

# Assessing Importance and Satisfaction with Factors in Intermodal Work Commuting



MTI Report WP 11-02



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REPORT WP 11-02

# **ASSESSING IMPORTANCE AND SATISFACTION WITH FACTORS IN INTERMODAL WORK COMMUTING**

Steven Silver, Ph.D.

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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](mailto:mineta-institute@sjsu.edu)  
[transweb.sjsu.edu](http://transweb.sjsu.edu)



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## EXECUTIVE SUMMARY

The general importance of intermodal travel (travel in which there is a combination of transport modes to a destination, for example, by train with a bus connection) has been emphasized in extensive congressional hearings and in state and regional sponsored transportation studies. As noted in those hearings and studies, single-passenger, privately owned vehicle (POV) travel in short-range trips that include commuting to work have well-recognized economic and environmental costs. While there have been a range of studies of intermodal travel, available empirical studies have predominantly been in cases where travel is across cities or regions.

The studies presented here differ from most available studies in that 1) they are limited to work commuters, who face an intermodal public transportation alternative to driving, and 2) there is a direct comparison of intermodal work commuters who are users of public transportation with POV work commuters, and 3) they compare travel corridors in a single county. The studies use samples from two travel corridors in Santa Clara County, California. The destinations in the counties differ in the predominant employers in the respective corridors. In one of these, high technology firms are the predominant employers. In the other (Downtown), the predominant employers are state, county, and city offices. Demographics of the commuter groups show corresponding differences. In one corridor, High Tech intermodal travel is on multiple buses. In the other corridor, travel is on a light-rail and bus combination. Results show the differences in commuter judgments that can be in place between travel corridors in close geographical proximity, and the managerial implications such differences have.

Managerial implications of the results for the two travel corridors clearly differ. In the travel corridor to high tech companies, cost is less important to public transportation commuters than distance, wait time, travel time, and uncertainty in travel time. Dissatisfaction with public transportation is primarily linked to total travel time and distance from residence to the appropriate station, mode interface, and/or distance from the closest station to the workplace. Importance-Satisfaction Analysis (ISA) indicates that total travel time, uncertainty in total travel time, and distance are the high importance factors with the lowest satisfaction ratings. Comparisons of the demographics of POV and public transportation users in this corridor suggest that work commuters continue to use the public transportation alternative when they are further into their careers and are less limited by income.

For the travel corridor to a city center (Downtown) with considerably less of a high tech industry presence, demographics show user groups to be earlier in their careers, with lower levels of completed education and income. For public transport commuters, results of the assessments of importance and satisfaction in this corridor were very different from the public transportation commuters in the High Tech corridor. Cost and total travel time were more important to public transport commuters than other factors, and more important than they were to POV commuters. Among POV commuters, distance, wait time and uncertainty in total travel time were of highest importance. In satisfaction ratings, public transport commuters were least satisfied with cost, wait time, and total travel time. POV commuters were more satisfied with all the factors than public transport commuters. They were least satisfied with total travel time and wait time in traffic.

Managerial implication of the results are that public transport commuters in the High Tech corridor respond most to improvements in distance, total travel time, wait time, and uncertainty of travel time. In the corridor to workers in downtown offices, cost appears to be of highest importance. This is followed by cleanliness and total travel time. It may be that in the Downtown corridor, reductions in frequency of transit vehicles to reduce cost are more of a priority than this would be in the High Tech corridor. The results we report underscore the importance of assessing demographic differences and contrasts between different travel corridors even when they are in close proximity in the same county.

Increasing the use of public transportation in work travel continues to be a challenge in the face of cost constraints. When compared to a large set of results that are predominantly from single mode commuters, our studies suggest the challenge is increased when travel is intermodal. In most previous studies, public transportation commuters have been grouped together whether or not travel is intermodal. Results for intermodal travel were found to have similarities in some factors, but important differences from results for single mode travel in the effects of wait time, total travel time, and uncertainty of travel time on choice of mode.

Studies of satisfaction in combination with the judged importance of factors can be important guides to design modification in the case of intermodal travel. Our results suggest significant differences in judgments between user groups within a corridor and across the travel corridors we studied. As noted, these differences are likely driven by differences in the location of employers and demographic differences between commuters in the corridors we study. The largest demographic difference appears to be in educational level.



## RESEARCH OBJECTIVES

The studies we report have two objectives. These are confirming underlying factors surrounding the use of public transportation in intermodal commuting to work, and contrasting differences in the importance of and satisfaction with these factors between public transport commuters and POV commuters. The objective of these studies is to indicate the factors and background variables that differentiate the two commuter groups in the respective study corridors, and to consider differences between the corridors as appropriately qualified by differences in travel mode and demographics.

The longer-term objective of these studies is to increase the understanding of these factors in regard to decisions on local commuting to work when travel is intermodal. These results can be used in subsequent studies of the tradeoffs that intermodal work commuters make and attributes that designers consider when creating sets of service bundles that they can deliver within cost and technology constraints. The intention is to use results from studies of intermodal work commuters to assist policy makers in the design of alternatives in intermodal transportation in local corridors that result in higher usage rates and cost-effectiveness.



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## I. INTRODUCTION

A frequently referenced public policy goal is to reduce or limit the growth of single-passenger private vehicle use for routine trips.<sup>1,2,3</sup> This policy goal continues to have limited success in the densely populated travel corridors of California. The most routine local commuting is the work commute. While work travel is about 20% of total travel in the U.S., it remains important because of its absolute size and the predictability of travel times.

For many households in the corridors studied, a primary difficulty in using public transportation for commuting to work is that it requires intermodal connections. Many of the employees in urban areas of California reside in locations that don't have access to a single transportation mode that allows them to travel directly to work. Although there is an extensive background on integrating land use and available transportation modes (for example<sup>4,5</sup>), decisions of private companies regarding location have most often heavily weighted cost and industry factors. In contrast, household decisions on residence location have most heavily weighted the price of a residence, size, neighborhood quality, and amenities such as the quality of schooling and location of cultural and ethnic facilities.<sup>6</sup>

While intermodal travel in urban corridors has now been well studied,<sup>7,8</sup> these studies have most often been of commuters with multiple purposes (for example, commuting to work, shopping, and visits to relatives or friends). Differences in priorities of commuters across segments with different purposes have not been reported. In particular, regular work commuters can be expected to judge the importance of factors in intermodal travel differently from those who have more casual travel purposes.

The studies we report use samples of work commuters from two travel corridors in Santa Clara County, California. The destinations in the counties differ in the predominant employers in the respective corridors. In one of these (High Tech), high technology firms are the predominant employers. Because of the location, intermodal commuters predominantly use multiple buses. Intermodal commuters who are regular users of public transportation were compared with privately owned vehicle (POV) commuters in commuting to work. In the other (Downtown), state county and city offices are the predominant employers. The comparison groups in this corridor are those who regularly use a combination of light-rail and bus in commuting to work and those who use light-rail enough to be familiar with the offering, but regularly use their POVs in commuting to work.

In investigating the importance of factors in intermodal work travel, we consider commuters own subjective judgments to be more informative than analyses of factors revealed from their travel behavior.<sup>9</sup> Studies of judgments by intermodal commuters in local markets have been in measures that rate and/or rank the importance of facility and trip factors and their satisfaction with these factors. We report these in both studies with multiple measures of satisfaction. Additionally, we use importance-satisfaction analyses (ISA) to highlight factors that are most important to commuters and their perceived shortcomings in satisfaction.

While many factors have been identified in previous studies of public transportation, it appears that four or five are dominant. Recent study suggests that these include safety,

waiting time, and uncertainty in arrival time.<sup>10</sup> There is clear indication in these studies that out-of-vehicle travel time is weighted as significantly more important than in-vehicle travel time.<sup>11,12,13</sup> Our own focus group results in the Santa Clara County<sup>14</sup> extends the lists of factors previously reported, but again indicates the predominant importance of a relatively small set of factors. We use these factors in closed end questionnaires.

In the two major travel corridors that we study, most work commuters reside at moderate distances from their work locations and cannot readily walk or cycle to work. We will contrast intermodal public transport commuters with POV commuters in these corridors. Our report focuses on the results of two questionnaire studies of intermodal work commuters. We first take note of results from focus groups of POV commuters as they supplement results of a previous study of public transportation commuters. A more extensive report of results from the POV commuter focus groups is offered in an Appendix A.

## COUNTY DEMOGRAPHICS

Santa Clara County has higher than the statewide averages for education, income, and population density, but reports about equivalent mean travel times to work as the rest of the state. County demographics are summarized in Table 1.

**Table 1. County Demographics (2009)**

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/>)

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## II. METHODOLOGY AND RESULTS

### FOCUS GROUP STUDIES: POV WORK COMMUTERS

We prefaced the study of work commuters in two travel corridors with focus group studies of POV commuters. These studies complement previous results from focus group studies with regular users of public transportation in commuting to work. The POV participants were selected from commuters who had enough experience with public transportation alternatives to offer informed judgments on the service. As in the previous focus group studies, their discussions were directed to focal topics of most burdensome, least burdensome, and most important to improve. The discussions were hierarchically decomposed into constituent factors, and the factors identified in the POV groups were compared to those identified in groups of public transportation commuters.

Although public transportation users were more detailed in their discussions and offered more exemplification, results of these studies showed that similar factors were of greatest importance to both users of POVs and public transport users in commuting to work. These results were used to design the closed end questionnaires used in both the travel corridors. The results are presented in detail in the Appendix A.

### IMPORTANCE AND SATISFACTION IN THE MODE CHOICE OF WORK COMMUTERS

We report results of two studies on the importance and satisfaction in mode choice of work commuters for whom public transportation is or would be intermodal. Both of these studies used closed end rating scales that operationalized factors identified in focus group studies. The comparisons within each study are between samples of those who regularly use an intermodal public option in commuting to work and those who regularly use their POVs in commuting to work. The POV commuters who participated are limited to those who indicate they also have experience in the use of the alternative of public transportation, even if they do not regularly commute to work this way. In POV commuters, we do not include those who participate in carpooling.

The sample in Study 1 (High Tech) is based on respondents from high tech companies who are located in close proximity to a center of technology in Santa Clara County, California. Because of the location, public intermodal commuters predominantly use multiple buses. The sample in Study 2 (Downtown) is based on respondents that use a light-rail and bus combination in travel to the downtown center of San José, California. Federal, state and county offices are large employers at this location. Respondents in this travel corridor were obtained at one of two major stations of the Valley Transit Authority (VTA) light-rail system in the central district. The comparison groups in this corridor are those who regularly use a combination of light-rail and bus in commuting to work and those who have used light-rail on occasion but regularly use their POVs in commuting to work.

## DESIGN OF QUESTIONNAIRES

A similar questionnaire was used in both studies. The introductory statement in the questionnaires indicated the general importance of the transportation modes that regular work commuters use. A first section elicited information on occupation, the regularity of their commuting to work, distance from their residence to work location, the frequencies of the modes they used in the past month, and the range of their waiting times in interfaces. A second section elicited ratings of the importance of factors that were identified in the focus group studies and satisfaction with these factors in public transportation offerings.

Ratings of importance and satisfaction were on an eleven point scale with end points “not at all important” and “extremely important”; or “not at all satisfactory” and “extremely satisfactory.” As will be reported, we define several measures of satisfaction from these data. The third and final section requested demographic information. Categories of age, education, and income in addition to gender and marital status were included in this section.

## STUDY 1: MULTIPLE BUS COMMUTERS AND POV COMMUTERS IN A HIGH TECH TRAVEL CORRIDOR

### Participants

In Study 1, questionnaires were distributed to full-time employees of high-tech companies located in a major travel corridor of Santa Clara County. The designations A and B in Figure 1 show the locations of the companies from which respondents were drawn and the bus routes that serve these locations. Contact members within these companies distributed the questionnaires to other members of their division as they were leaving to their POVs or to nearby bus stations. Names of participants were recorded. One reminder was sent to those who did not return the questionnaire in a week. Most employees of these companies were commuters who use POVs to commute to work. Only those commuters who either regularly used or had experience and awareness of the public transportation alternatives were included in the sample. Analyses were limited to completed questionnaires in which respondents traveled to work at least 20 times in a month. Public transit commuters were defined as those who use multiple public modes in at least ten of their trips in a month. A total 63 public transit commuters and 89 POV commuters were obtained in the final sample.

### Demographics of User Groups

Among public transportation commuters, 0.60 were male; POV commuters were equally divided in gender. Median education in both groups was completion of an undergraduate degree. Among public corridor, transportation commuters in this travel corridor, 0.48 had an undergraduate degree, 0.64 of POV commuters had an undergraduate degree. Correspondingly, 0.21 of public transportation commuters and 0.27 of POV commuters had graduate degrees. Median income category in both groups was in the range of \$30,000 - \$40,000. However, 0.263 of POV commuters were in the > \$40,000 category; less than 0.10 of the public transportation commuters were in that category ( $\chi^2 = 4.88$ ,  $p < .10$ ). The median age category in public transportation commuters was 22-27; the median age

category for POV commuters was 28-35. Only 0.096 of public transport commuters were in age categories  $\geq 36$ , 0.275 of POV commuters were in the same age category. Higher proportions of POV commuters are older, have graduate degrees and are in a higher income category. Only the income differences attain or approach statistical significance.



**Figure 1. Travel Corridor to High Technology Companies**

*Note:* A and B are locations of sampled companies. Bus routes are indicated by numbers.

## Results

Means and standard deviations for importance ratings of the eight factors assessed in the questionnaire are reported in Table 2. Table 3 presents satisfaction ratings for these factors in intermodal work travel.

## Study 1

**Table 2. Ratings of Importance for Factors in Intermodal Work Travel: Means and Std. Deviations**

Factor	Public Transport Commuters		POV Commuters	
	M	SD	M	SD
Comfort*	7.206	2.377	7.854	2.391
Cost	7.790	1.926	7.517	2.599
Distance**	8.097	2.163	8.764	1.659
Clean*	7.807	2.149	8.427	2.028
Environment	7.065	2.149	7.292	2.487
Wait time	8.429	1.873	8.888	1.668
Travel time	8.619	1.620	8.865	1.896
Uncertainty*	7.903	1.965	8.472	2.247

Note: "Comfort" is crowdedness and seat comfort; "Cost" is trip cost; "Distance" is distance between residence and location of initial mode, transfer between modes, and final station and work location; "Clean" is cleanliness of mode; "Environment" is the perceived consequence of mode choice by the respondent for the environment; "Wait time" is average time between mode connections; "Travel time" is total travel time; "Uncertainty" is the variance in total travel time.

\*  $p < .10$ , \*\*  $p < .05$

**Table 3. Ratings of Satisfaction for Factors in Intermodal Work Travel: Means and Std. Deviations**

Factor	Public Transport Commuters		POV Commuters	
	M	SD	M	SD
Comfort	7.241	1.976	6.659	2.363
Cost	7.000	2.420	6.553	2.428
Distance**	7.931	1.771	6.565	2.327
Clean	6.414	2.457	6.294	2.581
Environment	6.207	2.351	6.529	2.102
Wait time	6.552	2.213	6.400	2.569
Travel time	7.276	2.218	6.365	2.506
Uncertainty	6.638	2.318	6.471	2.438

Note: "Comfort" is crowdedness and seat comfort; "Cost" is trip cost; "Distance" is distance between residence and location of initial mode; transfer between modes, and final station and work location; "Clean" is cleanliness of mode; "Environment" is the perceived consequence of mode choice by the respondent for the environment; "Wait time" is average time between mode connections; "Travel time" is total travel time; "Uncertainty" is the variance in total travel time.

\*  $p < .10$ , \*\*  $p < .05$



## Summed Importance-Weighted Dissatisfaction Measure

We also calculated a summed importance-weighted dissatisfaction measure as an additional measure of satisfaction. This measure was defined as:

$$D_j = \frac{[\sum_i (m - S_i) I_i]}{n}$$

Where  $D_j$  is the summed importance-weighted dissatisfaction of the  $j$ th respondent

$m$  is the number of points on the rating scale ( $m=11$ )

$S_i$  is the rated satisfaction with the  $i$ th item

$I_i$  is the rated importance of the  $i$ th item and

$n$  is the number of rated items.

Mean POV commuters were higher than public transportation commuters on this measure of dissatisfaction:  $D_{own} = 36.268$  (SD=17.527);  $D_{pub} = 32.859$  (SD=14.402). Differences in means were not statistically significant.

### *Improve Most*

In this section, participants were also asked to rate the importance of operational features in intermodal commuting to work in terms of immediate modification. For these ratings, differences within commuters' ratings of factors were more significant than differences between the commuter groups. Notable differences between commuter groups in these ratings were the low importance of cost to both these groups and the significantly higher importance of routing and wait time in comparison to other factors among POV judgments of the public transportation alternative. Among public transport commuters, only the difference between both frequency and wait time in comparison to cost were non-chance ( $p < .05$ ).

**Table 4. Ratings of Improve Most for Factors in Intermodal Work Travel: Means and Std. Deviations**

Factor	Public Transport Commuters		POV Commuters	
	M	SD	M	SD
Frequency	8.2097	1.86545	7.8090	2.20473
Cost	7.6129	3.42294	7.5393	2.65885
Routing	7.8871	2.36854	8.2360	2.43564
Clean	8.1290	5.85195	8.1685	2.50561
Wait time	8.2742	1.83919	8.2584	2.01995

*Note:* "Frequency" is number of vehicles in a travel time period, "Routing" is the routing followed in the trip to work, "Cost" is trip cost, "Clean" is cleanliness of mode, and "Wait time" is average time between mode connections.

### Importance-Satisfaction Analysis (ISA)

Importance-performance and importance-satisfaction analyses (ISA) are frequently used methods for assessing the perceived quality of service offerings and identifying service quality areas requiring remedial adjustments.<sup>15</sup> It has now been applied to food; housing, education and health care as well as the study of public transportation usage.<sup>16,17,18,19,20</sup>

We follow the procedures commonly used in an ISA. In our application, the proportion of respondents rating importance or satisfaction as 9 or 10 on an 11 point scale is defined as indicating the factor that is most important or where satisfaction is highest. As in ISA, the scale range on y-axis and the origin point in the Figures 2, 3, 8 and 9 are generated by the range of the data. Figures 4 and 5 contrast these proportions for POV and public transport commuters across factors. For importance and satisfaction, uncertainty, and clean show the largest discrepancy in rated importance between POV and public option commuters. In satisfaction, distance and cost have high satisfaction among public transport commuters. Differences between factors are relatively small for POV. Travel time, wait time and distance are most important to both modes of commuters. Distance and cost show the largest discrepancy between POV and public transportation commuters. Although commuters of public transportation appear to be highly satisfied with cost, POV commuters appear to be considerably less so.

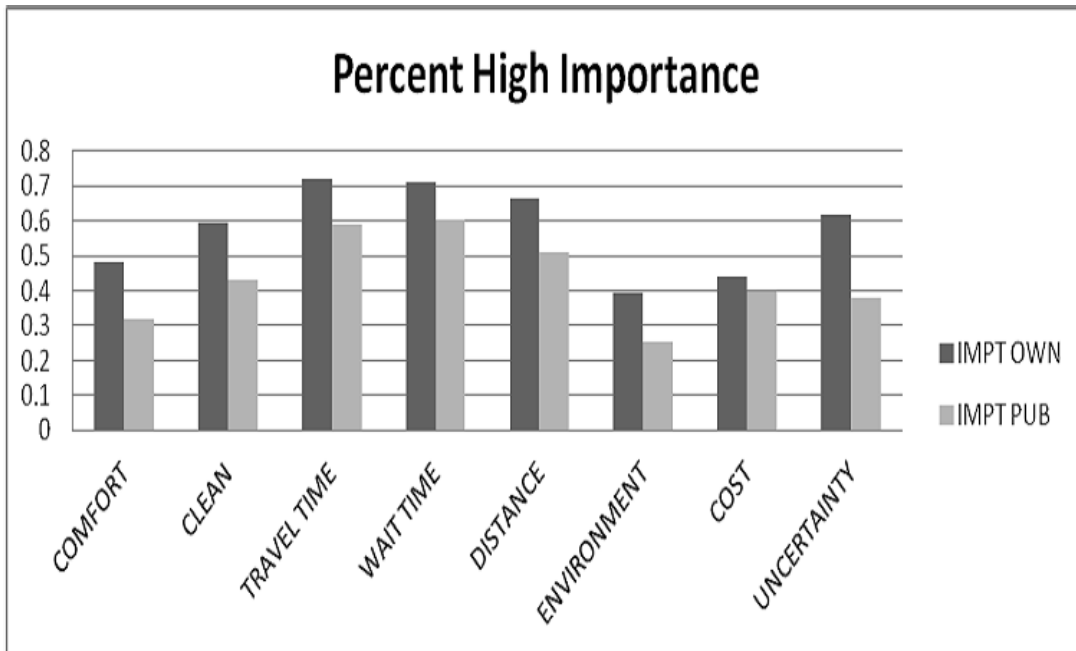
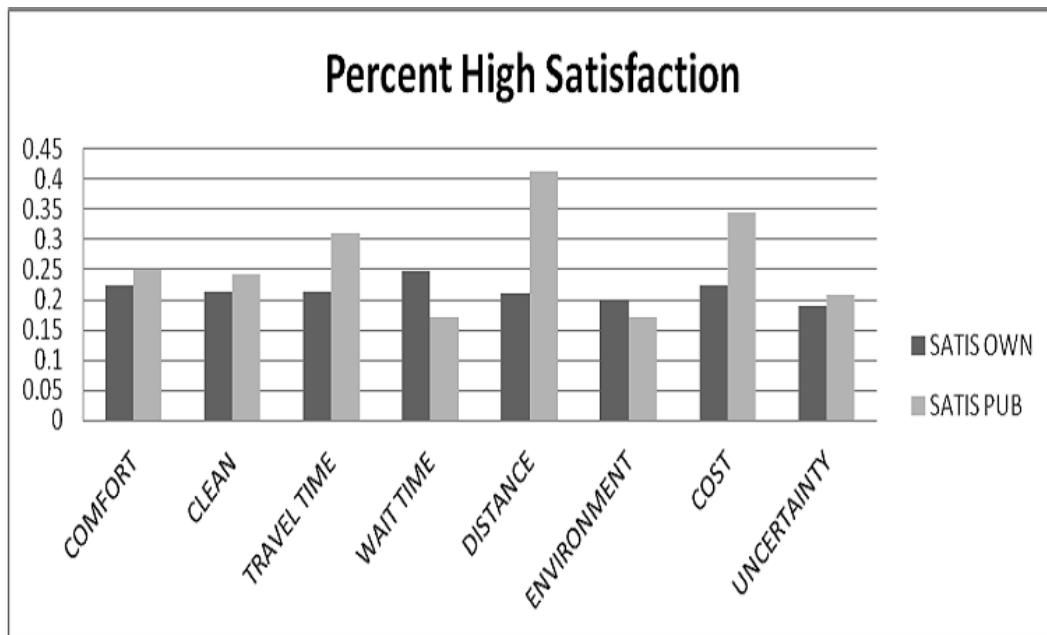


Figure 2. Percent High Importance: ISA Study 1



**Figure 3. Percent High Satisfaction: ISA Study 1**

### ISA Mapping of Importance and Satisfaction

ISA involves the simultaneous consideration of consumers' assessments of the importance of salient factors or attributes in service offerings and their level of satisfaction with the performance of the offerings. The method defines a two-dimensional surface with the horizontal axis indicating the consumers' judgments of the importance of a given attribute. The vertical axis indicates the satisfaction with the attribute in the service offering. User importance and performance/satisfaction are discussed in terms of the location of their ratings in the four quadrants based on means scores of their factor ratings.

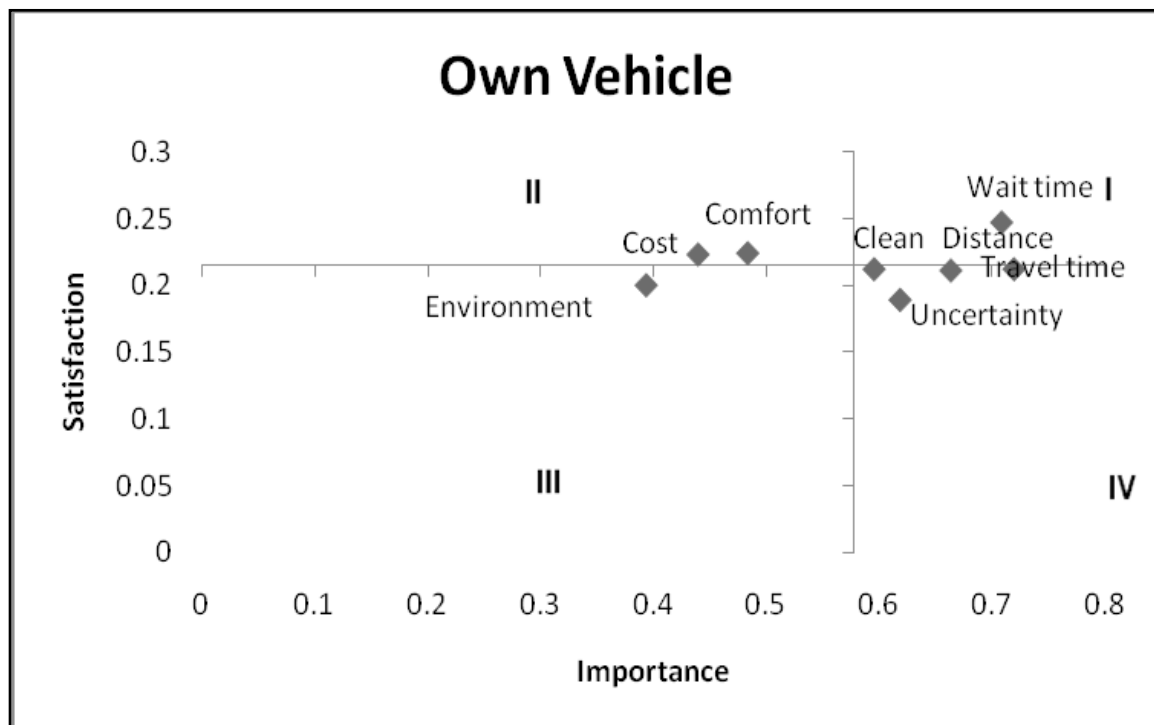
Each quadrant can be used to suggest a different managerial strategy. For example, factors that are rated high in importance and high in performance or satisfaction suggests that the service provider carefully maintain the service at the current levels and monitor to ascertain whether additional resources are necessary to maintain these standards. In contrast, attributes having a low importance rating and a low performance/satisfaction rating suggest that investing scarce resources on these attributes may have little strategic advantage. Those designations are summarized in Table 5.

In this study, factors that are rated high in importance and low in satisfaction are generally considered to be the ones that a service provider should pay particular attention to and direct the greatest amount of resources to improving. Lastly, factors rated low in importance and high in satisfaction are ones that a provider should also maintain at current levels, but not necessarily allocate any additional resources to. Table 5 summarizes these designations.

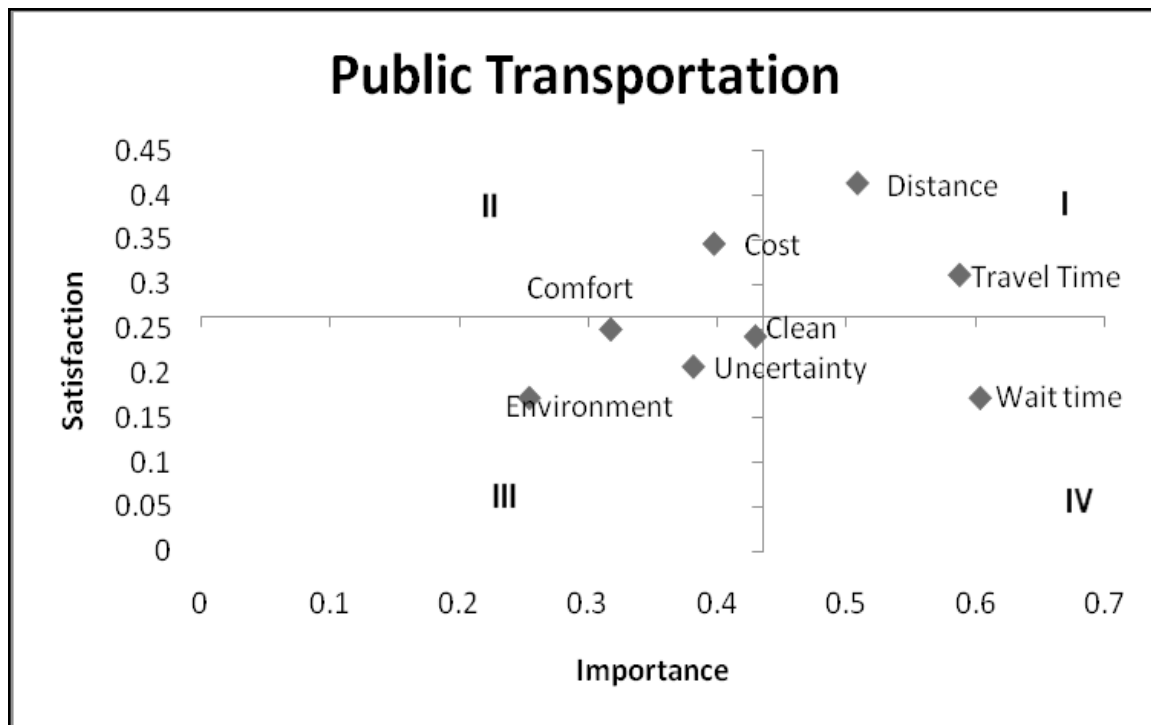
**Table 5. Quadrant Designations in ISA**

Quadrant labels
<b>I – Core satisfiers</b>
<b>II – Lower importance satisfiers</b>
<b>III – Less important to improve</b>
<b>IV – Most important to improve</b>

Figure 4 and 5 show mappings of the I-S factor space for POV and public transportation commuters, respectively. Mean importance and satisfaction across all factors is used to define the origin in each figure. As in ISA, the quadrants of the space were used to interpret and compare differences between samples.

**Figure 4. Importance x Satisfaction Factor Space: POV Commuters Study 1**

For POV commuters rating public transportation, uncertainty in public transportation is in the high importance and low satisfaction quadrant, and travel time, distance and cleanliness are at the margin of this quadrant.



**Figure 5. Importance x Satisfaction Factor Space: Public Transportation Commuters Study 1**

In public transportation user ratings, wait time, uncertainty in travel time, total travel time, distance and clean are factors of high importance that have low satisfaction. Among public option commuters, waiting time is clearly the high importance factor that these commuters are least satisfied with.

Considering the comparisons of the ISA figures for POV and public transport commuters, differences in the locations of service offerings in travel time, uncertainty and wait time vs. cost would appear to have the most policy relevance. Both POV and public transit commuters consider wait time and travel time as most important; public transport commuters have lower satisfaction with these factors. In this corridor, cost and comfort are of low importance to both POV and public transport commuters. Whereas uncertainty is of high importance to POV commuters, it is of lower importance to public transport commuters. The ISA results suggest that it is important to maintain or improve judgments of distance, wait time, travel time, and uncertainty in comparison to cost and comfort for both groups of commuters. A direct implication of these results would be to consider increasing small to moderate price increases to provide more frequent service that reduces travel time and uncertainty. Any price increase should be accompanied by a clear statement of what the price increase will be used for.

### Importance-Weighted Dissatisfaction

We will return to these results in an overview of policy implications for both studies. A limitation of traditional ISA is that the boundaries between high and low importance and satisfaction do not reflect the relative weights of these judgments in overall choice.

We also calculated a measure of dissatisfaction to further contrast public option and POV commuters. Although this measure is compensatory, it does directly indicate the combined effects that these criterion measure. As such, it has managerial relevance.

To define the importance-weighted dissatisfaction index, the proportion of respondents rating a factor as highly important (9 or 10 on an 11 point scale) was calculated. The proportion of respondents rating a factor as highly satisfied was similarly calculated. The importance-weighted dissatisfaction index was defined as:

$$D = I * (1 - S)$$

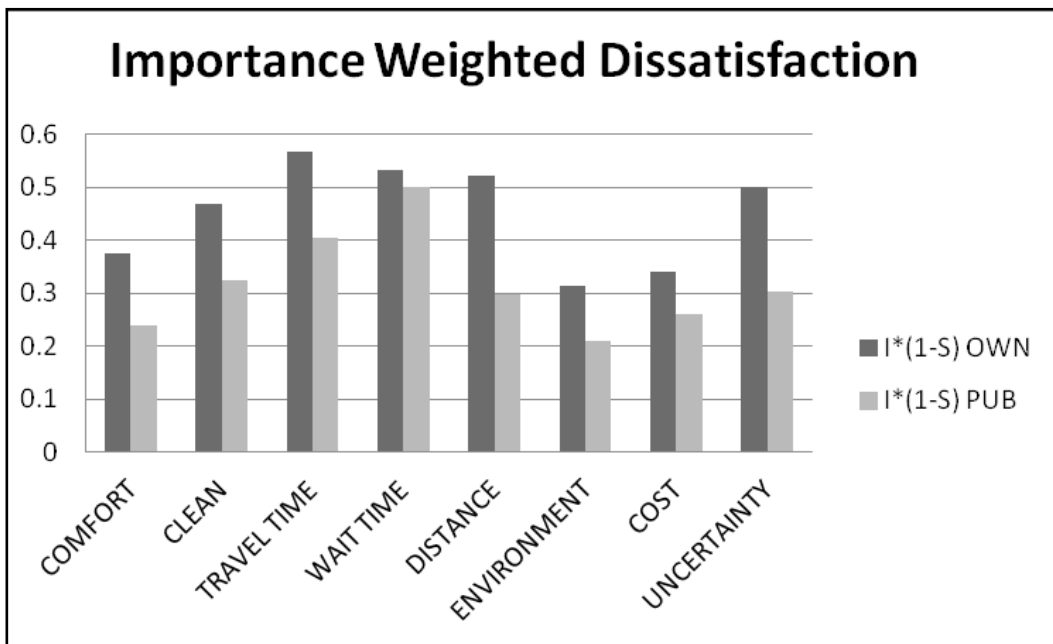
Where  $D$  = importance-weighted dissatisfaction.

$I$  = proportion of sample rating a factor as highly important.

$S$  = proportion of sample rating a factor as highly satisfied.

Figure 6 shows the profiles of importance-weighted dissatisfaction for the user groups.

Both of the user groups identify total travel time, wait time, and uncertainty in total travel time and distance to destination as the most importance-weighted dissatisfaction factors. The largest differences among these factors are in uncertainty in total travel time and distance to destination.



**Figure 6. Importance-Weighted Dissatisfaction: Study 1**

In results for importance-weighted dissatisfaction, both groups of commuters are most dissatisfied with travel time, distance, and uncertainty. The difference between the commuter groups is greatest for uncertainty with POV commuters being more dissatisfied

with uncertainty in trip travel time than public transportation commuters. The above factors are clearly more important than cost in this corridor for both commuter groups.

### Multidimensional Scaling of Ratings

We also investigated results of an application of multi-dimensional scaling (MDS)<sup>21,22</sup> to the ratings of importance, satisfaction and dissatisfaction. In ISA, factors are plotted independent of one another based on ratings. MDS procedures derive the distances between ratings of factors as generated by calculating the proximities in ratings of the factors. Correlation or covariance matrices for ratings of factors are used to derive distances.

From a non-technical perspective, multidimensional scaling (MDS) provides a visual representation of the pattern of proximities (for instance, similarities or dissimilarities) among a set of objects. For example, given a matrix measure of perceived similarities between various factors in work travel, MDS plots the factors on a map in a way that those factors that are perceived to be very similar to each other are placed near each other on the map, and those factors that are perceived to be very different from each other are placed far away from each other on the map. As such MDS can capture subjective distances better than independent plotting of factors coordinates from the data.

Although results of these applications showed a good fit by a standard measure of “stress”<sup>23</sup> to a two dimensional solution for proximities, we did not find substantial and interpretable differences in groupings from ISA results. As such, we note the application, but do not present the results in detail here.

### Factor Analysis of Ratings

Finally, we directly explore dimensionality in the ratings with principal component analysis (PCA). For importance, a varimax rotation converged in three iterations and indicated a two factor solution. In the results that follow, factor loadings of variables are in parentheses. The first factor accounted for 44.2% of total variation in importance and is made up of the variables total travel time (0.827), wait time (0.785), distance (0.715), cleanliness (0.645), and uncertainty in travel time (0.580). The second factor accounted for 16.2% of total variation in the rated factors and is made up of the variables of environment (0.887) and cost (0.756). Mean factor scores for importance of factor 1 were significantly higher ( $t = 2.24$ ,  $p < .05$ ) for POV commuters ( $IMPTM_{pub} = -0.211$ ,  $IMPTM_{own} = 0.147$ ). A principal component analysis of satisfaction yielded a single factor solution that accounted for 63.3% of total variation in the rated factors. All loadings on this factor exceeded 0.68.

In contrast to differences in rated importance, public transit commuters were more satisfied than POV commuters ( $SATM_{pub} = .165$ ,  $SATM_{own} = -.0446$ ). These differences were not statistically significant. Correspondingly, in rated overall satisfaction, public commuters were more satisfied than POV commuters ( $SAT_{pub} = 6.88$ ,  $SAT_{own} = 5.94$ ,  $t = 1.89$ ,  $p < .05$ ). A principal component analysis of the factors most important to improve ratings yielded a single factor solution that accounted for 55.2% of total variation in the rated factors. All loadings on this factor exceeded 0.672. Mean factor scores for the most important factors

to improve ratings are higher for POV commuters ( $IMPRM_{pub} = -0.030$ ,  $IMPRM_{own} = 0.020$ ). This difference is not statistically significant.

The correlation between the rating of overall satisfaction and the principal component of satisfaction items was 0.695. The weighted dissatisfaction score had a correlation of -0.800 with the principal component score and -0.501 with the rating of overall satisfaction.

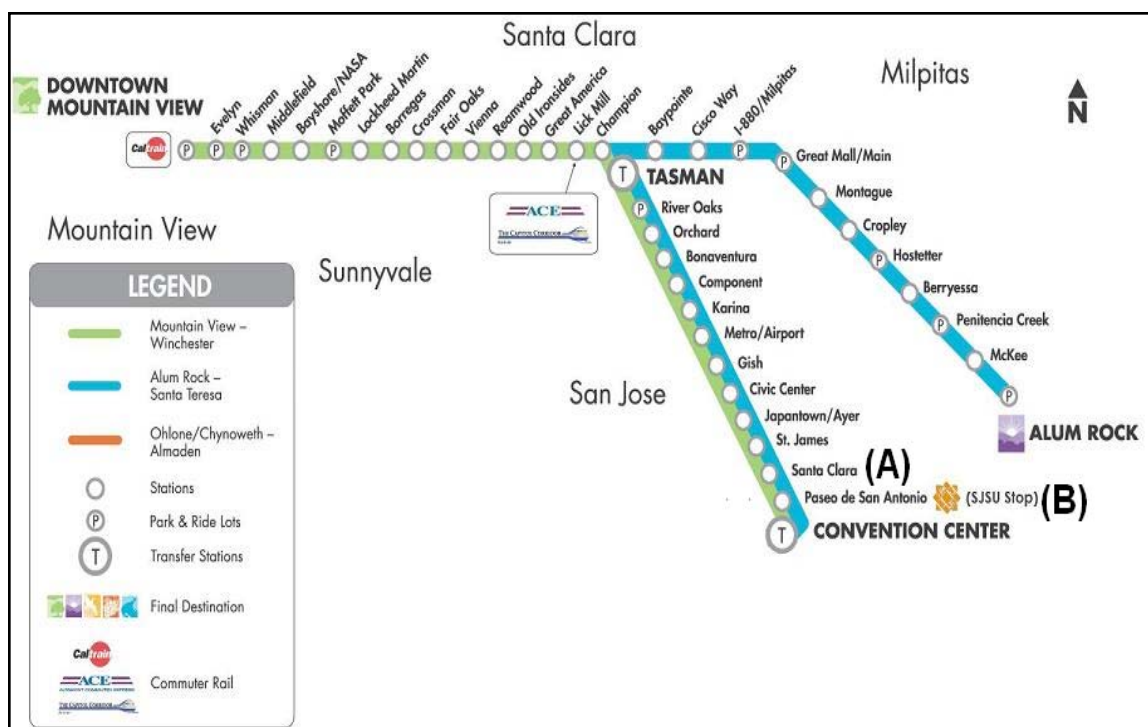
## **STUDY 2: LIGHT RAIL INTERMODAL COMMUTERS AND POV COMMUTERS IN A DOWNTOWN TRAVEL CORRIDOR**

### **Participants**

This study used a sample of commuters to work in the downtown of the largest city in the county (San José, California) whose trips included a light-rail and a bus connection. The sample was obtained at two major downtown stations of San José on the VTA light-rail system. Collection was from outbound commuters at the peak return from work, between 5:45 p.m. to 6:30 p.m., on multiple days of the same week. Male and female students working together collected the data. Questionnaires were given to respondents on clipboards with attached pens. If questionnaires were not completed when the travel vehicle arrived, a student rode with participants on light-rail until they were completed. Participants were limited to intermodal transit users. Of commuters that met study criteria, a participation rate of greater than 0.8 was obtained by the team of students.

The overall sample was divided into commuters who were commuting on light-rail at the time of data collection and regularly use light-rail and a bus in commuting to work (work travel  $\geq 20$  times a month, public option  $\geq 10$ ,  $n=34$ ) and those who regularly use their POV (work travel  $\geq 20$  times a month and public option  $<5$ ,  $n=28$ ) and do not regularly travel using public transportation. The light-rail travel corridor in which the commuter sample was obtained is shown in Figure 7. Since all respondents were using public transportation, it was assumed that all respondents had experience with this mode. Only completed questionnaires of commuters who met the definition of one of the two comparison groups were included in the final sample. A final total of 77 completed questionnaires were obtained. The questionnaire for this sample was a more compact version of the one used in Study 1. It included the factors in Study 1 with an additional factor of safety.





**Figure 7. Travel Corridor to Downtown Urban Center**

Note: The light-rail stations at which data was collected are indicated by A and B.

## Demographics of Commuter Groups

Among public transportation commuters, 0.54 were male; 0.61 of POV commuters were male. Median education in both groups was an associate degree or some college; 0.27 of public and .21 of POV commuters completed an undergraduate degree; 0.07 and 0.17, respectively, of these travel groups completed a graduate degree. Median income was \$20,000-\$30,000 among public transportation commuters and \$30,000-\$40,000 among POV commuters ( $\chi^2 = 9.348$ ,  $p < .05$ ). As in Study 1, median age was 22-27 for public transportation commuters and 28-35 for POV commuters ( $\chi^2 = 16.208$ ,  $p < .02$ ). Demographics of commuters in this corridor are closer to county medians in education and income than were commuters in Study 1. The greatest differences between commuter groups are the lower median age and income of public transportation commuters.

## Results

Means and standard deviation for importance and satisfaction ratings are shown in Tables 6 and 7.

**Table 6. Ratings of Importance for Factors in Intermodal Work Travel: Means and Std. Deviations**

Factor	Intermodal Public Transport Commuters		POV Commuters	
	M	SD	M	SD
Comfort**	7.091	1.893	6.214	1.595
Cost	8.353	2.521	7.357	2.656
Distance	8.000	2.309	7.893	1.449
Clean**	8.469	1.565	7.500	1.644
Environment	7.688	2.494	6.821	2.001
Wait time	8.147	1.987	7.964	1.895
Travel time**	8.470	1.600	7.393	1.685
Uncertainty	7.807	2.104	7.750	1.993
Safety	7.971	2.646	8.286	1.761

*Note:* “Comfort” is crowdedness and seat comfort; “Cost” is trip cost; “Distance” is distance between residence and location of initial mode, transfer between modes, and final station and work location; “Clean” is cleanliness of mode; “Environment” is the perceived consequence of mode choice by the respondent for the environment; “Wait time” is average time between mode connections; “Travel time” is total travel time; “Uncertainty” is the variance in total travel time; “Safety” is security in commuting.

\*  $p < .10$ , \*\*  $p < .05$

**Table 7. Ratings of Satisfaction for Factors in Intermodal Work Travel: Means and Std. Deviations**

Factor	Intermodal Public Transport Commuters		POV Commuters	
	M	SD	M	SD
Comfort**	6.088	2.598	7.393	1.663
Cost	6.294	2.960	7.321	2.373
Distance	7.032	2.316	7.214	1.475
Clean*	6.424	2.762	7.464	1.478
Environment	6.647	2.838	7.500	1.621
Wait time**	5.781	2.549	7.000	1.721
Travel time	6.206	2.027	6.679	1.541
Uncertainty	6.375	1.879	7.107	1.641
Safety	7.029	2.791	7.429	1.894

*Note:* “Comfort” is crowdedness and seat comfort; “Cost” is trip cost; “Distance” is distance between residence and location of initial mode, transfer between modes, and final station and work location; “Clean” is cleanliness of mode; “Environment” is the perceived consequence of mode choice by the respondent for the environment; “Wait time” is average time between mode connections; “Travel time” is total travel time; “Uncertainty” is the variance in total travel time; “Safety” is security in commuting.

\*  $p < .10$ , \*\*  $p < .05$

## Summed Importance-Weighted Dissatisfaction

As in Study 1, we calculated the measure of importance-weighted dissatisfaction summed across all factors. The definition is:

$$D_j = \frac{[\sum_i (m - S_i) I_i]}{n}$$

Where  $D_j$  is the summed importance-weighted dissatisfaction of the  $j$ th respondent

$m$  is the number of points on the rating scale ( $m=11$ )

$S_i$  is the rated satisfaction with the  $i$ th item

$I_i$  is the rated importance of the  $i$ th item and

$n$  is the number of rated items.

Mean public transportation commuters were higher than POV commuters on this measure of dissatisfaction:  $D_{own} = 27.984$  (SD=8.980);  $D_{pub} = 35.147$  (SD=16.948). Differences in means were statistically significant ( $t=-2.055$ ,  $p<.05$ ).

## Importance-Satisfaction Analysis (ISA): Study 2

Next, we report an ISA as described in Study 1. High importance and satisfaction were again defined as in Study 1. Figure 8 and 9 directly illustrates comparisons between samples on importance and satisfaction, respectively.

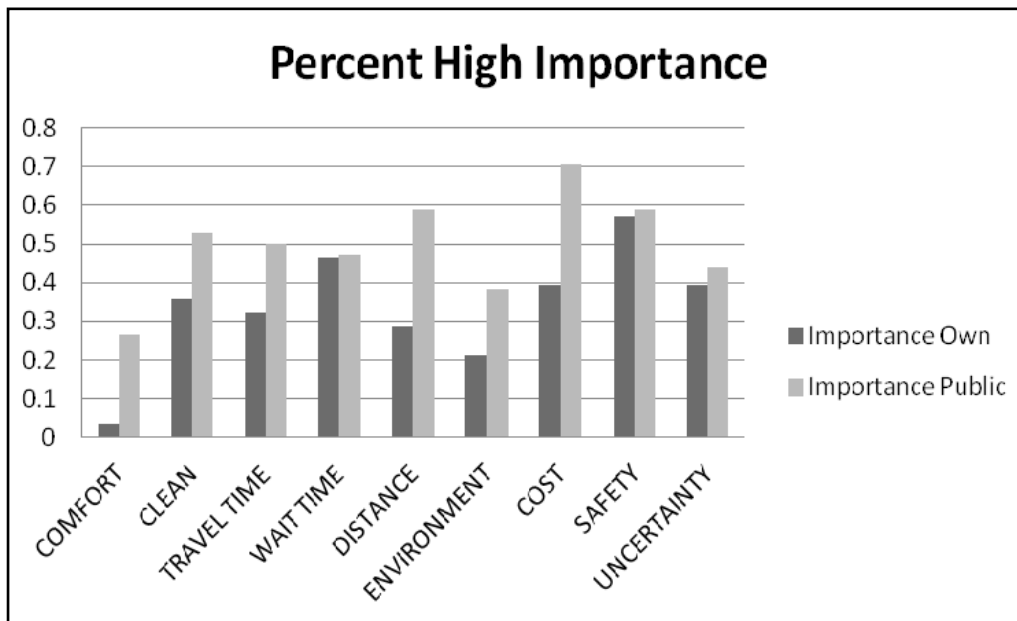
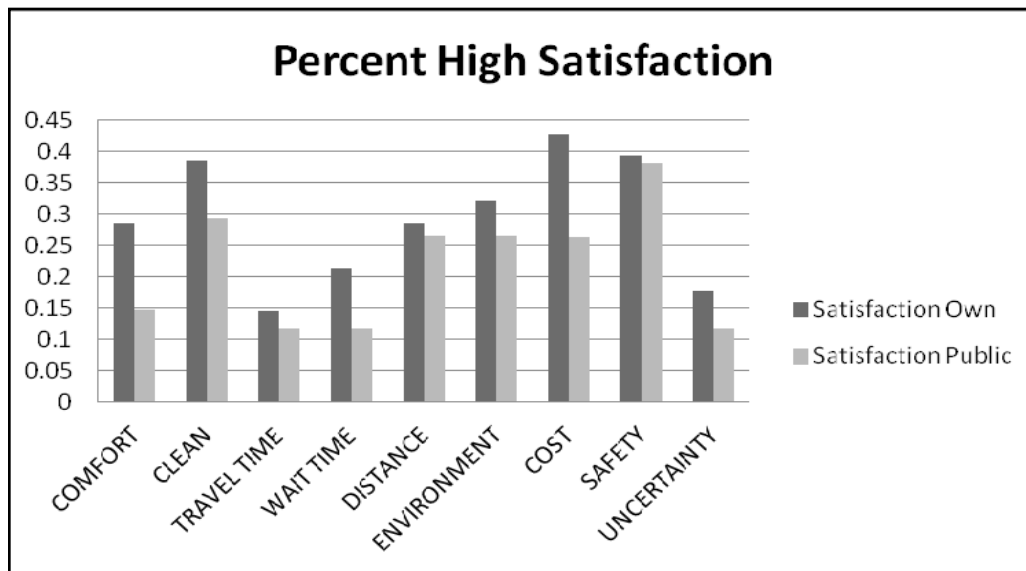


Figure 8. Percent High Importance: ISA Study 2

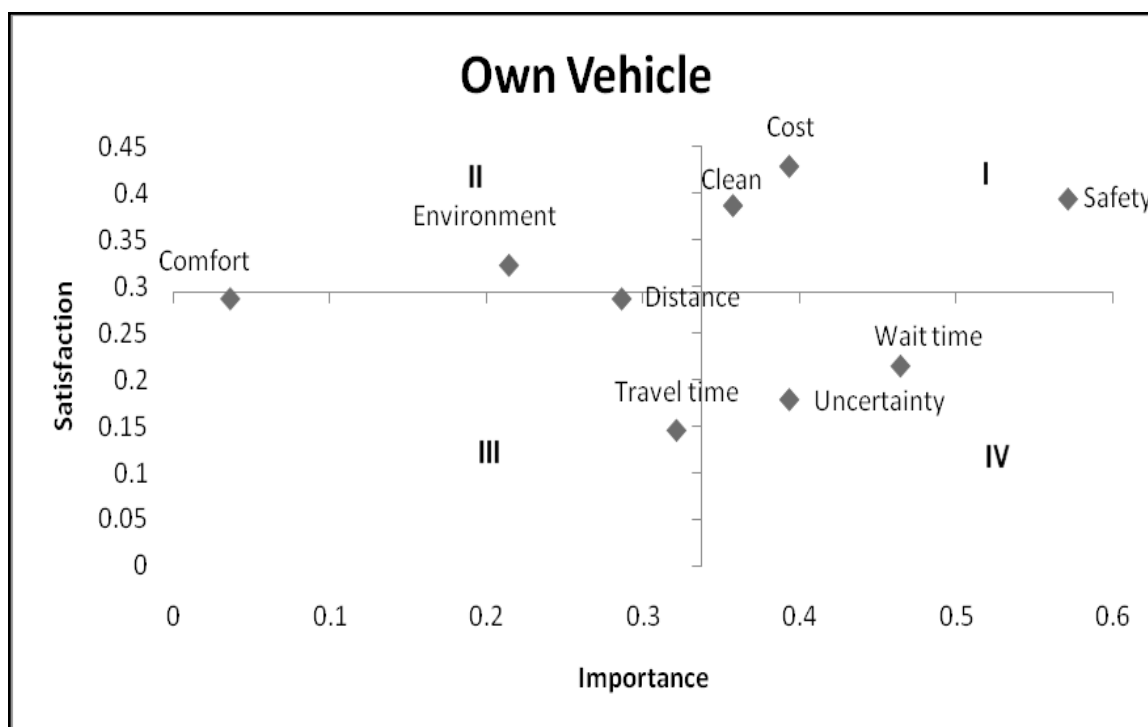
Importance, cost, and distance shows the greatest differences between POV and public transit commuters.



**Figure 9. Percent High Satisfaction: ISA Study 2**

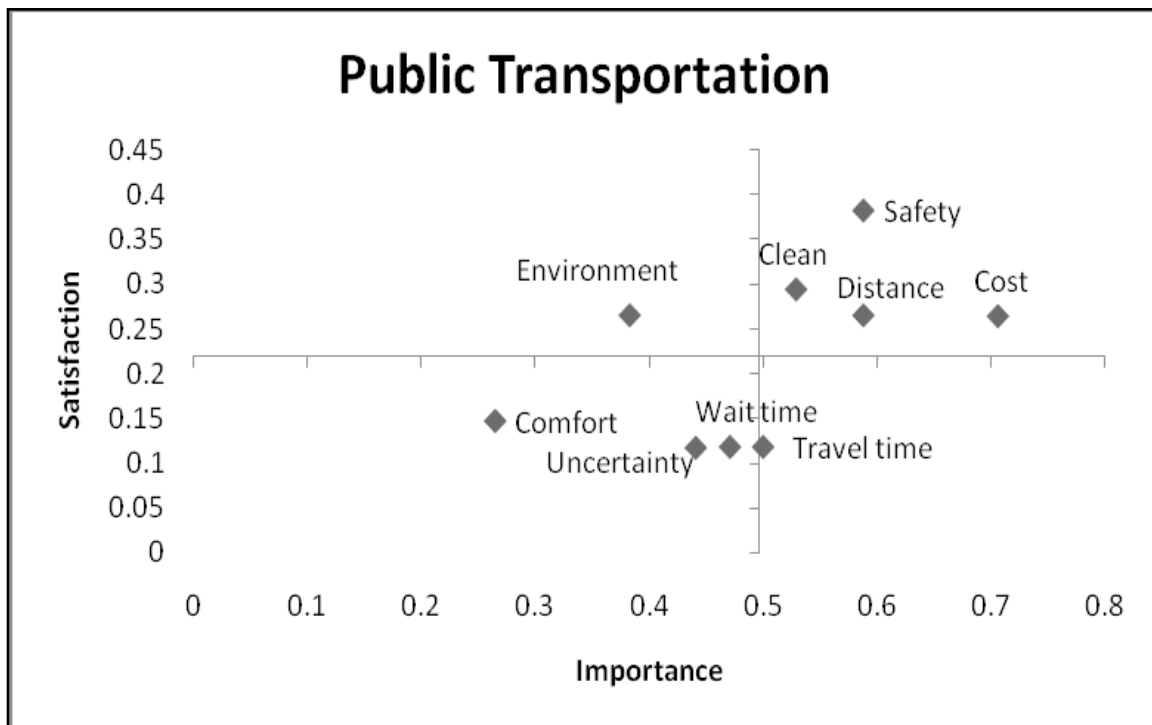
In satisfaction, cost and comfort show the greatest difference between POV and public transit commuters.

The I-S factor spaces were then plotted for each sample. We used the mean importance and satisfaction across all factors to define the origin. Figure 10 and 11 show the I-S space for each sample. The quadrants of the space were used to interpret and compare differences between samples.



**Figure 10. Importance x Satisfaction Factor Space: POV Commuters Study 2**

Wait time and uncertainty are clearly the high importance, low satisfaction factors to POV commuters. Total travel time and distance are low in satisfaction, although lesser in importance than the above factors. It is notable that cost is of high importance in this corridor.



**Figure 11. Importance x Satisfaction Factor Space: Public Transportation Commuters Study 2**

Although none of the factors are located in the low importance, low satisfaction quadrant for public transportation commuters, travel time, wait time, and uncertainty are low in satisfaction and close to the high importance quadrant. This is close to the results for POV commuters. It is notable that cost is even greater in importance and lower in satisfaction among public transportation commuters than it is among POV commuters.

In the comparisons with the High Tech travel corridor where cost was of low importance to both commuter groups, cost is of high importance to both commuter groups in travel to the Downtown corridor among employees in the public service sector. While this may be partly because of differences in median income, it is important to take note of this in the design of offerings.

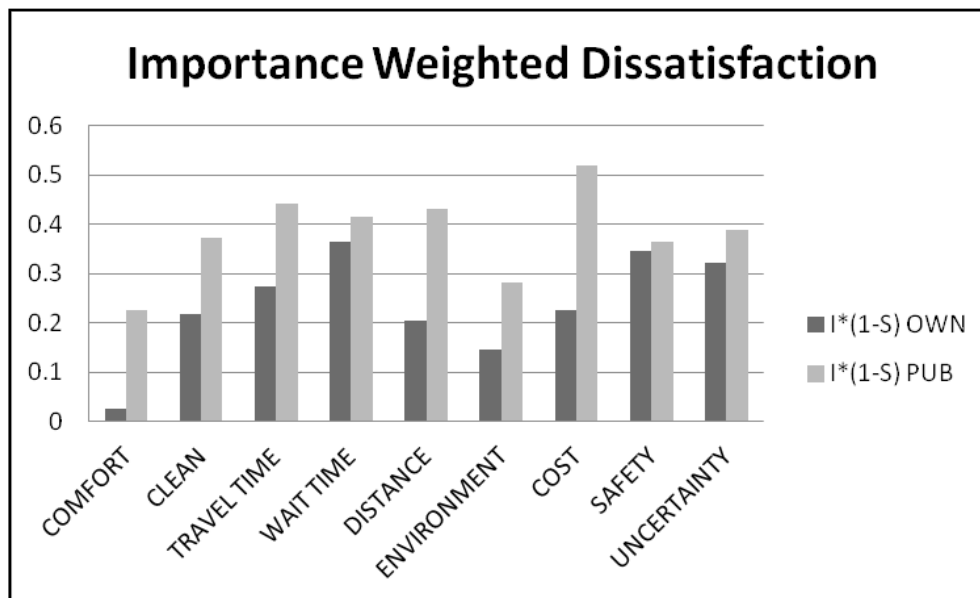
In the corridor with light-rail and bus commuters that has a large proportion of civil service employees, even a nominal fare decrease—such as better combination offers for bus and light-rail or some “travel dividends” program—would appear to be an important factor for increased satisfaction. Here we would suggest that fares be decreased by a dividend or travel point program for commuters rather than by actual fare reduction.

We also note managerial implications of these results that appear to be very different from those inferred in the High Tech corridor of Study 1. Age and income differences in demographics of commuters using the public transportation option in the Downtown corridor do suggest that they are more likely to be taking public transportation out of necessity. When career stability and income increases, this increases the likelihood that they will elect the POV option since they consistently show lower satisfaction than POV

commuters in the study. Focusing on retaining current public transportation commuters is important, as it is generally more expensive to convert non-users to users than to retain current users.<sup>24</sup>

### Importance-Weighted Dissatisfaction

As previously noted, a limitation of traditional ISA is that the boundaries between high and low importance and satisfaction do not reflect the relative weights of these judgments in overall choice. We report a combined measure of the importance-weighted dissatisfaction as a composite judgment to supplement the ISA, as in Study 1.



**Figure 12. Importance-Weighted Dissatisfaction: Study 2**

To public transport commuters, cost is clearly highest in importance-weighted dissatisfaction and shows the largest difference between POV commuters and public transport commuters. It is distinctly higher than any other factor including uncertainty, distance, and travel time. For POV commuters, cost is less important than travel time, safety, and uncertainty. These results emphasize the importance of low cost to public transport commuters in this corridor, and again suggest its priority over comfort, uncertainty, distance, and travel time.

The results for this corridor are in direct contrast to the results in the High Tech corridor where importance-weighted dissatisfaction was considerably higher for wait time and travel time. As noted in the High Tech corridor, increasing price to offset increases in services that reduce uncertainty, travel time, and distance may be justified for both POV and public transportation commuters. In this corridor, the opposite may be true for public transportation commuters.

## Factor Analysis of Ratings

Finally, we directly explore dimensionality in the ratings with principal component analysis. For importance, a varimax rotation converged in five iterations. We obtained a three factor solution. The first factor accounted for 43.6% of total variation in importance, and is made up of safety (0.816), cost (0.805), environment (0.711) and distance (0.639). The second factor accounted for 14.3% of total variation in importance, and is made up of time-related variables—wait time (0.849), uncertainty in total travel time (0.806), and total travel time (0.695). The third factor accounted for 13.6% of total variation in importance, and is made up of comfort (0.826) and cleanliness (0.804). For satisfaction, a varimax rotation converged in three iterations. We obtained two factor solutions. The first factor accounted for 54.8% of total variation in satisfaction, and is made up of cleanliness (0.884), environment (0.861), safety (0.853), comfort (0.845), cost (0.788) and wait time (0.691). The second factor accounts for 18% of total variation in satisfaction, and is made up of uncertainty (0.849), distance (0.782), and total travel time (0.767).

Mean scores from the PCA for importance were consistently higher for public transportation commuters  $IMPTM1_{pub} = .024$ ,  $IMPTM1_{own} = -.027$ ;  $IMPTM2_{pub} = .084$ ,  $IMPTM2_{own} = -.093$ ;  $IMPTM3_{pub} = .350$ ,  $IMPTM3_{own} = -.388$ ). Only the difference in factor 2 (comfort and cleanliness) was statistically significant,  $t = 3.03$ ,  $p < .01$ .

Mean scores from the PCA of rated satisfaction were consistently lower for public transportation commuters ( $SATM1_{pub} = -.168$ ,  $SATM1_{own} = .186$ ;  $SATM2_{pub} = -.110$ ,  $SATM2_{own} = .121$ ). The differences in satisfaction for factor 2 (distance, uncertainty, and travel time) were marginally significant ( $t = 1.41$ ,  $p < .10$ ).



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### III. SUMMARY AND DISCUSSION

#### OVERVIEW

Three studies of intermodal commuting to work are reported in this publication. Results of these studies differ from most available studies of urban commuters in both the study samples and the design. First, we limit our regular sample to *intermodal commuters*. It is important to study this sample exclusively since in many corridors of urban areas, work travel on public transport is primarily intermodal. Second, we limit our sample to *regular work commuters*. Although this is a relative small proportion of all commuters, the regularity in their trip time and consistency in their travel makes them important as a study sample. Third, we report direct *comparisons of POV commuters and public transport commuters* in both questionnaire studies.

We briefly noted results of the first study. This was in focus group studies of POV commuters who were experienced with the public transport alternative, and complements previous studies of public transport work commuters. These studies together with relevant background studies were used to define factors in the closed-end questionnaires. More detailed analysis of the POV focus group study results are reported in the Appendix A.

The two questionnaire studies that we report measured both importance and satisfaction in work commuters who have an intermodal alternative. Our first study details results from work commuters to high tech firms in a corridor at the center of Silicon Valley in Santa Clara County, California. These are predominantly commuters who have multi-bus intermodal alternatives. In demographics, these commuters tend to have higher educational and income levels than the sample in the second travel corridor we studied, and in the rest of the county. Although POV commuters tend to have higher education and income levels and are younger than public transportation commuters, the differences are relatively small and not statistically significant.

The corridor in the second study we report is limited to work commuters to a downtown city location in Santa Clara County. San José is the largest city in the county. A diverse assortment of city, state, and federal offices, as well as other service offices, are major employers in this location. Intermodal commuters in this corridor predominantly use light-rail and bus. Median income and educational level is lower in this corridor than it is in the High Tech corridor. In the Downtown corridor, POV commuters again tend to have higher educational and income levels, and are younger than public transportation commuters. The difference in median age and income categories between public transportation and POV commuters in this category is statistically significant with public transportation commuters in a lower median income category.

The importance and satisfaction judgments of commuters in the two studies are first interpreted independently since the mode combinations and demographics of the commuter samples differ. Each study provides contextualized information on commuters of the respective mode combination in intermodal work travel within a defined travel corridor. These studies show that differences in commuters and in mode offerings across corridors in close geographical proximity can have very different implications for optimizing design.

We will note managerial implications of both studies and compare some differences across the mode combinations with appropriate qualifications.

The results are analyzed by taking into account both importance and satisfaction judgments—importance-satisfaction analysis (ISA). We also calculate a combined measure of importance-weighted dissatisfaction as a composite of factors that have the most overall impact on commuters. The importance-weighted dissatisfaction measure assumes that the combination of these two judgments is managerially relevant. Our results on satisfaction with the public transportation alternative are in multiple measures. In Study 1, these are (1) an overall rating of satisfaction, (2) a score from principal component analyses of satisfaction ratings, and (3) an overall rating of importance-weighted dissatisfaction summed across each of the travel factors that are studied. In Study 2, these are in (1) a score from principal component analyses of satisfaction ratings and (2) a summed rating of importance-weighted dissatisfaction.

Across both studies, the important factors were similar for both public transport commuters and POV commuters, with travel time, distance, and uncertainty being the most important. Satisfaction with factors in public transportation were also similar across studies, though POV commuters were significantly less satisfied with anticipated travel time than were actual public transportation commuters.

However, other results in these studies evidenced important differences. In the travel corridor to high tech companies, public transportation commuters were generally more satisfied with transit than POV commuters, who were reporting their perceptions of commuting by public transportation. In contrast, public transportation commuters in the corridor to a city center were generally less satisfied than POV commuters. Whereas public transportation commuters in the High Tech corridor were most dissatisfied with distance and time, public transportation commuters in the Downtown corridor clearly were most dissatisfied with total travel cost. A more detailed summary of these results will follow, along with the managerial implications.

## **RESULTS**

### **Focus Group Study**

Results of the focus group studies of POV commuters were used to compare the factors they identified to those identified in previous studies of public transportation commuters. The POV participants were selected from commuters who had enough experience with public transportation to offer informed judgments on the service. As in the previous focus group studies, their discussions were directed to topics of most burdensome, least burdensome and most important to improve.

Video recordings of the discussions were transcribed and coded into organizing factors with Atlas  $t_i^{25}$  to heuristically define a hierarchical organization of the factors. Although the organization and detail of discussions differed, results of the set of focus groups with both public transportation and POV commuters did indicate common factors that could be used in the design of closed end questionnaires. A pre-test showed that the measurement of

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the factors evidenced adequate reliability and interpretable differences between POV and public transportation commuters.

## **STUDIES OF INTERMODAL WORK COMMUTERS**

### **Study 1: High Tech Corridor**

In the results of Study 1, with a sample of work commuters who faced a multiple bus combination in travel to a center of high tech companies, most factors were rated as more important, but less satisfactory by the POV commuters than by the regular public transportation commuters. The largest differences in importance between POV and public transport commuters were in uncertainty, travel time, and distance (*defined as*, distance from residence to the initial transit mode, between the interface of transit modes, and from final stop to work location). POV commuters rated all of these factors more important, and they were also less satisfied with each of these factors.

The largest differences between user groups were in distance, cost, and travel time. That is, POV commuters were less satisfied with their judgment of what that alternative offered in these factors. Directly calculating an importance weighted dissatisfaction measure across the factors, we find that importance-weighted dissatisfaction is also greater in distance uncertainty and travel time for POV commuters than for public transportation commuters. As anticipated, correlations between the multiple measures of satisfaction were highly significant ( $p < .01$ ).

In ISA, results indicated that for POV commuters, travel time, uncertainty, and distance in the public transportation offering were factors of high importance and low satisfaction. In public transportation commuters' ratings, wait time was clearly the factor identified in this quadrant with cleanliness and uncertainty closest as lower satisfaction factors to the boundary of the quadrant with high importance.

### **Study 2: Urban City Center Corridor**

In Study 2, with a sample of work commuters who faced a light-rail and bus combination, most factors were rated as more important, but less satisfactory by commuters who used public transportation. The differences of largest magnitude in both importance and satisfaction were in cost, total travel time, and distance. Directly calculating the importance-weighted dissatisfaction measure, we found that public transportation users had significantly higher summed scores on dissatisfaction than did POV users. The correlation between measures of satisfaction was again highly significant ( $p < .01$ ) and showed corresponding differences in the same factors across user groups. In the measure of satisfaction, cost showed the largest difference between POV and public transportation commuters in this corridor.

In ISA, the greatest difference in rated importance between commuter groups was in cost and distance. Cost and comfort showed the largest differences in rated satisfaction. In the quadrant of high importance, which is managerially relevant, low satisfaction, uncertainty, and wait time were the main factors among POV commuters. For these commuters, total travel time was rated as low satisfaction and close to the boundary of the high

importance quadrant. Among public transportation commuters, total travel time, wait time, and uncertainty were rated low in satisfaction and at or close to the boundary of high importance.

### **Cross-Study Comparisons**

As initially noted, the studies that we report differ in mode combinations, and commuters in the study samples show demographic differences. Nevertheless, the differences in results in the comparisons across both public transportation commuters and POV commuters in each sample suggest that independent studies of travel corridors with different mode alternatives can be informative even when they are within the same county and in close geographical proximity. In many previous studies, commuters in counties with what may well be heterogeneous travel corridors have been studied as common entities across the county corridors.

As noted, commuters, age, and income of the sample of public transportation commuters in the urban city center we studied suggests that they may travel more out of necessity (for example, an absence of perceived feasible alternatives). In the higher tech travel corridor, demographic differences between POV and public transportation commuters are smaller. In this corridor, public transportation commuters are more likely to be long-time commuters who have more discretion in choice of travel mode than their counterparts in light-rail commuters to the Downtown corridor we have studied.

In the Downtown corridor with light-rail service, commuters who use intermodal public transportation, whatever their demographics are less satisfied. The dissatisfaction with cost among public transportation commuters may be biasing their judgments downwards. While in both corridors, total travel time, uncertainty in total travel time, and wait time are of high importance to each of the commuter groups, as they are in results of a range of previous studies of public transportation commuters,<sup>26,27</sup> the ISA and importance-weighted dissatisfaction measure indicated that cost was of predominant importance to public transportation commuters and was the basis for the largest differences in satisfaction between the commuter groups in this corridor.

### **Managerial Implications**

The managerial implications of the results for the two travel corridors differ. Again, the differences between travel corridors in close geographical proximity suggest that even local segmentation of travel markets can be important to designs that increase overall satisfaction. In the travel corridor to high tech companies, public transportation commuters continue to use this option when they are further into their careers and are less limited by income. This suggests a large stable user base. Total travel time, distance from their residence to the appropriate station, distance in mode interface, and/or distance from the closest station to their workplace are the basis of greatest dissatisfaction. The ISA indicates total travel time, uncertainty in total travel time, and distance to also be the high importance factors with lowest satisfaction.

Since cost appears to be lower in importance and higher in satisfaction to both POV and public transportation commuters, the managerial implication may be to increase frequency of vehicles and modify routing, increasing fares moderately to offset the cost. Converting POV commuters to public transportation users in this travel corridor appears to be a more difficult undertaking since dissatisfaction appears to be across many more of the factors. Explicitly communicating that the basis for any fare increase is to increase service would be important for employees in this corridor.

For the travel corridor to the Downtown corridor that was and commuters groups that appear to be earlier in their careers and generally have lower levels of educational attainment and income, implications are very different. The demographics of commuters by public transportation suggest that they are more likely to be taking this option out of necessity. When career stability and income increases, this increases the likelihood that will elect the POV option since they consistently show lower satisfaction than POV commuters in the study. Focusing on retaining current public transportation commuters is important, as it is generally more expensive to convert non-users to users than to retain current users.<sup>28</sup>

In implications for converting POV commuters to public transport commuters in the Downtown corridor, the factors of travel time, uncertainty, and wait time appear to be the most relevant. Cost is clearly of the greatest importance to the public transportation commuters in this travel corridor. Any fare deduction is a challenge given budget constraints. For public transport commuters in this corridor, lowering cost through forms of travel point accumulation (as with airline travel) that can be used to offset subsequent fares, appears to be a managerial application that merits consideration. Travel point programs directly target regular users of public transportation and have lower provider costs than a general fare decrease. Given externalities in environment and road-related maintenance that are introduced by POV commuters, maintaining a satisfied user base of public transportation commuters is increasingly important as a policy objective.



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## IV. CONCLUSIONS

Increasing the use of public transportation in work travel continues to be a challenge in the face of cost constraints. When compared to a large literature of results that are predominantly from single mode commuters, our studies suggest the challenge is increased when travel is intermodal. In most previous studies, public transportation commuters have been grouped together whether or not travel is intermodal. Results for intermodal travel were found to have similarities in factors, but important differences from results that have been reported for single mode travel in the effects of interfacing on wait time, total travel time, and uncertainty. At the least, this implies that there should be greater contrasts between single mode and multi-mode commuters in large scale studies. The results we report also underscore the importance of assessing demographic differences and contrasts in commuter judgments across travel corridors, even when they are in close proximity in the same county.

As now well recognized, studies of satisfaction in conjunction with reported importance of factors can be important managerial guides to design modification in the case of intermodal travel. Our results suggest significant differences in judgments between commuters within a corridor and across the travel corridors we studied. As noted, these differences are likely to be driven by differences in the location of employers and related demographic differences between commuters in the corridors. Whatever the basis for the differences, they do suggest that designs of the corridors may have different priorities. We have discussed explicit managerial implications of the studies from the data analyses.

Finally, the methodology of most reported studies of work travel and the one implemented in these studies merits comment. Direct ratings and ranking methods that dominate in almost all studies of public transport commuters have limitations in higher correlations between factor ratings or rankings and the absence of constrained trade-offs between factors. Methodology to improve these limitations has been used in a few instances,<sup>29,30,31,32</sup> and merits being more generally applied in the samples and user comparisons we make. The studies we report can be extended with available methodology that can better indicate the actual trade-offs that commuters would make.

The future of public transportation usage has great significance to the cost and quality of life in urban areas. It also ultimately matters to employers making location decisions. A range of studies and the studies we report indicate the contributions that direct study of work commuters can offer to design and management to retain and increase usage of public transportation alternatives. Substantive and methodological bases to increase the quality of information in support of this are suggested.





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## APPENDIX A: FOCUS GROUP STUDIES OF POV COMMUTERS

The POV participants were selected from commuters who had enough experience with public transportation to offer informed judgments on the service. As in the previous focus group studies, their discussions were directed to focal topics of most burdensome, least burdensome, and most important to improve. Results of the focus group studies of POV commuters that we report here were used to compare the correspondence of factors between them and the public transportation commuters.

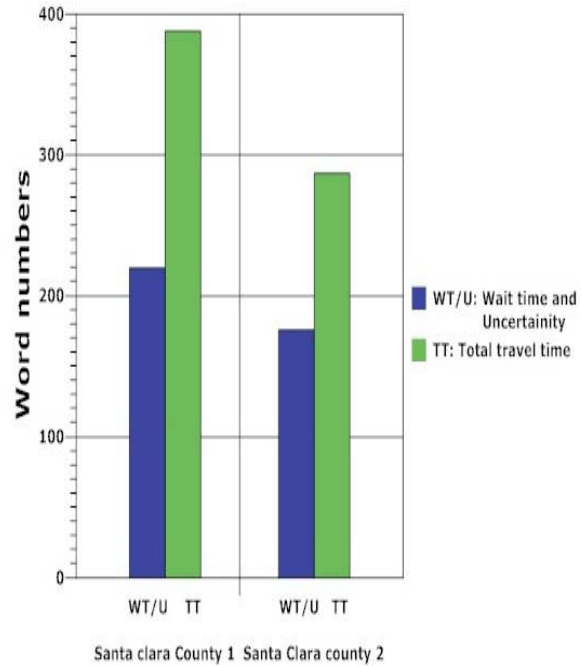
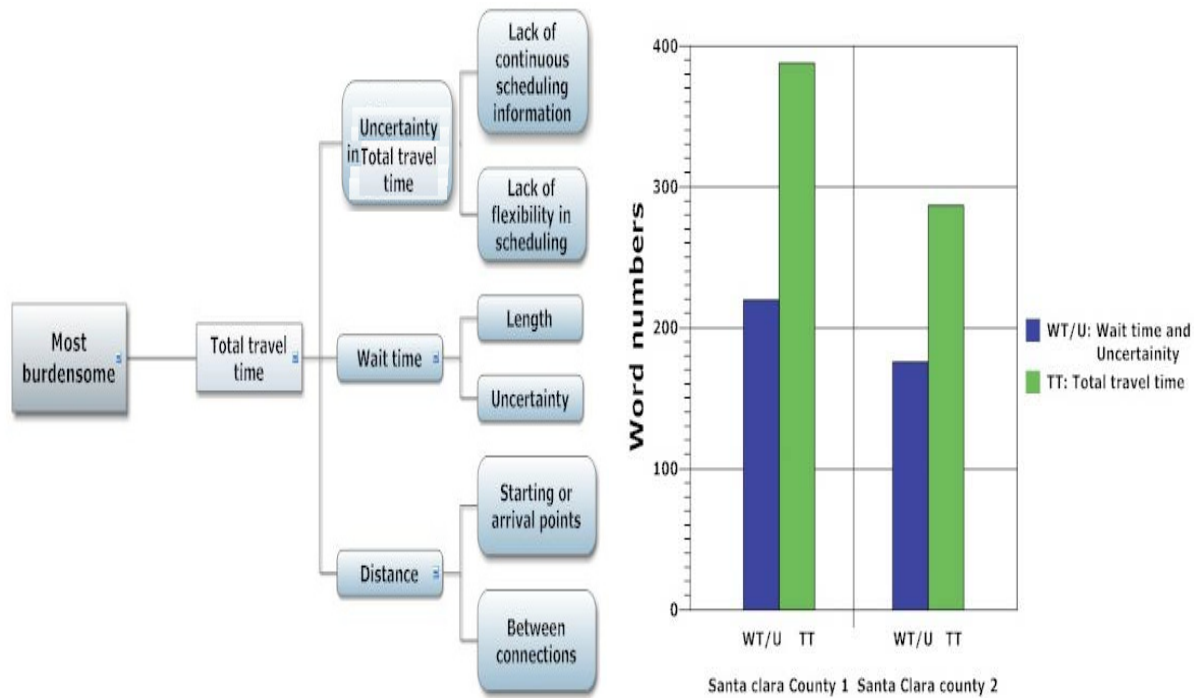
Transcripts of the focus group sessions were analyzed with software for coding and categorizing qualitative data (Atlas  $t_i$ ).<sup>25</sup> The analysis used qualitative definitions of factors in Atlas  $t_i$  to generate word counts. These counts are conservative in that only on-topic discussion directly related to discussion questions was included. Analytical hierarchy process<sup>33,34</sup> methodology was used to hierarchically decompose an exhaustive list of the factors identified in the transcripts. For each focus group, the study's author reviewed both line and word counts generated in Atlas  $t_i$ . Within each of the discussion topics of "most burdensome," "least burdensome," and "recommend/use more," factors were categorized into the tree organization of sub-factors shown in Figures A.1, A.2 and A.3. Comparable figures for public transportation commuters in intermodal commuting to work in the county studied and a nearby county have been reported.<sup>35</sup> In the figures, Santa Clara County 1 is High Tech and Santa Clara County 2 is Downtown.

In general, the hierarchical decomposition of POV commuters was less elaborate than the ones reported for public transportation commuters. This may be because regular commuters of public transit are more familiar with the factors and differentiate them in greater detail. The majority of identified factors are common to both POV and public transit commuters.

### MOST BURDENSOME

Within this main grouping factor, first order sub-factors were organized by factors related to trip time and distance—between transportation modes and/or distance from home to the first mode, and from the final mode stop to work. The second order sub-factors elaborated on these initial factors—the length and uncertainty of wait time in connections between modes.

From a qualitative review of the POV focus groups' transcripts, uncertainty in intermodal public transportation was seen as notably irksome for many of the participants, since arriving late to work is not an option. In contrast, arriving early was seen as having a small benefit, but generally made necessary because of the large variance in connection wait times. In discussing uncertainty in trip time, the lack of continuously shared information on scheduling, and managerial flexibility dispatching vehicles were discussed separately as underlying factors for the high uncertainty intermodal commuters face in wait time. This is reflected in the hierarchical order in the organizational schematic.



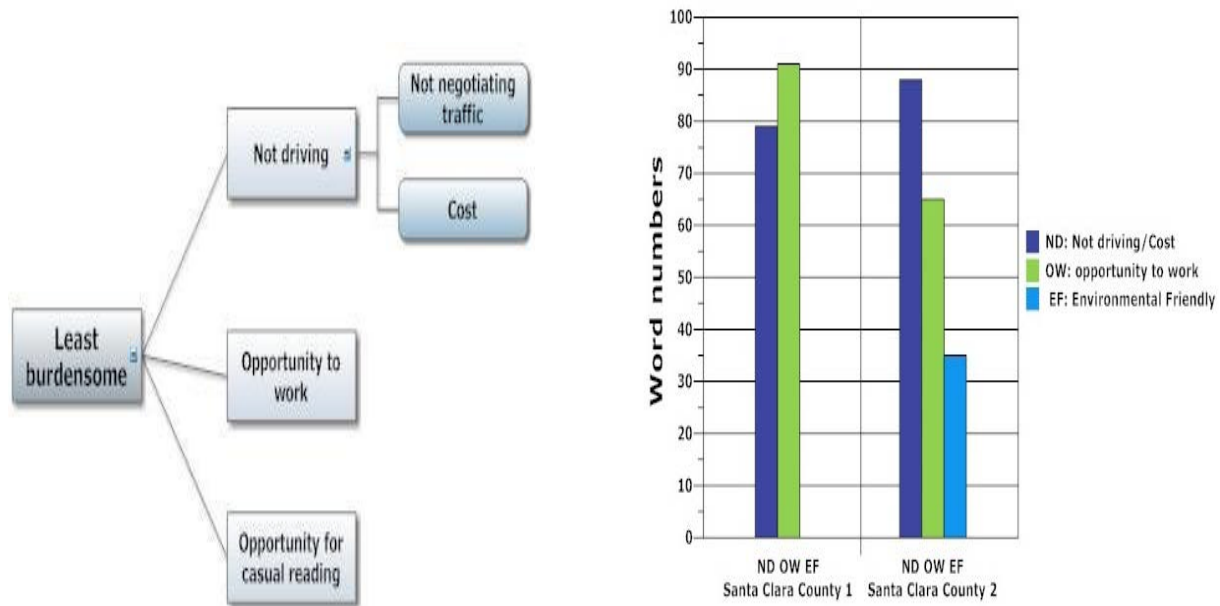
Organizational schematic of grouping topics

Number of words by grouping topics

**Figure 13. Organizational Schematic of POV Commuter Focus Group Discussions: Most Burdensome**

**LEAST BURDENSOME**

The principal sub-grouping factors for discussion in the least burdensome category were in consequences of not driving, opportunity to work while riding in a transit vehicle, or to engage in leisure activities such as casual reading. Not driving was further discussed in terms of not negotiating traffic and reduced cost.



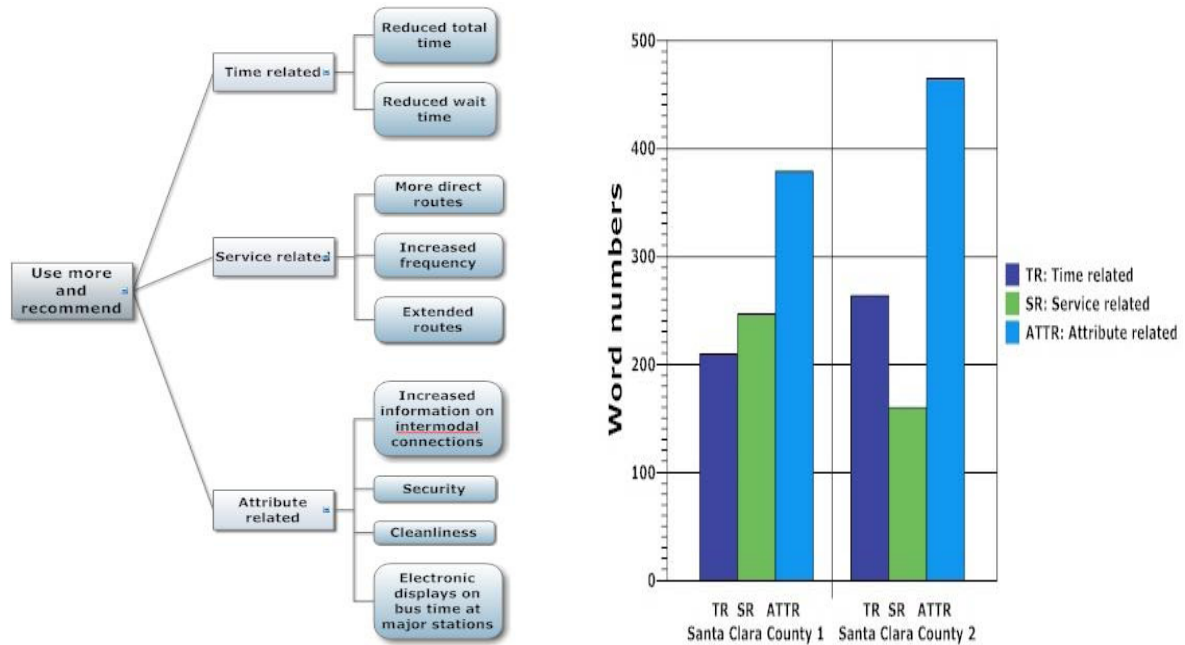
Organizational schematic of grouping topics

Number of words by grouping topics

**Figure 14. Organizational Schematic of POV Commuter Focus Group Discussions: Least Burdensome**

## USE MORE/RECOMMEND

In the discussion of factors that would increase the use of intermodal options by work commuters and general recommendations to facilitate this goal, the first order grouping factors were time related, service related, and attribute related. Time related was further divided into total and wait time. Service related was decomposed into factors on directness of route and frequency. Attribute related included those related to necessary factors such as cleanliness and information display.



Organizational schematic of grouping topics

Number of words by grouping topics

**Figure 15. Organizational Schematic of POV Commuter Focus Group Discussions: Use More and Recommend**

Factors identified in previously reported focus groups and the results we report here provided the basis for a common set of factors in closed end questionnaire studies of public transportation commuters and POV commuters in commuting to work.

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## 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.



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