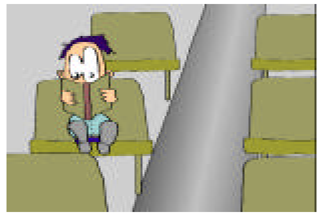
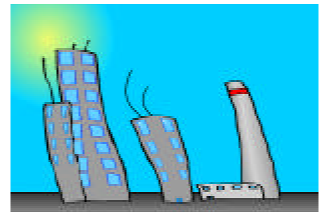
Traveler Attitudes

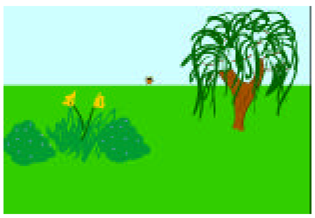
Need for Flexibility



Sensitivity to Personal Travel Experience



Desire to Help the Environment



Need for Time Savings

Insensitivity to Transport Costs

Sensitivity to Stress

Use of Structural Equation Modeling for an Attitudinal Market Segmentation Approach to Mode Choice and Ridership Forecasting

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Abstract

The San Francisco Bay Area Water Transit Authority is evaluating expanded ferry service, as required by the California Legislature. As part of this process, Cambridge Systematics developed forecasts using a combination of market research strategies and the addition of non-traditional variables into the mode choice modeling process. The focus of this work was on expanding the mode choice model to recognize travelers' attitudes and different types of urban travelers making different modal choices.

We used structural equation modeling to simultaneously identify the attitudes of travel behaviours and the causal relationships between traveler's socioeconomic profile and traveler attitudes. We extracted six attitudinal factors, three of which were used to partition the ferry riding market into eight segments. These market segments were used to estimate stated-preference mode choice models for 14 alternative modes, which separated the traveler's reaction to time savings by market segment and recognized that modal choices are different for market segments that are sensitive to travel stress or desire to help the environment.

The new mode choice models were applied within the framework of the Metropolitan Transportation Commission's regional travel model and calibrated to match modal shares, modes of access to each ferry terminal, ridership by route and time period, and person trips by mode at screenline crossings. Additional validation tests of significant changes in ferry service in recent years were used to confirm the reasonableness of the SP model. The model has been applied for three future year alternatives and to test the sensitivity of pricing, service changes and alternative transit modes.

Keywords

Ridership Forecasting, Market Segmentation, Structural Equation Modeling, Mode Choice, Traveler Attitudes, International Conference on Travel Behaviour Research, IATBR

Preferred Citation

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1. Introduction and Background

1.1 Overview of the Planning Process

The WTA is in the midst of a planning process to expand water transit service in San Francisco Bay, as required by the California Legislature (see publication links for enabling and appropriations legislation). Two critical documents were completed for the California Legislature to consider funding the WTA as an operating agency with authority to own vessels, operate new ferry routes and construct facilities. The documents were supported by technical studies in the areas of physical planning, environmental planning, design, and other areas as specified by the legislation:

- ENVIRONMENTAL REVIEW DOCUMENT – This document is in compliance with both Federal and State laws (EIR/EIS) that address regionwide impacts of ferry expansion.
- IMPLEMENTATION AND OPERATIONS PLAN – The Plan recommends priorities for new ferry routes, vessels, and facilities for submission to the California Legislature. It summarizes costs and propose revenue options. The Plan also will propose an organizational framework for expanded service.

1.2 Objectives of Ridership Forecasting

The objectives of the ridership forecasting were three-fold:

- Enhance the accuracy and reliability of ferry ridership forecasting within the regional travel forecasting model;
- Segment the market and determine modal choices based on traveler attitudes and market segments; and
- Develop market research data for strategic planning of future ferry alternatives.

The initial objective was met in two ways: first, to update the Metropolitan Transportation Commission (MTC) regional travel model ferry service networks, including mode of access assumptions, and re-validate these updated models using recent ridership data available from WTA, identified as the Phase 1 model, and second, to develop new mode choice models based on stated-preference household surveys, identified as the Phase 2 model. The Phase 2 model completely addressed the second objective as well, as it was based on traveler attitudes combined into six traveler factors and correlated to sociodemographic factors using structural equation modeling. Eight market segments were derived from the traveler factors using cluster analysis and these were incorporated into the mode choice model. The market segments were forecasted to the year 2025 and used to predict future ferry ridership for a series of ferry network alternatives, as well as a series of sensitivity analyses on pricing, service frequencies, and alternative transit investments. The use of the market research data for strategic planning of future ferry alternatives is underway at this time.

The focus of this paper is on the development of the Structural Equation Model (SEM) for an attitudinal market segmentation approach to mode choice and ridership forecasting. The work completed in the Phase 1 modeling and for strategic planning purposes is not covered in this paper due to space limitations. The paper also includes a brief literature review, a description of the data collected, discussion of the three methods used to identify and forecast traveler attitudes, analysis of market segments, model choice model development, a brief description of the calibration and validation results, and a conclusion of the modeling approach for ridership forecasting.

2. Literature Review

The importance of market segmentation in travel behaviour is well documented (Badoe and Miller, 1998), (Button and Hensher, 2001) and analyzing travel demand by market segments has become a common practice (Brand et al., 1994), (Roberts and Vougioukas, 1993). Segmentation by trip purpose, geographical location, time and some other trip characteristics is a common practice in travel demand choice models as shown for example by (Mandel, 1998) (Cascetta, 1991) and (Lythgoe, 2002). Recently there has been growing interest in segmentation by attitude as shown for example in early work by (Koppelman and Hauser, 1978) and more recently by (Proussaloglou, 1989). Some of the more recent and interesting works in this area are:

- (Cambridge Systematics, 2001) for the Metropolitan Transit Development Board (MTDB) in San Diego, California (Lieberman et al., 2001) adopted an attitude-driven market segmentation combined with an econometric analysis of travelers' mode choice behaviour to quantify total travel and potential transit market share by market segment. Using factor analysis they developed eight latent variables that presented the key underlying attitudinal dimensions. They then used cluster analysis to define six discrete segments of travelers.
- (Golob, 2001) developed joint models of attitude and behaviour to explain how both mode choice and attitudes regarding the San Diego I-15 Congestion Pricing Project differ across the population. Results show that some personal and situational explanations of opinions and perceptions are attributable to mode choices, but other explanations are independent of behaviour. With respect to linkages between attitudes and behaviour, none of the models tested found any significant effects of attitude on choice; all causal links were from behaviour to attitudes.

- (Golob and Hensher, 1998) studied the dichotomy between an individual's behaviour and his or her attitudinal support for policies that are promoted as benefiting the environmental. They developed a measurement model to establish a set of latent attitudinal factors. These factors were related in a structural equation model to a set of behavioural variables representing commuter's mode choice and choice of compressed work schedules.

Some other advances in the area of segmentation for travel behaviour analysis include (Badoe and Miller, 1998) who developed an analytical procedure that automatically identify segments by simultaneously dealing with level of service, socioeconomic and spatial factors to determine the relative role each plays in determining travel behaviour; and (Bhat, 1997) who used an endogenous segmentation approach to model mode choice, which jointly determines the number of market segments in the travel population, assigns individuals probabilistically to each segment, and develops a distinct mode choice model for each segment group.

3. Data

3.1 The Household Survey

The purpose of the household survey was to obtain a random sample of the potential market of existing and new ferry services that will serve as the main database for model estimation. The survey was conducted in November 2001 among residents of Bay Area, who were making trips in the TransBay or potential ferry market (some future ferry services are proposed along the Peninsula). The sample includes 852 completed questionnaires, 823 of which were geo-coded and used for modeling purposes. The household survey was conducted in three phases: recruitment, mail-out and phone retrieval. Respondents were screened based on whether they made any trip that would be a potential trip for a ferry service in the last couple of weeks.

The survey included a stated-preference exercise, in which each respondent was presented with four choice experiments, each with four travel alternatives tailored for the specific trip that he/she took. The four alternatives included: drive alone, carpool, rail or bus transit and ferry, and in the case of rail/bus transit or ferry, modes of access and egress to and from the rail/bus or ferry. Each alternative was presented in term of cost (transit fare or auto toll and parking cost), in-vehicle time, rail and ferry frequency, and time and cost of the different transit access and egress alternatives.

The questionnaire also included 30 attitude questions that the respondent has to rank on a scale from zero to 10. Attitude questions included questions related to time spent on traveling, how daily schedules affect travel choices, measures of comfort and stress in traveling and to different modes of traveling. Additional questions regarding the specific trip the respondent made were asked, including frequency of making such a trip, mode, cost and reimbursement. Finally, the respondent was asked some socioeconomic questions including household characteristics, employment, and income.

3.2 The On-Board Survey

Given the low number of ferry users in the household survey, the purpose of the on-board survey was to enrich the revealed-preference data of the household survey with ferry riders and to provide observed data for calibration and validation of the models. The survey was conducted in December 2001on seven existing ferry routes. Riders were asked all the travel details of their current trip, socioeconomic status, and attitude questions, similar to those asked in the household surve y. A total of 3,065 onboard surveys were collected and used in model calibration, 1,273 of these were geo-coded and used to enrich the RP model estimation resulting in a significant number of ferry users. There was a high number of surveys that contained destinations that could not be geo-coded, because the surveys were self-administered onboard the ferries.

4. Identifying and Forecasting Traveler Attitudes

4.1 Factor Analysis

Factor analysis was performed to analyze the interrelationships among 30 attitudinal variables collected in the household survey. It involved a statistical procedure that transforms a number of possibly correlated variables into a smaller group of uncorrelated variables called principal components or factors (Gorsuch, 1983). The objectives of performing factor analysis were to reduce the number of attitudinal variables (data reduction) and to detect the underlying structural relationships between variables, i.e., structure detection (Stapleton, 1997).

There were two phases of factor analysis. The first phase was an exploratory factor analysis (EFA), a process where the statistics of data determined the structure and content of the resulting factors. EFA was used to explore the survey data to determine the nature of factors that accounted for most of the co-variation between variables without imposing any a priori hypothesis about the number and structure of factors underlying the data. The second phase was a confirmatory factor analysis (CFA), a process where we applied judgment regarding the structure and content of the factors and then estimated the statistical results of these established factors. CFA offered a more robust procedure for evaluating construct validity of the attitudinal survey (Long, 1983; Harris and Schaubroeck, 1990). It also enabled us to explicitly test hypotheses concerning the factor structure of data, and provides more logical and consistent factors that may provide better information for market segmentation and mode choice. The best fit of CFA found in this study was with six factors:

- Desire to help the environment,
- Travelers' need for timesaving,
- Need for flexibility,
- Sensitivity to travel stress,
- Insensitivity to transportation cost, and
- Sensitivity to personal travel experience.

The Goodness of Fit Index (GFI) was 0.8966, indicating that 89.66 percent of the co-variation in the data could be reproduced by the given model. Thus, the confirmatory factor analysis supported a six-dimension attitudinal construct.

4.2 Logistic Regression Analysis

Logistic regression analysis is often used to investigate the relationship between binary or discrete responses and a set of explanatory variables (Hosmer and Lemeshow, 2001). We dummy-coded the scores of the six factors that were derived from confirmatory factor analysis. Each dummy variable had the value of zero when the corresponding factor score was negative, and one when the factor score was positive. Then we ran a stepwise logistic regression on each dummy factor against all the socioeconomic as well as demographic variables. Only the significant variables were retained in the logistic models. The results were logical, but not statistically significant enough to support forecasting.

4.3 Structural Equation Modeling

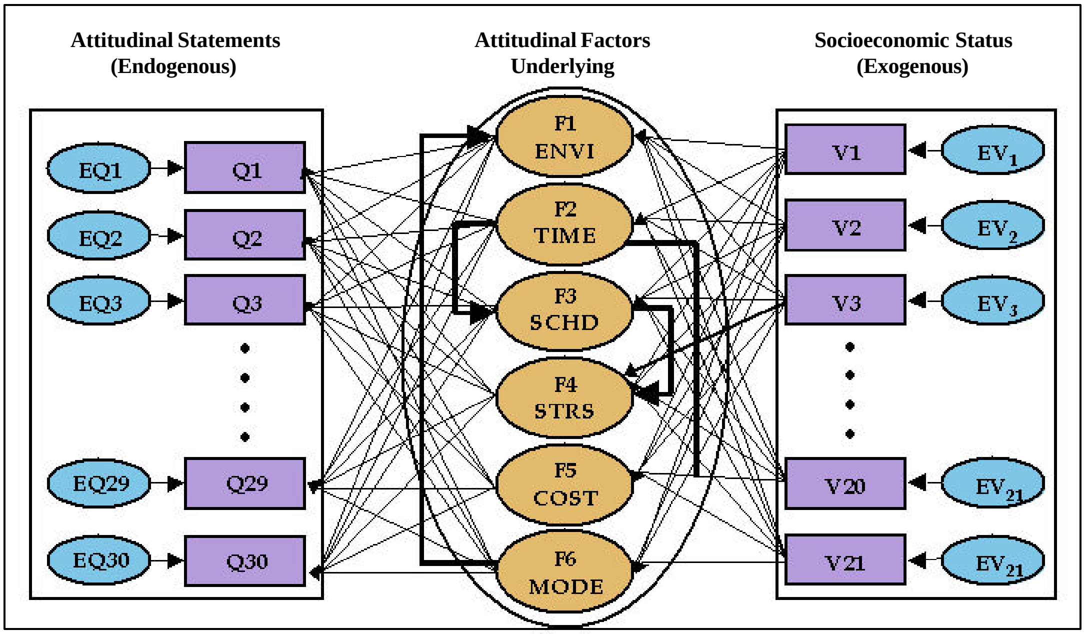
The next stage of the analysis was to develop a Structural Equation Model (SEM) in which the six attitudinal factors were related to the 30 attitudinal statements, and ultimately, to available socioeconomic variables. SEM is a modeling technique that enables us to identify the structural attitudes of travel behaviours and to quantify the causal relationships between travelers' socioeconomic status or demographic profile and travel attitudes. Applications of SEM to travel behaviour research dated from around 1980, but the method was not widely used in transportation research until the 1990s, when the application of SEM was rapidly expanding (Golob, 2001).

The primary objective of SEM in this study was to improve the statistical reliability of the relationship between the socioeconomic data and the estimation of factors. This process modified the attitudinal variables in each factor in order to improve the forecasting abilities of the model.

There were two types of variables used in the SEM: manifest and latent variables. Manifest variables were observed variables that were directly measured from the data. In this study, there were two main groups of manifest variables: 1) 30 attitudinal variables, the ratings of which indicated travelers' certain attitude toward travel; and 2) socioeconomic and demographic variables, such as household size, household income, vehicle ownership, etc. Latent variables were unobserved variable that were not directly measured, but were inferred by the relationships or correlations among manifest variables in the analysis. The two groups of latent variables in the SEM were: 1) six attitudinal factors representing the most important attitudinal dimensions for traveler behaviours, and 2) error terms associated with each variable involved in the SEM model. Conceptually, every variable should have an associated measurement error that was included in the SEM model.

The SEM was constructed in AMOS 4.0, a software program developed by SmallWater, Inc. AMOS uses path diagrams to represent relationships among manifest and latent variables. Ovals or circles represent latent variables, while rectangles or squares represent manifest variables (Arbuckle and Wothke, 1999). Figure 1 outlines the schematic structure of the SEM model. The Single-headed arrows in the path diagram represent causal effects. In the SEM structure, people's socioeconomic and demographic statuses were regarded as exogenous variables, while the ratings of attitudinal statements were endogenous variables. A structural model was used to capture the causal influences of the exogenous variables on the endogenous variables through sets of underlying attitudinal factors. In order to do so, there were three basic sets of simultaneous equations being estimated concurrently in the SEM:

Figure 1 SEM Model Structure



- **Functions between attitudinal factors and socioeconomic, demographic variables.** The attitudinal latent variables were specified as linear equations of observed social economic and demographic variables, which acted as the indicators of the underlying attitudinal structure toward travel. The socioeconomic and demographic variables included household size, number of children (under 18) in the household, household vehicle ownership, household worker number, age information, income level, college student, and household worker number compared with vehicle number. All the categorical variables were dummy coded, resulting in 21 socioeconomic or demographic variables being built into the model.
- **Functions between ratings on attitudinal statements and underlying attitudinal factors.** Each latent factor was associated with multiple attitudinal statements through a confirmatory factor analysis structure, where the modeler predetermined the model structure. If the modeler assumed no direct relationship between an attitudinal factor and an attitudinal statement, the path coefficient in the diagram was set to be zero. For each attitudinal factor, there was one and only one path coefficient being fixed to be one. This was the anchor variable that was used to set the scale of measurement for the latent factor and residuals. The SEM model estimated all other path coefficients.
- **Functions between the latent variables.** The structure of six attitudinal factors from confirmatory factor analysis was used in the initial run of the SEM model. One advantage of SEM over factor analysis is that the causal influences of latent variables upon one another can be represented as linear equations in the SEM. There were four pairs of causal relationships between factors being modeled: 1) need for flexibility as a function of need for time savings, 2) sensitivity to travel stress as a function of need for flexibility, 3) insensitivity to transport cost as a function of need for time savings, and

4) desire to help the environment as a function of sensitivity to personal travel experience.

All the linear equations in SEM were estimated simultaneously. The results of the SEM process were a final series of traveler factors that were estimated simultaneously with the demographic data required to estimate these factors. Table 1 presents the attitudinal factors and variables in the SEM process, with statistics on standard error (Std. Error) and significance (t-value) for each variable. Attitudinal factors scores were calculated using the estimated coefficients for functions between attitudinal factors and socioeconomic, demographic variables. Table 2 presents an example of the SEM results for the desire to help the environment factor and its relationship with socioeconomic variables. There were separate SEM equations for each of the six traveler factors.

Table 1 Attitudinal Factors and Variables in SEM

Factor/Variable	Variable Statements	Coefficient	Std Error	t-value
Factor One	Desire to help the environment			
PAYENVIR	I would be willing to pay more when I travel if it would help the environment.	1.000		
MODENVIR	I would switch to a different form of transportation if it would help the environment.	0.949	0.028	33.447
TRNENVIR	Use of transit can help improve the environment.	0.376	0.018	20.887
Factor Two	Need for timesavings			
CHANGMOD	I would change my form of travel if it would save me some time.	1.000		
HURRY	I am usually in a hurry when I make a trip.	0.911	0.023	39.283
FASTEST	I always take the fastest route to my destination even if I have a cheaper alternative.	0.760	0.024	32.044
NOSTRESS	Having a stress-free trip is more important than reaching my destination quickly.	-0.680	0.030	-22.978
CROWDSOK	I'll put up with crowds if it means I'll get to my destination quickly.	0.657	0.020	32.082
COMFORT	I don't mind delays as long as I am comfortable.	-0.511	0.021	-23.848
DLDRIVE	I don't like to drive, but it is usually the fastest way to get where I need to go.	0.418	0.025	16.791
Factor Three	Need for flexibility			
VARIETY	I need to make trips to a wide variety of locations each week.	1.000		
NEEDFLEX	I need to have the flexibility to make many trips during the day if necessary.	0.841	0.031	27.555
REGULAR	Generally, I make the same types of trips at the same times of the day.	-0.489	0.023	-21.654
Factor Four	Sensitivity to Travel Stress			
ANXIOUS	I am usually anxious and unsettled by the time I reach my destination.	1.000		
NOSTRESS	Having a stress-free trip is more important than reaching my destination quickly.	1.106	0.080	13.883
BRIDGES	Driving on the bridges across the bay is stressful for me.	1.266	0.074	17.099
STRESSFL	I avoid making certain trips at certain times, because it is too stressful to make the trip.	1.519	0.080	19.059
Factor Five	Insensitivity to transport cost			
CONVENNT	I use the most convenient form of transportation regardless of cost.	1.000		
PAYENVIR	I would be willing to pay more when I travel if it would help the environment.	0.248	0.032	7.797
FASTEST	I always take the fastest route to my destination even if I have a cheaper alternative.	0.680	0.070	9.716
Factor Six	Sensitivity to personal travel experience			
PRFDRIVE	I would prefer to drive than to be driven.	1.000		
TRANCOMF	The people who ride transit to work are like me.	-1.181	0.081	-14.608
WALKING	I am comfortable walking near my destination during the day.	-0.678	0.055	-12.289
FERNOBUS	I would ride a ferry, but I wouldn't ride the bus.	1.273	0.092	13.887
PRFALONE	I prefer to make trips alone, because I like the time to myself.	0.861	0.072	12.025
DLDRIVE	I don't like to drive, but it is usually the fastest way to get where I need to go.	-0.352	0.065	-5.413

Table 2 Structural Equation for the Desire to Help the Environment Factor

Variable*	Stratification	Name	Estimate	Std Error	C.R.	P
Age	18-24	AGE1824	0.838	0.247	3.400	0.001
	25-34	AGE2534	0.583	0.118	4.939	0.000
	35-44	AGE3544	1.145	0.093	12.269	0.000
	45-54	AGE4554	0.935	0.093	10.093	0.000
	55-64	AGE5564	0.664	0.115	5.749	0.000
	65-74	AGE6574	0.782	0.189	4.138	0.000
College student	None	CSTUDENT	0.457	0.306	1.492	0.136
Household size	1 Person	HHSIZE_1	-0.358	0.402	-0.892	0.372
	2 Persons	HHSIZE_2	0.319	0.088	3.631	0.000
	3 Persons	HHSIZE_3	0.011	0.104	0.110	0.912
Households with children (<18 years old)	0 Kid	HHSU18_1	0.020	0.112	0.175	0.861
	1 Kid	HHSU18_2	0.411	0.106	3.868	0.000
	2 Kids	HHSU18_3	0.334	0.229	1.463	0.143
Household income	$25-50,000	INC2550K	0.601	0.153	3.937	0.000
	<$25,000	INC25K	0.838	0.374	2.239	0.025
	$50-75,000	INC5075K	0.375	0.114	3.281	0.001
Vehicles per household	0 vehicle	VEHS0	-1.669	0.528	-3.162	0.002
	1 vehicle	VEHS1	0.191	0.115	1.667	0.096
Workers per household	0 worker	WORK0	-0.568	0.186	-3.055	0.002
	1 worker	WORK1	-0.269	0.095	-2.830	0.005
Households with more workers than vehicles	None	WORKCARS	-0.214	0.143	-1.499	0.134
Sensitivity to personal travel experience factor	None	f6_mode	-0.658	0.059	-11.151	0.000

* For each categorical variable, there is one category that is not used in the structural equation model. For example, there are actually three workers per household categories: 1) 0 worker households, 2) 1-worker households, and 3) 2+ worker households. Only the first two of these three categories are included in the model.

5. Market Segmentation Models

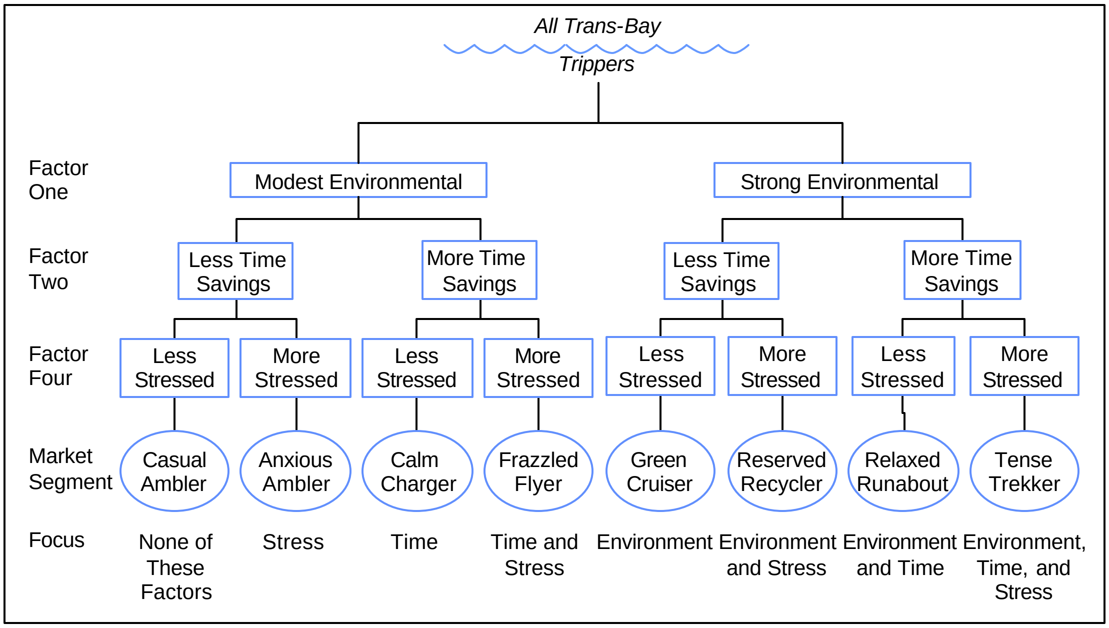
5.1 Cluster Analysis

Market segmentation is one of the most important strategic concepts in market research (Myers, 1996). The process of market segmentation involves identifying variations in customer needs and determining how to fill these needs (Chaston, 1999). The attitudinal factors derived from SEM were used as the basis for market segmentation, the core concept of which is to view a market as several segments rather than one homogeneous group. Since each market segment is unique in its characteristics and attitudes toward travel behaviours, we can develop strategic marketing plans that involve applying different marketing strategies to different market segments (Thompson, 1998).

Cluster analysis was used for segmentation. The objective of cluster analysis was to identify unique travel groups for market profiling. It was useful to the extent that people within the same cluster shared similar attitudes toward travel behaviour, while people in different clusters held different views (Thompson, 1998). There were two phases of cluster analysis. The first phase involved an exploratory cluster analysis using the FASTCLUS procedure in SAS/STAT software, while the second phase was a confirmatory cluster analysis, where we applied judgment regarding the structure and content of the clusters. While exploratory cluster analysis provided the basis for confirmatory factor analysis, we used the confirmatory results as the market-based clusters for use in the remainder of market analysis.

From an exploratory point of view, all available attitudinal factors should be included in the cluster analysis as basis variables. From a practical point of view, however, we select basis variables that have the greatest potential to be both analytically and strategically useful for market segmentation purpose. In exploratory cluster analysis, Factor 1 (Desire to help the environment) and Factor 3 (Need for flexibility) were chosen to be the key attitudinal basis for clustering because of their highest explanatory power. In order to decide the best segmentation scheme and the optimal number of clusters, we conducted a range of cluster analyses and plotted the resulting Cubic Clustering Criterion (CCC). CCC can be used for crude hypothesis testing and estimating the number of population clusters. The local peak of the CCC indicates a good clustering number (SAS/STAT User's Guide, 1999). In our study, the CCC has a local peak at six to seven clusters. Since we are using a two-dimensional segmentation scheme, six (rather than seven) clusters are analyzed. The factor scores for all six clusters show a segmentation scheme of partitioning the market into three segments based on Factor 1: those favor environment protection, those against it, and those who do not care. Each environmental segment is further divided into two groups based on their need for flexibility: those who have high need (indicated by a high positive score in Factor 3), and those who have low needs for scheduling (negative score in Factor 3). In the confirmatory market segmentation, however, we decided to add Factor 2 (Need for timesaving) as an additional dimension. The need for time saving stood out to be an important concern for many travelers in the attitudinal survey. It also had the highest statistical reliability among all six attitudinal factors derived from SEM. The results of the confirmatory cluster analysis are presented in Figure 2. Each basis factor was divided into two groups for a resulting stratification of a total of eight market segments. Each market segment was identified with a descriptive name that invokes the primary drivers behind the traveler attitudes in that segment.

Figure 2 Final Market Segmentation



5.2 Characteristics of Market Segments

The market segmentation process produced market segments of various sizes from the original household survey. The smallest market segment was the Anxious Ambler, with six percent of the total surveyed; and the largest market segment is the Reserved Recycler, with 18 percent of the total surveyed. One means of evaluating the specific traveler attitudes present in each of the market segments was to calculate average factor scores for the original six factors that are present within each segment. These were compared to the overall mean total factor scores to identify whether each market segment was higher or lower than the overall average. The following conclusions can be made regarding these analyses:

- Anxious Amblers, Calm Chargers, and Frazzled Flyers are the most sensitive to personal travel experience, while Green Cruisers and Reserved Recyclers are the least sensitive;
- Tense Trekkers and Reserved Recyclers are the most sensitive to cost (note that this factor identifies insensitivity to cost and is, therefore, reversed in concept from the other factors), while Joe Six Pack and Calm Chargers are the least sensitive to cost;
- Tense Trekkers are more sensitive to stress than all other categories, while Joe Six Packs are the least sensitive to stress;

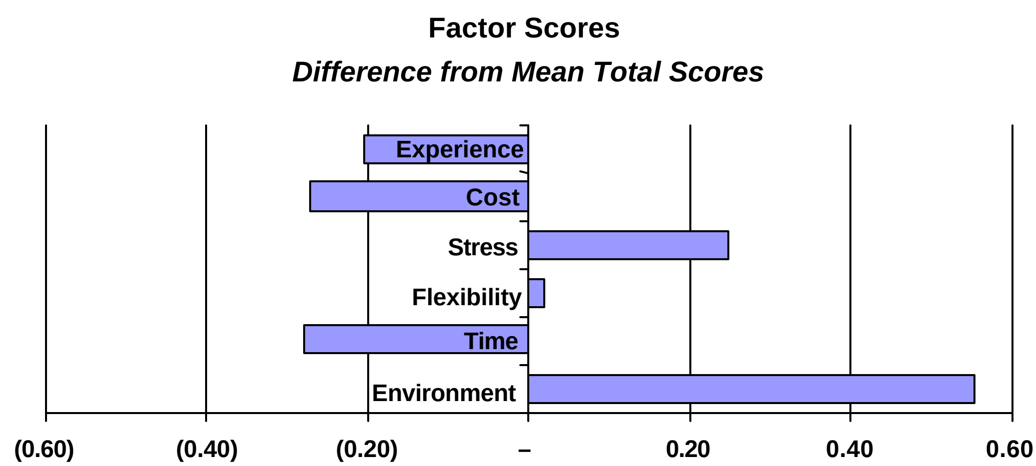
- Tense Trekkers and Relaxed Runabouts have the highest need for flexibility, while Green Cruisers have the least need for flexibility;
- Frazzled Flyers have the highest need for time savings, while Joe Six Packs have the least need for time savings; and
- Reserved Recyclers have the highest desire to help the environment, while Joe Six Packs have the least desire to help the environment.

Each market segment has specific demographic characteristics that can be used to understand the market segment and to support forecasting market segments for future populations. An example of the demographic characteristics of Reserved Recyclers is presented in Figure 3. The socioeconomic characteristics of each market segment can be used to target each population with services and marketing messages that will appeal to the specific traveler attitudes of each segment. By examining the socioeconomic variables of each market segment, we can make the following conclusions regarding the relationships between socioeconomic characteristics and market segments:

- Younger persons have a higher need for time savings than older persons;
- Middle-aged persons have a higher desire to help the environment than either younger or older persons;
- Households with three or more persons have a higher need for time savings than households with one or two persons;
- Households with kids have a higher need for time savings than households with no kids;
- Households with three or more kids are more sensitive to stress than households with one or two kids;
- Lower-income households (less than $50,000 per year) and middle-income households ($50,000 to $100,000 per year) are more sensitive to stress than upper-income;
- Households with only one vehicle are more sensitive to stress than households with two or more vehicles;
- Households with two or more workers have a higher desire to help the environment and a higher need for time savings than households with zero or one worker;
- There are no significant differences in gender by market segment, although there is a slight tendency for females to be more sensitive to stress than males;
- College students and college graduates are slightly more likely to be sensitive to stress than postgraduates; and
- Single people are slightly more likely to be sensitive to stress than any other marital status group.

After summarizing these socioeconomic characteristics by market segment and characteristic, we identified clear demographic differences among each market segment, contributing to the overall differences in traveler attitudes.

Figure 3 Demographics and Factor Scores for Reserved Recycler



Reserved Recycler

Focus on Stress and Environment

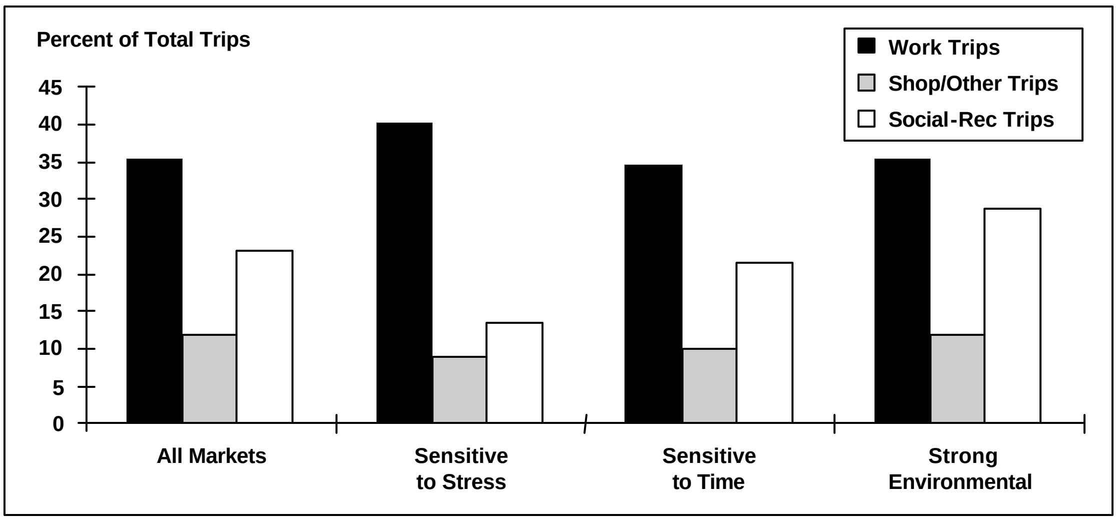
- **Middle-Age People**
- **0-1 persons per household**
- **No kids**
- **Low Income**
- **1 vehicle households**
- **2+ workers per household**

5.3 Market Segmentation Forecasting

The survey-based market segmentation model was applied to the whole population in the San Francisco Bay Area. TAZ-level socioeconomic and demographic data for year 1998 were used to calculate the score of each attitudinal factor using the estimated parameters from Structural Equation Model. The resulting scores of Factor 1 (Desire to help the environment), Factor 2 (Need for timesaving) and Factor 4 (Sensitivity to travel stress) were then used to divide the Bay Area population into eight segments. The model also was used to forecast the market segments of year 2025 using the Metropolitan Transportation Commission (MTC) data.

The information on market segments can be very useful in designing ferry services. For example, market segments with a high need for timesavings and a high need for flexibility (such as Relaxed Runabouts and Tense Trekkers) are more difficult to serve with fixed-route transit systems. But market segments with a desire to help the environment and sensitivity to stress (such as Reserved Recyclers) are more likely to be well served by proposed ferry services. The market segments determined for each ferry route are presented in Figure 4.

Figure 4 Ferry Modal Shares by Market Segment



6. Mode Choice Models

6.1 Overview

For comparative purposes, two sets of models are developed – revealed-preference (RP) and stated-preference (SP) mode choice models. The RP models are primarily estimated to test the explanatory power of various levels of service (LOS) and socioeconomic variables in different purpose-specific models. These models are then used as a reference while estimating the SP models that could support a much more detailed set of choice alternatives and include the market segments.

For the RP model estimation, household and ferry on-board survey data are used in combination with skim data from the MTC model. The SP models are based only on the household survey data. Three models are estimated in both cases: home-based work (HBW) including all the commute trips, home-based shop/other (HBSh/Oth) including shopping, work-related, personal business and other trips, and home-based recreation (HBRec). School trips and non-home-based trips are estimated using the regional forecasting model rather than estimating new SP models due to small sample sizes.

6.2 Revealed-Preference Models

The RP models include four choice alternatives: drive alone, carpool, bus/rail, and ferry. All models are multinomial logit model. The estimated results are summarized below.

- All the LOS variable coefficients have the correct sign (-) in all the three models. Time-related LOS variables are significant at 90 percent confidence level but the cost-related variables are not very significant.
- In all the three models, only one coefficient is estimated for travel cost specific to all modes and is found to be significant at 90 percent confidence level in HBW model.
- As expected, the time-related LOS variables are larger in HBW model when compared to HBSh/Oth and HBRec models.
- As expected, in the HBW model, number of vehicles has a significant negative impact on transit utility suggesting an inclination towards auto modes in the event of a higher vehicle ownership. It is found to be insignificant in the HBSh/Oth model but significant at the 95 percent confidence level in the HBRec model.
- Household income has the correct sign (+) and is significant in the HBRec model indicating that higher-income group households have an inclination towards auto modes.
- A dummy variable where the number of vehicles is less than number of workers in a household also is tested, and was found insignificant though it had the correct sign (+ for transit, – for drive alone) in the HBSh/Oth model.
- The ratio between out-of-vehicle and in-vehicle time is found to be reasonable in HBW and HBSh/Oth models, ranging from 1.0 to 2.5 by purpose and mode. However, in HBRec model, the transit out-of-vehicle time was found to be less than in-vehicle time and hence it was constrained to be three times that of transit in-vehicle time.
- On average, the value of time is found to be the highest for HBW model and the least for HBSh/Oth model. The value of time for auto modes is higher that that of transit modes, except for ferry HBW trips, which has a high value of time due to a higher than expected in-vehicle time coefficient. Other values of time by purpose and mode are within the range $5 to $16 per hour, compared to SP values of time ranging from $3.5 to $21 per hour.

6.3 Stated-Preference Models

For SP model estimation, household survey data combined with preferences and attitudes of travelers were used. As in the RP case all models are multinomial logit and the estimation results are presented in Table 4. These models use the market segments developed above to better model mode choice by those segments and understand the differences in mode choice behaviour among these markets. Fourteen alternatives were specified including two auto modes (drive alone and carpool), six bus/rail modes differentiated based on access/egress modes, and six ferry modes differentiated based on access/egress modes. The characteristics of the model and the main results are as follow.

- Travel costs and in-vehicle travel times are modeled specific to three main modes – auto, bus/rail, and ferry. These are found to be significant at the 95 percent confidence level and have the correct sign.
- Out-of-vehicle travel times are differentiated across two general modes – auto and transit. The auto out-of-vehicle time captures the walk time to parking lot and waiting for carpool and is found to be significant in the HBW model but not in HBSh/Oth and HBRec models. The ratio of out-of-vehicle time to in-vehicle time is greater than one for HBW and HBSH/Oth models indicating the reasonableness of the coefficients. However, this ratio is less than one in HBRec model. The transit (bus/rail and ferry) out-of-vehicle time is a combination of access and egress walk times and is found to be highly significant in all the three models. The ratio between out-of-vehicle and in-vehicle times are greater than one for HBW and HBSH/Oth models but less than one for HBRec model.
- Car access and bus/rail access time coefficients are negative and significant. These variables are not included in in-vehicle times in order to isolate the effect of travel times of main modes from access modes.
- In all, seven mode choice constants are estimated with drive alone constant as the reference. Three bus/rail constants are estimated based on the transit type; namely, BART, bus, and rail (AMTRAK/CalTrain). Two additional constants also are estimated based on the access/egress modes – car access and transit access/egress. For all the six ferry submodes, a single ferry constant is specified and estimated.
- Household income has a significant impact on various modal alternatives in the HBW model. The household-income coefficients specific to drive alone, car access-bus/rail and car access-ferry modes are positive indicating that commuters with higher household income are more inclined to drive alone and access transit stations by auto modes. The coefficient specific to walk access-bus/rail mode is negative suggesting that lower-income households prefer accessing transit stations by cheaper non-auto modes. In HBSh/Oth model, household income does not have a significant impact on various alternatives. However, in the HBRec model, household-income coefficients are negative and significant in reference to the carpool mode showing that higher-income people are more prone to carpool for recreational activities.
- Number of vehicles per household plays a significant role in explaining the mode choice behaviour of travelers. The coefficients specific to drive alone and bus/rail

mode with auto access is found to be positive in the three models indicating that households with higher vehicle ownership are more prone to opt for auto modes such as drive alone and transit with auto access.

- In additional to the different travel time coefficient and additional total travel time coefficient is estimated specific for market segments that are sensitive to travel time. It is found to be a very significant variable and has the correct sign in the three models. As expected, the coefficient values for time-sensitive segments are higher than those of other market segments.
- In addition to travel time sensitive segments, coefficients for stress-sensitive and environmentally friendly segments also were estimated in the models as mode-specific constants. While these variables are not significant for in the HBW model,, they are positive and significant in HBSh/Oth and HBRec models suggesting that stress-related market segments prefer auto and to some extend ferry in the case of HWSh/Oth over transit modes for non-work trips.
- The environmental friendly mode-specific constant is not included in HBW and HBSh/Oth models as it was not significant and did not have the correct sign. In HBRec model, this constant is specified to carpool, transit and ferry modes and is found to be positive and significant. This finding suggests that the market segments that are environmental friendly have an inclination towards carpool, transit and ferry modes.
- In all the three models, the value of time for auto modes is found to be higher than that of the transit modes, and on average, the value of time for non-work trips is found to be higher than that of commute trips. We believe that this is related to the specific geographic market of shopping, other and recreational trips that are correlated with high-end shopping, personal business and recreational trips. In other words, the primary destination of these non-work trips are to higher cost shopping, other and recreational destinations than the regional average and the value of time is therefore higher than it would be for a more typical shopping, other or recreational trip.

All the models presented above are multinomial logit models. Various nesting structures also were tested but did not improve the likelihood of the models and the nesting coefficients (logsum values) were found to be not significantly different than one indicating that the alternatives are not forming a significant nest.

Table 4 Mode Choice Model Estimation Results – SP

Constants	Modes	HBW – SP Coeff	t-stat	HBSh/Oth – SP Coeff	t-stat	HBRec – SP Coeff	t-stat
Carpool	Auto	-0.2085101	-0.6	-0.3319733	-0.76	-1.447214	-2.98
BART	Transit	1.861703	3.37	1.3173711	1.91	2.174823	2.26
Other rail	Transit	0.5900163	0.99	0.6385499	0.88	1.514266	1.47
Bus	Transit	0.9602115	1.66	-0.1090708	-0.15	1.275635	1.31
Ferry	Transit	0.0184942	0.03	0.235847	0.29	-0.652326	-0.62
Drive access	Auto	-1.6825113	-4.21	-1.4432361	-2.76	0.014167	0.02
Transit Access/Egress	Transit	-0.683682	-3.65	-0.2864258	-1.23	-0.548317	-1.64
Level of service	Submodes/market segments						
Total cost	Rail/bus	-0.0038383	-5.4	-0.0026914	-2.96	-0.006327	-4.58
	Ferry	-0.0031572	-3.52	-0.0012804	-1.14	-0.002563	-1.7
	Auto	-0.0012912	-4.95	-0.0006963	-2.42	-0.001495	-3.94
In-vehicle time	Auto	-0.0367257	-8.49	-0.0247593	-4.04	-0.04603	-5.52
	Rail/bus	-0.0233347	-5.95	-0.0156354	-2.98	-0.038986	-5.08
	Ferry	-0.0241803	-3.59	-0.0173758	-1.96	-0.029138	-2.75
Walk time	Transit	-0.0297759	-6.75	-0.0229923	-3.82	-0.027511	-4.22
Transit access/egress time	Transit	-0.0602804	-4.91	-0.0480998	-3.15	-0.062081	-3.04
Drive access time	Transit	-0.01077	-0.62	-0.0689959	-2.83	-0.061132	-1.95
Out-of-vehicle time	Auto	-0.0431927	-2.1	-0.0386627	-1.47	-0.025037	-0.95
Total travel time	Timesensitive market segments*	-0.00776316	-2.14	-0.0094045	-2.12	-0.005607	-1.02
Socioeconomic data	Submodes						
Household income	Drive alone	4.46E-06	1.69	-9.29E-07	-0.3	-6.90E-06	-2.24
	Rail/bus drive access	7.06E-06	2.3	7.10E-06	1.68	-1.69E-05	-3.59
	Ferry drive access	1.47E-05	3.86	-2.13E-06	-0.45	-1.19E-05	-2.05
	Rail/bus walk/transit access	-2.15E-07	-0.06	-5.27E-07	-0.12	-2.39E-05	-4.3
	Ferry walk/transit access	7.40E-06	1.83	-1.16E-05	-2.17	-1.49E-05	-2.57
Vehicles per household	Drive alone	0.1358595	1.7	0.41993736	3.69	0.070405	0.85
	Rail/bus walk/transit access	-0.6047203	-4.05	-0.3465766	-1.76	0.017849	0.09
	Ferry walk/transit access	-0.4965095	-3.01	-0.1281851	-0.58	-0.083009	-0.39
	Rail/bus drive access	0.0257747	0.27	0.30569162	2.23	0.009961	0.06
	Ferry drive access	-0.2805015	-2.17	0.41639055	2.86	-0.263244	-1.12
Additional constants	Market segment						
Auto modes	Stress-related market segments**	-0.00307112	-0.02	1.06684314	4.81	0.573667	2.41
Ferry modes	Stress-related market segments**	0.12487234	0.54	0.75732604	2.45	–	–
Carpool, transit and ferry modes	Pro-environmental market segments***	–	–	–	–	0.720028	3.37
Summary statistics							
Log-likelihood at convergence		-1754.4966		-1115.5829		-780.3198	
Rho-squared with respect to zero		0.3278		0.3926		0.4575	
Rho-squared with respect to constants		0.1187		0.0928		0.1112	
Other statistics							
Auto out-of-vehicle time/in-vehicle time		1.18		1.56		0.54	
Bus/rail out-of-vehicle time/in-vehicle time		1.28		1.47		0.71	
Ferry out-of-vehicle time/in-vehicle time		1.23		1.32		0.94	
Auto – value of time		$17.07		$21.34		$18.47	
Bus/rail – value of time		$3.65		$3.49		$3.70	
Ferry – value of time		$4.60		$8.14		$6.82	
*	Timesensitive market segments are Calm Charger, Frazzled Flyer, Relaxed Runabout, and Tense Trekker.						
**	Stress-related market segments are Anxious Ambler, Frazzled Flyer, Reserved Recycler, and Tense Trekker.						
***	Pro-Environmental Market Segments are Green Cruiser, Reserved Recycler, Relaxed Runabout, and Tense Trekker.						

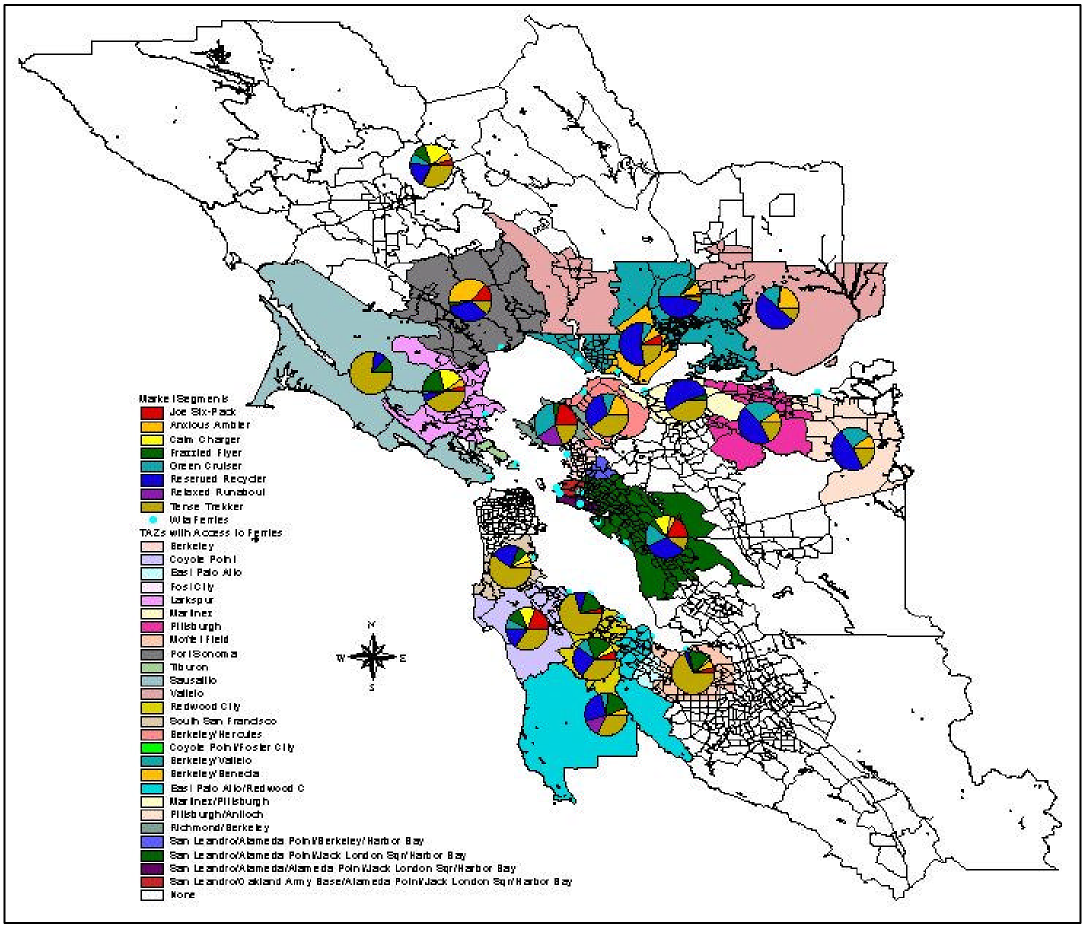
6.4 Effects of Market Segments on Mode Choice

As shown in the results above, market segment-related LOS and submode-specific constants are estimated to better understand the implications of various market segments on their mode choice behaviour. Only one LOS variable, total travel time, is estimated for market segments that are sensitive to travel time. The in-vehicle travel time coefficient for these market segments is the sum of this coefficient and the in-vehicle travel times of the specific mode. It is found that the market segments that are more sensitive to time have a larger and more negative coefficient than the other market segment coefficients.

The sensitivity to travel costs is exactly the same across all the market segments in every model, because no market segment-specific cost coefficients were estimated that were significant and logical. As expected, the values of time for time sensitive market segments are higher than that of other market segments. It also is found that, these market segments are slightly more sensitive to time when executing shopping/other trips than when commuting to work.

Additional constants were estimated for various market segments to understand the influence of various factors like travel stress and environmental friendliness towards mode choice behaviour. Overall, it was found that stress sensitive travelers are prone to prefer auto modes to transit modes for making non-work trips. Environmental friendly commuters seem to be inclined to ride transit modes for recreational trips. This constant was not significant and did not have the correct sign in work and shopping/other trips models. These effects are displayed in Figure 5.

Figure 5 Market Segments for Each Route



7. Model Validation and Forecasting

The calibration and validation of the market-based ridership models developed for the San Francisco Water Transportation Authority (WTA) involve adjusting modal choice constants to match mode shares and modes of access, adjusting walk and drive access assumptions at each terminal by time period, and incorporating estimates of visitor and weekend ferry riders. The application of the market-based ridership models involved estimating market segments for the entire nine-county Bay Area as input to the new mode choice models. The ridership models are validated to boardings by route and time period, and the overall regional models are validated for person trips by mode across screenlines to ensure reliable estimates of competing modes in significant ferry corridors.

The results of the regional market segmentation process are quite a bit different than the household survey, given the fact that the household survey is limited to travelers who cross the San Francisco Bay. The largest difference in these market segments are between the Tense Trekkers and the Relaxed Runabouts, where the regional market is much higher for Tense Trekkers and lower for the Relaxed Runabouts. Also, there were more people sensitive to stress and who desire to help the environment in the region than in the potential ferry market.

The ridership model validation involved a series of validation tests to ensure that the model predicted ferry and other trans-bay persons by mode, purpose, and modes of access and time period. These tests are designed to ensure that the ferry ridership is logical across several dimensions of travel behaviour. Most of the validation tests compare ferry ridership with onboard survey (observed) data. A few of the validation tests compare the model results of the Phase 1 and Phase 2 models because these observed data were not available from the onboard survey. Phase 1 models are the MTC regional travel demand forecasting models with ferry networks that have been enhanced to ensure more accurate representation of ferry service and access modes. Phase 2 models are the market-based models within the MTC modeling framework developed for this study. Phase 2 models use MTC trip generation, distribution and assignment models directly and contain newly developed mode choice models. A summary of the model calibration and validation results is presented in Table 5.

Table 5 Summary of Calibration and Validation Tests

Test	Observed Data Source	Results	Target
Ferry Trips by Purpose and Time Period	On-Board Survey	All categories of trips meet the established validation target; in fact, most of the categories of trips are within +/- five percent difference.	+/-10 percent
Trips by Mode of Access for Each Ferry Terminal	On-Board Survey	This test results in an over-estimation in bus/rail access trips to the Oakland/Alameda terminals and an under-estimation of bus/rail access trips to the Sausalito terminal. All other categories of trips by mode of access were within the established validation target.	+/-10percent
Trips By Routeand Time Period	Observed ridership data is provided by WTA for the average weekday period, and average weekday peak ridership is derived from these daily estimates by applying the percentage of trips in the peak period by route from the on-board survey data.	All of the routes and operators are well within these targets except one; the East Bay Ferries average weekday ridership, which is six percent high, instead of the target of five percent.	+/-10 percent by route and +/- five percent by operator
Person Trips Across a Screenline	MTC model updated during the PhaseI	Auto vehicle trips are within a target of +/-5 percent, ferry and non-ferry transit are within +/- 10 percent.	+/-10 percent
Changes in Service, To Test Sensitivity of the Model	Ridership data collected before and after significant changes in ferry service in recent years, provided by WTA	All routes were within +/-two percent of observed ridership changes.	+/-5 percent

8. Summary and Conclusions

This project evaluated two methods for identifying and forecasting traveler attitudes (factor analysis with logistic regression and structural equation modeling) and recommended the use of SEM for use in developing market segments. SEM provided significantly better statistical results for correlating available demographic data with traveler factors and allowed us to forecast market segments to the year 2025 for use in mode choice and ridership forecasting models. The mode choice and ridership forecasting models were calibrated and validated across trip purposes, primary modes, modes of access, routes, time periods, and screenlines. The models were used to evaluate a series of future year alternatives and sensitivity analyses were conducted. All current and future year ridership results were considered reasonable. The project demonstrated that stated-preference models, in combination with attitude and market segmentation data, enhance the accuracy and explanatory nature of the models.

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10. References

Arbuckle, J.L and Wothke, W., 1999. AMOS 4.0 User's Guide, SmallWaters Corporation.

Badoe, D. A. and Miller, E. J. (1998) An automated segmentation procedure for studying variations in mode choice behavior. Journal of Advanced Transportation, 32, 190-215.

Bhat, C. R. (1997) An endogenous segmentation mode choice model with an application to intercity travel. Transportation Science, 31, 34-48.

Brand, D., Parody, T. E. and Kiefer, M. R. (1994) Estimating user benefits for high-speed ground transportation systems In Compendium of Technical Papers, 64th ITE Annual Meeting, Vol. Institute of Transportation Engineers, Dallas, Texas, pp. 338-342.

Button, K. J. and Hensher, D. A. (2001) Handbook of transport systems and traffic control. Chapter 8. Modal diversion., pp. 107-23.

Cambridge Systematics (2001) Market research approach for transit works long-range strategy Cambridge Systematic, Oakland, CA.

Cascetta, E. (1991) Some application of a stochastic assignment model for the evaluation of parking policy In Transportation planning mehtods. Proceedings of Seminar G held at PTRC European Transport, Highway and planning 19th summer annual meeting., Vol. University of Sussex, pp. 17-29.

Cattell, R. B. (1958). Extracting the Correct Number of Factors in Factor Analysis. Educational Researcher, 18, 791-838.

Chaston, I., 1999. New Market Strategies. Guilford, UK: Biddles.

Golob, T. F. (2001) Joint models of attitudes and behavior in evaluation of the San Diego I-15 congestion pricing project. Transportation Research Part A: Policy and Practice, 35, 495-514.

Golob, T. F. and Hensher, D. A. (1998) Greenhouse gas emissions and australian commuters' attitudes and behavior concerning abatement policies and personal involvement. Transportation Research Part D: Transport and Environment, 3, 1-18.

Golob, T.F., 2001. Structural Equation Modeling for Travel Behavior Research: Literature Review. Center for Activity Systems Analysis, Institute of Transportation Studies, University of California, Irvine.

Gorsuch, R.L. (1983). Factor analysis (2nd ed.). Hillsdale, NJ: Lawrence Earlbaum Associates.

Harris, M. M., & Schaubroeck, J. (1990). Confirmatory modeling in organizational behavior/human resource management: Issues and applications. Journal of Management, 16, 337-360.

Hosmer, D.W., Lemeshow, S., 2001. Applied Logistic Regression, 2nd Edition, Wiley, 2001.

Koppelman, F. S. and Hauser, J. R. (1978) Destination choice behavior for non-grocery-shopping trips. Transportation Research Record, 673, 157-165.

Lieberman, W., Schumacher, D., Hoffman, A. and Wornum, C. (2001) Creating a new century of transit opportunity: strategic planning for transit. Transportation Research Record, 1747, 60-67.

Long, J. S., 1983. Confirmatory factor analysis. Beverly Hills, CA: Sage. Louis, M. R., 1983.

Lythgoe, W. F. (2002) Demand for rail travel to and from airports. Transportation, 29, 125-43.

Mandel, B. N. (1998) Interdependency of airport choice and travel demand Center for Transportation Research, Montreal, Canada.

Myers, J.H., 1996. Segmentation and Positioning for Strategic Marketing Decisions, American Marketing Association, 1996.

Proussaloglou, K. K., FS (1989) Use of travelers' attitudes in rail service design. Transportation Research Record, 1221, 42-50.

PTM Consultants, "Actual Commuter Preference Data," memorandum by Michael Fajans to Steve Castleberry on December 14, 2001.

Roberts, D. J. W. and Vougioukas, M. (1993) Forecasting Travel Demand For The Channel Tunnel In Development In European Land Use And Transport. Proceedings of Seminar E held at the PTRC European Transport, Highway and Planning 21st summer annual meeting., Vol., pp. 173-90.

Sapleton, C.D., 1997. Basic Concepts and Procedures of Confirmatory Factor Analysis. Working Paper at Texas A&M University, January 1997.

SAS/STAT USER'S Guide, Version 8. SAS Institute Inc., Cary, NC, 1999.

Thompson, M.E., 1998. The Science and Art of Market Segmentation Using PROC FASTCLUS. Prepared for Publication in PNWSUG's 98 Conference Proceedings.