reference: WI2
Jurisdiction: Wisconsin
Subject: Licensed drivers' opinions on transportation-related issues
Method: Mailback questionnaire surveys
Date: Selected dates 1984-86
Number of respondents: 1,800-2,200, depending on survey
Sponsor: Wisconsin Department of Transportation
Contact: Vernon A. Reding, Chief, Planning Analysis and Data Section (608-267-7751)
Reports and other written materials:

Internal report on previous surveys conducted by or for the Wisconsin Department of Transportation (no date).

Copies of several mail survey questionnaires (January 1985; June 9, 1986; October 1986).

Reference: US1
Jurisdiction: United States
Subject: Toll roads
Method: Telephone survey
Date: February 26-March 3, 1986
Number of respondents: 1,031
Sponsor: The Transportation Infrastructure Advisory Group
Contact: The Transportation Infrastructure Advisory Group, Washington DC (202-429-8877)
Reports and other written materials:

"The Attitudes of American Drivers Toward Toll Roads," report of a study conducted by The Roper Organization Inc. for The Transportation Infrastructure Advisory Group (April 1986).

Reference: US2
Jurisdiction: United States
Subject: Transportation funding and road conditions
Method: Telephone survey
Date: Late 1981-early 1982 (report February 1982)
Number of respondents: 2,000
Sponsor: The Road Information Program (TRIP)
Contact: Sally Thompson (202-466-6580)
Reports and other written materials:

"Public Highway User Fee System: An Assessment of Public Understanding and Priorities," Final Report MRI Project No. 7193-D, prepared for TRIP by Midwest Researcfh Institute, Kansas City MO (February 26, 1982).

Reference: ON1
Jurisdiction: Ontario, Canada
Subject: Provincial highways
Method: Telephone survey
Date: October, 1987
Number of respondents: 1,803
Sponsor: Ontario Ministry of Transportation
Contact: A.G. Kelly, Assistant Deputy Minister, Engineering and Construction (416-235-4453)
Reports and other written materials:
Public Attitudes Toward Provincial Highways, Survey Report, Ontario Ministry of Transportation (Autumn 1987).

Reference: ON2
Jurisdiction: Toronto, Ontario, Canada
Subject: Elasticity of demand for bus service
Method: Panel survey based on trip records
Date: Four separate weeks September-November, 1987
Number of respondents: 57
Sponsor: Toronto Transit Commission
Contact:
Reports and other written materials:
Eric J. Miller and David F. Crowley, "A Panel Survey Approach to Measuring Transit Route Service Elasticity of Demand," Paper No. 880444, presented at the 68th Annual Meeting, Transportation Research Board (January 22-26, 1989, Washington DC).

APPENDIX E

GLOSSARY OF TERMS

BANNER AND STUB OUTPUT - numerical answers to survey questions disaggregated into population subgroups; "stubs" are the response categories; "banners" are the population subgroups.

BRANCHING - questionnaire structure in which the selection of follow-up questions is dependent upon the answers given previously; each branch question is a juncture and the line of questioning branches out in a direction determined by the answer at the juncture. Often referred to in market research as a "skip pattern."

CATEGORICAL DATA - data showing number of answers in each response category for a given variable rather than values for each variable; for example, for the variable "location of residence," data on the number of persons in suburbs, central city, small city/town, and rural areas.

CLUSTER ANALYSIS - statistical technique of identifying groups of observations not previously defined; explores similarities and differences among people based on multiple items (described by values of descriptive variables) and then segregates them into groups having similar values for the variables measured.

CONJOINT ANALYSIS - technique in quantitative analysis to evaluate priorities and/or assign relative values to factors or attributes traded off against each other; based on survey respondent strength of support for hypothesized packages composed of varying combinations of these factors or attributes.

CORRESPONDENCE ANALYSIS - statistical technique for analysis of categorical data; resulting spatial map indicates proximity between categories and thus possible relationships; uses same type of categorical data as crosstabs but more flexible since it can deal with more than two dimensions/variables at a time.

CROSS TABULATIONS (CROSSTABS) - tabular presentation of categorical data for two variables at a time to identify possible relationships between variables; categories for first variable define columns and categories for second variable define rows.

DISCRIMINANT ANALYSIS - statistical technique used to understand the relationships among several variables by identifying the factors or combinations of variables that account for the separation of individuals into different groups.

FACTOR ANALYSIS - statistical technique that takes a large number of variables and searches to see whether there are underlying forces or factors they hold in common; the procedure can be used to reduce a large number of variables down to a minimum number of statistically-defined factors the seem to underlie the original variables.

FOCUS GROUP - qualitative market research technique to explore issues, generate ideas, gauge response to new policies, in small group (10-15 persons) environment; discussion led by trained leader using outline; participants may be selected to represent population segments important to the study, but results cannot be projected or generalized to the total population.

IMPORTANCE-PERFORMANCE ANALYSIS - data analysis technique utilizing respondent grading of level of importance and quality of performance for a series of services, factors, or service components, to evaluate whether performance is commensurate with importance and, by inference, to prioritize expenditure on these components.

INTERCEPT SURVEY - survey data is collected from passers-by who are intercepted by interviewers in selected locations such as airports or shopping malls. Although participants usually are drawn from a fairly broad spectrum of the targeted population, selection is not truly random since interviewers may be biased unconsciously in their choice of participants and some population groups of interest may not frequent certain public places.

MARGINALS - simple percentage or numerical responses to each survey question.

MEAN - the arithmetic "average" value; computed as the sum of all observed values divided by the number of observations (each observation is included, even if it is the same value as other observations).

MEDIAN - the "middle" value; arranging all observed values in order from lowest to highest (and each observation is included even if it is the same as other observations), the median is the value that splits the line so that half of the observations are equal or higher in value and half the observations are equal or lower in value.

MODE - the most frequently observed value in a range of values; the peak of a statistical (frequency) distribution of values.

MULTIDIMENSIONAL SCALING - measurement and statistical technique that produces a graphical mapping of products/objects; translates perceptions of objects and/or their attributes into distances used to create a single map revealing perceived relationships among objects and/or attributes simultaneously; each axis represents a dimension that is inferred from the data as important in comparisons of these objects.

MULTIPLE REGRESSION - see **REGRESSION**

OVERSAMPLING - sampling a larger proportion of persons from a population subgroup than from the target population overall; done to generate a subgroup sample large enough for separate subgroup analysis with an acceptable margin of error.

PANEL SURVEY - technique for data collection in which a selected group of participants (the panel) records data over a period of time in a set format; generally used to track personal responses or actions in response to changes in participants' environment or note patterns over a longer period of time when recollection is considered inaccurate.

PERCEPTUAL MAPPING - statistically-derived graphical mapping of respondents' perceptions or evaluation of item attributes; essentially a graphical presentation of the results of discriminant analysis where each graphical axis is the dimension described by a discriminant function.

PSYCHOGRAPHIC MARKET SEGMENTATION - analytical technique used to classify respondents into groups representing distinct market segments, based on similarities and differences in their answers to questions about attitudes and behavior; utilizes statistical procedures such as factor analysis and cluster analysis to define groups; analogous to demographic segmentation except it uses psychographic (attitudinal, behavioral) data.

QUALITATIVE ANALYSIS - analysis based on data that has not been collected from a sample that adequately represents the full population; characteristically, analysis based on a small sample, probably not randomly selected, and not using systematic measurement techniques.

QUANTITATIVE ANALYSIS - any of a number of techniques applied to data collected from a large sample that is a statistically representative microcosm of the full population.

QUASI-QUANTITATIVE ANALYSIS - analysis based on a fairly large sample but where data collection did not satisfy all the criteria for statistically valid quantitative analysis.

RANDOM DIGIT DIALING - technique of selecting participants in telephone survey to ensure randomness; area codes and prefixes are specified to include targeted geographic areas, last four digits are randomly selected by computer and dialed.

RANDOM SAMPLE - sample chosen by methods that ensure that each member of the target population has an equal probability or chance of being selected, so that results will be representative or generalizable to target population within some margin of error.

REGRESSION - statistical technique used to understand and sort out the relationships among a several factors and their individual influence on a given outcome; structured as a multi-variable equation with one "dependent variable" or outcome as a function of one or more "independent variables" or factors that affect the outcome; called simple regression with one independent variable and multiple regression with two or more independent variables.

STANDARD DEVIATION - a measure of the spread of observations about the mean value for that variable; essentially the average variation; computed statistically as the square root of the variance which, in turn, is defined as:

$$\text{Variance} = [1/(N-1)][(X_1 - X^*)^2 + (X_2 - X^*)^2 + (X_3 - X^*)^2 \ldots$$

where there is a term for each X or observation, X^* is the mean (average) value of all observations, and N is sample size.

STANDARDIZATION - transformation of data from original units of measurement to units expressed as number of standard deviations away from the mean value for that variable; essentially an index of deviation from the average; used so that there is a single measurement scale for all variables and comparisons and consolidations are possible. Thus, an individual observation exactly equal to the mean value becomes 0 on a standardized scale; an individual observation exactly one standard deviation below the mean becomes -1.

VARIANCE - see **STANDARD DEVIATION**.

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