

Managerial Segmentation of Service Offerings in Work Commuting



MTI Report WP 12-02



MINETA TRANSPORTATION INSTITUTE

The Norman Y. Mineta International Institute for Surface Transportation Policy Studies was established by Congress in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The Institute's Board of Trustees revised the name to Mineta Transportation Institute (MTI) in 1996. Reauthorized in 1998, MTI was selected by the U.S. Department of Transportation through a competitive process in 2002 as a national "Center of Excellence." The Institute is funded by Congress through the United States Department of Transportation's Research and Innovative Technology Administration, the California Legislature through the Department of Transportation (Caltrans), and by private grants and donations.

The Institute receives oversight from an internationally respected Board of Trustees whose members represent all major surface transportation modes. MTI's focus on policy and management resulted from a Board assessment of the industry's unmet needs and led directly to the choice of the San José State University College of Business as the Institute's home. The Board provides policy direction, assists with needs assessment, and connects the Institute and its programs with the international transportation community.

MTI's transportation policy work is centered on three primary responsibilities:

Research

MTI works to provide policy-oriented research for all levels of government and the private sector to foster the development of optimum surface transportation systems. Research areas include: transportation security; planning and policy development; interrelationships among transportation, land use, and the environment; transportation finance; and collaborative labor-management relations. Certified Research Associates conduct the research. Certification requires an advanced degree, generally a Ph.D., a record of academic publications, and professional references. Research projects culminate in a peer-reviewed publication, available both in hardcopy and on TransWeb, the MTI website (<http://transweb.sjsu.edu>).

Education

The educational goal of the Institute is to provide graduate-level education to students seeking a career in the development and operation of surface transportation programs. MTI, through San José State University, offers an AACSB-accredited Master of Science in Transportation Management and a graduate Certificate in Transportation Management that serve to prepare the nation's transportation managers for the 21st century. The master's degree is the highest conferred by the California State University system. With the active assistance of the California

Department of Transportation, MTI delivers its classes over a state-of-the-art videoconference network throughout the state of California and via webcasting beyond, allowing working transportation professionals to pursue an advanced degree regardless of their location. To meet the needs of employers seeking a diverse workforce, MTI's education program promotes enrollment to under-represented groups.

Information and Technology Transfer

MTI promotes the availability of completed research to professional organizations and journals and works to integrate the research findings into the graduate education program. In addition to publishing the studies, the Institute also sponsors symposia to disseminate research results to transportation professionals and encourages Research Associates to present their findings at conferences. The World in Motion, MTI's quarterly newsletter, covers innovation in the Institute's research and education programs. MTI's extensive collection of transportation-related publications is integrated into San José State University's world-class Martin Luther King, Jr. Library.

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the information presented herein. This document is disseminated under the sponsorship of the U.S. Department of Transportation, University Transportation Centers Program and the California Department of Transportation, in the interest of information exchange. This report does not necessarily reflect the official views or policies of the U.S. government, State of California, or the Mineta Transportation Institute, who assume no liability for the contents or use thereof. This report does not constitute a standard specification, design standard, or regulation.

REPORT WP 12-02

MANAGERIAL SEGMENTATION OF SERVICE OFFERINGS IN WORK COMMUTING

Steven Silver, Ph.D.

March 2015

A publication of

Mineta Transportation Institute

Created by Congress in 1991

College of Business
San José State University
San José, CA 95192-0219

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. CA-MTI-14-1232	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Managerial Segmentation of Service Offerings in Work Commuting		5. Report Date March 2015	
		6. Performing Organization Code	
7. Authors Steven Silver, Ph.D.		8. Performing Organization Report MTI Report WP 12-02	
9. Performing Organization Name and Address Mineta Transportation Institute College of Business San José State University San José, CA 95192-0219		10. Work Unit No.	
		11. Contract or Grant No. DTRT12-G-UTC21	
12. Sponsoring Agency Name and Address <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> California Department of Transportation Office of Research—MS42 P.O. Box 942873 Sacramento, CA 94273-0001 </div> <div style="width: 45%;"> U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology (OST-R), University Transportation Centers Program 1200 New Jersey Avenue, SE Washington, DC 20590 </div> </div>		13. Type of Report and Period Covered Final Report	
		14. Sponsoring Agency Code	
15. Supplemental Notes			
16. Abstract <p>Methodology to efficiently segment markets for public transportation offerings has been introduced and exemplified in an application to an urban travel corridor in which high tech companies predominate. The principal objective has been to introduce and apply multivariate methodology to efficiently identify segments of work commuters and their demographic identifiers. A set of attributes in terms of which service offerings could be defined was derived from background studies and focus groups of work commuters in the county. Adaptive choice conjoint analysis was used to derive the importance weights of these attributes in available service offering to these commuters. A two-stage clustering procedure was then used to explore the grouping of individual's subsets into homogeneous sub-groups of the sample. These subsets are commonly a basis for differentiation in service offerings that can increase total ridership in public transportation while approximating cost neutrality in service delivery. Recursive partitioning identified interactions between demographic predictors that significantly contributed to the discrimination of segments in demographics. Implementation of the results is discussed.</p>			
17. Key Words Urban work commuting; Multivariate methodology; Market segmentation; Design of service offerings	18. Distribution Statement No restrictions. This document is available to the public through The National Technical Information Service, Springfield, VA 22161		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 31	22. Price \$15.00

Copyright © 2015
by **Mineta Transportation Institute**
All rights reserved

Library of Congress Catalog Card Number:
2015934871

To order this publication, please contact:

Mineta Transportation Institute
College of Business
San José State University
San José, CA 95192-0219

Tel: (408) 924-7560
Fax: (408) 924-7565
Email: mineta-institute@sjsu.edu

transweb.sjsu.edu

ACKNOWLEDGMENTS

I thank Santosh S. Shetty for competent research assistance.

The authors thank MTI staff, including Executive Director Karen Philbrick, Ph.D.; Director of Communications and Technology Transfer Donna Maurillo; Research Coordinator Joseph Mercado; and Webmaster Frances Cherman, who also provided additional editorial support.

TABLE OF CONTENTS

Executive Summary	1
I. Introduction	3
Market Segmentation in Urban Transportation	3
Background of Market Segmentation in Transportation Research	4
Conjoint Analysis	5
Adaptive Choice-Based Conjoint Analysis (ACBC)	5
Satisfaction Measures	6
II. Method	7
Travel Corridor under Study	7
Respondent Sample	8
III. Procedure	9
Attribute Set in Profiles of Service Offerings for Work Commuting	9
IV. Results	11
Conjoint Weights of the Attributes in Profiles of Service Offerings	11
Clustering of Conjoint Derived Importance Weights for Service Attributes	12
Cluster Profiles in Demographics	13
Importance-weighted Dissatisfaction with Service Offerings	17
Implications for Design	19
V. Summary and Discussion	21
Appendix A: Decomposition of Focus Group Discussion	23
Appendix B: Scaling Satisfaction Scale for Attributes of Service in Public Transportation Offerings	24
Appendix C: Applications	25
Bibliography	27
About the Author	30
Peer Review	31

LIST OF FIGURES

1. Geographic Location of Sampled Companies	8
2. Exemplary Screen in Full Profile Choice Task	10
3. Recursive Partitioning of Cluster Membership in Demographic Predictors	16
4. Organizational Schematic of Traveler Focus Group Discussions	23

LIST OF TABLES

1. County Demographics	7
2. Means and Standard Deviations of Conjoint-derived Importance Weights of Attributes	11
3. Constant Sum Allocation to Attributes of Service Offerings	11
4. Centroids of a Three-Cluster Solution in K-Means Clustering	13
5. Cross Tabulation of Cluster Membership and Demographic Variables	14
6. Demographic Descriptors of Clusters in Conjoint-derived Importance	17
7. Mean and Standard Deviations of Satisfaction Ratings	17
8. Demographic Descriptors of Clusters in Importance Weighted Dissatisfaction	19
9. Ten Item for Satisfaction Scale	24

EXECUTIVE SUMMARY

While the U.S. Department of Transportation and Caltrans have set strategic goals that include increasing public transit ridership, both agencies recognize that these goals have been difficult to achieve. Part of the difficulty is that, on one hand, riders and potential riders have diverse needs in public transport services. On the other hand, designers and managers of public transport services often do not have well defined indication of these needs from travelers themselves. The purpose of this study is to use multivariate methodology to assess the relative importance of service attributes to a sample of work commuters. Assessment results will then be used to indicate how a work commuting market can be segmented based on user indications of the importance of particular service attributes. Work commuting is a useful starting point to address goals in public transportation use because of its regular timing and importance to the economy. It is the research team's contention that designs of service offerings to meet needs of users and potential users remain an important capability to increase work commuting ridership.

Market segmentation has been shown to be an effective method to guide the design of variable transit services that can help transit agencies increase ridership and revenues. Combinations of methodologies that have not been previously used in transportation studies but are accessible to service designers in public transportation are implemented in this study. A set of attributes in terms of which service offerings can be defined was first derived from background studies and focus groups of work commuters in the county under study. Adaptive choice conjoint analysis was then used to define the importance weights of these attributes. This methodology allows respondents to indicate the services that they prefer from full profiles of service offerings. Finally, a clustering procedure was then used to explore the grouping of individuals' subsets into homogeneous sub-groups of the sample, and the combination of demographic differences that discriminate clusters was examined.

In the research results, clusters in which 1) cost predominates, 2) time predominates, and 3) both of these attributes were prominent have been obtained in the three-cluster solution. The demographics that discriminate memberships in the clusters were then examined. Main effects of demographics in cross-tabulations were not found to significantly discriminate segments. Methodology that was introduced to identify interactions among demographic variables did increase the discrimination of segments.

Satisfaction with current service offerings was next examined. A measure of importance-weighted dissatisfaction was used to assess judgments of current service offerings. Clustering the judgments of individual respondents' dissatisfaction identified segments in 1) cost and 2) a combination of cost, uncertainty, and time-related variables. Non-professional managers with higher incomes who were more than 45 years of age had the highest level of dissatisfaction with current service offerings. The report discusses implications of these results for reaching segments with different judgments on the importance of attributes and on the satisfaction with these attributes in available service offerings.

The reported results indicate a basic implementation of the proposed methodology and its interpretation. It is now timely to use available multivariate methodology more widely in disaggregating public transportation markets.

Research Objective

The research objective is to define and implement multivariate methodology of conjoint analysis to define importance weights for attributes of service offerings in work commuting, and to use cluster analysis to segment the user sample based on the importance weights they indicated. An additional objective is to implement procedures to identify the demographics that differentiate the traveler sample segments.

Research Methodology

First, attributes of work commuting service offerings will be defined. Second, multivariate methodology in conjoint analysis will be used to assess importance weights of these attributes. Third, two-stage clustering methodology will then be introduced to define respondent subgroups or segments that are relatively homogenous in importance weights. Finally, methodology will be implemented to define the combinations of demographic variables that discriminate the segments. The methodologies to uncover importance weights for the attributes of service offerings and to cluster users on these weights will then be applied to measure satisfaction with current service offerings.

I. INTRODUCTION

While the U.S. Department of Transportation and Caltrans have set strategic goals that include increasing public transit ridership, these goals have been difficult to achieve (Siggerud 2006; US Government Accountability Office 2010; Weiner 2008). Part of the difficulty is that, on one hand, riders and potential riders have diverse needs in public transport services. On the other hand, designers and managers of public transport services often do not have well defined indication of these needs from travelers themselves. Work commuting is a useful starting point to address goals in public transportation usage because of the regular timing of the travel and its importance to the economy. The challenges to riders and managers are clearly increased when the trips are intermodal,¹ as a large percentage of work commuting is.

Clearly, public transit exists in a competitive environment in which many potential customers have alternatives ranging from driving alone to telecommuting, and transit managers are challenged to find the most effective methods to maintain and increase ridership. Variability in designing service offerings to meet needs of users and potential users remains an important capability to increase work commuting ridership.

Market segmentation has been shown to be an effective method to guide the design of transit services that can help transit agencies increase ridership and revenues. The report next provides a background on segmentation that can be a design procedure for applications in segmenting work commuting usage.

MARKET SEGMENTATION IN URBAN TRANSPORTATION

A typically high level of aggregation by transit agencies in conventional analysis of urban commuting may be obscuring meaningful differences in usage sensitivity to design variables among identifiable sub-groups of work travelers. In many cases, work travelers would likely increase their usage for designs that more closely match their needs even under a constraint that the increased revenue from the service differentiation equals or exceeds the cost of differentiation.

Segmentation perspectives recognize that markets can be disaggregated based on product or services levels that the users prefer. Under commonly encountered conditions, willingness to use a mode of work commuting is expected to depend on the closeness of attributes in actual service offerings to user ideal levels of these attributes. While the benefits of segmentation have been recognized in transportation studies, there are few real applications of efficient methods to accomplish that segmentation in the study of work commuting on public transportation. There are a number of recognizable reasons for this. Since public transportation offerings are often organized in close geographical proximity, it is more difficult to define and operationally segment these markets. However, Silver (2012) has demonstrated significant differences in preferred service offerings among travel corridors in close proximity in a transit district. At a minimum, market segmentation can provide the transit manager a better understanding of the user while promoting a better balance between the operational

¹ As used here, intermodal will mean that at least one transfer is required in a work trip. This is frequently across modes (e.g., light rail to bus).

and promotional functions of the transit agency. Generally, it is anticipated that although there are regional differences reflected in various coefficient weights for design variables, a commonality remains in the existence of multiple user segments that can be designated within feasible design variables across the regional differences.

To summarize, it has been suggested that there is considerably more opportunity to conceptualize, operationalize, and implement segmentation in work commuting than has been recognized. Some of this arises from newer methodology that can efficiently measure what is most important to users when they consider trip attributes. The background of these observations in public transportation will be reviewed next.

BACKGROUND OF MARKET SEGMENTATION IN TRANSPORTATION RESEARCH

More than a decade ago, Elmore-Yalch (1998) directed attention to the contributions that market segmentation can offer to help increase public transportation usage. Wedel (2000) is among the authors who have more recently reviewed the general contributions that market segmentation can make to consumers' and providers' objectives. The current capabilities in assessment methodology, design, and implementation can substantially increase this contribution.

In more recent studies, Hunecke, Haustein, et al. (2010) analyzed the usefulness of an attitude-based targeting of groups in predicting a transportation usage measure. An expanded version of the Theory of Planned Behavior (e.g., Ajzen 2011) was used to identify distinct attitude-based target groups. Their results show that the five groups identified by unique combinations of attitudes, norms, and values differed significantly from each other with regard to travel-mode choice, distances traveled, and ecological impact. Wen, Wang, and Fu (2012) explored mode choice behavior in market segments using survey data collected in Taiwan. They used nested logit models to capture flexible substitution patterns among service offerings attributes while simultaneously identifying the number, sizes, and characteristics of market segments. Their results found that most high-speed rail travelers were cost-sensitive, and thus strategies that reduce the access costs were suggested as more effective than those that reduce the travel times.

Beirão and Cabral (2008) exemplify the use of attitudes to segment a leisure travel market. Their results further indicate that traveler preferences, as well as demographic variables, are important components of travel behavior. In using travel attitudes, factor and cluster analyses were conducted to segment the sample. Six distinct groups were identified: transit enthusiasts, anxious status seekers, carless riders, green cruisers, frugal travelers, and obstinate drivers. The segments showed unique combinations of attitudes with distinct travel behaviors and various degrees of intention to use public transportation.

Shiftan, Outwater, and Zhou (2008) present a comprehensive approach for identifying potential segments in transit markets. These authors studied a combination of work and leisure travelers. Their approach used structural equation modeling to identify the relationship of travelers' attitudes and behavior to their socio-economic profiles. Bernetti, Longo, Tomasella, and Violin (2008) studied the transportation mode choice of different

socio-demographic groups in a middle-sized European city. Analysis allowed in their effects of the different transportation planning initiatives on different socio-demographic groups to be evaluated. The authors conclude that even if the effects of any transportation initiative may not affect the population as a whole, they can be quite different in their effects for discrete socio-demographic groups.

The above studies exemplify the benefits of segmentation in public transportation. A first task in implementing a segmentation design is to create efficient and reliable assessment of travel judgments regarding the importance of attributes in available offerings and satisfaction with these attributes. Presently available multivariate methods can contribute to implementing these applications. Applications of methodology in assessing the importance of service attributes and satisfaction with current levels of these attributes, and segments of the traveler market will be indicated in the corridor under study.

CONJOINT ANALYSIS

Conjoint measurement has psychometric origins as a theory to decompose holistic judgments (e.g., ratings or rankings of full profiles of different levels of service attributes) into interval scales for the importance of each component attribute. The objective of conjoint analysis is to determine which combination of a limited number of attributes is most influential in respondent choice. Rather than directly asking respondents to indicate what they prefer in a product, or what attributes they find most important, conjoint analysis employs the more realistic context of respondents evaluating potential profiles in attribute levels of products or services. Huber (2005) provides a review of the history and application of conjoint methodology.

ADAPTIVE CHOICE-BASED CONJOINT ANALYSIS (ACBC)

Commonly implemented conjoint methodology presents respondents individual profiles of levels of a set of attributes in a product or service offering. The respondent is asked to rate or rank “liking” or the equivalent for each profile. The variation in attribute levels across evaluated profiles provides a basis on which to generate overall importance weights for each attribute. In early choice based conjoint designs, the number and complexity of profiles that respondents were asked to rank or rate was recognized as a methodology limitation. Investigators now have more detailed understanding of the way respondents typically process a large number of profiles in choice-based conjoint tasks. When respondents tend to rate a large number of profiles, they commonly simplify by not weighting all the variation in factors or factor levels, and this reduces the quality of information in the results.

Methods to reduce this include designs in which each of a pair of respondents provides complementary judgments on a fraction of the total number of profiles. While the efficacy of this method has been demonstrated, it introduces an additional source of error variance in combining judgments of multiple individuals. Additionally, early conjoint designs assumed a compensatory model in linear combinations of attributes to define a respondent’s utility, and it has become evident that important relationships can be non-linear.

Adaptive choice-based conjoint (ACBC) models are designed to reduce the number and complexity of the choice profiles presented to respondents. ACBC uses early judgments of ratings or ranking of full profiles to select the profiles that the respondent is subsequently shown for rating or ranking. This methodology generally reduces the number of profile judgments a respondent is asked to make. In the initial stage of ACBC, “must have” questions directly follow “unacceptable level” questions. Once the respondent has completed the initial stage of screening questions, a transition is made to the second stage of the choice task.

In this stage, the respondent is shown only a series of choice tasks presenting attributes that were indicated to be actively processed in the first stage. The screening procedure of ACBC also allows non-linear combinations of attributes in a respondent’s judgment that more realistically represent processing on attribute levels. The procedures that are implemented here will assess *the importance of service attributes* to work travelers with adaptive choice conjoint analyses. As in most applications, respondents also complete a direct allocation of a fixed budget amount (constant sum) to each of the attributes. Binner, Neggers, and Hoogerbrugge (2009) provide a detailed application of ACBC in their report of a case study.

SATISFACTION MEASURES

Rated satisfaction with service offerings in terms of the study attributes of current service offerings was assessed on ratings of items taken from a scale for agree-disagree judgments (e.g., Andrich, 2005; Ludlow, 2010). The list of questions is presented in Appendix C.

II. METHOD

TRAVEL CORRIDOR UNDER STUDY

Electronic survey methodology was used to identify segments of work commuters in a travel corridor of Santa Clara County in the San Francisco Bay area of Northern California, where high-technology employers predominate. U.S. census datasets allow demographic profiles of residents in this county, along with a comparison of these profiles to profiles for the state of California at the last census. The profiles of the county and state are shown in Table 1.

Figure 2 shows the geographical transit routes in the travel corridor under study.

Table 1. County Demographics

Descriptor	Santa Clara County	State of California
Percent of Residents with Bachelor's Degree or Higher	40.5	26.6
Median Household Income	\$88,525	\$61,017
Mean Travel Time to Work (Minutes)	26.1	27.7
Persons per Square Mile	1,303	217

Source: U.S. Census Bureau 2010 (<http://www.census.gov/>).

As indicated in the table, Santa Clara County has higher educational levels and income and is more densely populated than California. However, travel time for work commuting in the county does not significantly differ from that of the state. Given the education and income differences, commuters in the county may be able to better discriminate service qualities and more willing to pay more for service that better fulfills their needs. This increases the importance of defining their judgments over a range of influential factors in service offerings. The travel corridor under study primarily services high-tech companies. The boundaries of the travel corridor and the transit routes are shown in Figure 2. This travel corridor is used by individuals who are largely in professional occupations and who have higher-than-mean educational and income levels than do people in California or even in Santa Clara County. Sample demographics will be reported in detail in a later section.



Figure 1. Geographic Location of Sampled Companies

RESPONDENT SAMPLE

Participants were obtained from a number of major companies in the densest geographical concentration of high-tech companies in the county. In each company that was a source of respondents, a coordinating employee obtained from ten to 24 other employees who were interested in participating. Participation was done as a public service and as a learning experience with modern survey methods. To increase incentives for participation, 50 \$10 gift cards were distributed to participants through a random drawing from completed questionnaires. A total of 274 respondents completed both the conjoint tasks and questionnaires.

III. PROCEDURE

Defined Sequential Steps in the Study Procedure

1. Conduct pre-study phone interviews with transit district managers (The intent of the interviews was to convey study objectives and to query about special needs, interests, and implementation capabilities.)
2. Pre-test the efficacy of adaptive conjoint design and the scaling of satisfaction measure with participants in study districts who are not in study samples
3. Establish company contacts for sample sources of participants from technology companies within the target travel corridor; and generate a participant list
4. Identify attributes of service offerings to be used in conjoint designs
5. Prepare electronic survey, including conjoint procedure participants, and load to host site

Sections of the Questionnaire

1. Introductory statement on background and objective of the survey
2. Determination of current work commuting in frequency, modes used, and mean and range of travel time and wait time
3. Procedures for ratings of full-profile screens in conjoint estimation of importance weights of trip attributes
4. Constant sum allocation of a fixed budget amount to improve attributes in current offerings of behavior
5. Ratings of items for a measure of satisfaction with attribute levels under study as they are in current service offerings the commuter uses or faces
6. Demographics in occupation, education, income, marital status, and age

ATTRIBUTE SET IN PROFILES OF SERVICE OFFERINGS FOR WORK COMMUTING

While large numbers of relevant attributes have been identified in previous study of public transportation, it appears that four or five are clearly most important. For example, recent study suggests that safety, waiting time, and uncertainty in arrival time are among the attributes that are most important (e.g., Iseki and Taylor, 2010) in an urban setting. Additionally, there is clear indication in these studies that out-of-vehicle travel time (wait time) is weighted as significantly more important than in-vehicle travel time (Iseki and

Taylor, 2010; Wardman, 2001). A hierarchical decomposition of the focus group results of work commuting in public transportation and privately owned vehicles (POVs) in the county extends the lists of factors previously considered. However, it does again indicate the predominance of a relatively small set of factors. These factors were used in designing the conjoint analysis task and closed-end questionnaire. Appendix Figure 4 shows the decomposition in factors for one of these groups.

Figure 2 shows an exemplary screen from the ACBC task that was used.

Next could you please rate how well the following profile of features in a public service offering for work commuting meets your personal needs?

<u>Cost</u> 15% above current	
<u>Comfort</u> about the same	
<u>Uncertainty</u> 15% less than current	
<u>Total travel time</u> about the same	
<u>Wait time</u> 10% less than current	

Which of the following reflects your judgment above how well the offering meets your needs?

- Does not at all meet my needs.
- Partially meets my needs.
- Neutral for all my needs.
- Mostly meets my needs.
- Perfectly meets my needs.

Figure 2. Exemplary Screen in Full Profile Choice Task

The top of this screen shows the levels in a profile of service offerings for work commuting. Because exact statistics for current levels of all attributes are not available, the common method of comparing this profile to the current profile a respondent faces is in percentage comparisons to current levels. The bottom of the screen shows the rating scale that the respondent faces for each screen.

IV. RESULTS

CONJOINT WEIGHTS OF THE ATTRIBUTES IN PROFILES OF SERVICE OFFERINGS

The conjoint derived weights for the importance of attributes and a constant sum allocation to these attributes in the sample are reported in Tables 2 and 3, respectively.

Table 2. Means and Standard Deviations of Conjoint-derived Importance Weights of Attributes²

	Mean	Standard Deviation
Importance Cost	23.145	10.5042
Importance Comfort	8.2391	7.4622
Importance Uncertainty	14.1638	9.0747
Importance Total Travel Time	18.675	10.0458
Importance Wait Time	16.9781	10.0757

² Monotone Regression.

Note: "Cost" is trip cost, "comfort" is crowdedness and seat comfort, "wait time" is average time between mode connections, "travel time" is total travel time, and "uncertainty" is the variance in total travel time. N = 274.

Table 3. Constant Sum Allocation to Attributes of Service Offerings

	Mean	Standard Deviation
Money Spent Cost	22.83	18.989
Money Spent Comfort	15.72	13.143
Money Spent Uncertainty	19.43	14.410
Money Spent Total Travel Time	22.84	15.827
Money Spent Wait Time	19.42	14.745

Note: "Cost" is trip cost, "comfort" is crowdedness and seat comfort, "wait time" is average time between mode connections, "travel time" is total travel time, and "uncertainty" is the variance in total travel time. N = 274.

Recall that conjoint analysis uses the ratings of profiles of the attributes in a service offering to derive overall importance weights. The benefits of this method have been reviewed earlier. Constant sum allocations ask the respondent to directly assign importance weights to each attribute under the condition that the sum of the weights is a constant; here it is 100. A significant relationship between the sets of conjoint derived and constant sum importance weights that are measuring the same underlying judgments is anticipated (Louviere and Islam, 2008). This is consistent with previous findings and is an indicator of a stable underlying judgment of importance weights.

Because differences in derived importance weights between POV and public transport work commuters in the sample were small and not statistically significant, results were analyzed for the entire sample. The research process first considered the relationship of the conjoint derived importance weights to the constant sum allocations as an indicator of importance weights. In measurement properties, weights derived from the conjoint procedure have significantly smaller standard deviations, and background studies have

extensively demonstrated that conjoint derived weights are meaningful predictors of actual choice (e.g., Huber, 2005). The relationship between conjoint weights and the “willingness to pay” measure of a constant sum allocation to each of the attributes was assessed with canonical correlation.

Canonical correlation is a generalization of bivariate correlation. It is a method for estimating relationships between two vectors of variables in contrast to the scalars in bivariate correlations. Given two sets of variables, X_1, \dots, X_n and Y_1, \dots, Y_m , canonical correlation assesses linear combinations of the X and the Y vectors that have maximum correlation with each other.

Correlations between the conjoint derived importance rates and constant sum allocations to attributes indicate that the relationships between the two sets of variables were reducible to two dimensions (canonical variates) that each explains more than 20 percent of the measured variables. The first pair of canonical variates showed a significant correlation of 0.382 ($p < 0.05$).

CLUSTERING OF CONJOINT DERIVED IMPORTANCE WEIGHTS FOR SERVICE ATTRIBUTES

Following the results of conjoint analysis to estimate part-worths (importance weights) for each of the attributes in terms of which service offerings have been defined, cluster analyses were used to identify traveler segments based on the revealed conjoint weights. Cluster analysis identifies groups (clusters) of individuals or objects that are similar to each other but different from objects in other groups (clusters). Methods of cluster analysis are commonly distinguished as hierarchical and non-hierarchical. Hierarchical clustering groups data that are generally for multiple measure variables by creating a cluster tree or *dendrogram*. The tree is not a single set of clusters, but rather it is a multi-level hierarchy in which clusters at one level are joined as clusters at the next level.

Non-hierarchical clustering partitions a dataset into a small number of clusters by minimizing the distance between each data point and the center of the cluster while maximizing the distance from other clusters. Instead of using the tree-like construction of hierarchical clustering, non-hierarchical procedures use pre-specified starting points (cluster seeds) and a pre-defined number of clusters to generate a cluster solution.

In the present application, a two-stage design of cluster analyses was used to obtain the benefits that alternative clustering methods can offer (e.g., Chapman and Goldberg, 2011). In the first stage, hierarchical clustering (e.g., Ward's method, Murtagh, 1983) was used to maximize within cluster homogeneity and indicate the number of clusters to be further investigated. In the second stage, non-hierarchical analysis was used to generate maps of the cluster distribution.

The Ward hierarchical clustering results indicated a three- or four-cluster solution using the standard methods of the dendrogram pattern and increases in the agglomeration coefficient. Both three- and four-cluster solutions were investigated in applications of K-means clustering. Results of the four-cluster solution were similar to those in the three-

cluster solution, with an additional cluster that had a small number of respondents and offered no additional insight into the distribution of importance weights across attributes.

Mean Kappa coefficients (e.g., Fleiss, 2011) also indicated the best fit of a three-clusters solution. The robustness of this solution was confirmed by using holdout sampling to repeatedly define clustering in .66 samples of the total numbers of respondents. In this procedure, different random draws of respondents are used to examine the clustering results and support the stability of the clustering that will be interpreted. Results of the three-cluster solution in K-means clustering are presented in Table 4.

Table 4. Centroids of a Three-Cluster Solution in K-Means Clustering^{1,2}

Cluster	1 Cost/uncertainty	2 Cost predominate	3 Time predominant	F Sig
Cost	18.950	32.149	18.981	70.758**
Comfort	9.579	6.321	7.431	5.680*
Uncertainty in Travel Time	18.878	7.961	10.112	64.843**
Total Travel Time	16.858	19.736	23.204	7.181*
Wait Time	14.942	12.792	34.043	128.608***
n	148	97	39	

¹ * 0.05

** 0.01

*** 0.001

² (bootstrap 1000 samples, $\alpha = .05$) Because the clusters have been chosen to maximize the differences among cases in different clusters and the observed significance levels are not corrected for this, the F tests cannot be interpreted as tests of the hypothesis that the cluster means are equal.

Results in Table 3 indicate that the attribute comfort is least important across all clusters. The predominant clusters can be discriminated as follows:

Cluster 1: Uncertainty in travel time and cost are most important

Cluster 2: Cost as a single attribute is most important in this cluster and is more important than in other clusters.

Cluster 3: Total travel time and wait time are most important in this cluster

CLUSTER PROFILES IN DEMOGRAPHICS

The research next examined demographic profiles across the relationship of cluster memberships to differences in demographic measures. Cross-tabulation of differences in main effects of demographic categories across clusters is reported in Table 5.

Table 5. Cross Tabulation of Cluster Membership and Demographic Variables

Characteristic	Cluster 1	Cluster 2	Cluster 3
	Cost/uncertainty (n=129)	Cost predominant (n=91)	Time predominant
(n=51)	Occupation		
1=professional	16	12	5
2=non-professional manager	13	9	13
3=administrative support	15	15	8
4=technical support	24	12	9
5=skilled labor	7	2	4
6=other service	8	9	8
7=other	25	18	25
Test statistic	$\chi^2 = 18.052$	$p < 0.10$	
Male/Female			
1=Male	57	52	29
2=Female	72	39	22
Test statistic	$\chi^2 = 4.471$	$p < 0.10$	
Marital status			
1=Single	82	63	41
2=Married or living together	47	28	10
Test statistic	$\chi^2 = 5.767$	$p < 0.20$	
Education			
1=High school graduate or less	19	9	4
2=Some college	57	41	26
3=College graduate	40	31	17
4=Post graduate education	13	10	4
Test statistic	$\chi^2 = 3.573$	$p = 0.89$	
Income group			
1=0-25,000	40	24	29
2=25,001-50,000	28	27	8
3=50,001-75,000	20	19	7
4=>75,000	41	21	7
Test statistic	$\chi^2 = 19.535$	$p < 0.01$	
Mode of commuting			
1=private	78	50	25
2=public	42	38	13
Test statistic	$\chi^2 = 1.692$	$p = 0.42$	
Age			
1=<25	64	38	20
2<26-35	49	28	13
3<36-45	16	3	4
4<46-54	8	7	2
5>=55	10	9	0
Test statistic	$\chi^2 = 9.077$	$p = 0.33$	

Although log-linear analyses could be used to examine interactions of demographic categories that better define clusters, recursive partitioning methodology (e.g., Stroby, Mally, and Tutz, 2009) provides a basis for an efficient discrimination of interactions in demographic variables that can define cluster differences. Recursive partitioning is a nonparametric statistical procedure that identifies mutually exclusive and exhaustive subgroups of independent variables that most efficiently predict a dependent variable of interest. Recursive partitioning typically produces a visual output that is a multi-level structure resembling branches of a tree. The Gini improvement measure (e.g., Lemon, Roy, Clark, et al., 2003) is a common criterion for making a next split in a set of predictors. This measure indexes the contribution of alternative linear and non-linear combination of predictor variables in terms of the reduction in unexplained variance of the dependent variable they can offer. Typically, the initial tree grown by a recursive partitioning algorithm is “pruned” to eliminate branches that do not add to prediction accuracy of the independent variables.

The result of the decomposition of the demographic variables as predictors of cluster membership is shown in Figure 3. This figure shows the tree in demographic variables and their interactions that were most efficient in discriminating clustering. Table 6 summarizes the conjoint derived weights of attributes in the public transportation option for work commuting across clusters and the non-linear combinations of demographics that predict cluster membership.

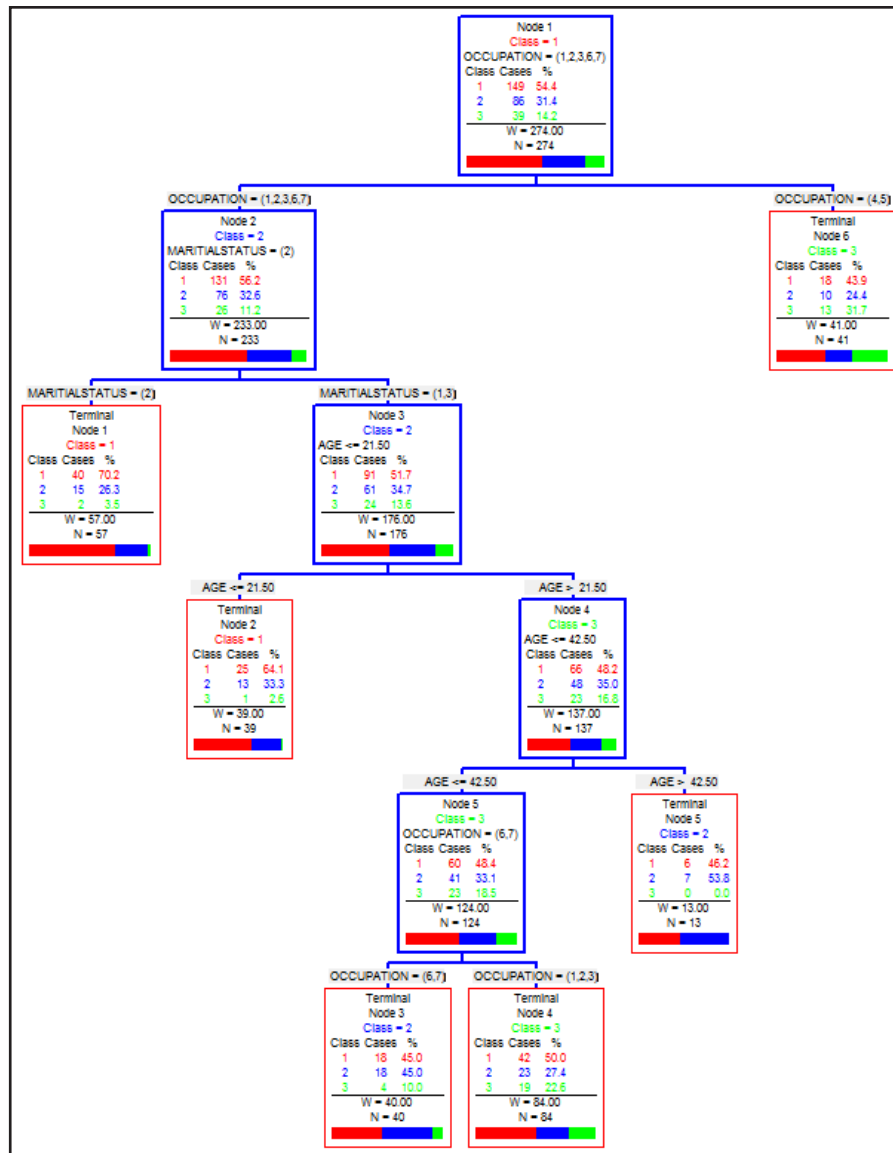


Figure 3. Recursive Partitioning of Cluster Membership in Demographic Predictors

In the results, occupation, age, and marital status are the most important variables in decomposing the demographics that define cluster membership. Because occupation is generally strongly related to education and income, it is not surprising that the latter variables did not further contribute to classify cluster membership. The model that is implied by these results includes an interaction among occupational group, marital status, and age. In occupational categories, distinguishing professional, sales and administrative support occupations from skilled labor and technical support occupations was the split that appeared to have the largest reduction in variability of cluster membership. The latter was a terminal node, meaning that no further splits on skilled labor occupations significantly reduced variability in cluster membership. Subsequent splits on professional sales and support occupations did contribute to significant reductions in the variability in cluster memberships.

The next split was on marital status, with married respondents being a terminal node. Among single respondents and unmarried couples, split was on age, with younger travelers being a terminal mode. The final splits further discriminated age and occupational groups. Cross-validation procedures were used to ensure the stability of results. A discriminant analysis indicated that the non-linear combinations of demographic variables correctly identified .67 of the sample, while assignment of individuals to the largest segment would have correctly classified by the .55 of the sample. The non-linear combinations of demographic variables that discriminated clusters and the conjoint weights of attributes are presented in Table 6.

Table 6. Demographic Descriptors of Clusters in Conjoint-derived Importance (CDI) Weights for Attributes of Service Offerings

	Cluster 1	Cluster 2	Cluster 3
	Uncertainty/Cost	Cost predominant	Time predominant
	Cluster Centroids		
CDI Cost	<u>18.950</u>	<u>32.149</u>	18.981
CDI Comfort	9.579	6.321	7.431
CDI Uncertainty in Travel Time	<u>18.878</u>	7.961	10.112
CDI Total Travel Time	16.858	19.736	<u>23.204</u>
CDI Wait Time	14.942	12.792	<u>34.043</u>
<u>Independent Variables:</u> Demographic predictors of cluster membership			
Occupation	professional, sales, admin support	tech support, skilled labor, other service	non-professional managers
Marital Status	married	single, not married couple	married
Education	college graduate/post graduate	some college	college graduate
Income Group	\$50-75,000	\$0-50	\$50-75,000, >\$75,000
Age Group	35 to >55	<35	36-45

Dependent variable: K-means clustering of conjoint derived importance weights.

IMPORTANCE-WEIGHTED DISSATISFACTION WITH SERVICE OFFERINGS

Satisfaction with attributes of service offerings was investigated by one item for each attribute selected from a seven-point Rasch scale of agree/disagree statements. Results for these measures are reported in Table 7.

Table 7. Mean and Standard Deviations of Satisfaction Ratings

	Mean	Standard Deviation
Satisfaction Cost	5.07	1.938
Satisfaction Comfort	5.12	1.763
Satisfaction Uncertainty	4.63	1.977
Satisfaction Total Travel Time	4.62	1.982
Satisfaction Wait Time	4.47	1.770

The satisfaction ratings were rescaled to have a corresponding mean and standard deviation to the importance weights and combined with these weights to define a measure of importance-weighted dissatisfaction that has been used in a number of applications.

The combined measure of a conjoint-derived importance weight and a satisfaction measure for an attribute is defined as follows:

$$D_{ij} = (m - S_{ij})I_{ij}$$

m is the number of points on the rating scale

S_i is the rated satisfaction with the i th item

I_i is the rated importance of the i th item

The two-stage clustering procedures reported for conjoint derived importance was applied to the measure of importance-weighted dissatisfaction. Demographic indicators of cluster membership were then investigated. As with conjoint-derived importance weights, the X^2 test statistic for cross tabulation of clusters and demographic variables indicated that only income categories significantly differentiated clusters. The main effects of other demographic variables do not clearly differentiate cluster memberships. Recursive partitioning models were again implemented to investigate the contribution of interactions of the demographic variables to discriminating demographics of clusters. Comparing results for the importance ratings that were previously reported, results for importance-weighted dissatisfaction indicated greater weights for the time-related variables of wait time, total time, and uncertainty in total travel time.

Recursive partitioning of the decomposition of demographics by cluster indicates that those in this cluster are professional and sales occupation, have higher-than-average education, and are married, middle income, and at or close to middle age. In contrast, the cost-predominant second cluster is primarily in technical support and skilled labor occupations, are younger than the sample mean, are predominantly single, have lower-than-mean incomes, and have not completed a college degree. Finally, in the third cluster, travel time to the work destination is most important attribute for married non-professional managers who are college graduates, middle age, and highest in income.

Both means of importance-weighted dissatisfaction for clusters and the combinations of demographic variables that best discriminate the clusters are reported in Table 8.

Table 8. Demographic Descriptors of Clusters in Importance Weighted Dissatisfaction (IWD) for Attributes of Service Offerings

<u>Dependent variable: cluster membership</u>			
	Cluster 1	Cluster 2	Cluster 3
	Uncertainty/Cost	Cost predominant	Cost and time predominant
<u>Cluster Centroids:</u> K-means clustering of IWD for attributes			
	n = 142	n = 78	n = 39
IWD cost	53.56	<u>155.58</u>	<u>64.20</u>
IWD comfort	51.88	32.06	27.42
IWD uncertainty	<u>158.85</u>	58.37	40.31
IWD travel time	117.04	84.01	<u>52.07</u>
IWD wait time	108.11	90.76	<u>55.72</u>
<u>Independent Variables:</u> Demographic predictors of cluster membership from recursive partitioning			
Occupation	professional, sales and admin support	tech support and skilled labor	non-professional managers
Marital Status	married	single	married
Education	college graduate/post graduate	some college	college graduate
Income Group	50-75,000	0-50	50,000-75,000, >75,000
Age Group	35 to >55	<35	36-45

IMPLICATIONS FOR DESIGN

A typically high level of aggregation in conventional analysis of urban commuting by transit agencies may be obscuring meaningful differences in usage sensitivity to design variables among identifiable sub-groups of work travelers. In many cases, work travelers can be expected to increase their usage of public transportation designs that more closely match their needs. This increase can support a constraint that the increased revenue from the service differentiation equals or exceeds the cost of differentiation. Defining segments of work travels in actionable attributes of service offerings remains an essential prerequisite to designing variation in these attributes that most satisfy the needs of travelers. However, inferring policy from the results presents a challenge for delivering service differences to members of distinct clusters who travel in a common corridor.

One approach is to segment travel into geographical subsets with different employers. As has been established, employers in common industries tend to cluster in their locations (Swann, Prevezer, and Stout, 1998). This has been directly demonstrated in a comparison of corridor to private industry and government-related facilities with a high-tech corridor in the demographic profiles of employee who travel to these locations (Silver, 2012). More generally, sampling ridership on different travel routes to define profiles of those who travel the route can be a basis for design when geographical segmentation is not informative.

In delivering service offerings to different segments, route differences that vary in both day and time are design variables meriting consideration. This can differentially serve shopping needs of married commuters and social needs of younger professional commuters. On routes with travelers that approximate the demographics of the first and third clusters in Table 9, reducing uncertainty and wait time can be accomplished by increasing frequency of service in critical time periods to reduce total travel time and waiting times, and by providing direct displays and mobile-accessed information on exact timing of service vehicles. Travel times at different times of the day that include approximation of random delays and using these in scheduling can be indexed. An additional possibility is in using smaller sized but larger numbers of transit vehicles that go to locations not on the regular schedule. While these procedures have been implemented independently, matching their delivery in combination with identifiable traveler segments in work commuting has not been previously examined.

V. SUMMARY AND DISCUSSION

Public transportation has high fixed costs because of the required capital in conveyance, maintenance, and labor costs that are at least insensitive to levels of usage. When variable costs are typically much less important than fixed costs, increased ridership from more accurate and efficient matching of design attribute to stated needs of travelers can offset modified design costs. Segmenting traveler markets can be a basic approach to doing this.

Methodology to efficiently segment markets for public transportation offerings has been introduced and exemplified in an application to an urban travel corridor in which high-tech companies predominate. A principal objective of this study has been to introduce and apply multivariate methodology to efficiently identify segments of work commuters and their demographic discriminants. A set of attributes in terms of which service offerings could be defined was derived from background studies and results of work commuter focus groups in the county. Adaptive choice conjoint analysis was used to derive the importance weights of these attributes in available service offering a sample of work commuters in the travel corridor under study. A two-stage clustering procedure was then used to explore the grouping of individuals' subsets into homogeneous sub-groups of the sample that can be the basis for differentiation in service offerings.

In the first stage of the procedure, hierarchical clustering was used to determine the number of clusters and the initial cluster centers. K-means non-hierarchical clustering was next used to examine the clustering in derived levels of the attributes. A cost predominant cluster, a time predominant cluster, and a hybrid cluster in which both of these attributes were highly weighted are indicated in the three-cluster solution. The demographics that discriminate memberships in the clusters were then examined. Cross-tabulation in main effects was not found to significantly discriminate segments, and recursive partitioning was used to identify interactions between demographic predictors. Income and education were correlated with professional occupations and were not significant predictors after occupational group and age were entered. In occupation, the time- and cost-predominant cluster was discriminated from other clusters by younger commuters in professional and administrative support occupations. Discriminant analysis of the non-linear combinations of demographic variables indicated the increased contribution of non-linear combinations of demographics in classifying clusters.

This method was then applied to a measure of importance-weighted dissatisfaction that assessed current service offerings. The results suggested that a combination of cost and uncertainty, and cost and time-related variables in service offerings predominated in attribute weights of clusters. In demographic discriminants of clusters, non-professional managers with higher income who were more than 35 years of age had the highest level of dissatisfaction with these variables in current service offerings, and they weighted cost- and time-related attributes as most important. Uncertainty in travel time was most important for the cluster in professional, sales, and administrative support occupations with the highest level of education. These results indicate that, aside from cost, time-related attributes were the greatest source of dissatisfaction.

Implications of these results for delivering design variation to different segments were discussed. The challenge of delivering design variation when segments travel in corridors that are not geographically distinct was noted, and directions to accomplish this were reviewed. In this case, segments can be defined in terms of demographics of those who most travel different routes. Combinations of methodologies that have not been previously integrated in transportation studies have been exemplified in the reported application. These methods are accessible to service designers in public transportation or to those who consult for designers. Although the results of this application are not easily generalized because of the non-representative sample, the size of the sample, and its high-tech location, they do indicate a basic implementation of the proposed methodology and its interpretation.

The fact that unmarried people are the most segmented group when it comes to their preferences for service attributes in the results offers a potentially significant insight for long-range transit planning in the U.S. Over the past few decades, the share of unmarried people in the U.S. population increased dramatically. Because this sub-group of the study sample appears to be a highly segmented market, transit planners face an important challenge if they want to increase (and maintain existing) transit ridership. The market segmentation techniques employed in this report suggest the challenges that planners face, and they point planners toward how to address them successfully. While it is a challenge to deliver differentiated service offerings in this and other transit markets, companies in a range of other industries that include airlines and department stores have used effective methods to accomplish this.

Current offerings display price differentiation in fares for students, regular travelers, seniors, and company-subsidized fares. Segmentation on the basis of service attributes that include reducing uncertainty, wait time, and total travel time through running more frequent buses and trains on certain routes at certain times is already a limited practice. It can be given more definite guidance from analysis of the sensitivity of usage to service attributes in different segments. Implementing the capabilities of segmentation and coordinating analyses in the design of actual service offerings merit further examination in independent studies. It is timely to use available multivariate methodology more widely in disaggregating markets for the use of public transportation. Work commuting is an appropriate sub-group of travel toward which researchers can initially direct attention because of its regularity and economic importance.

APPENDIX A: DECOMPOSITION OF FOCUS GROUP DISCUSSION

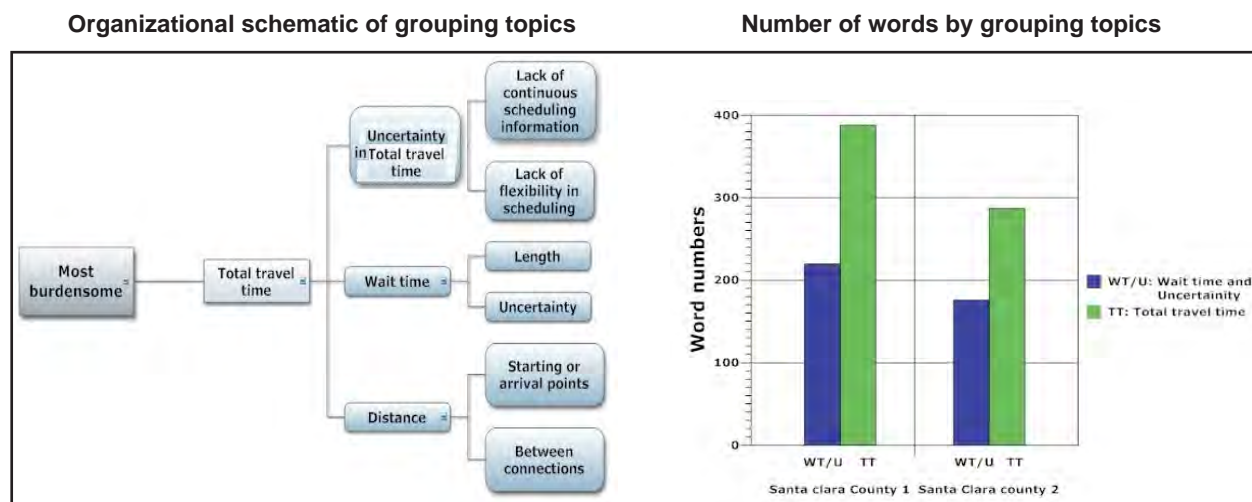


Figure 4. Organizational Schematic of Traveler Focus Group Discussions

APPENDIX B: SCALING SATISFACTION SCALE FOR ATTRIBUTES OF SERVICE IN PUBLIC TRANSPORTATION OFFERINGS

Table 9. Ten Item for Satisfaction Scale

SA	SD
1 Waiting time for my connections seems reasonable to me.	1 2 3 4 5 6 7
2 I do not feel that I can reliably plan for the variation in wait times that I face. (Reversed)	1 2 3 4 5 6 7
3 Total travel time including wait time is not a burden to my schedule.	1 2 3 4 5 6 7
4 Generally public transportation is not managed to provide adequate comfort for travelers. (Reversed)	1 2 3 4 5 6 7
5 Variation in wait time does not interfere with my planning a schedule.	1 2 3 4 5 6 7
6 All considered, total travel time including wait time is reasonable for the distance I travel and the time of day.	1 2 3 4 5 6 7
7 Comfort is reasonable on the public transportation that I use.	1 2 3 4 5 6 7
8 Increases in the cost of public transportation generally do not exceed cost of living increases.	1 2 3 4 5 6 7
9 I do not generally find waiting time for my connections to be excessive.	1 2 3 4 5 6 7
10 The cost of public transportation is excessive for what it offers. (Reversed)	1 2 3 4 5 6 7

APPENDIX C: APPLICATIONS

This appendix lists programs that support the statistical procedures used in the analyses and their supporting documentation.

A basic tutorial on using conjoint and cluster analysis for market segmentation.

<http://www.slideshare.net/ragsvasan/a-simple-tutorial-on-conjoint-and-cluster-analysis>

Conjoint Analysis in SPSS

<http://www-01.ibm.com/support/docview.wss?uid=swg27038407#en>

Manuals-- IBM_SPSS_Conjoint.pdf

Conjoint Analysis Sawtooth

<http://www.sawtooth.com/index.php/blog/archives/understanding-conjoint-in-15-minutes-by-joseph-curry/>

Sawtooth specializes in Conjoint Analysis programs. There are working papers on applications at their site.

Conjoint analysis in JMP (SAS)

Youtube on application in JMP by a leading practitioner. Part I and II

<http://www.youtube.com/watch?v=MTIIUp8bujE>

Tutorial on two-step cluster analysis in SPSS

<http://spss.co.in/video.aspx?id=62>

Hierarchical cluster analysis in R

<http://www.r-tutor.com/gpu-computing/clustering/hierarchical-cluster-analysis>

K means clustering in R

<http://www.r-statistics.com/2013/08/k-means-clustering-from-r-in-action/>

Cluster analysis in JMP (SAS)

http://www.jmp.com/support/help/Cluster_Analysis.shtml

Recursive partitioning in JMP

Using JMP® Partition to Grow Decision Trees in Base SAS

Recursive partitioning in SPSS (CHAID)

http://pic.dhe.ibm.com/infocenter/spssmodl/v16r0m0/index.jsp?topic=%2Fcom.ibm.spss.modeler.help%2Fclementine%2Fnodes_treebuilding.htm

Recursive partitioning Salford Systems

Owner of the original and most used software for recursive partitioning

<http://www.salford-systems.com/>

BIBLIOGRAPHY

- Andrich, D. "The Rasch Model Explained." In S. Alagumalai, D. Curtis, N. Hungi (eds.). *Applied Rasch Measurement: A Book of Exemplars* (2005): 7-59. N.L. Dordrecht: Springer.
- Ajzen, I. "Theory of Planned Behavior." *Handbook of Theoretical Social Psychology, Vol One, 1*, (2011): 438.
- Beirão, G., and J.S. Cabral. "Market Segmentation Analysis using Attitudes toward Transportation: Exploring the Differences between Men and Women." *Transportation Research Record: Journal of the Transportation Research Board*, 2067 (1), (2008): 56-64.
- Bhat, C. R. "Accommodating Variations in Responsiveness to Level-of-Service Measures in Travel Mode Choice Modeling." *Transportation Research Part A: Policy and Practice*, 32 (7), (1998): 495-507.
- Binner, S., R. Neggers, and M. Hoogerbrugge. "ACBC: A Case Study." Presented at the joint *SKIM/Sawtooth Software Training Event*, 2009, Prague, Czech Republic.
- Bennett, C. "Metro-North's Cortlandt Station: Regional Intermodal Success Story." *Transportation Research Record* 1677: (1999): 3-9.
- Bernetti, G., G. Longo., L. Tomasella, and A. Violin. "Sociodemographic Groups and Mode Choice in a Middle-Sized European City." *Transportation Research Record: Journal of the Transportation Research Board*, 2067 (1), (2008): 17-25.
- Chapman, B.P., and L.R. Goldberg. "Replicability and 40-year Predictive Power of Childhood ARC Types." *Journal of Personality and Social Psychology*, 101 (3), (2011): 593.
- Elrod, Terry. "Recommendations for Validation of Choice Models," *Sawtooth Software Conference Proceedings*, Sequim, WA (2001).
- Elmore-Yalch, R. *Using Market Segmentation to Increase Transit Ridership*. A Handbook: Transportation Research Board (1998).
- Everitt, B., and D. Howell, (Eds.), (ref) *Encyclopedia of Statistics in Behavioral Science*. Chichester, UK: John Wiley and Sons.
- Fleiss, J.L. *Design and Analysis of Clinical Experiments* (Vol. 73). John Wiley & Sons, (2011).
- Gaskin, S., T. Evgeniou, D. Bailiff, and J. Hauser. "Two-stage Models: Identifying Non-Compensatory Heuristics for the Consideration Set then Adaptive Polyhedral Methods within the Consideration Set," *Sawtooth Software Conference Proceedings*, Sequim, WA, (2007).

- Hauser, J., E. Dahan, M. Yee, and J. Orlin. "Must Have Aspects vs. Tradeoff Aspects in Models of Customer Decisions." *Sawtooth Software Conference Proceedings*, (2006): 169-181.
- Huber, J. "Conjoint Analysis: How We got Here and Where We Are (An Update)." In *Sawtooth Software Conference*. (2005).
- Hunecke, M., S. Haustein, S. Böhler, and S. Grischkat. "Attitude-based Target Groups to Reduce the Ecological Impact of Daily Mobility Behavior." *Environment and Behavior*, 42 (1), (2010): 3-43.
- Iseki, H., and B.D. Taylor. "Style Versus Service? An Analysis of User Perceptions of Transit Stops and Stations." *Journal of Public Transportation*, 13 (3), (2010): 23-48.
- Jain, A.K. "Data Clustering: 50 Years beyond K-means." *Pattern Recognition Letters*, 31 (8), (2010) 651-666.
- Lemon, S.C., J. Roy, M.A. Clark, P.D. Friedmann, and W. Rakowski. "Classification and Regression Tree Analysis in Public Health: Methodological Review and Comparison with Logistic Regression." *Annals of Behavioral Medicine*, 26 (3), (2003): 172-181.
- Ludlow, L.H. *Classical Test Theory, Item Response Theory, and Rasch Measurement Principles: Transforming Psychometric Theory into Practice*. Chestnut Hill, MA: Larry H. Ludlow, (2010).
- Louviere, J.J., and T. Islam. "A Comparison of Importance Weights and Willingness-to-Pay Measures Derived from Choice-based Conjoint, Constant Sum Scales and Best-worst Scaling." *Journal of Business Research*, 61 (9), (2008): 903-911.
- Manaugh, K., L. Miranda-Moreno, and A. El-Geneidy. "The Effect of Neighborhood Characteristics, Accessibility, Home-work Location, and Demographics on Commuting Distances," *Transportation* 37, (2010): 627-646.
- Muller, K.E. "Understanding Canonical Correlation through the General Linear Model and Principal Components." *American Statistician*, (1982) 36: 342-354.
- Murtagh, F. "A Survey of Recent Advances in Hierarchical Clustering Algorithms." *The Computer Journal*, 26 (4), (1983): 354-359.
- Metropolitan Transportation Commission, (2003). "A Smart Growth Friendly Transportation System" (Presentation at Local Government Commission Conference).
- Nurul Habib, K.M. "Modeling Commuting Mode Choice Jointly with Work Start Time and Work Duration." *Transportation Research Part A: Policy and Practice* 46, (2012): 33-47.

-
- Olsson, L., T. Garling, D. Ettema, M. Friman, and S. Fujii. "Happiness and Satisfaction with Work Commute." *Social Indicators Research*, 111 (2013): 255-263.
- Short, J., and A. Kopp. "Transport Infrastructure: Investment and Planning. Policy and Research Aspects." *Transport Policy*, 12 (2005): 360-367.
- Shiftan, Y., M.L. Outwater, and Y. Zhou. "Transit Market Research using Structural Equation Modeling and Attitudinal Market Segmentation." *Transport Policy*, 15 (3), (2008) 186-195.
- Siggerud, K. "Intermodal Transportation: Challenges to and Potential Strategies for Developing Improved Intermodal Capabilities." Testimony Before the Subcommittee on Highways, Transit and Pipelines, Committee on Transportation and Infrastructure, U.S. House of Representatives Thursday, June 15, 2006, Washington D.C.
- Silver, S. "Assessing Importance and Satisfaction Judgments of Intermodal Work Commuters with Electronic Survey Methodology." *Proceedings of the Decision Science Institute*, Atlanta, GA: Decision Science Institute. (2012).
- Stroby, C., J. Mally, and G. Tutz. "An Introduction to Recursive Partitioning: Rationale, Application and Characteristics of Classification and Regression Trees, Bagging and Random Forests," *Psychological Methods*, 14 (4), (2009): 323-348.
- Swann, G.P., M.J. Prevezer, and D. Stout. *The Dynamics of Industrial Clustering: International Comparisons in Computing and Biotechnology*. Oxford University Press. (1998).
- Wardman, M. "A Review of British Evidence on Time and Service Quality Valuations." *Transportation Research Part E: Logistics and Transportation Review*, 37 (2), (2001): 107-128.
- Wedel, M. *Market Segmentation: Conceptual and Methodological Foundations*. Dordrecht, NL. Kluwer Academic Publications. (2000).
- United States Government Accountability Office, *Public transportation: Report to Congressional Committees*, Report GAO-10-781 (2010).
- Weiner, E. *Urban Transportation Planning in the United States: History, Policy and Practice* (Third Edition). 2008. Westport, CT: Springer.

ABOUT THE AUTHOR

STEVEN SILVER, PH.D.

Steven Silver is a professor in the Lucas Graduate School of Business and College of Business at San José State University. He has earned an MA and MBA from the University of Chicago, a Ph.D. from the Haas School of Business, University of California, Berkeley, and has been a visiting scholar and post-doctoral fellow at the London School of Economics and at Stanford University. Dr. Silver has authored numerous reports and publications in consumer behavior, urban economics and measurement methodology. He has also served on advisory groups and panels for management of the arts and the design of transportation-related programs.

PEER REVIEW

San José State University, of the California State University system, and the MTI Board of Trustees have agreed upon a peer review process required for all research published by MTI. The purpose of the review process is to ensure that the results presented are based upon a professionally acceptable research protocol.

Research projects begin with the approval of a scope of work by the sponsoring entities, with in-process reviews by the MTI Research Director and the Research Associated Policy Oversight Committee (RAPOC). Review of the draft research product is conducted by the Research Committee of the Board of Trustees and may include invited critiques from other professionals in the subject field. The review is based on the professional propriety of the research methodology.

MTI FOUNDER

Hon. Norman Y. Mineta

MTI BOARD OF TRUSTEES

Founder, Honorable Norman Mineta (Ex-Officio)
Secretary (ret.), US Department of Transportation
Vice Chair
Hill & Knowlton, Inc.

Honorary Chair, Honorable Bill Shuster (Ex-Officio)
Chair
House Transportation and Infrastructure Committee
United States House of Representatives

Honorary Co-Chair, Honorable Peter DeFazio (Ex-Officio)
Vice Chair
House Transportation and Infrastructure Committee
United States House of Representatives

Chair, Stephanie Pinson (TE 2015)
President/COO
Gilbert Tweed Associates, Inc.

Vice Chair, Nuria Fernandez (TE 2014)
General Manager/CEO
Valley Transportation Authority

Executive Director, Karen Philbrick, Ph.D.
Mineta Transportation Institute
San José State University

Thomas Barron (TE 2015)
Executive Vice President
Strategic Initiatives
Parsons Group

Joseph Boardman (Ex-Officio)
Chief Executive Officer
Amtrak

Donald Camph (TE 2016)
President
Aldaron, Inc.

Anne Canby (TE 2014)
Director
OneRail Coalition

Grace Crunican (TE 2016)
General Manager
Bay Area Rapid Transit District

William Dorey (TE 2014)
Board of Directors
Granite Construction, Inc.

Malcolm Dougherty (Ex-Officio)
Director
California Department of Transportation

Mortimer Downey* (TE 2015)
Senior Advisor
Parsons Brinckerhoff

Rose Guilbault (TE 2014)
Board Member
Peninsula Corridor Joint Powers Board (Caltrain)

Ed Hamberger (Ex-Officio)
President/CEO
Association of American Railroads

Steve Heminger (TE 2015)
Executive Director
Metropolitan Transportation Commission

Diane Woodend Jones (TE 2016)
Principal and Chair of Board
Lea+Elliot, Inc.

Will Kempton (TE 2016)
Executive Director
Transportation California

Jean-Pierre Loubinoux (Ex-Officio)
Director General
International Union of Railways (UIC)

Michael Melaniphy (Ex-Officio)
President & CEO
American Public Transportation Association (APTA)

Jeff Morales (TE 2016)
CEO
California High-Speed Rail Authority

David Steele, Ph.D. (Ex-Officio)
Dean, College of Business
San José State University

Beverly Swaim-Staley (TE 2016)
President
Union Station Redevelopment Corporation

Michael Townes* (TE 2014)
Senior Vice President
Transit Sector
HNTB

Bud Wright (Ex-Officio)
Executive Director
American Association of State Highway and Transportation Officials (AASHTO)

Edward Wytkind (Ex-Officio)
President
Transportation Trades Dept., AFL-CIO

(TE) = Term Expiration or Ex-Officio
* = Past Chair, Board of Trustee

Directors

Karen Philbrick, Ph.D.
Executive Director

Hon. Rod Diridon, Sr.
Emeritus Executive Director

Peter Haas, Ph.D.
Education Director

Donna Maurillo
Communications Director

Brian Michael Jenkins
National Transportation Safety and Security Center

Asha Weinstein Agrawal, Ph.D.
National Transportation Finance Center

Research Associates Policy Oversight Committee

Asha Weinstein Agrawal, Ph.D.
Urban and Regional Planning
San José State University

Jan Botha, Ph.D.
Civil & Environmental Engineering
San José State University

Katherine Kao Cushing, Ph.D.
Environmental Science
San José State University

Dave Czerwinski, Ph.D.
Marketing and Decision Science
San José State University

Frances Edwards, Ph.D.
Political Science
San José State University

Taeho Park, Ph.D.
Organization and Management
San José State University

Diana Wu
Martin Luther King, Jr. Library
San José State University



MINETA
TRANSPORTATION INSTITUTE
MTI



SAN JOSÉ STATE
UNIVERSITY

Funded by U.S. Department of
Transportation and California
Department of Transportation

