Perceptions of Comfort, Convenience, and Reliability for the Work Trip

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This research uses perceptual mapping techniques to examine the influence of comfort, convenience, and reliability on the travel behavior of work travelers. Several studies have examined these variables individually, but no research has yet been performed that considers the use of all three notions in the context of one study so that the joint effect of these variables can be analyzed. A self-administered survey was distributed among work commuters in the northern suburbs of Chicago to collect the perceptual data needed to perform this analysis. By use of factor analysis, preference regression, and first-preference logit models, several conclusions were reached: (a) People do not perceive comfort, convenience, and reliability as independent variables in selecting their mode of travel to work. Significant overlapping of these variables occurs in the public's perception of these notions. (b) Travelers do not perceive the comfort, convenience, and reliability of access and main modes in the same fashion. Each mode was perceived differently by the respondents. Thus, the use of a combined perceptual space to represent the underlying dimension for line-haul and access modes may lead to erroneous results. (c) Preference regression and first-preference logit modeling lead to almost identical results. Despite slightly higher estimation costs, the use of first-preference logit is recommended because of more efficient estimation properties.

Considerable ongoing research effort has been in the area of mode-choice analysis in the field of travel-demand forecasting. Large strides have been made to improve modeling and forecasting procedures. As the drive for better understanding and improved models progresses, the need for inclusion of qualitative variables in travel-demand models has become evident. In recent years, researchers have examined work in the modeling of the choice processes performed by psychologists, sociologists, and marketing researchers in order to incorporate their results into travel-choice modeling efforts. One approach that has shown great promise is the use of perceptual data and analytical techniques from experimental psychology and marketing methods. These techniques allow the model builder to use qualitative, nonmetric information in a quantitative, metric context and allow the use of subjective variables such as comfort, convenience, and reliability in travel-behavior models.

This research uses perceptual mapping techniques to examine the influence of various aspects of comfort, convenience, and reliability on the travel-to-work behavior of commuters. The major focus of this study is the way in which individuals perceive these aspects for their work trips. Several studies have used those aspects that relate to one of these dimensions individually, but no research has yet been performed that considers the use of all three notions in the context of one study so that the joint effect of these variables can be examined.

A self-administered survey was distributed among work commuters in the northern suburbs of Chicago to collect the perceptual data needed to perform this analysis. By use of factor analysis, preference regression, and first-preference logit models, it was discovered that people do not perceive comfort, convenience, and reliability as independent variables in the selection of their mode of travel to work. Significant overlapping of these attributes occurs in the public's perception of these abstract concepts.

BACKGROUND

Several recent research efforts have employed attitude-scaling techniques in an attempt to quantify the notions of comfort, convenience, and reliability for use in travel-behavior models. Nicolaidis investigated the influence of comfort in individual mode-choice models of the work trip (1). By use of psychometric scaling procedures, a comfort index was derived and used, along with travel time and cost, in the models. These models were found to be statistically significant, and the comfort index added to the explanatory power of the models.

At the same time, Spear studied the effect of a generalized convenience variable in a mode-choice model of the work trip (2). Binary (automobile versus transit) logit models were developed, by using travel time, travel cost, and the convenience variable. The convenience variable was highly significant in all models.

The most recent work was performed by Prashker (3). He investigated the effect of a reliability variable in mode-choice models of the work trip. Multinomial logit mode-choice models were constructed by using travel time, travel cost, and reliability performance measures, which were derived by using psychometric scaling techniques. In all models, the reliability performance measures were statistically significant. The explanatory power of the models was increased by using the reliability variable.

The results from these studies demonstrate the need to include qualitative variables in travel-behavior models. Individually, comfort, convenience, and reliability add to the explanatory power of the models; however, no study has been performed that examines the joint effect of these concepts. This study hopes to fill in some of this gap.

METHODOLOGY

To most individuals, the terms comfort, convenience, and reliability are ambiguous. It is, therefore, necessary to collect less ambiguous information about service characteristics. One method that enables this to be done is to represent each qualitative concept by a small set of nonambiguous attributes, each of which describes some facet of the concept.

Our research uses attributes to define the concepts of comfort, convenience, and reliability.

Variable	Attribute
Comfort	Protection from weather
	Cleanliness of vehicle and station
	Fatigue felt when traveling
	Control of immediate surroundings
	Feeling of personal safety
	Feeling of privacy

Variable	Attribute
Convenience	Transfers required
	Stops required
	Frequency of service
	Accessibility to means of travel
Reliability	Variability of travel time
	Waiting required
	Likelihood of accident or breakdown
	Influence of weather on travel time
Performance	Speed of vehicle
	Total travel time
	Cost of use means of travel

The small number chosen for each variable represents an attempt to keep the length of the questionnaire reasonable. In addition, three attributes that deal with objective performance measures were included to complete the set of attributes considered important for an individual's travel behavior.

This research was designed to obtain individual ratings of the various stimuli (modes) on each of 17 attributes. The use of semantic scales to gain the information proved effective in two of the recent projects (1, 3) and was adopted for use in this research.

Two techniques were considered for analysis of the responses—multidimensional scaling and principal components factor analysis with rotation. Two recent studies that compared multidimensional scaling methods (INDSCAL) and factor analysis as techniques for analyzing perceptual data (3, 4) indicate that both approaches yield consistent results. However, factor analysis did so more easily and at a lesser cost in computer time. Also, in one study, factor analysis provided better interpretation of the dimensions of the perceptual space (4). Hence, factor analysis, with rotation of the factors, was used in this research.

The definition of the attitudinal variables is similar to that used in the earlier studies. Three perceptual spaces were constructed, one for access modes, one for main modes, and the last for all modes together. This is done to test the assumption made by earlier researchers that individuals perceive access and main modes in the same way. Preference models are constructed in two ways. One uses variables from the separate main- and access-mode spaces, and the other represents both main and access modes in a single perception space.

Factor analysis provides a set of factor scores for each stimulus for each individual. These factor scores are the coordinates of an individual's rating of the stimulus in the perceptual space. In this study, the coordinates of the stimuli in the perceptual space are included as separate variables in the models. Values are assigned to each perceptual dimension of each mode (both access and line-haul) for each individual.

These variables were used as input to a set of preference models in an attempt to uncover the importance associated with the dimensions in the perceptual spaces. Two types of models were estimated: preference regression and first-preference logit (4). Comparisons were made between the spaces of the separate and combined modes for both model types. Further details of the methodology may be found elsewhere (5).

Table 1. Distribution and response characteristics.

Mode	Distribution Number	Distribution Percent	Usable Returns Number	Usable Returns Percent
Commuter rail	649	45	76	43.7
El or subway	497	35	71	40.7
Automobile	294	20	27	15.6
Total	1440	100	174	100.0

SURVEY DESIGN AND SAMPLE STATISTICS

The survey was conducted in the cities of Evanston and Wilmette among commuters to downtown Chicago. Although this area is biased toward the higher levels of education and income, these biases were not thought to be harmful to this study since the research is exploratory in nature and not intended for policy formulation or total generalization, so that a representative sample is not required.

Three major modes exist for travel from Evanston and Wilmette to downtown Chicago: commuter rail, elevated rapid transit, and automobile. To ensure that each of these alternatives was represented in the sample, the surveys were distributed at commuter rail and elevated train stations in the Evanston and Wilmette areas in proportion to their morning peak-period demand, and at parking garages in the Chicago central business district (CBD). The survey was distributed in December 1976. The number and percentage of usable returns by each of the alternative main modes are presented in Table 1. The distribution procedure allowed a good representation of all three main modes in the sample. Thirty-six percent of the 484 surveys returned were usable. Only 12 percent of the 1440 surveys sent out were returned and usable.

The survey form consisted of four parts. The first part deals with the actual behavior of the respondent: time of travel, mode used, and a carpool question. The second part constituted the attitudinal portion of the survey. Three types of questions are asked in this section. The first type deals with the individual's preferences for a travel mode to work. The preference data are used to develop the preference model that provides the importances of the dimensions of the perceptual space. The second type deals with the importance of each attribute in the choice of travel mode to work. The last type is the most important in the entire survey, and also the most complicated. The respondent is asked to rate each access and main mode on each of the attributes on a seven-point scale. The modes are divided into the access and line-haul segments because it was felt that these portions of a trip to work might be perceived differently and that their importance in preference and choice might also be different.

The third part of the questionnaire deals with the collection of disaggregate travel times and travel costs. This part is divided into three sections, one for each of the main modes of travel to downtown Chicago: automobile, commuter train, and elevated rapid transit. For each mode of travel, the respondent is requested to answer the questions in that section as if he or she used that mode of travel for the work trip. In this way, everyone answers the questions in the same context. The fourth part collects the standard demographic data used in most transportation-planning studies, including age, sex, income, and automobile ownership.

The demographic statistics of the total sample are presented in Table 2. It can be seen that the expected representation of higher levels of education and income is obtained. In addition, the majority of the respondents report high-status occupations.

ANALYSIS

By use of the 174 usable observations, various perceptual spaces were constructed and evaluated by use of factor analysis, preference regression, and first-

Table 2. Demographic characteristics.

Characteristic	Percent	Characteristic	Percent
Sex		Occupation	
Male	75.6	Professional or technical	52.3
Female	24.4	Manage or administrate	22.6
Age		Sales	6.6
<20	0.9	Clerical	5.5
20-29	27.0	Service	2.1
30-39	24.0	Other	10.9
40-49	19.6	Length of residency	
50-59	17.8	<1 year	14.0
≥60	10.7	1-5 years	37.1
Education		6-10 years	15.6
High school	4.4	>10 years	33.3
College	54.7	Marital status	
Graduate level	32.6	Married	72.6
Other	8.3	Not married	27.4
Income		Automobile ownership	
<$5000	3.5	0 per household	4.4
$5000-$15 000	28.4	1 per household	57.8
$15 000-$25 000	36.5	2+ per household	37.8
$25 000-$35 000	17.1	Driver's license	
>$35 000	14.6	Yes	96.6
		No	3.4

Table 3. Four-factor perceptual space.

Measure	Attribute
Access mode	
1. Reliability, on-time performance	Number of stops required
	Frequency of service
	Accessibility to means of travel
	Cost to use means of travel
	Variability of travel time
	Waiting required
	Influence of weather on travel time
	Number of transfers required
2. Time and effort	Protection from weather
	Fatigue felt when traveling
	Total travel time
	Speed of vehicle
3. Comfort	Cleanliness of vehicle and station
	Feeling of personal safety
	Likelihood of accident or breakdown
4. Personal autonomy	Control of immediate surroundings
	Feeling of privacy
Main mode	
1. On-time performance	Fatigue felt when traveling
	Total travel time
	Number of stops required
	Speed of vehicle
	Feeling of personal safety
	Variability of travel time
	Likelihood of accident or breakdown
	Influence of weather on travel time
2. Amenities	Cleanliness of vehicle and station
	Control of immediate surroundings
	Feeling of privacy
	Cost to use means of travel
3. Service measures	Frequency of service
	Accessibility to means of travel
	Waiting required
4. Waiting measures	Protection from weather
	Number of transfers required
Combined modes	
1. On-time performance	Number of stops required
	Cost to use means of travel
	Feeling of personal safety
	Variability of travel time
	Likelihood of accident or breakdown
	Influence of weather on travel time
2. Time and effort	Protection from weather
	Fatigue felt when traveling
	Total travel time
	Speed of vehicle
3. Amenities	Cleanliness of vehicle and station
	Control of immediate surroundings
	Feeling of privacy
	Number of transfers required
4. Service measures	Accessibility to means of travel
	Frequency of service
	Waiting required

preference logit. This section discusses the steps followed in each phase of the analysis and the conclusions reached in each step.

Data were collected about each individual's rating of each of the 17 attributes for each of 11 mode segments, for both the access and line-haul modes. Factor analysis was used to construct the three perceptual spaces. Various dimensionalities were attempted, ranging from a two-factor solution to a five-factor solution. The appropriate dimensionality for each space was selected based primarily on clarity of interpretation of the factor space. The four-factor solution was selected for all three perceptual spaces. Table 3 presents the attributes that load onto each factor.

One objective of this research was to test the assumption that individuals perceive main and access modes differently. To test the assumption, the three perceptual spaces were constructed. In examining the attributes' loading on each dimension for each perceptual space, it can be seen that in no case are the dimensions comparable between the access- and main-mode types. This result is true as the dimensionality is increased from the two- to four-factor solution. Therefore, it is concluded that these individuals do not perceive the comfort, convenience, and reliability of access and main modes in the same fashion, so the use of only one perceptual space to represent the underlying perceptual dimensions may lead to erroneous results. This is a significant departure from the three earlier works described previously.

Labels were developed for the dimensions of each of the three perceptual spaces and are presented in Table 3 along with the attribute loadings on each dimension. For the access-mode space, the dimensions were labeled reliability, on-time performance; time and effort; comfort; and personal autonomy. For the main-mode space, the dimensions are given different labels, which reflect the different attribute loadings. The dimensions in the combined-modes space are labeled as on-time performance, time and effort, amenities, and service measures. Although some dimensions of the three spaces are similar, the spaces are not similar overall.

As stated earlier, one objective of this research was to investigate whether people perceive comfort, convenience, and reliability as separate concepts. In the results obtained, none of the dimensions can be labeled strictly as a comfort dimension, a convenience dimension, or a reliability dimension. Elements of each concept appear on more than one dimension. Therefore, based on this analysis, people do not appear to perceive comfort, convenience, and reliability as independent attributes when they choose a travel mode for their journeys to work. Although the attributes of these qualitative variables play a role in the choice process, travelers appear to consider them in a different manner than was previously believed.

Given the respondent's stated preferences for nine combined travel modes, and factor scores for each dimension of the mode-perception spaces, preference models were estimated to test how effectively the derived perception spaces predict the stated preferences. Two techniques were used to estimate these models: preference regression and first-preference logit.

The general definition of the preference model is as follows:

$$P_{ij} = \sum_k \alpha_k a_{ijk} + \sum_k \mu_k m_{ijk} + \text{automobile dummy} \quad (1)$$

where

P_{ij} = preference rank of alternative j by individual i,
α_k = access-mode parameter for dimension k,
μ_k = main-mode parameter for dimension k,
a_{ijk} = access-mode factor score for dimension k, and
m_{ijk} = main-mode factor score for dimension k.

Several points must be made about the definition of the model. First, the preference ratings were solicited with respect to the nine alternative travel modes that consist of access-mode and main-mode segments. The factor scores are defined for each mode segment separately. Thus, the factor scores for both the access and line-haul portions of the trip must be included in the model. Second, special consideration must be made for the automobile-all-the-way alternative. Unlike the other modes, this alternative consists of only one mode segment; it has no access portion. An automobile dummy variable is included to represent the absence of any access mode.

Preference ratings include ties, and some respondents did not use the entire seven-point scale in the ranking. Therefore, the respondent's preference ratings were normalized so that the sum of the ratings is constant and ties were defined as the mean value of their ranks.

Two preference-regression models were constructed by using separate access-mode and main-mode spaces versus a combined-mode space. The goodness-of-fit statistics for these models are presented in Table 4. The models were able to predict 49.4 percent of the first preferences for the separate-modes space and 52.3 percent for the combined-modes spaces.

The models all have highly significant F values, although the R^2 values are low. However, previous uses of preference regression show that R^2 values are usually low (3), and so these values are acceptable for this research. In addition, the first-preference recovery percentages compare favorably to the results obtained in other studies (3, 4). The large and significant automobile dummy-variable parameter indicates that the variable is picking up the effect of the absence of the need to use an access-mode for automobile-all-the-way.

Table 4. Preference regression results.

	Separate-Modes Space		Combined-Modes Space	
Dimension	Coefficient	Significance	Coefficient	Significance
Access 1	0.714	0.000*	0.540	0.000*
Access 2	0.080	0.262	0.051	0.477
Access 3	0.075	0.390	-0.051	0.554
Access 4	0.086	0.271	0.492	0.000*
Main 1	0.665	0.000*	0.049	0.630
Main 2	0.201	0.076*	0.770	0.000*
Main 3	0.014	0.869	0.208	0.032*
Main 4	-0.003	0.972	-0.147	0.122
Automobile dummy	-2.309	0.000*	-2.534	0.000*
Constant	4.941	0.000*	5.135	0.000*

Notes: F = 33.57 for the separate-modes space and 33.63 for the combined-modes space and was significant at the 0.10 level; R^2 = 0.163 for the separate-modes space and 0.171 for the combined-modes space.
*Significant at 0.10 level.

Table 5. First-preference logit results.

	Separate-Modes Space		Combined-Modes Space	
Dimension	Coefficient	t	Coefficient	t
Access 1	-1.045	-6.96*	-1.273	-6.37*
Access 2	0.097	0.88	0.027	0.24
Access 3	-0.958	-4.26*	-0.631	-3.56*
Access 4	-0.464	-3.12*	-0.342	-2.04*
Main 1	-1.032	-5.46*	0.190	0.78
Main 2	0.002	0.01	-1.649	-5.46*
Main 3	-0.917	-3.88*	0.029	0.12
Main 4	0.170	0.67	-0.625	-2.57*
Automobile dummy	9.011	6.16*	7.868	6.16*

Notes: Pseudo R^2 = 0.2744 for the separate-modes space and 0.2809 for the combined-modes space; $-2\,[L(B^*) - L(B^0)]$ = 209.8 for the separate-modes space and 218.8 for the combined-modes space.
*Significant at 0.10 level.

The two different perceptual spaces do not perform significantly differently. However, based on intuitive reasoning and the differences in perception structure, the use of separate access-mode and main-mode perceptual spaces is recommended instead of the combined-modes space.

The implied importance rankings of the dimensions of the separate-modes space derived from the model are intuitively more appealing than those derived from the combined-modes space. The three most important factors from the separate-modes model are access-mode reliability, main-mode on-time performance, and main-mode amenities. The other dimensions are much less important. The combined-modes model has as its most important dimension main-mode amenities, followed by access-mode reliability. The results from the separate-modes space present a ranking that seems more reasonable. A priori, we would expect that access-mode reliability would be one of the most important factors in the choice of travel mode to work. That is, if the access mode is not reliable, the probability of arriving at the main mode on time would be small, thus causing the traveler to miss his or her connection. That the main-mode's reliability was more important than main-mode amenities is also no surprise. In general, the importance rankings of the dimensions adds further support to the recommendation that the separate access-mode and main-mode space be used in future research efforts.

Two first-preference logit models were constructed; one for each type of perceptual space. The coefficients and goodness-of-fit statistics are presented in Table 5. The models were able to predict 43.1 percent of the first preferences for the separate-modes space and 44.25 percent for the combined-modes space.

As before, the automobile dummy variable is highly significant and accounts for the absence of the automobile access-mode segment. The goodness-of-fit statistics are low, but this is expected based on previous studies and the preference-regression results. The pseudo-R^2 values are low, but the likelihood-ratio statistics are significant in both cases.

The implied importance rankings are similar to those derived from the preference-regression models. The rankings for the models from the separate-mode space are identical in the first two positions, as are the rankings for the models from the combined-mode space. The first-preference logit models have a greater number of significant variables than do the preference-regression models. This result is important and justifies the higher cost of using logit estimation. Therefore, based on the similarity of the rankings between the two different preference models, differences in parameter significance, and considering cost, first-preference logit modeling is recommended to identify relative importance of dimensions of service perceptions.

The first-preference logit analysis also supports the use of the separate-mode spaces over the combined-mode space. The results, which are similar to the ones from preference regression, are more intuitively pleasing and seem to be more meaningful.

CONCLUSIONS AND EXTENSIONS

The relative importance of dimensions in these perceptual spaces was estimated by using preference-regression and first-preference logit models. From this analysis, several conclusions are reached.

1. The use of a single perceptual space to represent both access-mode and main-mode segments is not acceptable. There is no basis for an assumption that travelers perceive these two mode types in the same

fashion. Perceptual spaces were built to examine the differences between a single perceptual space for both mode segments and separate perceptual spaces for each mode segment. The results indicate that individuals perceive these two segments differently. Hence, the use of separate perceptual spaces for access and main modes is recommended for future research efforts. The results obtained by using the separate-mode spaces were more understandable than those for the combined-modes space and support the hypotheses of this research.

2. Examination of the attributes that loaded onto the dimensions of the perceptual spaces indicates that individuals probably do not perceive comfort, convenience, and reliability as independent factors when they select a means of travel for their work trips. There is significant overlapping of the attributes of each concept across all dimensions.

3. The use of preference regression and first-preference logit lead to almost identical results in the preference-modeling phase of the analysis. However, due to better estimation properties, the use of first-preference logit is preferred.

Several extensions can now be discussed. In conducting this research, only 14 attributes of the three qualitative concepts were used. Those 14 attributes were chosen because they were the most important ones in the previous studies. A large share of the convenience and reliability attributes are time related, so that it is possible that little information was gained about those variables; the comfort attribute does not seem to suffer from this problem. Further research to identify an appropriate set of attributes is needed. Specifically, an investigation of the attributes of convenience and reliability must be undertaken in an attempt to identify a well-defined, mutually exclusive set of attributes for these concepts.

Another issue to be considered concerns the validity of questioning individuals about abstract concepts, such as high travel time or low variability of travel time. The use of a set of attributes eliminated some problems of ambiguity; however, the use of the abstract ranges introduces some confusion. One study (3), which considered this problem in dealing with time variations, found that specification of actual ranges greatly aided the respondents in answering those questions.

Another problem with the abstract ranges arises in the mapping of perceptual data into the objective performance space. Each respondent determines his or her own values for those ranges, so it is quite plausible for two individuals to have the same perception of some attribute on some mode when the performance characteristics are vastly different. For example, one individual may consider a wait of 5 min to be an extremely long wait, but another may consider an extremely long wait time to be on the order of an hour or more. These individuals would have identical perceptions for vastly different cases. The ranges must be explicitly specified with actual values when the information will be used to attempt a mapping of the perceptual data into reality.

The use of the reported preferences as the dependent variable in the preference modeling to derive the importances of the dimensions provides one approach to understanding travel-choice behavior. Because data were collected on observed behavior, the use of these actual choices as the dependent variable would also uncover revealed importances of the individuals. Since the link between preference and behavior is complex, this extension is warranted.

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