CAMBRIDGE SYSTEMATICS

South Cook County – Will County Service Restructuring Initiative

Market Research Report

final

report

prepared for

Pace Suburban Bus Service

prepared by

Cambridge Systematics, Inc.

with

MORPACE International
Perteet, Inc.
Transportation Management & Design, Inc.

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Executive Summary

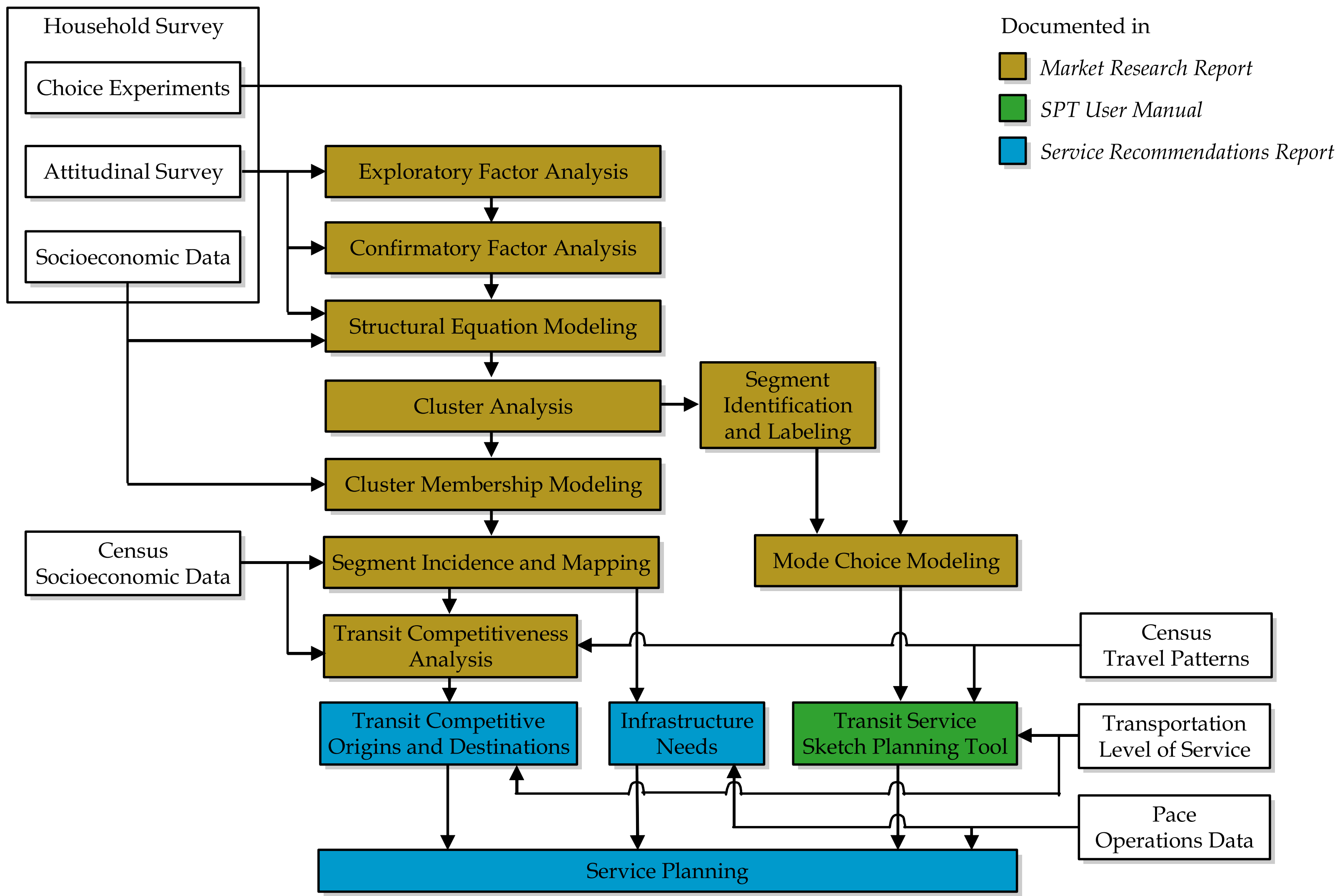
Through the use of market segmentation techniques applied extensively in product design in the private sector, Pace is expanding on the binary "choice rider / captive rider" approach that is traditionally applied in transit planning. Specifically, Pace desires to target its family of transit services more effectively to retain current and attract new customers. This paper describes the comprehensive regional market research effort that Pace has conducted as part of its South Cook County – Will County Service Restructuring Initiative, particularly the development of market segments and the segments' applications to suburban transit planning.

Because more than 75 percent of all trips on Pace are for work purposes, the market research focused on work trips. Major steps in the process included conducting a household travel survey, identifying market segments, mapping the incidence of market segments across the region, developing mode choice models for each segment, using a combination of factors to identify "transit competitive" origins and destinations and developing an interactive GIS tool to allow transit planners to test the relative effects of alternative service strategies.

This report summarizes the market research efforts undertaken by Cambridge Systematics as part of the South Cook County – Will County Service Restructuring project for Pace. MORPACE International assisted in the development of the survey instrument and was responsible for implementing the final design of the survey and collecting all survey data using a telephone-mail-telephone approach.

Figure ES.1 describes the overall work flow and information flow of the Initiative, including the elements documented herein. The analysis process and results described in this document provide the basis for the Transit Service Sketch Planning Tool (SPT) and the service restructuring recommendations in southern Cook County and Will County that also are being developed as part of this Initiative.

Figure ES.1 Initiative Work Flow and Information Flow



ES.1 Data Collection

A sampling plan was developed to obtain a representative sample of commuters in the six-county Pace service area. The sample was not limited to current transit users – a stratified sampling approach was used to ensure adequate representation by respondents' geography, type of commute and socioeconomic characteristics. Suburban residents were recruited by telephone via random-digit dialing and existing Pace contact lists, while Chicago-to-suburb commuters were recruited through Pace contact lists or self-identified through other sources.[1] In all, Pace collected travel attitude and behavior information from 1,330 commuters.

The primary data-collection vehicle was a stated-preference survey that sought to identify the tradeoffs that commuters make in their daily travel. Through the survey, Pace collected information on commuters' actual daily travel patterns, observed mode choice behavior, attitudes toward everyday commuting and responses to a stated choice experiment. The survey consisted of three components:

- **Recruit Survey:** Households were contacted by telephone and asked about daily travel patterns. Respondents had to be at least 16 years old, work either a full- or part-time, commute to work at least 3 days a week, and travel for at least 10 minutes between home and work. Commute-related questions focused on mode(s) used and travel times and costs, including fare payment method and/or parking costs. Demographic questions centered on household structure – such as size, number of workers, annual income and number of vehicles available for daily travel – as well as gender, level of education and ethnic background.

- **Attitudinal and Travel Behavior Survey:** Recruited commuters were mailed a survey designed to highlight the values that different commuters place on their everyday travel by transit or automobile. Travelers' attitudes toward all aspects of their travel experience were explored. **Table ES.1** shows 36 attitudinal statements for which respondents were asked to rate on a scale of zero to 10 their degree of agreement. (Zero indicated strong disagreement with a statement while 10 signaled strong agreement.) Attitudinal statements were pre-tested by a small portion of the sample to refine wording and ensure comprehension by participants. The order of questions was randomized within a structured experiment framework to minimize the effects of survey length on responses.

- **Choice Experiment:** Along with the Attitudinal and Travel Behavior Survey, each survey participant received a customized set of three choice experiments designed to

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[1] Pace sent recruitment e-mails to several suburban business associations and non-profit organizations for distribution to members and placed noticed on websites of other regional transportation agencies.

quantify the tradeoffs that commuters make in choosing among different travel options. Each experiment consisted of three commute options between the participant's home and work locations: an automobile-based option, namely driving alone or sharing a ride; an existing transit option entailing use of current transit service or a vanpool; and a proposed "Rapid Bus" transit option based on a hypothetical regional grid of service complemented by a shuttle network. Each option carried different characteristics (i.e., travel time, cost, number of transfers) in each of the three choice experiments to determine the conditions under which a respondent might change his or her mode of travel. A sample choice experiment is shown in **Table ES.2**.

ES.2 Market Segmentation

As part of this market research exercise, Pace desired to identify distinct segments of the commuting public that differed in terms of their attitudes toward everyday travel and their mode-choice behavior. The market segments traditionally used in transportation planning are most often based on socioeconomic characteristics – such as income, gender or automobile ownership – or type of commute, namely city-to-city, suburb-to-city or city-to-suburb. Here, we relied on commuters' attitudes toward different aspects of their travel experience to understand the values that they place on everyday travel by transit and automobile.

Using the attitudinal survey data as the main source of information, we conducted a factor analysis to reduce the large number of observed variables reflected in the ratings of the 36 attitudinal statements to five factors that represent the underlying dimensions driving traveler behavior. The factor analysis was implemented as a series of multivariate statistical procedures, shown in **Figure ES-1**.

Table ES.1 Attitudinal Questions in Survey

Number	Question
1	Driving is usually the fastest way to get to work
2	I would change my form of travel if it would save me some time
3	I like to make productive use of my time when I travel
4	I am usually in a hurry when I make a trip to work
5	I need to make work trips according to a fixed schedule
6	I need to make stops on the way to or from work
7	I need to travel mostly during the morning and afternoon rush hours
8	It's important to be able to change my travel plans at a moment's notice
9	It is important to have comfortable seats when I travel
10	Having my privacy is important to me when I travel
11	When I travel with others, I prefer to be the driver
12	I wouldn't mind walking a few minutes to get to and from a bus or train stop
13	I don't mind transferring between buses or between bus and rail service
14	Public transit vehicles in the Chicago area are usually clean
15	It is important to be able to control heat and air conditioning when I travel
16	I feel safe walking near my home
17	I feel safe walking near my workplace
18	I feel safe on a bus or train to my workplace
19	I feel safe while waiting for a bus or train to my workplace
20	I avoid traveling through certain areas because they are unsafe
21	If my travel is delayed, I want to know the cause and length of the delay
22	I don't mind delays as long as I am comfortable
23	Riding transit is more reliable than driving during rainy and snowy weather
24	Predictable and reliable travel to work is important to me
25	I often commute before or after the rush hour to avoid highway congestion
26	I want to know when the next bus or train is coming while waiting at a stop or station
27	Having a stress-free trip is more important than reaching my destination quickly
28	Riding transit is less stressful than driving on congested highways
29	Figuring out how to use public transportation is easy
30	When driving, I worry about my vehicle breaking down
31	When traveling, I like to talk and visit with other people
32	My family and friends use public transportation
33	I don't like riding transit with total strangers sitting next to me
34	I'm willing to pay a higher fare for higher quality transit service
35	I use the fastest form of transportation to work regardless of the costs
36	If gas prices increase substantially, I am likely to consider using public transportation to get to work

Table ES.2 Sample Choice Experiment

Suppose these were your transportation options for your trip from:
16,101 SOUTH LOOMIS, Calumet Park to ABBOTT LABS at 1401 SHERIDAN ROAD, Lake Bluff

Your choices are…	**OPTION A**	**OPTION B**	**OPTION C**
Method of travel	You **drive by yourself** from your home to a parking place at or near where you work. You walk from that parking place to your workplace.	You **walk to the Rapid Bus System and ride that** to a stop at or near where you work. You do not need to make any transfers. You walk from the final transit stop to your workplace.	You **ride in a Vanpool with up to six other people** from your home to a parking place at or near where you work. You walk from that parking place to your workplace.
Service frequency	–	Every 60 minutes	–
Time to get to transit	–	8 minutes	–
Time in vehicle(s)	66 minutes	60 minutes	83 minutes
Time spent transferring between buses or trains	–	0 minutes	–
Time to walk from your car or transit stop to your workplace	1 minute	1 minute	1 minute
Gas cost	$7.20	–	–
Fare cost	–	$1.25	$1.00
Parking cost	Free parking	–	–
Reliability: You will be more than 15 minutes late…	Twice a month	Once every 3 months	Twice a month
Which of the three options above would you choose? (Please circle one)	**OPTION A**	**OPTION B**	**OPTION C**

The factor analysis identified five main dimensions driving respondents' decisions about how they travel to work. Each factor reflects sensitivities to a particular theme and encompasses a non-mutually exclusive group of attitudinal statements:

1. **Transit Advantages –** All statements under this factor point to a transit-friendly attitude, namely a recognition of transit as a comfortable and stress-free means of commute, knowledge of transit use, acceptance of transit access and delays, social dimension/interaction with strangers that is positive toward transit (i.e., talk and visit while traveling) and positive normative beliefs (my friends use transit).

2. **Personal Safety –** This factor incorporates perceptions of feeling safe while traveling on transit, including while walking to stations/bus stops at the beginning and end of the commute trip, waiting for service and riding transit.

3. **Time and Schedule –** Statements under this factor reflect a need for predictable travel patterns and arrival times, need to know sources of delay, desire to save time and make productive use of time en route, and willingness to change modes based on speed and reliability of travel.

4. **Privacy and Comfort –** This factor encompasses a need for privacy and control of one's personal space while traveling to maximize comfort and have a pleasant commute experience.

5. **Driving Advantages –** This factor reflects respondents' needs to make trips outside of the a.m. and p.m. rush hours, be able to make stops en route to/from work and arrive at work in the fastest way possible; it also includes statements focused on the perceived unreliability of transit and an unwillingness to consider other modes as fuel prices increase.

Based on patterns of sensitivities to each of the five factors, socioeconomic characteristics, geography of travel and mode choice behavior, the 1,330 survey respondents were then grouped into seven distinct market segments through a k-means analysis. The factor scores for each market segment were used to "label" the segment and describe its positioning relative to the others; we developed names for each segment to reflect distinguishing characteristics of each:

1. **Million Milers** – Only the "Driving Advantages" factor garnered above average ratings among members of this market segment, so named for its members' predominantly automobile-based commutes (83 percent), suburban and exurban home and work locations and higher car ownership rates. Million Milers are mostly well-educated men living in larger households (with the highest percentage of two or more workers of any segment).

2. **Great Middle –** The largest segment of the seven, members yielded generally middling ratings for each of the five factors. Great Middle members' socioeconomic characteristics, home and work locations and commuting patterns largely parallel those of Million Milers; however, members of this segment are somewhat more transit-

friendly as evidenced by a slightly higher incidence of transit usage (just under 20 percent) and lower scores for the "Driving Advantages" factor.

3. **Demanding Survivors –** Members of this segment have high requirements for "Time and Schedule" and "Privacy and Comfort" factors; they tend to be women supporting small households, exhibit the lowest levels of education and auto ownership overall, and have a higher incidence of incomes of less than $35,000 per year. Demanding Survivors commute via transit heavily (48 percent) – including the highest usage of CTA rail and Pace bus (10 and 19 percent respectively) – while feeling secure doing so and showing positive attitudes toward the "Transit Advantages" factor. Members of this segment have varying commute patterns but the highest incidence of Chicago-to-suburb commutes (15 percent).

4. **Cautious Individuals –** Similar to Demanding Survivors, Cautious Individuals tend to be women living in one-person households with relatively lower incomes, though they are much more sensitive to "Personal Safety" statements. While their attitudes toward the "Time and Schedule" and "Privacy and Comfort" factors also parallel those of Demanding Survivors, three of four Cautious Individuals commute by automobile. Commute patterns in this segment vary considerably.

5. **Educated Professionals –** Members of this market segment have the highest levels of education, favorable attitudes toward commuting by transit with high usage (39 percent with a 25-percent market share for Metra) and consequently less-favorable attitudes toward commuting by automobile with relatively low usage (58 percent). Educated Professionals are typically men living in large households with at least two cars available; nearly half reside in the suburbs. Suburb-to-suburb and suburb-to-downtown Chicago are the primary commute patterns for this segment.

6. **Downtown Commuters –** True to its name, many of this segment's members live in suburbs or exurbs but work in downtown Chicago; many thus commute by transit, primarily Metra (36 percent) or Pace (11 percent). Downtown Commuters have very demanding schedules and rated "Personal Safety" statements highly yet show the most positive attitudes toward "Transit Advantages"; they carry average concerns about "Privacy and Comfort" and negative attitudes toward "Driving Advantages." While the socioeconomic profile in this market segment showed great variability, most respondents belong to high-income households.

7. **Determined Drivers –** 95 percent of Determined Drivers commute by car, most commute between suburban and exurban locations and "Privacy and Comfort" and "Personal Safety" factors are of greatest concern; in short, they are strongly inclined towards using their own automobiles for commuting. Nearly 70 percent of Determined Drivers are women but their socioeconomic profile otherwise varies.

ES.3 Segment Incidence

A Cluster Membership Model based on discrete choice theory was then estimated to link membership in each segment with the socioeconomic characteristics of the respondents. The resultant model was applied to the six-county region based on 2000 U.S. Census block-group data; model results were translated to the Census Transportation Planning Package (CTPP) traffic analysis zone (TAZ) level to support the application of the market segmentation results to Census Journey-to-Work travel pattern data. The membership probabilities calculated for each segment were used to create incidence maps for each market segment.

Figure ES.2 depicts the market segment with the largest incidence in each TAZ across the region. Throughout much of suburban Cook and DuPage Counties, Educated Professionals and Cautious Individuals are most prevalent; in Will, Kane, McHenry and Lake Counties, the Great Middle tends to dominate. Demanding Survivors, Cautious Individuals, and Downtown Commuters appear prominently in the City of Chicago. (Million Milers and Determined Drivers are smaller segments that are not predominant in any TAZ throughout the region.)

ES.4 Mode Choice Modeling

In order to determine mode choice probabilities for each market segment, a multinomial logit mode choice model was developed for each segment using the results of the choice experiments. The unique models reflect the individual characteristics of each segment; however, similar coefficients were applied to some groups of segments for some variables to improve statistical significance. The mathematical expression used to calculate the probabilities and corresponding market shares of each mode is given by the following equation:

$$P_{Mode\ 1} = \frac{\exp(U_{Mode\ 1})}{\sum_{i=1}^{N} \exp(U_i)}$$

Where:

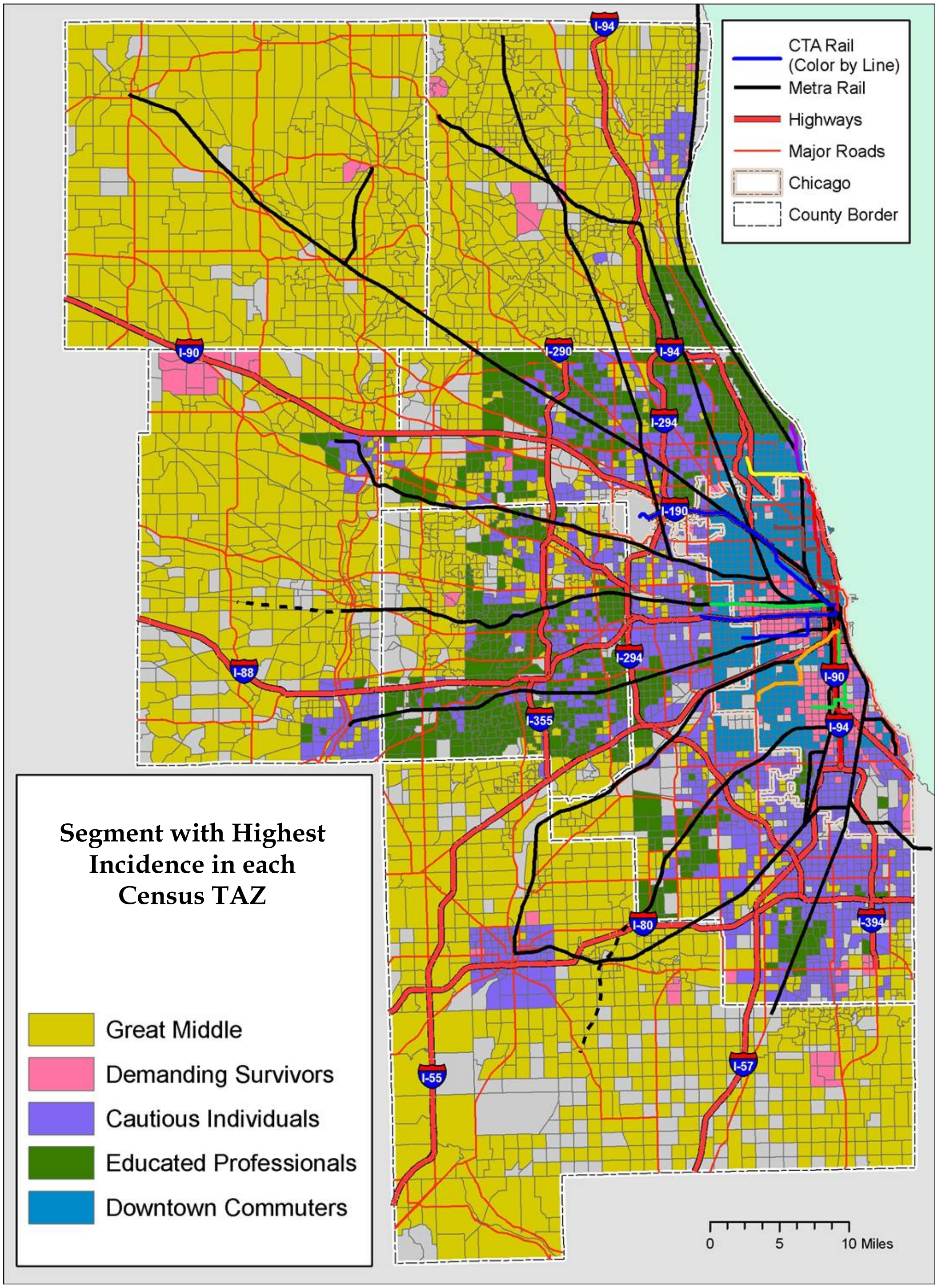
P_{mode1} = Probability of selecting mode 1;

U_{mode1} = Utility function for mode 1;

U_i = Utility function for all five modes (i); and

N = The five modes used in the model.

Figure ES.2 Market Segments with Highest Incident in TAZ



The utility functions reflect the dimensions of trip characteristics evaluated in the choice experiments, including transit service frequency, access time from home to transit, in-vehicle travel time, time spent transferring between buses or trains, egress time from transit to workplace, travel cost, and travel time reliability.

ES.5 Transit Competitiveness Analysis

"Transit competitiveness" analysis provides a bridge between market segmentation analysis and service planning by adding land use, socioeconomic and transportation components to the segment incidences shown in **Figure ES.2** to describe the relative merits of providing transit service to any location across the region. In the analysis, each TAZ is assigned two indices, one for trip origins (home locations) and another for trip destinations (work locations). The indices apply weights derived from the market segment-specific mode choice models to combine information including

- market segment incidence,
- development density,
- traffic congestion,
- parking cost, and
- household vehicle availability

into a single score, referred to as Transit Competitiveness Factor (TCF) scores. The TCF score thus provide a relative measure for each TAZ to identify opportunity markets for all forms of transit with greater values indicating higher levels of opportunity for transit. The TCF score is normalized so that a value of 100 or more generally represents a transit competitive location. The value of 100 corresponds to a location with population or employment density levels that are within the range of transit-supportive densities cited in the literature, and otherwise is similar to the regional average in terms of congestion, parking cost, and vehicle availability.

Demand, rather than supply, drives TCF analysis. Existing conditions for automobile work trips – such as congestion levels and parking costs – are considered, but existing transit provision and characteristics are not. The intention of TCF analysis is not to identify how well customers are currently served by existing transit, but to assess the market potential for transit given the existing pattern of land use, population, and employment and travel patterns. In service planning and resource allocation planning, the results of the TCF analysis are applied to consider market demands alongside current and future transit supplies and identify areas currently underserved or overserved by transit.

The TCF analysis can be distinguished from other transit planning and transit market research methods by its enhanced scale, level of detail and flexibility. On the matter of scale, most transit market research conducted in Chicago is either limited to a smaller study area or uses a larger-scale unit of analysis (such as the roughly 1,600 CATS TAZs that comprise the six-county region); by using Census TAZs, TCF analysis provides results for 6,320 zones with an average area of about 0.6 square miles. As for the level of detail, TCF analysis blends typical transit market research components (such as the socioeconomic and land-use information described above) with market segmentation research results, thereby reflecting segments' unique responses to service provisions and amenities or the relative tradeoffs between congestion and costs, for example. Finally, TCF analysis provides a highly flexible means of analysis given that TCF scores can be broken down to determine which factor(s) – high incidence of a particular market segment, number of originating commute trips or parking costs, for instance – explain a high or low TCF score.

Figure ES.3 shows the overall TCF for origins in the six-county region. TAZs in blue have a TCF value of 100 or greater and are considered transit competitive: these zones represent markets with high transit potential. Noncompetitive zones should not be eliminated from further analysis or considered undesirable for service investment but rather should be considered relative to each other (i.e., a darker green zone indicates more transit potential than a lighter green zone) and as potential targets for non-traditional service types such as flexible routings or other demand-responsive services. About 43 percent of the six-county region's work trips originate from a transit competitive TAZ. The City of Chicago has the largest concentration of transit competitive TAZs; other communities with concentrations of competitive TAZs include Aurora, Oak Park, and Schaumburg.

Figure ES.4 displays the relative transit competitiveness of each destination location, as defined by the TCF for attractions. About one-third (34 percent) of the six-county region's total work trips are destined to a transit competitive attraction zone. Transit competitive zones are concentrated in Chicago, though other competitive areas include Oak Brook, the Warrenville Road corridor, Schaumburg, and downtown Evanston.

Travel patterns and the components of TCF associated with specific transit competitive origins and destinations were evaluated in more detail to help to inform the development of service restructuring concepts in the South Cook County – Will County area. This analysis is described in the *Service Recommendations Report*. In addition, the Transit Service Sketch Planning Tool (SPT) applies similar market research results not only for origin and destination locations themselves, but for specific travel markets between selected origins and destinations. This tool is described in the *SPT User Manual*.

Figure ES.3 Transit Competitiveness Factor for Origins

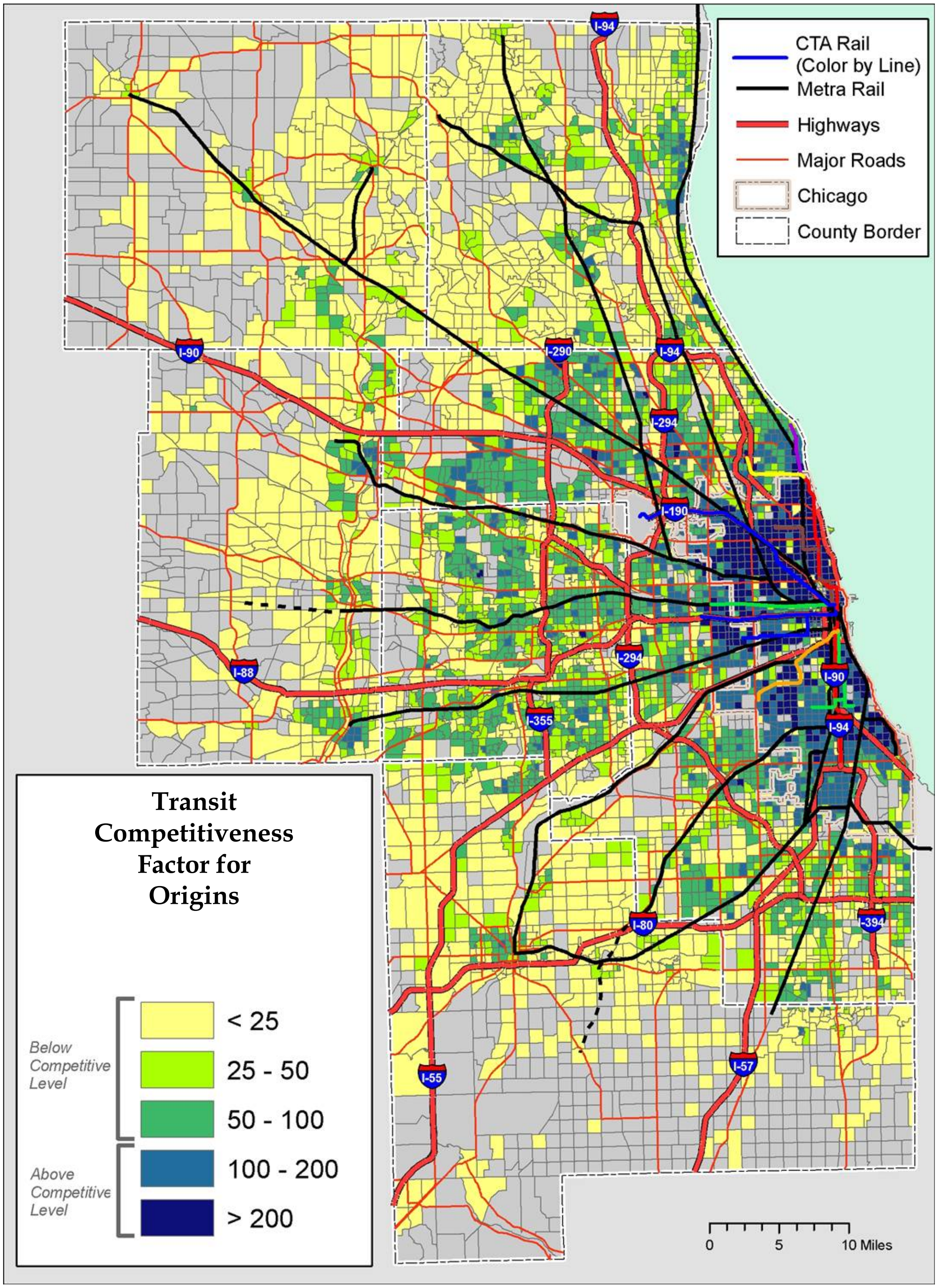
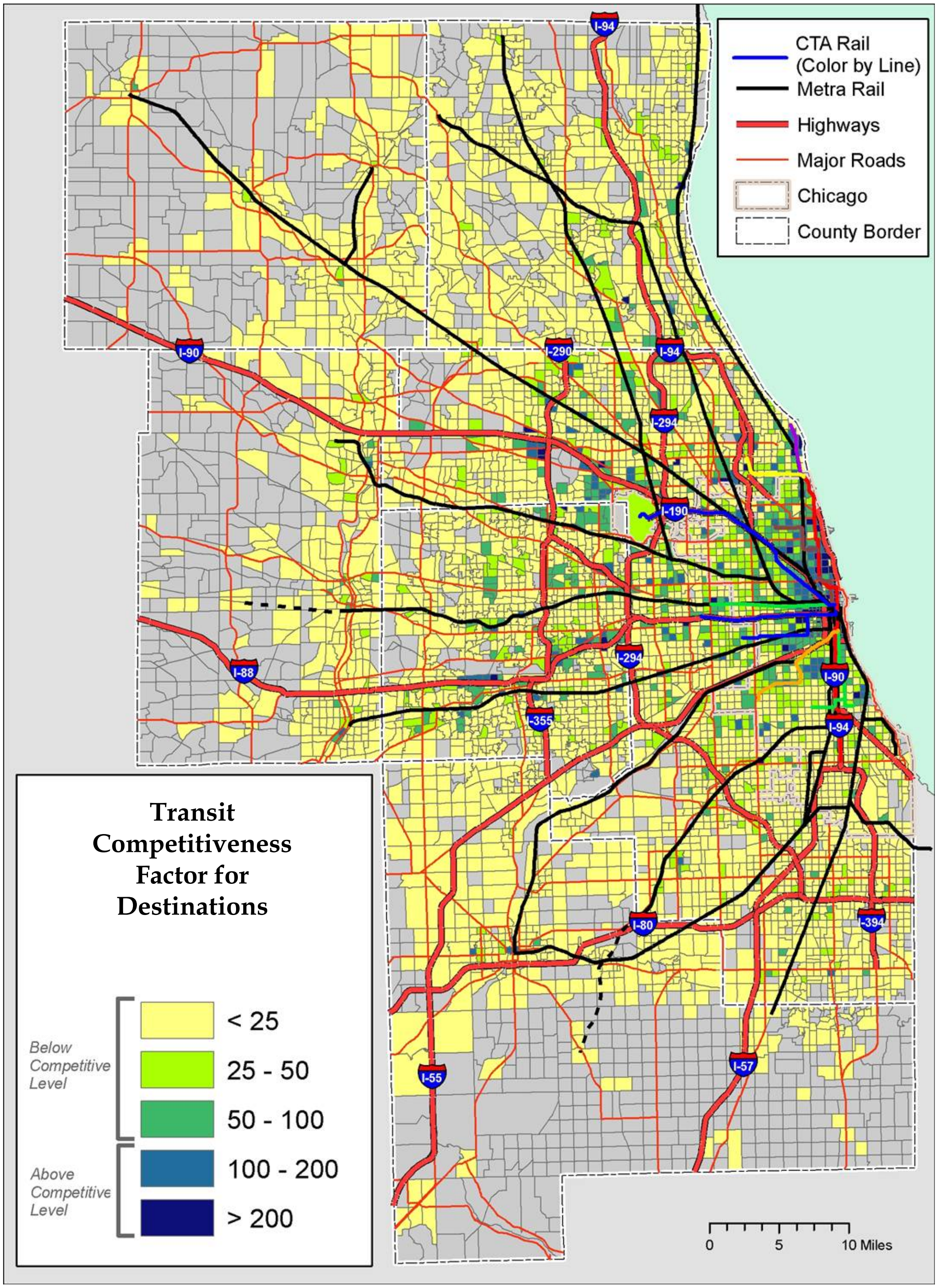


Figure ES.4 Transit Competitiveness Factor for Destinations



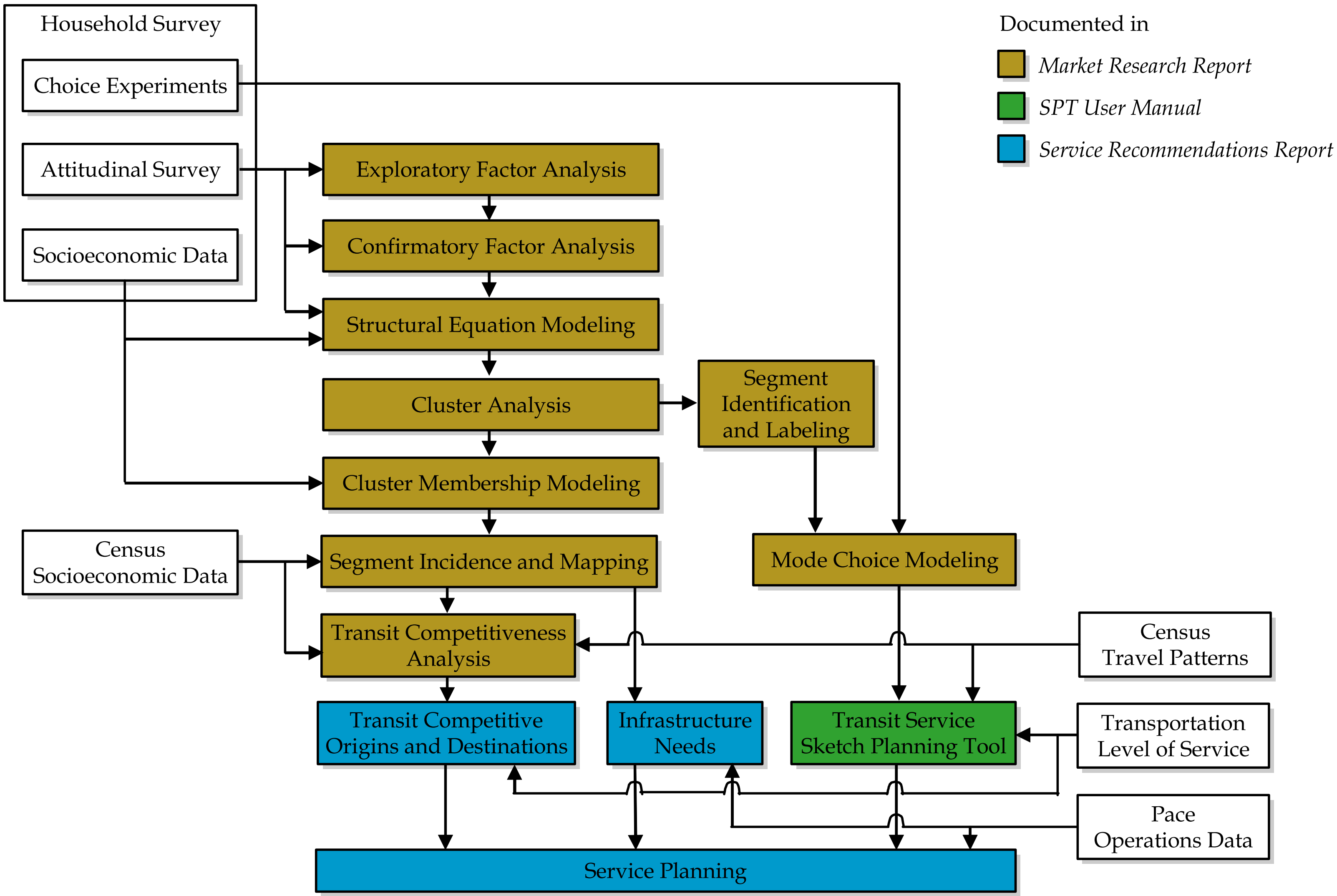
1.0 Introduction

This report summarizes the market research efforts undertaken by Cambridge Systematics as part of the South Cook County – Will County Service Restructuring project for Pace. MORPACE International assisted in the development of the survey instrument and was responsible for implementing the final design of the survey and collecting all survey data using a telephone-mail-telephone approach.

The report documents activities related to the design of the sample and the development of the survey instrument, the descriptive statistical analysis of the survey, the development of clusters as part of market segmentation, the analysis of traveler choice behavior, and the competitive positioning exercise that integrates the findings from all previous steps of the analysis. These activities were conducted under Task 1 of the Initiative scope of work.

Figure 1.1 describes the overall work flow and information flow of the Initiative, including the elements documented herein. The analysis process and results described in this document provide the basis for the Transit Service Sketch Planning Tool (SPT) and the service restructuring recommendations in southern Cook County and Will County that also are being developed as part of this Initiative.

Figure 1.1 Initiative Work Flow and Information Flow



Section 2.0 outlines the original sampling plan for the data collection effort and documents the design and contents of the recruit survey, the attitudinal survey, and the choice experiment that was used in the stated-preference exercise. The analysis of the survey includes a comparison of the original targets with the obtained sample by stratum, discusses how sample size affects the precision of estimates from the survey, and outlines the weighting scheme used to obtain a representative sample of travelers in the six-county Pace service area.

The design and contents of the recruit survey, the attitudinal survey, and the choice experiment that was used in the stated-preference exercise are documented. The analysis of the survey includes an examination of the missing values for key variables in the dataset and the imputation of values for these key variables. This section concludes with a descriptive analysis of the survey responses that includes summary tables along with a discussion of key findings.

Section 3.0 discusses how the attitudinal statements about travelers' everyday experience are grouped into dimensions of service that affects their attitudes toward travel and their choice of how they travel. The exploratory factor analysis is presented, followed by the structural equations model that relates both attitudinal and socioeconomic characteristics in developing dimensions of service. Section 3.0 concludes with the presentation of the seven market segments that were developed in this effort. The cluster analysis results discuss how respondents were grouped together in seven unique clusters to reflect their attitudes toward everyday travel. Respondents' socioeconomic characteristics, origin-destination travel patterns, and mode choice behavior are used to further describe each of these market segments.

Section 4.0 examines the mode choice behavior of respondents in the Chicago metropolitan area. We first analyze respondents' observed mode choice behavior and relate it to the type of origin-destination market and other geographic and socioeconomic characteristics. We then present the mode choice model that addresses travelers' sensitivity to level of service and cost characteristics and their likelihood of using the proposed bus rapid transit service that was presented to them.

Section 5.0 describes the competitive positioning exercise, which represents the first step in the application of the market research results to service planning. We first developed a model to predict the incidence of each segment in each Census zone across the region. While the geographic distribution of attitudes provides some insight into service design, we then developed a Transit Competitiveness Index for each origin and destination zone that combines information on the relative incidence of each segment, level of congestion, automobile travel costs, and other variables to compare the attractiveness of transit with the automobile across the six-county region. This analysis provides the basis for more detailed assessments of specific origin-destination combinations associated with the most transit competitive zones in the South Cook County – Will County area, which are described in the *Service Recommendations Report*.

The analysis process and results described in this document provide the basis for the Transit Service Sketch Planning Tool (SPT) that also is being developed as part of this Initiative. The SPT is custom software implemented in ArcGIS that estimates changes in ridership given changes in service characteristics (e.g., travel time, wait time, price, etc.), network structure (e.g., number of transfers), or customer experience (e.g., travel time reliability). The tool allows the user to conduct iterative testing of different service characteristics or more aggressive improvements of a single characteristic. Transit planners may conduct multiple iterations to test changes of alignment or service characteristic changes, and estimate the changes in potential ridership. Results from the SPT can be used by transit planners to reconfigure transit level of service anywhere in the six-county Chicago metropolitan region. Additional detail on this tool is provided in the *SPT User Manual*.

2.0 Data Collection

2.1 Sampling Plan

The objective of the sampling plan was to obtain a representative and randomly drawn sample of all residents in the six-county Pace service area. A stratified sampling approach was used to ensure adequate representation by geography, type of commute, and socio-economic characteristics of the respondents.

One of the primary objectives of the travel behavior survey was the design of a stated-preference survey that was used to examine the trade-offs that travelers make in their daily travel. Data on household members' actual daily travel activities, their observed mode choice behavior, their attitudes toward everyday travel, and their responses to the stated choice experiment were collected.

As part of this survey, we collected travel behavior information from 1,330 households in the six-county Pace service area against an original target of 1,500 households. The survey totals were slightly below the original target of surveys because of a lower than expected cooperation rate among respondents who were originally recruited via the recruit survey. Other reasons included lower than expected cooperation by suburban employers and greater than expected difficulty reaching reverse commuters and respondents of Hispanic origin.

A detailed discussion of the impact of sample size on the statistical significance of the sample and the accuracy of individual variables is discussed in **Appendix A.** This technical memo discusses the consequences of different sample sizes on the accuracy of the estimates for variables of interest.

A stratified sample was used to ensure a proper mix of respondents and adequate representation of different socioeconomic and geographic segments in our sample. Stratification dimensions that were used included the following:

- **County of Origin –** Respondents' home location was tracked to ensure adequate representation of households in suburban Cook County, DuPage County, Lake County, Will County, Kane County, and McHenry County;
- **Direction of Commute –** A mix of suburb-to-suburb, traditional commute, and reverse commute trips were sampled to provide a representative picture of travel in the Pace service area; and
- **Socioeconomic Characteristics –** Data on household income, automobile ownership, household size, number of workers, and departure time to work were collected during the data collection phase to ensure adequate representation of different socioeconomic strata in the population.

Table 2.1 shows the original sample design for the survey. It should be noted that given the origins and destinations served by Pace, the focus of the sampling plan was to interview suburban residents with work destinations anywhere in the region and reverse commuters who live in the City and work in the suburbs. People who both live and work in the City were not recruited.

There was an emphasis on people who live in the South Cook County – Will County portion of the region, with these areas targeted for approximately 30 percent more representation in the sample than the proportion of regional population would suggest. In addition, three groups of travelers in the region were targeted given their importance to Pace. As shown in **Table 2.2**, these included:

- Current riders of Pace were oversampled to ensure an adequate representation of current users in the sample. A total of 88 Pace riders responded to the survey.
- Hispanic respondents also were targeted given their importance to planned Pace service initiatives. Pace staff translated the recruit and attitudinal surveys and MORPACE International administered the Spanish survey versions. A total of 110 respondents of Hispanic origin responded using either an English or a Spanish version of the survey.
- Finally, to reach reverse commuters most efficiently at their work site, a list of suburban employers was submitted to the project team by Pace. Suburban employers were first contacted by the project team to obtain their cooperation in interviewing their employees. Because of lower than expected success in reaching reverse commuters via this method, the project team recruited additional respondents through the web and with outreach through an Illinois Tollway publication. However, neither of these methods yielded enough observations to meet the original target of reverse commuters. A total of 140 reverse commuters responded to the survey.

Table 2.1 Original Sampling Plan by Geography

	U.S. Census Figures					
Illinois Counties	**2000 (Estimated) Population**	**Percent Total Population**	**2000 Households**	**Percent Total Households**	**Proportional Allocation (by Households)**	**Disproportional Allocation**
Cook (Total)	5,340,940		2,083,894			
Cook (Chicago)	3,106,778		1,225,789			
Cook (Balance, North)	1,451,715	28.1%	562,852	31.4%	283	254
Cook (Balance, South)	782,447	15.1%	295,253	16.5%	148	191
DuPage	925,188	17.9%	325,601	18.2%	164	147
Lake	685,019	13.2%	216,297	12.1%	109	98
McHenry	286,091	5.5%	89,403	5.0%	45	40
Kane	457,122	8.8%	133,901	7.5%	67	60
Will	586,706	11.3%	167,542	9.4%	84	109
Total Pace Service Area	**5,174,288**	**100.0%**	**1,790,849**	**100.0%**	**900**	**900**

Table 2.2 Original Sampling Plan by Target Markets

Strata			Sample	Recruit	Sample Source
1	Hispanic Population	12.50%	**200**	**400**	**Listed Surname**
2	Pace Riders	0.76%	**200**	**400**	**Pace List**
3	City-to-Suburb	12.00%	**200**	**400**	**Supplemental Employer Frame**
4	Suburb-to-Suburb and Suburb-to-City	72.00%	**900**	**1,800**	**RDD**
			1,500	**3,000**	

2.2 Survey Design

The objective of the survey design was to develop a survey of a random sample of travelers in the Chicago area to better understand the factors that affect their attitudes toward daily travel and their mode choice behavior. The survey obtained information on the following:

- Travelers' observed travel patterns on a daily basis and their current mode choice behavior;
- Their attitudes toward everyday travel as reflected in their responses to a long list of attitudinal questions; and
- Their stated choice in response to a stated-preference exercise.

The survey has been analyzed to better understand the current market, identify the underlying dimensions of service, develop unique market segments, and quantify travelers' trade-offs in their choice behavior.

2.2.1 Recruit Survey

The recruit survey was administered by MORPACE International between January and April 2006. Respondents were contacted and asked about their daily travel patterns to identify members of the household who were candidates for the survey. To ensure a proper sample of work-related trips that could be potentially served by the proposed transit services, respondents had to fulfill the following criteria:

- Be at least 16 years old;
- Have either a full- or part-time job;
- Commute to work at least three days a week; and
- Their trip from home to work had to be at least 10 minutes long.

Detailed questions on origin and destination of their travel included the mode they use, the travel times they experience, and the costs they incur during their daily commute, including fare payment method and parking costs. Information on the structure of the household included the size of the household, the number of workers, annual household income, and the number of vehicles available for daily travel. Information on respondents' gender, level of education, and ethnic background also was collected.

2.2.2 Attitudinal and Travel Behavior Survey

The attitudinal and travel behavior survey was designed to better understand the values that different travelers place on their everyday travel by transit or by highway. Travelers' attitudes toward all aspects of their travel experience were explored. **Table 2.3** shows the complete list of attitudinal statements that was developed jointly with all members of the project team. Survey respondents were asked to rate 36 attitudinal statements on a scale of 0 to 10 stating their degree of agreement. A value of 0 indicated that they strongly disagreed with a statement and a value of 10 meant that they strongly agreed. These attitudinal statements were pretested to refine wording and ensure that they were well understood by survey respondents.

Table 2.3 Attitudinal Questions in Survey

Number	Question
1	Driving is usually the fastest way to get to work.
2	I would change my form of travel if it would save me some time.
3	I like to make productive use of my time when I travel.
4	I am usually in a hurry when I make a trip to work.
5	I need to make work trips according to a fixed schedule.
6	I need to make stops on the way to or from work.
7	I need to travel mostly during the morning and afternoon rush hours.
8	It's important to be able to change my travel plans at a moment's notice.
9	It is important to have comfortable seats when I travel.
10	Having my privacy is important to me when I travel.
11	When I travel with others, I prefer to be the driver.
12	I wouldn't mind walking a few minutes to get to and from a bus or train stop.
13	I don't mind transferring between buses or between bus and rail service.
14	Public transit vehicles in the Chicago area are usually clean.
15	It is important to be able to control heat and air conditioning when I travel.

Table 2.3 Attitudinal Questions in Survey (continued)

Number	Question
16	I feel safe walking near my home.
17	I feel safe walking near my workplace.
18	I feel safe on a bus or train to my workplace.
19	I feel safe while waiting for a bus or train to my workplace.
20	I avoid traveling through certain areas because they are unsafe.
21	If my travel is delayed, I want to know the cause and length of the delay.
22	I don't mind delays as long as I am comfortable.
23	Riding transit is more reliable than driving during rainy and snowy weather.
24	Predictable and reliable travel to work is important to me.
25	I often commute before or after the rush hour to avoid highway congestion.
26	I want to know when the next bus or train is coming while waiting at a stop or station.
27	Having a stress-free trip is more important than reaching my destination quickly.
28	Riding transit is less stressful than driving on congested highways.
29	Figuring out how to use public transportation is easy.
30	When driving, I worry about my vehicle breaking down.
31	When traveling, I like to talk and visit with other people.
32	My family and friends use public transportation.
33	I don't like riding transit with total strangers sitting next to me.
34	I'm willing to pay a higher fare for higher quality transit service.
35	I use the fastest form of transportation to work regardless of the costs.
36	If gas prices increase substantially, I am likely to consider using public transportation to get to work.

The order of questions was randomized within a structured experiment framework to minimize the effects of survey length on responses.

Appendix C shows the entire attitudinal survey that was sent to respondents via mail following their agreement to participate in the study during the recruit survey.

2.2.3 Choice Experiment

An important component of the attitudinal and travel behavior survey was the customized set of choice experiments that also was distributed as part of the attitudinal survey. The objective of the choice experiments was to quantify the trade-offs that people make in choosing among different travel options.

The origin, destination, and mode choice information that was provided in the recruit survey was used to design individual choice experiments for each respondent that were realistic, as they reflected each individual's unique travel patterns.

The experimental design templates used a recent trip as input. To better correspond with the Census Journey-to-Work data that are used in the development of the SPT, the choice experiments focused on work travel. Respondents were presented with a total of three choice experiments where they had to choose between a highway option, an existing transit option, and a proposed enhanced bus transit option.

The level of service characteristics that were used to describe each highway and transit mode reflected each respondent's current work travel. Alternatives that were developed as part of the choice exercise included:

- to work;
- Sharing a ride to work;
- Taking existing transit to work, including Pace, Metra, or CTA service;
- Taking a Driving vanpool to work; and
- Taking a proposed "Rapid Bus" service to work.

Land Use Settings

To support distinctions between land use patterns throughout the region, particularly as they relate to general transit supportiveness and potential transit service strategies, CS developed a categorization of land use settings. The land use categories define urban, suburban, and exurban areas at the township level based on development density, general development patterns, and types of local transit service available. This categorization is used to distinguish land use settings throughout the Initiative, including elements of the choice experiments, market segmentation analysis, and the SPT.

1. **Category 3 ("Urban")** townships include the majority of the City of Chicago and the inner suburbs. In these townships, bus routes are generally provided by CTA and Pace in a dense grid network with routes spaced every one mile or less. As a result, nearly every point is within walking distance of transit and there are relatively few itineraries in the sample for which walk distance would be greater than one-half mile. Population density also is generally six or more households per gross acre, which is considered to be sufficient to support frequent bus service.[1]

2. **Category 2 ("Suburban")** townships have at least one traffic analysis zone (TAZ) with a density of three or more households per acre or 15 jobs per gross acre. (Several contiguous townships that did not meet this standard, but were surrounded on three sides by Category 2 townships, also were included in Category 2.) This area includes most of suburban Cook County, most of DuPage County, the Highland Park area of Lake County, and the satellite cities of Joliet, Aurora, Elgin, and Waukegan. Population density varies widely, but is generally at least one to two households per

[1] The results of a literature review of transit-supportive residential and employment densities is included in Appendix D.

acre, a level that supports dial-a-ride or flex-route local transit services in other metropolitan areas.

3. **Category 1 ("Exurban")** townships have at least one TAZ with a density of one or more households per acre and no TAZs with more than 15 jobs per acre. (Several contiguous townships surrounded by Category 1 townships also were included.) This area includes several areas in the far reaches of Cook County, most of northern Will County, northwestern DuPage County, parts of eastern Kane County, southeast McHenry County, and most of Lake County. Population density in these areas is generally near the low end of areas that support transit service, but general public dial-a-ride services could provide essential "first mile/last mile" connections to existing transit services and local circulation.

The land use settings are shown in **Figure 2.1**.

Existing Highway and Transit Level of Service

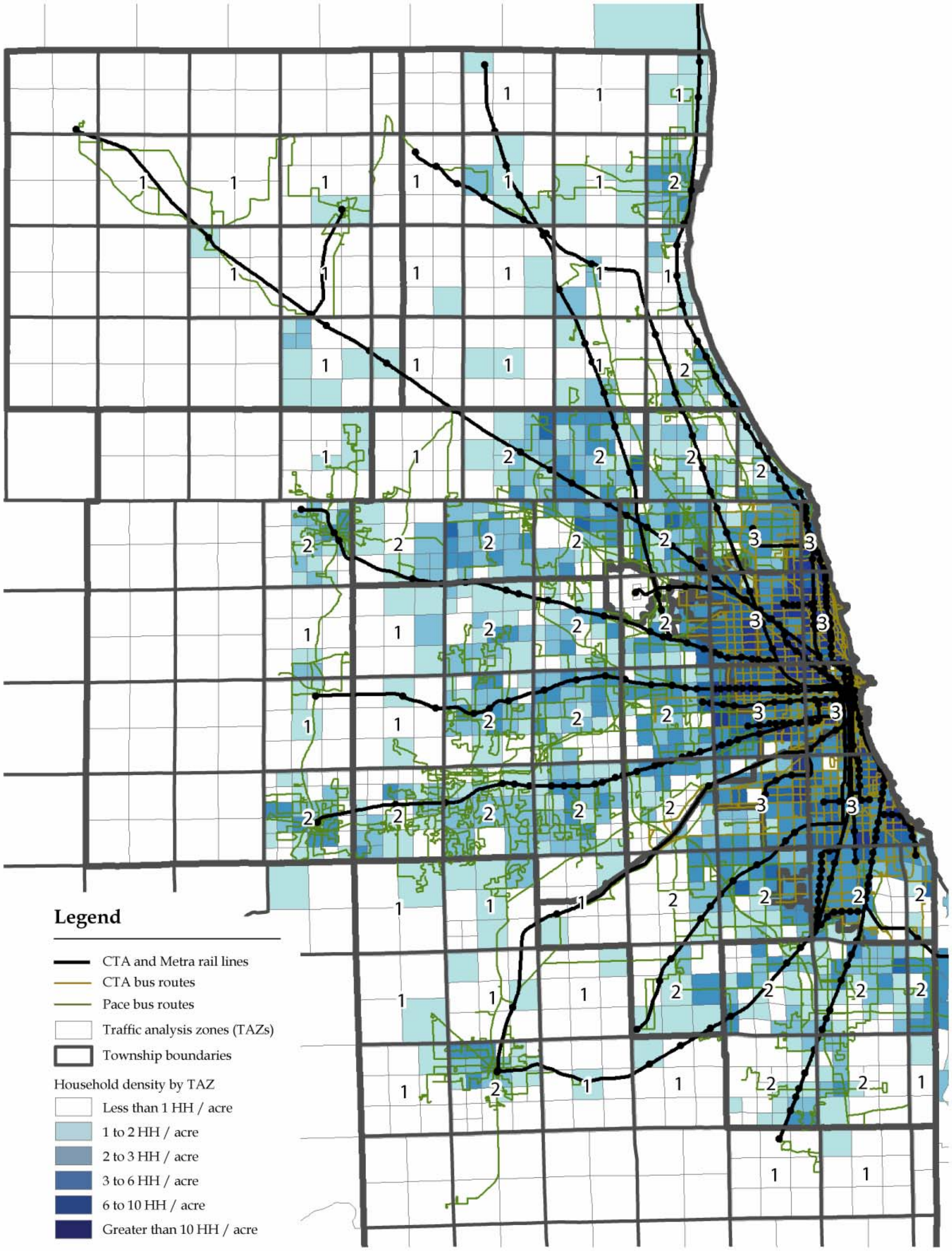
Level of Service (LOS) data for each question in the choice experiments were tailored to the origin-destination data that were provided by each respondent. LOS data for each respondent's corresponding origin and destination were retrieved from a database. Next, the levels of each variable were modified for the survey questions.

The LOS database was created by CS using a customized procedure that extracted highway and transit skims from the CATS 2005 EMME/2 databank. The EMME/2 modeling software calculates LOS by weighting the attractiveness of each transit path that is possible for a given zone pair. The resulting LOS incorporates the reality that multiple transit paths are possible for many O-D pairs in the six-county region.

Two model runs were conducted. In the first run, only walk access was permitted. This allowed the creation of LOS variables that could be properly associated with O-D pairs that only have walk access available at the origin. Furthermore, it allowed estimation of the model using walk access as a submode. Similarly, another run was conducted in which only drive access was permitted.

The LOS data were generated using the simplifying assumption that drive access is not available for Pace services. This is because the CATS databank only contained Metra and CTA park-and-ride lots and walk access to Pace is much more prevalent than drive access to Pace.

Figure 2.1 Land Use Setting Categories



Enhanced Bus Treatment

A future enhanced bus or bus rapid transit (BRT) mode ("Rapid Bus" in the survey) was presented randomly at two levels of amenities in a glossary with descriptions of other Existing Bus/Rail service and Vanpool service. The high level of Rapid Bus service was described as follows.

Proposed high-quality bus service that provides frequent, fast, and reliable service on major suburban roads. Stations and vehicles have special design features that are consistent throughout the network. Rapid Bus is like rail transit on rubber tires.

- *The route network is easy to understand and allows travel throughout the region. Traffic signals give priority to buses to speed travel.*
- *You board at stations, which include maps and real-time bus arrival information as well as heat and lighting for increased safety and comfort. The floor of the bus is level with the platform for easier boarding.*
- *If you are not in walking distance from a station, a Shuttle service will pick you up at or near your home and take you to the nearest station.*
- *You pay the fare at stations rather than on the bus, which reduces travel time.*
- *Service is available from 6:00 a.m. to 8:00 p.m.*

The description of low level of Rapid Bus service omitted references to traffic signal priority and level boarding.

CS developed a Choice Experiment generator spreadsheet that presented Rapid Bus level of service values within ranges based on a hypothetical Rapid Bus network. The values presented were randomized within a structured experiment framework. The network reduces to three the maximum number of transfers needed to travel throughout the region by simulating a grid network of arterial express bus services and complementary local transit services. The City of Chicago and inner suburbs already are served by a dense grid network of arterial bus routes that provide direct connections between many places outside the central area and make it possible to avoid downtown transfers for many trips. The proposed grid network would expand this general concept to the majority of the region, but with a wider three-mile average spacing between routes. This network eliminates the need to travel downtown on Metra, transfer to another line, and travel back out to make some suburb-to-suburb movements. Policy headways and timed transfers between local and express services further reduce the time spent transferring.

The network embodies the concept of universal accessibility provided by line-haul and community-based services in Pace's Vision 2020 strategic plan, but generalizes the network for implementation within a spreadsheet environment. Rapid Bus services are assumed to be spaced uniformly every three miles across the region, beginning at State and Madison Streets in downtown Chicago. The geographic extent of the Rapid Bus service is based on the same township geography used to describe land use settings throughout the market segmentation analysis. Express services are assumed to be provided on arterial streets in the rectangular area bounded by the townships containing Waukegan, Elgin, Aurora, Joliet, and Lake Michigan. This includes 22 east-west routes, ranging from approximately IL-132 in Lake County to 231st Street or Schweizer Road in Will County, and 15 north-south routes, ranging from Torrance Avenue in Cook County to approximately Randall Road in Kane County. For simplicity, the network is service board neutral. Services within the City of Chicago are assumed to be provided with similar characteristics and seamless connections (perhaps as CTA X-routes) to services in the inner-ring suburbs.

Rapid Bus itineraries in the choice experiments included random combinations of walk and shuttle access, Rapid Bus line-haul, and walk and shuttle egress. Accordingly, there was a 25 percent probability that a given choice experiment would include Walk-Rapid Bus-Walk, Walk-Rapid Bus-Shuttle, Shuttle-Rapid Bus-Walk, or Shuttle-Rapid Bus-Shuttle. Shuttle service assumptions varied from fixed routes spaced every one-half mile in Urban areas, flex routes with on-demand stops every one-quarter mile in Suburban areas, and dial-a-ride services with curbside pickup in Exurban areas.

1. Wait time ("service frequency" in the survey) was presented as randomized headways derived from a seed value based on the land use setting of the origin and whether the respondent commutes from home during the morning peak period. Seed Rapid Bus headways were 10-15 minutes peak/off-peak in Urban areas, 15-20 minutes in Suburban areas, and 20-30 minutes in Exurban areas. The seed values were then modified randomly to reflect shorter or longer headways based on even clockface divisions. Values could vary between 6 minutes and 60 minutes.

2. Access time ("time to get to transit" in the survey) was presented as randomized multiples of 0.2 to 2 times a seed value based on the land use setting of the origin and whether the itinerary included walk or shuttle access. The seed value for walk access was always assumed to be 5 minutes (approximately the time it takes to walk one-quarter mile – the midpoint value between zero and a one-half-mile maximum walk distance to a station). The seed value for shuttle service ranged from 3 minutes in Urban and Suburban areas (the rounded midpoint value between zero and the one-quarter-mile maximum distance to a fixed route operating on quarter-section streets spaced about one-half mile apart or on-demand flex route stops spaced every one-quarter mile) to one minute in Exurban areas (the generally brief walk time from your house to the curb).

3. In-vehicle travel time ("time in vehicle(s)" in the survey) was presented as randomized multiples of 0.9 to 1.2 times a seed value based on the travel time associated with the simulated best path itinerary through the hypothetical Rapid Bus network, plus any time spent on an access or egress shuttle. The best path was based on the geographic coordinates of the residence and workplace location of the respondent, as provided in

the recruit survey. Based on the location of the origin, the spreadsheet selected a Rapid Bus boarding station at one-mile intervals, computed the distance traveled to a transfer point at the intersection with another Rapid Bus route at a three-mile interval, selected an alighting Rapid Bus station near the destination, and computed the distance traveled on the second Rapid Bus route from the transfer point to the final station. If the trip was nearly due north-south or due east-west, no transfer would be required, and zero distance would be added on the second Rapid Bus route. The distance traveled in Urban, Suburban, and Exurban townships was multiplied by 14 miles per hour, 21 miles per hour, or 28 miles per hour, respectively, to compute Rapid Bus in-vehicle travel time. Shuttle travel time was added as appropriate for the itinerary based on the orthogonal distance between the origin point and the boarding Rapid Bus station or the orthogonal distance between the alighting Rapid Bus station and the destination point, multiplied by 12 miles per hour.

4. Transfer time ("time spent transferring between buses or trains" in the survey) was presented as randomized multiples of 0.6 to 1.5 times a seed value based on the number of Rapid Bus-to-Rapid Bus transfers, the headway of the Rapid Bus service, and the number of shuttle transfers. Rapid Bus-to-Rapid Bus transfers were assumed to require one-half of the headway on average, because timed transfers would not be possible in such a grid network. Transfers between Rapid Bus and shuttle services were assumed to take 5 minutes each.

5. Egress time ("time to walk from your car or transit stop to your workplace" in the survey) was computed in a similar manner as access time.

6. Travel cost ("fare cost" in the survey) was presented as randomized values ranging from $1.75 to $6.

7. Travel-time reliability ("you will be late more than 15 minutes …" in the survey) was presented as randomized values ranging from "once every six months" to "once a month."

■ 2.3 Data Collection

As respondents were being recruited, their origin and destination information was geocoded and was then used to tailor the choice exercises for each individual. Choice exercise materials and personalized cover letter information were mailed in a distinctive envelope. The processing of the origin and destination data aimed at minimizing delays between the recruiting stage, the mailing of the choice exercise materials, and the corresponding retrieval interviews that collected information on attitudes and the choice experiment.

Household retrieval telephone interviews were automatically scheduled by the Computer Assisted Telephone Interviewing (CATI) system. Retrieval interviews continued to be scheduled automatically for the following five days until the CATI system recorded that the attitude section and choice exercises had been completed. Telephone messages were left, respondents were asked for the most convenient time to call them back, and the CATI scheduler automatically brought the call up at that time for an available interviewer. Attempts also were made during the day and on weekends. Difficult-to-reach respondents were asked to call into a toll-free number. Callbacks were made for address information when an address was found to be nongeocodable.

Throughout the project duration, a toll-free telephone number was available for answering respondents' questions. Quality checks and detailed data collection procedures were used to ensure quality data deliverables. The data collection effort was closely monitored and managed by the MORPACE International project team and used fully-trained travel interviewers along with supervisors, monitors, and coders who were supported by Internet searchers for geocoding.

The CATI and scheduling system tracked and documented the disposition of all calls. Refusals were coded in the system as uninformed refusals, soft refusals, and hard refusals. Uninformed refusals are households where the respondent hung-up before the interviewer was able to get through the introduction. These numbers were "rested" for a seven-day period and then retried until a minimum of six calls are made over different days of the week and at different times or a refusal or complete is secured. Soft refusals were recontacted by senior, specially trained interviewers on a different day in an attempt to complete the interview. Hard refusals were not called back since the respondent specifically asked to be removed from the sample list, or the respondent was threatening or abusive in their refusal.

A minimum of six calls were made to each number in the sampling frame over different days and weekends in an attempt to reach lines that were formerly busy, were not answered, or were answered by an answering machine. The real-time CATI sample disposition for both the recruit and retrieval was used to determine nonresponsive households. Responsive interviewing techniques, including incentives and targeted RDD samples, were introduced to fill or replace incomplete or unaccepted households as the study progressed.

■ 2.4 Survey Weights

The objective of developing weights for the Pace survey is to ensure that the final survey data used in model estimation represent as closely as possible the socioeconomic profile of residents in the six-county area served by Pace.

Therefore, the incidence of respondents in the Pace survey across socioeconomic segments and by geography was compared with the incidence found in the 2000 Census. The most recent information that was available in the American Community Survey (ACS) was used to reflect the true incidence of each of these segments in the population. Variables of interest included:

- Home county;
- Household size;
- Number of workers;
- Household income; and
- Vehicles in the household.

The retrieval tally for the 1,330 completed surveys and the breakdown by each of the socioeconomic variables of interest is shown in **Table 2.4** for the six-county region, Cook County, and the five suburban counties together. It should be noted that the survey was specifically designed not to sample respondents from households with no workers. As a result, the comparisons for the distribution of the number of workers focuses only on those households with one or more workers present.

The first comparison at a county level showed that the sample proportion by county in the Pace survey was quite comparable to the incidence in the Census reflecting in part the sampling strategy used (**Table 2.4**). This table also suggests that lower-income households, households with zero vehicles, and households with only one member were relatively underrepresented in the original Pace survey sample. **Table 2.5** shows the same data presented at the county level of detail for each of the five suburban counties. The same pattern of relative underrepresentation of lower-income, one-person, and zero vehicle households emerges.

Table 2.4 Distribution of Key Socioeconomic Characteristics in the Sample

	Total Sample	Percent in Pace Survey	Six-County Census Totals	Percent in 2000 Census	Cook County Sample	Percent in Pace Survey	Cook Census Totals	Percent in 2000 Census	Suburban Counties Sample	Percent in Pace Survey	Suburban Counties Census Totals	Percent in Census
Total Sample	1,330	**100.0%**	4,659,791	100.0%	698	**100.0%**	1,919,008	100.0%	632		1,013,169	
Telephone	342	**25.7%**			184				158			
Mail	988	**74.3%**			514				474			
Total	**1,330**				**698**				**632**			
Household Size												
One Person	222	**16.8%**	1,309,497	28.1%	140	**20.2%**	583,232	30.4%	82	**13.0%**	216,630	21.4%
Two Persons	427	**32.3%**	1,456,892	31.3%	225	**32.4%**	547,717	28.5%	202	**32.1%**	308,261	30.4%
Three Persons	239	**18.1%**	693,363	14.9%	119	**17.1%**	284,355	14.8%	120	**19.1%**	165,417	16.3%
Netted: Four or More Persons	435	**32.9%**	1,200,039	25.8%	210	**30.3%**	503,704	26.2%	225	**35.8%**	322,861	31.9%
Total	**1,323**	**100.0%**	**4,659,791**	**100.0%**	**694**	**100.0%**	**1,919,008**	**100.0%**	**629**	**100.0%**	**1,013,169**	
Number of Household Vehicles												
Zero Vehicles	69	**5.2%**	466,525	10.0%	59	**8.5%**	316,148	16.5%	10	**1.6%**	36,007	3.6%
One Vehicle	332	**25.0%**	1,593,875	34.2%	216	**31.0%**	760,051	39.6%	116	**18.4%**	271,012	26.7%
Two Vehicles	607	**45.7%**	1,808,488	38.8%	281	**40.3%**	611,648	31.9%	326	**51.6%**	484,974	47.9%
Three or More Vehicles	321	**24.2%**	790,903	17.0%	141	**20.2%**	231,161	12.0%	180	**28.5%**	221,176	21.8%
Total	**1,329**	**100.0%**	**4,659,791**	**100.0%**	**697**	**100.0%**	**1,919,008**	**100.0%**	**632**	**100.0%**	**1,013,169**	**100.0%**
Number of Household Workers												
Zero Workers	5	**0.4%**	1,237,870	26.6%	5	**0.7%**	528,842	27.6%	0	**0.0%**	189,689	18.7%
One Worker	513	**38.7%**	1,810,007	38.8%	281	**40.4%**	780,109	40.7%	232	**36.7%**	389,463	38.4%
Two Workers	638	**48.1%**	1,297,452	27.8%	330	**47.5%**	473,227	24.7%	308	**48.7%**	348,966	34.4%
Three or More Workers	171	**12.9%**	314,462	6.7%	79	**11.4%**	136,830	7.1%	92	**14.6%**	85,051	8.4%
Total	**1,327**	**100.0%**	**4,659,791**	**100.0%**	**695**	**100.0%**	**1,919,008**	**100.0%**	**632**	**100.0%**	**1,013,169**	**100.0%**
Household Income												
Below $15,000	26	**2.3%**	157,161	8.2%	21	**3.5%**	85,922	9.4%	5	**0.9%**	71,239	7.0%
$15,000 to Below $25,000	52	**4.6%**	158,030	8.2%	37	**6.2%**	85,091	9.3%	15	**2.8%**	72,939	7.2%
$25,000 to Below $35,000	57	**5.0%**	172,536	9.0%	32	**5.4%**	86,763	9.5%	25	**4.6%**	85,773	8.5%
$35,000 to Below $55,000	197	**17.3%**	264,520	13.8%	110	**18.4%**	137,792	15.1%	87	**16.0%**	126,728	12.5%
$55,000 to Below $75,000	250	**21.9%**	400,992	20.8%	138	**23.1%**	197,125	21.7%	112	**20.6%**	203,867	20.1%
$75,000 to Below $100,000	236	**20.7%**	291,987	15.2%	122	**20.4%**	131,428	14.4%	114	**20.9%**	160,559	15.8%
$100,000 to Below $125,000	142	**12.4%**	179,313	9.3%	60	**10.1%**	69,881	7.7%	82	**15.0%**	109,432	10.8%
$125,000 or More	182	**15.9%**	298,783	15.5%	77	**12.9%**	116,151	12.8%	105	**19.3%**	182,632	18.0%
Total	**1,142**	**100.0%**	**1,923,322**	**100.0%**	**597**	**100.0%**	**910,153**	**100.0%**	**545**	**100.0%**	**1,013,169**	**100.0%**

Table 2.5 Key Socioeconomics in the Sample and Census for Each Suburban County

	Sample	Percent		Sample	Percent		Sample	Percent		Sample	Percent		Sample	Percent	
	Will County	Pace Survey	2000 Census	DuPage County	Pace Survey	2000 Census	Lake County	Pace Survey	2000 Census	McHenry County	Pace Survey	2000 Census	Kane County	Pace Survey	2000 Census
Total Sample	140	**100.0%**	100.0%	203	**100.0%**	100.0%	150	**100.0%**	100.0%	56	**100.0%**	100.0%	83	**100.0%**	100.0%
Telephone	41			47			39			14			17		
Mail	99			156			111			42			66		
Total	**140**			**203**			**150**			**56**			**83**		
Household Size															
One Person	12	**8.6%**	20.0%	32	**15.9%**	24.5%	20	**13.4%**	21.1%	8	**14.3%**	18.3%	10	**12.0%**	18.7%
Two Persons	39	**27.9%**	28.4%	66	**32.8%**	32.0%	52	**34.9%**	29.5%	13	**23.2%**	30.1%	32	**38.6%**	31.1%
Three Persons	28	**20.0%**	17.0%	39	**19.4%**	15.4%	29	**19.5%**	16.2%	9	**16.1%**	19.3%	15	**18.1%**	15.7%
Netted: Four or More Persons	61	**43.6%**	34.7%	64	**31.8%**	28.1%	48	**32.2%**	33.1%	26	**46.4%**	32.2%	26	**31.3%**	34.5%
Total	**140**	**100.0%**	**100.0%**	**201**	**100.0%**	**100.0%**	**149**	**100.0%**	**100.0%**	**56**	**100.0%**	**100.0%**	**83**	**100.0%**	**100.0%**
Number of Household Vehicles															
Zero Vehicles	2	**1.4%**	2.8%	4	**2.0%**	3.6%	0	**0.0%**	4.1%	0	**0.0%**	2.7%	4	**4.8%**	4.2%
One Vehicle	19	**13.6%**	24.5%	39	**19.2%**	29.4%	32	**21.3%**	27.6%	11	**19.6%**	23.6%	15	**18.1%**	24.6%
Two Vehicles	76	**54.3%**	50.0%	104	**51.2%**	47.4%	82	**54.7%**	47.1%	27	**48.2%**	49.0%	37	**44.6%**	46.5%
Three or More Vehicles	43	**30.7%**	22.8%	56	**27.6%**	19.6%	36	**24.0%**	21.1%	18	**32.1%**	24.7%	27	**32.5%**	24.7%
Total	**140**	**100.0%**	**100.0%**	**203**	**100.0%**	**100.0%**	**150**	**100.0%**	**100.0%**	**56**	**100.0%**	**100.0%**	**83**	**100.0%**	**100.0%**
Number of Household Workers															
Zero Workers	0	**0.0%**	18.5%	0	**0.0%**	19.3%	0	**0.0%**	19.0%	0	**0.0%**	19.8%	0	**0.0%**	16.6%
One Worker	41	**29.3%**	40.1%	75	**36.9%**	37.9%	57	**38.0%**	40.1%	25	**44.6%**	31.8%	34	**41.0%**	39.5%
Two Workers	76	**54.3%**	32.9%	95	**46.8%**	34.3%	78	**52.0%**	33.2%	23	**41.1%**	39.0%	36	**43.4%**	35.6%
Three or More Workers	23	**16.4%**	8.5%	33	**16.3%**	8.6%	15	**10.0%**	7.7%	8	**14.3%**	9.4%	13	**15.7%**	8.2%
Total	**140**	**1**	**100.0%**	**203**	**1**	**100.0%**	**150**	**1**	**100.0%**	**56**	**1**	**100.0%**	**83**	**1**	**100.0%**
Household Income															
Below $15,000	4	**3.3%**	7.6%	1	**0.6%**	5.5%	0	**0.0%**	7.7%	0	**0.0%**	7.3%	0	**0.0%**	8.6%
$15,000 to Below $25,000	1	**0.8%**	8.2%	2	**1.2%**	7.0%	8	**6.3%**	7.3%	2	**4.1%**	5.5%	2	**2.7%**	7.5%
$25,000 to Below $35,000	3	**2.5%**	7.8%	8	**4.6%**	9.6%	5	**4.0%**	8.2%	2	**4.1%**	5.5%	7	**9.3%**	9.2%
$35,000 to Below $55,000	21	**17.2%**	14.2%	25	**14.5%**	12.4%	19	**15.1%**	11.1%	11	**22.4%**	11.5%	11	**14.7%**	13.4%
$55,000 to Below $75,000	22	**18.0%**	21.9%	38	**22.0%**	19.3%	23	**18.3%**	18.7%	14	**28.6%**	23.9%	15	**20.0%**	19.2%
$75,000 to Below $100,000	26	**21.3%**	16.8%	38	**22.0%**	15.7%	22	**17.5%**	14.6%	12	**24.5%**	17.3%	16	**21.3%**	15.7%
$100,000 to Below $125,000	20	**16.4%**	9.8%	28	**16.2%**	11.5%	18	**14.3%**	10.7%	3	**6.1%**	10.4%	13	**17.3%**	11.0%
$125,000 or More	25	**20.5%**	13.8%	33	**19.1%**	19.1%	31	**24.6%**	21.6%	5	**10.2%**	18.7%	11	**14.7%**	15.5%
Total	**122**	**1**	**100.0%**	**173**	**1**	**100.0%**	**126**	**1**	**100.0%**	**49**	**1**	**100.0%**	**75**	**1**	**100.0%**

Based on these patterns, the home county and income variables were selected for developing weights for the Pace survey. The rationale was that the use of weights for home county and income would provide the most important correction for the sample and also would help adjust the incidence for automobile ownership and household size. **Table 2.6** summarizes the weights used in the analysis of the Pace survey to ensure a properly balanced sample both by region and by income category.

Table 2.6 Weights by Home County and Income Level

Income/County	Will	DuPage	Lake	McHenry	Kane	Cook
Below $25,000	3.57	7.18	2.20	3.48	7.04	2.72
$25,000 to under $35,000	2.93	2.09	1.92	1.49	1.16	1.97
$35,000 to under $75,000	0.95	0.87	0.83	0.77	1.10	0.81
$75,000 to under $100,000	0.73	0.72	0.78	0.79	0.86	0.60
$100,000 to under $125,000	0.55	0.71	0.70	1.88	0.74	0.65
$125,000 or more	0.62	1.00	0.82	2.03	1.23	0.83

The impact of the calculated weights on the sample were tested by comparing the weighted frequency for the same socioeconomic characteristics and the departure time to work distribution to the corresponding information from the Census. The comparisons shown in **Table 2.7** show that the weighted observations percentage are very close to the ACS figures and account for the original underrepresentation of certain income categories and county residents.

Table 2.7 Comparisons between the Weighted Pace Survey and the ACS Survey 2004

	Pace Survey	ACS Estimate	Weighted Pace Survey
Time of Departure to Work			
12:00 a.m. to 5:59 a.m. (Midnight)	14.9%	13.8%	14.5%
6:00 a.m. to 8:59 a.m. (Morning Peak Period)	73.1%	64.0%	71.3%
9:00 a.m. to 3:59 p.m. (Day Time)	9.1%	16.2%	12.0%
4:00 p.m. to 11:59 p.m. (Night)	2.9%	6.1%	2.2%
Workers in Each County and Respondents in Each County			
Will	22.2%	20.5%	20.7%
DuPage	32.1%	32.2%	31.8%
Lake	23.7%	22.1%	21.5%
McHenry	8.9%	9.8%	10.0%
Kane	13.1%	15.4%	16.1%
Number of Vehicle Available			
Universe: HOUSEHOLDS: No Vehicles Available (Estimate)	1.6%	3.6%	4.7%
Universe: HOUSEHOLDS: 1 Vehicle Available (Estimate)	18.4%	26.7%	21.1%
Universe: HOUSEHOLDS: 2 Vehicles Available (Estimate)	51.6%	47.9%	48.7%
Universe: HOUSEHOLDS: 3 or More Vehicles Available (Estimate)	28.5%	21.8%	25.5%
Household Size			
Universe: HOUSEHOLDS: 1-Person Household (Estimate)	13.0%	21.4%	15.1%
Universe: HOUSEHOLDS: 2-Person Household (Estimate)	32.1%	30.4%	34.3%
Universe: HOUSEHOLDS: 3-Person Household (Estimate)	19.1%	16.3%	18.7%
Universe: HOUSEHOLDS: 4-or-More-Person Household (Estimate)	35.8%	31.9%	31.9%
Number of Workers in Household			
Universe: HOUSEHOLDS: No Workers (Estimate)	0.0%	0.0%	0.0%
Universe: HOUSEHOLDS: 1 Worker (Estimate)	36.7%	47.3%	41.4%
Universe: HOUSEHOLDS: 2 Workers (Estimate)	48.7%	42.4%	46.1%
Universe: HOUSEHOLDS: 3 or More Workers (Estimate)	14.6%	10.3%	12.5%
Income of Household			
Below $25,000	3.7%	14.2%	14.3%
$25,000 to under $35,000	4.6%	8.5%	8.5%
$35,000 to under $75,000	36.5%	32.6%	32.7%
$75,000 to under $100,000	20.9%	15.8%	15.9%
$100,000 to under $125,000	15.0%	10.8%	10.8%
$125,000 or More	19.3%	18.0%	17.9%

2.5 Missing Survey Data

Survey efforts often result in datasets with a small number of observations that have partially incomplete information. This reflects the inability of respondents to provide information in response to complicated questions or their unwillingness to reveal sensitive information about themselves and their family. CS conducted an analysis of missing data in the traveler survey. Overall, the pattern of missing data does not adversely affect the reliability of the estimates we obtain from the survey. This reflects the few observations for which socioeconomic data were missing and the small impact of these missing observations on the attitudinal questions that serve a key role in the analyses throughout the Initiative.

Table 2.8 shows the number of observations for which there was missing information for individual socioeconomic variables. As expected, the income information was the most commonly missing variable, especially when the more detailed follow-up question about income levels was asked. There also was a small number of observations with missing information on age and ethnic background.

Table 2.8 Summary of Records with Missing Socioeconomic Variables

Socioeconomic Variable	Labels	Missing Records	Total Records
Gender	–	1	N=1,330
Age	–	22	
Income	Household Income	188	
Income_3	If Income Less/More Than 35,000	79	
Hhsize	Household Size	7	
Hhwrks	Household Workers	3	
Ethnic	–	20	
Hhautos	Household Vehicles	1	

Given the importance of attitudinal statements in this project, we focused on the impact of missing socioeconomic data on the value of each of the 36 attitudinal statements (**Table 2.9**). The analysis focused on whether the missing socioeconomic variables had a systematic effect on respondents' attitudes. A negative answer to this question would confirm that there were no systematic biases in the nonresponse patterns.

Table 2.9 Analysis of Missing Socioeconomic Variables

Attitudinal Statements	$N_{present}$	Mean	$N_{missing}$	Mean	p Value
Driving is usually the fastest way to get to work.	1,128	7.85	191	8.02	0.48
I would change my form of travel if it would save me some time.	***1,125***	***7.12***	***191***	***6.67***	***0.03***
I like to make productive use of my time when I travel.	1,130	7.51	191	7.84	0.06
I am usually in a hurry when I make a trip to work.	1,134	6.53	192	6.60	0.73
I need to make work trips according to a fixed schedule.	1,133	6.55	192	6.77	0.34
I need to make stops on the way to or from work.	1,131	5.37	192	5.28	0.68
I need to travel mostly during the morning and afternoon rush hours.	1,128	7.54	192	7.46	0.71
It's important to be able to change my travel plans at a moment's notice.	1,134	6.97	191	6.77	0.33
It is important to have comfortable seats when I travel.	1,134	8.10	192	8.18	0.56
Having my privacy is important to me when I travel.	1,134	6.60	191	6.58	0.89
When I travel with others, I prefer to be the driver.	1,128	5.85	189	5.77	0.73
I wouldn't mind walking a few minutes to get to and from a bus or train stop.	1,123	7.45	190	7.25	0.29
I don't mind transferring between buses or between bus and rail service.	1,100	5.04	187	4.73	0.16
Public transit vehicles in the Chicago area are usually clean.	1,088	5.93	187	5.86	0.66
It is important to be able to control heat and air conditioning when I travel.	1,133	6.74	192	6.90	0.38
I feel safe walking near my home.	1,135	9.02	192	9.19	0.15
I feel safe walking near my workplace.	1,130	8.34	192	8.26	0.65
I feel safe on a bus or train to my workplace.	1,045	7.37	179	7.10	0.17
I feel safe while waiting for a bus or train to my workplace.	1,059	7.13	173	7.03	0.63
I avoid traveling through certain areas because they are unsafe.	***1,128***	***6.03***	***192***	***6.52***	***0.03***
If my travel is delayed, I want to know the cause and length of the delay.	1,133	8.60	192	8.45	0.26
I don't mind delays as long as I am comfortable.	1,130	4.55	191	4.29	0.21
Riding transit is more reliable than driving during rainy and snowy weather.	1,117	6.84	190	7.07	0.30
Predictable and reliable travel to work is important to me.	1,135	9.16	191	9.30	0.19
I often commute before or after the rush hour to avoid highway congestion.	***1,120***	***5.63***	***189***	***4.96***	***0.008***
I want to know when the next bus or train is coming while waiting at a stop or station.	1,114	8.64	187	8.51	0.41
Having a stress-free trip is more is more important than reaching my destination quickly.	1,128	5.98	191	5.98	0.99
Riding transit is less stressful than driving on congested highways.	1,121	7.78	190	7.84	0.76
Figuring out how to use public transportation is easy.	1,126	6.35	190	6.23	0.56
When driving, I worry about my vehicle breaking down.	1,121	4.17	191	4.24	0.78
When traveling, I like to talk and visit with other people.	1,129	4.64	191	4.49	0.47
My family and friends use public transportation.	1,132	5.06	191	4.83	0.32
I don't like riding transit with other people.	1,128	4.32	190	4.45	0.52
I'm willing to pay a higher fare for higher quality transit service.	1,125	6.13	192	6.05	0.68
I use the fastest form of transportation to work regardless of the costs.	1,128	6.29	191	6.10	0.42
If gas prices increase substantially, I am likely to consider using public transportation.	1,110	5.81	187	5.66	0.56

To test this hypothesis, we formed two groups of observations distinguishing between the roughly 1,130 observations for which the socioeconomic variables were present ($N_{present}$) and the roughly 190 observations for which one or more of these socioeconomic variables was missing ($N_{missing}$).

We then conducted a comparative analysis of the mean values of the attitudes in each one of the two groups for each of the 36 attitudinal statements. These comparisons helped identify if missing socioeconomic variables had a systematic effect on the attitudinal variable values. The t-statistic test was used to evaluate if there is a significant difference in the means of the 36 attitude statements between the two groups.

Table 2.9 summarizes the results from the first comparison where we identified observations where all socioeconomic variables were present and compared them with observations where one or more of the nine socioeconomic variables were missing. In the majority of the attitudinal statements, there was no discernible difference in mean ratings between the two groups. There were only 3 of the 36 statements where there was a statistically significant difference: *"I often commute before or after the rush hour to avoid highway congestion," "I would change my form of travel if it would save me some time,"* and *"I avoid traveling through certain areas because they are unsafe."* A second round of analysis focused on the impact of missing values for the income variable. The almost identical results are summarized in **Table 2.10.**

The nonresponse analysis focused on the observations with the missing socioeconomic variables and the impact of these missing variables on respondents' attitudes. The analysis suggests that income accounted for most of the missing information and that neither income nor the other missing variables had a measurable impact on respondents' attitudes as reflected in the 36 individual attitudinal statements.

Table 2.10 Analysis of Missing Income Values

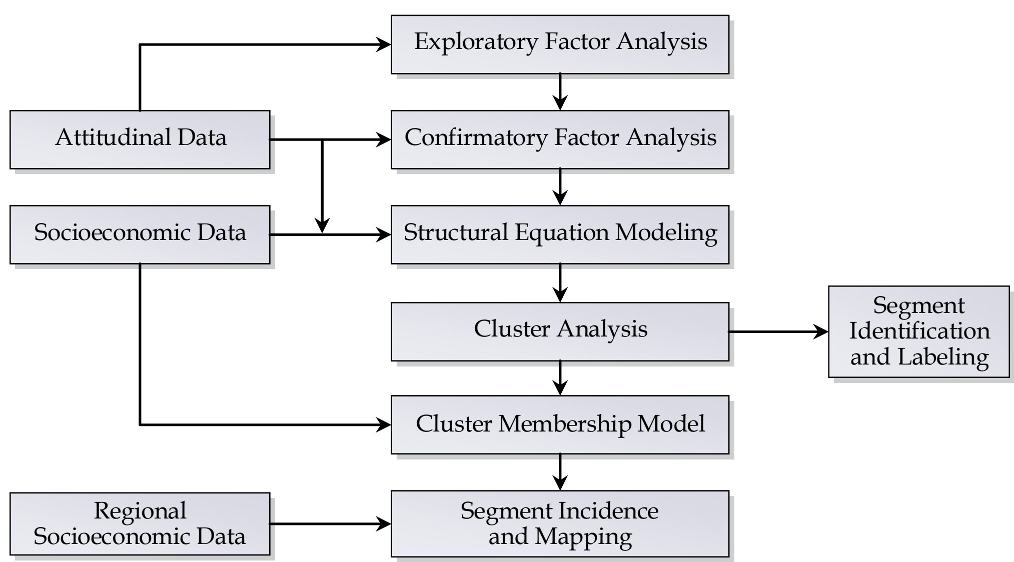
Attitudinal Statements	$N_{present}$	Mean	$N_{missing}$	Mean	p Value
Driving is usually the fastest way to get to work.	1,132	7.84	187	8.06	0.35
I would change my form of travel if it would save me some time.	***1,129***	***7.12***	***187***	***6.68***	***0.04***
I like to make productive use of my time when I travel.	1,134	7.52	187	7.81	0.11
I am usually in a hurry when I make a trip to work.	1,138	6.53	188	6.61	0.70
I need to make work trips according to a fixed schedule.	1,137	6.54	188	6.80	0.27
I need to make stops on the way to or from work.	1,135	5.37	188	5.26	0.63
I need to travel mostly during the morning and afternoon rush hours.	1,132	7.54	188	7.50	0.87
It's important to be able to change my travel plans at a moment's notice.	1,138	6.96	187	6.81	0.44
It is important to have comfortable seats when I travel.	1,138	8.10	188	8.15	0.76
Having my privacy is important to me when I travel.	1,138	6.60	187	6.61	0.94
When I travel with others, I prefer to be the driver.	1,132	5.84	185	5.80	0.86
I wouldn't mind walking a few minutes to get to and from a bus or train stop.	1,127	7.45	186	7.26	0.33
I don't mind transferring between buses or between bus and rail service.	1,104	5.04	183	4.68	0.10
Public transit vehicles in the Chicago area are usually clean.	1,092	5.93	183	5.85	0.62
It is important to be able to control heat and air conditioning when I travel.	1,137	6.73	188	6.90	0.35
I feel safe walking near my home.	1,139	9.02	188	9.18	0.17
I feel safe walking near my workplace.	1,134	8.34	188	8.26	0.66
I feel safe on a bus or train to my workplace.	1,049	7.37	175	7.07	0.13
I feel safe while waiting for a bus or train to my workplace.	1,063	7.14	169	6.98	0.44
I avoid traveling through certain areas because they are unsafe.	***1,132***	***6.03***	***188***	***6.53***	***0.03***
If my travel is delayed, I want to know the cause and length of the delay.	1,137	8.60	188	8.44	0.24
I don't mind delays as long as I am comfortable.	1,134	4.55	187	4.26	0.15
Riding transit is more reliable than driving during rainy and snowy weather.	1,121	6.84	186	7.05	0.35
Predictable and reliable travel to work is important to me.	1,139	9.16	187	9.28	0.26
I often commute before or after the rush hour to avoid highway congestion.	***1,124***	***5.62***	***185***	***4.96***	***0.008***
I want to know when the next bus or train is coming while waiting at a stop or station.	1,118	8.64	183	8.49	0.30
Having a stress-free trip is more is more important than reaching my destination quickly.	1,132	5.99	187	5.93	0.77
Riding transit is less stressful than driving on congested highways.	1,125	7.78	186	7.84	0.73
Figuring out how to use public transportation is easy.	1,130	6.36	186	6.18	0.40
When driving, I worry about my vehicle breaking down.	1,125	4.17	187	4.23	0.80
When traveling, I like to talk and visit with other people.	1,133	4.64	187	4.45	0.37
My family and friends use public transportation.	1,136	5.06	187	4.84	0.35
I don't like riding transit with other people.	1,132	4.32	186	4.45	0.51
I'm willing to pay a higher fare for higher quality transit service.	1,129	6.13	188	6.05	0.68
I use the fastest form of transportation to work regardless of the costs.	1,132	6.28	187	6.12	0.49
If gas prices increase substantially, I am likely to consider using public transportation.	1,114	5.82	183	5.57	0.34

3.0 Market Segmentation

One of the objectives of the Pace study was to identify distinct segments of the market that differed in terms of their attitudes toward everyday travel and their choice behavior. The market segments traditionally used in transportation planning are most often based on socioeconomic characteristics such as income, gender, or automobile ownership. To better understand the values that different travelers place on their everyday travel by transit and highway, we relied on their attitudes toward different aspects of their travel experience.

We implemented a series of multivariate statistical procedures to incorporate user attitudes towards transit into the market segmentation task. **Figure 3.1** demonstrates the multiple steps that are involved in the identification of market segments and the mapping of the incidence of different market segments in the six-county region.

Figure 3.1 Phases of Market Segmentation Task and Information Flow



The approach uses attitudinal data from the survey as the main source of information. It starts with Exploratory Factor Analysis (EFA), an exploratory analysis of the main underlying dimensions that exist in the data. These dimensions are then refined to achieve a stable, statistically valid, and easy-to-interpret model using the Confirmatory Factor Analysis (CFA). Relationships between socioeconomic attributes and attitudinal statements are established in the Structural Equation Modeling (SEM) phase of the analysis. The factor scores produced by SEM are then used as inputs in the Cluster Analysis to form market segments.

A Cluster Membership Model based on discrete choice theory is then estimated to link cluster membership to the socioeconomic characteristics of the respondents. The resultant model is applied to the six-county region by using as inputs socioeconomic data from the Census at the block group level of detail. The membership probabilities that are calculated for each segment are then used to create incidence maps for each market segment.

■ 3.1 Data Sources

As described in Section 2.2.2, survey respondents were asked to rate 36 attitudinal statements on a scale of 0 to 10 stating their degree of agreement. A value of 0 indicated that they strongly disagreed with a statement and a value of 10 meant that they strongly agreed. The objective of these attitudinal statements was to explore travelers' attitudes toward every attribute of their commuting experience. Examples of these statements include travelers' attitudes towards the various components of travel time, the cost of commuting, feeling of safety, and the flexibility and convenience offered by competing travel modes. The full list of these 36 questions, including variable names assigned in the analysis, is shown in **Table 3.1**.

In addition to the attitudinal data, the survey also collected socioeconomic and demographic information from each respondent. Socioeconomic data from the 2000 Census at the block group level and Public Use Microdata Area (PUMA) level of detail also were used for in-model application. PUMA level data provided detailed tabulations of socioeconomic variables at a larger level of geographical detail and was used as control totals to calibrate estimates of the detailed Census block-level distribution of socioeconomic characteristics.

Table 3.1 List of Attitudinal Questions in the Survey

	Variable Name	Attitudinal Statement
1	DRVFASTR	Driving is usually the fastest way to get to work.
2	SAVETIME	I would change my form of travel if it would save me some time.
3	PRODCTVE	I like to make productive use of my time when I travel.
4	INAHURRY	I am usually in a hurry when I make a trip to work.
5	FXDSCHED	I need to make work trips according to a fixed schedule.
6	STOPS	I need to make stops on the way to or from work.
7	PEAKTRVL	I need to travel mostly during the morning and afternoon rush hours.
8	CHNGPLAN	It's important to be able to change my travel plans at a moment's notice.
9	COMFSEAT	It is important to have comfortable seats when I travel.
10	PRIVACY	Having my privacy is important to me when I travel.
11	DRIVPREF	When I travel with others, I prefer to be the driver.
12	LIKEWALK	I wouldn't mind walking a few minutes to get to and from a bus or train stop.
13	TRNSFROK	I don't mind transferring between buses or between bus and rail service.
14	CLEAN_TR	Public transit vehicles in the Chicago area are usually clean.
15	HEAT_AC	It is important to be able to control heat and air conditioning when I travel.
16	SAFEHOME	I feel safe walking near my home.
17	SAFEWORK	I feel safe walking near my workplace.
18	SAFETRAN	I feel safe on a bus or train to my workplace.
19	SAFEWAIT	I feel safe while waiting for a bus or train to my workplace.
20	AVOID	I avoid traveling through certain areas because they are unsafe.
21	DELAYWHY	If my travel is delayed, I want to know the cause and length of the delay.
22	DELAYCMF	I don't mind delays as long as I am comfortable.
23	TRANRELB	Riding transit is more reliable than driving during rainy and snowy weather.
24	RELIABLE	Predictable and reliable travel to work is important to me.
25	AVOIDPKS	I often commute before or after the rush hour to avoid highway congestion.
26	ARRTIMES	I want to know when the next bus or train is coming while waiting at a stop or station.
27	STRSFREE	Having a stress-free trip is more important than reaching my destination quickly.
28	TRANCONG	Riding transit is less stressful than driving on congested highways.
29	HOWTOUSE	Figuring out how to use public transportation is easy.
30	CARBREAK	When driving, I worry about my vehicle breaking down.
31	SOCIALZE	When traveling, I like to talk and visit with other people.
32	FAM_TRAN	My family and friends use public transportation.
33	STRANGER	I don't like riding transit with total strangers sitting next to me.
34	QUAL_WTP	I'm willing to pay a higher fare for higher quality transit service.
35	FASTEST	I use the fastest form of transportation to work regardless of the costs.
36	CONSIDER	If gas prices increase substantially, I am likely to consider using public transportation to get to work.

3.2 Factor Analysis

Factor Analysis refers to a set of methods that reduces the large number of observed variables reflected in the attitudinal statement ratings to a smaller number of five to eight factors that represent the underlying dimensions. The outcome is a set of factors which represent linear combinations of the observed variables. Factor analysis applications can be classified into two categories depending on the purpose and level of a priori knowledge about the data.

The Exploratory Factor Analysis is generally used to investigate the factor structure underlying the observed data. This method uses a relatively large set of variables as inputs and does not impose any specific hypothesis about how these variables are related to each of the underlying dimensions. The principle of this method is that the correlation or covariance matrix of the observed variables (the attitudinal ratings) exhibits distinctive patterns of similarity that are reflected in a smaller number of intrinsic dimensions (the factors). In other words, the observed correlations among variables are caused by factors that are used to "group" the similar attitudinal statements together. This procedure allows the analyst to make informed decisions on the number of factors to be extracted and the method of extraction.

The Confirmatory Factor Analysis seeks to determine if the number of factors and the loadings of observed variables on them conform to what is expected on the basis of pre-established theory. The set of observed variables that will load on each factor and the number of factors are selected a priori. The outcome from CFA includes measures of fitness of the proposed model, levels of significance of the postulated relationships, and factor scores.

For this Initiative and in most practical applications, the exploratory factor analysis is used to support the decisions in the confirmatory factor analysis. The confirmatory approach is then used to refine the composition of factors to provide better interpretability and a practical application.

Starting with the Exploratory Factor Analysis, five main underlying dimensions in the data were defined. Principal Axis Factoring and Varimax methods were employed for extraction and rotation of the factors, respectively.[1] The number of factors for extraction was selected based on Scree Plot analysis and interpretability of results. Factor solutions with four, five, and six factors were reviewed. **Table 3.2** presents the levels of relationships between each factor and 36 attitudinal statements. The procedure yielded a five-factor factor structure and the patterns of loadings between indicators and each factor were used to provide preliminary labels for each factor.

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[1] For more detailed discussions on Factor Analysis and other multivariate statistical procedures, refer to **Sharma, S., (1996)**, Applied Multivariate Techniques, Wiley & Sons, New York and **Tabachnick, B.G., and Fidell, L.S., (2000)** Using Multivariate Statistics, 4th Edition, Prentice Hall.

Table 3.2 Exploratory Factor Analysis Results – Factor Loadings

		Rotated Factor Pattern	
		Factor 1	**Factor 2**
DELAYCMF	I do not mind delays if comfortable.	**0.461**	0.004
TRNSFROK	I do not mind transferring.	**0.442**	-0.029
STRSFREE	Stress-free is more important than speed.	**0.420**	-0.220
SOCIALZE	I like to talk and visit during commute.	**0.389**	0.074
TRANCONG	Transit is less stressful in congestion.	**0.380**	-0.335
FAM_TRAN	Family and friends use transit.	**0.349**	-0.228
LIKEWALK	I do not mind walking to/from bus.	**0.342**	-0.138
HOWTOUSE	How to use transit is easy.	**0.341**	-0.189
CARBREAK	I worry about car breakdowns.	**0.336**	-0.041
CLEAN_TR	Buses in Chicago are clean.	**0.299**	-0.029
QUAL_WTP	Willing to pay for quality transit.	**0.260**	0.115
DRVFASTR	Driving is fastest way to work.	-0.154	**0.548**
CONSIDER	If gas prices increase I will consider.	0.407	**-0.449**
FASTEST	I use fastest form of transportation.	0.040	**0.413**
TRANRELB	Transit more reliable in bad weather.	0.389	**-0.409**
STOPS	I make stops to/from work.	0.040	**0.386**
CHNGPLAN	Flexibility to change plans.	-0.014	**0.333**
AVOIDPKS	I often commute before/after rush hours.	0.238	**0.286**
PEAKTRVL	A.M. and P.M. peak work travel.	0.037	**-0.278**
DELAYWHY	I want to know source of delay.	-0.013	-0.043
RELIABLE	Predictable travel is important.	-0.024	-0.014
SAVETIME	Change mode if I could save time.	0.155	0.172
ARRTIMES	I want to know transit arrival time.	0.123	-0.066
PRODCTVE	Productive use of my time.	0.201	-0.069
INAHURRY	In a hurry when I travel to work.	-0.025	0.097
FXDSCHED	Fixed schedule for work travel.	0.075	-0.127
SAFEWAIT	I feel safe waiting for transit.	0.241	-0.287
SAFETRAN	I feel safe riding transit.	0.356	-0.267
SAFEWORK	I feel safe walking near work.	0.075	-0.035
SAFEHOME	I feel safe walking near my home.	-0.062	0.043
PRIVACY	Privacy is important.	-0.051	0.073
HEAT_AC	Control heat and air conditioning.	-0.021	0.141
STRANGER	I do not like riding with strangers.	-0.050	0.082
COMFSEAT	Importance of comfortable seats.	0.077	0.002
DRIVPREF	I prefer driving when with others.	-0.065	0.271
AVOID	I avoid traveling in unsafe areas.	0.198	0.066

These preliminary factors can be described as follows:

1. **Easy-Going/Stress-Free Travel Experience –** All the statements under this factor point to the advantages of a comfortable, stress-free commute, knowledge of transit use, acceptance of transit access and transit delays, a social dimension/interaction with strangers that is positive toward transit (talk and visit while traveling), and positive normative beliefs (my friends use transit). All statements point to a transit-friendly attitudinal dimension. This was refined to become the "Transit Advantages" factor later in the analysis.

2. **Need for Flexibility and Speed –** This dimension reflects respondents' need to make trips outside the a.m. and p.m. peak periods, the flexibility to make stops to/from their main destination, the need to arrive at their destination in the fastest way possible, the unreliability of transit, and their unwillingness to consider other modes even in the presence of higher gas prices. This was refined to become the "Driving Advantages" factor later in the analysis.

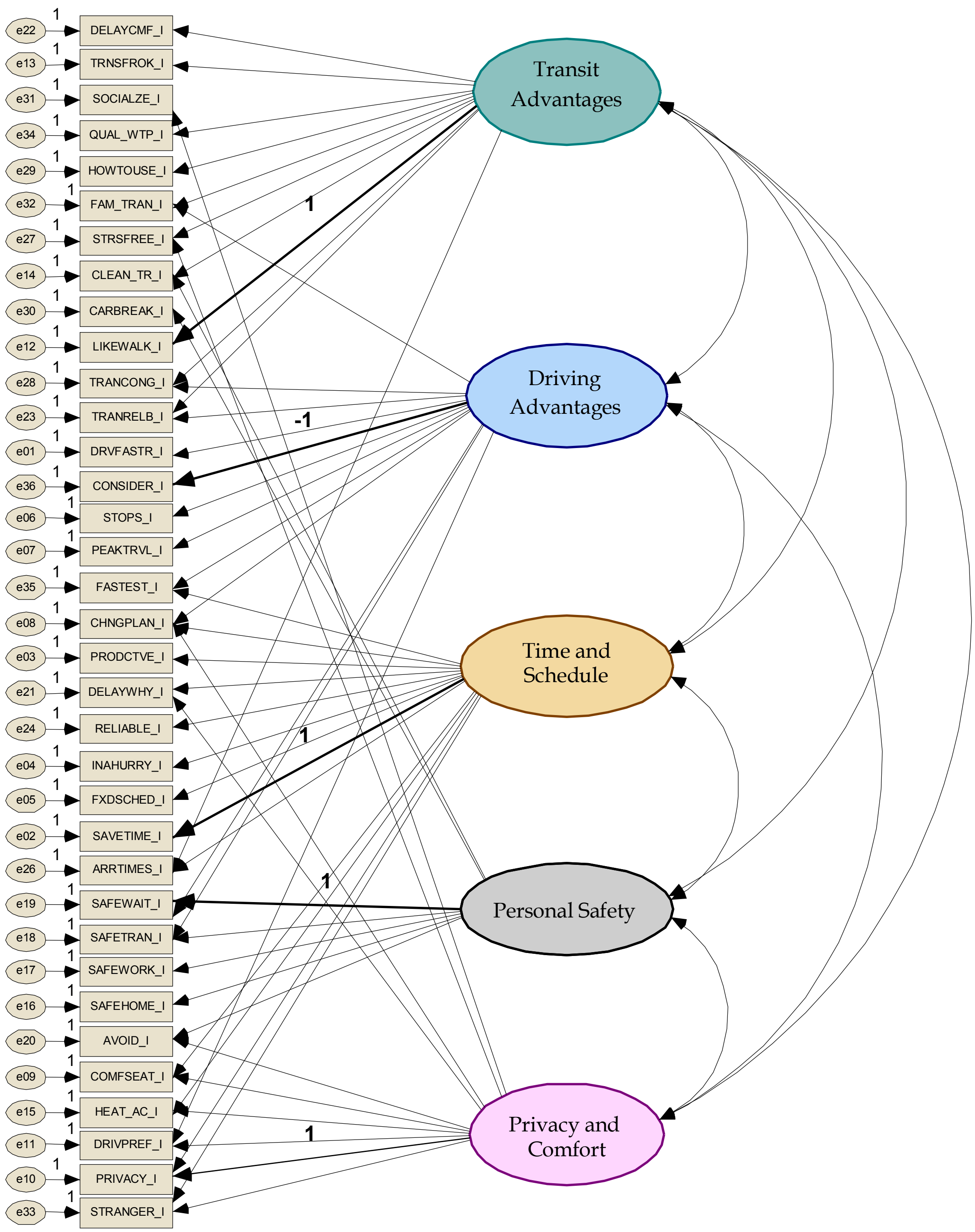
3. **Sensitivity to Use of Time –** These statements reflect the need for predictable travel patterns, a pragmatic approach to "getting there" (need to know arrival times), seeking ways to save time, the need to know the source of delay, flexibility in terms of which modes get them at their destination, and the desire to make productive use of time. This was refined to become the "Time and Schedule" factor later in the analysis.

4. **Sensitivity to Personal Safety –** This dimension incorporates all aspects of feeling safe while considering daily travel options. It includes feeling safe while walking to the station/bus stop at the origin end of their trip, walking at the destination end, feeling safe while waiting for service, and feeling safe while riding transit. This was refined to become the "Personal Safety" factor later in the analysis.

5. **Personal Travel Experience –** This dimension is heavily loaded on privacy-related statements and on issues related to the "control of the environment" while traveling to maximize comfort and to have a pleasant travel experience. This was refined to become the "Privacy and Comfort" factor later in the analysis.

During the Confirmatory Factor Analysis (CFA), the five-factor structure implied by the exploratory factor model was used as a basis. The specification of the model was refined to include only those attitudinal statements with substantial loadings on each factor. The specification was finalized by dropping observed variables with no substantial loading or very low reliability values. The final Confirmatory Factor model specification is shown in **Figure 3.2**.

Figure 3.2 Confirmatory Factor Analysis Model Specification



The goodness of fit measures listed in **Table 3.3** indicated a good level of model fit. In selecting a final model specification, the search for an improved model considered the following items in the following order of importance:

- Statistical (theoretical) strength of individual variables;
- Interpretation of the findings;
- Measures of overall model fit; and
- Ease of model application.

As part of this effort, the objective was not to exclusively maximize overall model fit which can be accomplished by:

- Reducing the number of input variables – for example, by dropping attitudinal statements the model "tries to explain less variability" and, therefore, has a better fit; or by
- Increasing the underlying complexity of the model – for example, when all variables are related to all factors the fit improves but the model becomes more complex and difficult or impossible to interpret.

Table 3.3 Goodness of Fit for Confirmatory Factor Analysis Model

Measure	Value
N	1,317
NPAR	96
DF	534
Chi Square – Zero Model	22,785
Chi Square – Default Model	1,697.8
GFI	0.925
AGFI	0.912
RMSEA	0.041

Table 3.4 features the regression weights that relate observed and latent variables. These weights were used to refine the labeling of the five factors. It should be noted that the overall factor structure as indicated by the exploratory factor analysis was maintained and refined by the confirmatory factor model.

Table 3.4 Distribution of Regression Weights in the CFA Model

Attribute	Factor	Estimate	S.E.	C.R.	P
LIKEWALK	Transit Advantages	1			
HOWTOUSE		0.967	0.076	12.779	***
TRANCONG		0.695	0.08	8.718	***
TRANRELB		0.614	0.089	6.898	***
STRSFREE		0.565	0.077	7.321	***
QUAL_WTP		0.543	0.062	8.721	***
FAM_TRAN		0.464	0.098	4.732	***
CLEAN_TR		0.314	0.058	5.371	***
DELAYCMF		0.299	0.062	4.822	***
ARRTIMES		0.201	0.049	4.074	***
TRNSFROK		0.2	0.019	10.755	***
SAFEWAIT	Personal Safety	1			
SAFETRAN		0.987	0.051	19.194	***
SAFEWORK		0.67	0.05	13.383	***
SAFEHOME		0.388	0.033	11.631	***
CLEAN_TR		0.277	0.049	5.63	***
AVOID		-0.254	0.058	-4.379	***
CARBREAK		-0.232	0.064	-3.616	***
SAVETIME	Time and Schedule	1			
PRODCTVE		0.885	0.145	6.112	***
DELAYWHY		0.881	0.133	6.62	***
FASTEST		0.877	0.156	5.625	***
ARRTIMES		0.723	0.122	5.924	***
RELIABLE		0.685	0.107	6.408	***
CHNGPLAN		0.634	0.127	4.973	***
FXDSCHED		0.487	0.127	3.837	***
HEAT_AC		0.433	0.108	4.012	***
INAHURRY		0.324	0.1	3.233	0.001
PRIVACY		0.313	0.103	3.045	0.002
COMFSEAT		-0.216	0.106	-2.039	0.041
STRANGER		0.178	0.032	5.495	***
PRIVACY	Privacy and Comfort	1			
STRANGER		0.966	0.078	12.361	***
HEAT_AC		0.683	0.063	10.896	***
DRIVPREF		0.454	0.074	6.167	***
AVOID		0.405	0.076	5.35	***
STRSFREE		0.346	0.072	4.791	***
CHNGPLAN		-0.256	0.061	-4.182	***
DELAYWHY		0.242	0.061	3.964	***
COMFSEAT		0.143	0.041	3.473	***
SOCIALZE		0.115	0.015	7.85	***
DRVFASTR	Driving Advantages	-1			
STOPS		0.851	0.059	14.477	***
FASTEST		-0.563	0.043	-13.025	***
CHNGPLAN		-0.534	0.065	-8.195	***
DRIVPREF		-0.498	0.044	-11.294	***
PEAKTRVL		0.491	0.054	9.062	***
TRANCONG		0.399	0.055	7.227	***
FAM_TRAN		-0.369	0.07	-5.295	***
SAFEWAIT		-0.363	0.055	-6.598	***
TRANRELB		-0.337	0.047	-7.1	***
SAFETRAN		0.311	0.052	6.037	***
CONSIDER		0.251	0.053	4.744	***

3.3 Structural Equation Model

Structural equation modeling (SEM) is a collection of statistical techniques that allows one to examine a set of relationships between one or more independent variables and one or more dependent variables. These variables can be either latent variables (factors that are unobserved dimensions) or measured variables (attitudinal ratings that are observed variables).

The main strength of SEM is that it allows the examination of complex relationships simultaneously and treats measurement error explicitly. It also specifies and examines the model pictorially to enable a clearer conceptualization of the theory under study. If the goodness of fit is adequate, the plausibility of the specified relationships is implied. In cases of an inadequate model fit, the validity of the modeled relations is rejected.

The underlying theory of SEM is similar to the factor analysis. The observed correlation matrix formed by the observed variables (attitudinal ratings) can be replicated by a postulated factor structure and hypothesized relationships between the various latent variables (factors). The success of a SEM is gauged by how well the implied covariance matrix produced by the model can replicate the observed covariance matrix. Structural equation models also are widely referred to as covariance structure modeling.

A SEM is composed of two main parts: a measurement model and a structural model. The measurement model refers to the specification and estimation of relationships between latent and observed variables which is analogous to the confirmatory factor analysis. The structural model consists of relationships between latent variables (factors).

In this analysis, the factor structure defined by the CFA is adopted for the SEM specification and socioeconomic characteristics of the respondents were included in the model in addition to the attitudinal statements. The model specifies that attitudes towards transit, as reflected in the responses to the attitudinal statements in the survey, are driven by attitudinal factors and that those factors are driven by the socioeconomic and demographic characteristics of the respondents.

The SEM approach provides the only means to include socioeconomics as part of market segmentation in addition to accounting for the impact of respondents' attitudes. More importantly, it also allows us to develop clusters based on observed socioeconomic characteristics. This provides a critical link to the model application where only socioeconomic data, as available from the Census, are used as explanatory variables to drive and help explain cluster membership.

Figure 3.3 displays a schematic representation of relationships between attitudinal statements, factors, and socioeconomic variables. **Figure 3.4** features the model specification for the SEM developed in this analysis. During the process of finalizing the model specification, some of the relationships that appeared in CFA have been dropped or redefined due to insignificant estimates.

Figure 3.3 Linkage Between Socioeconomics and Attitudinal Responses

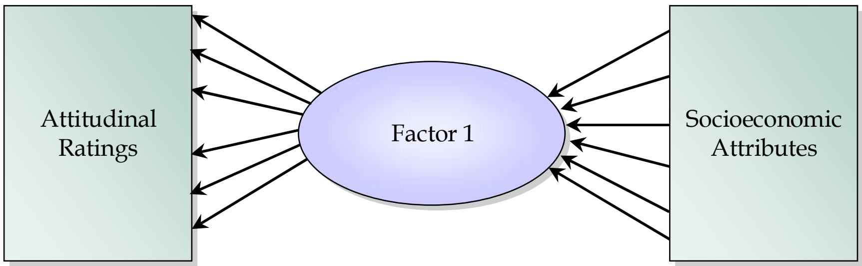


Figure 3.4 SEM Specification

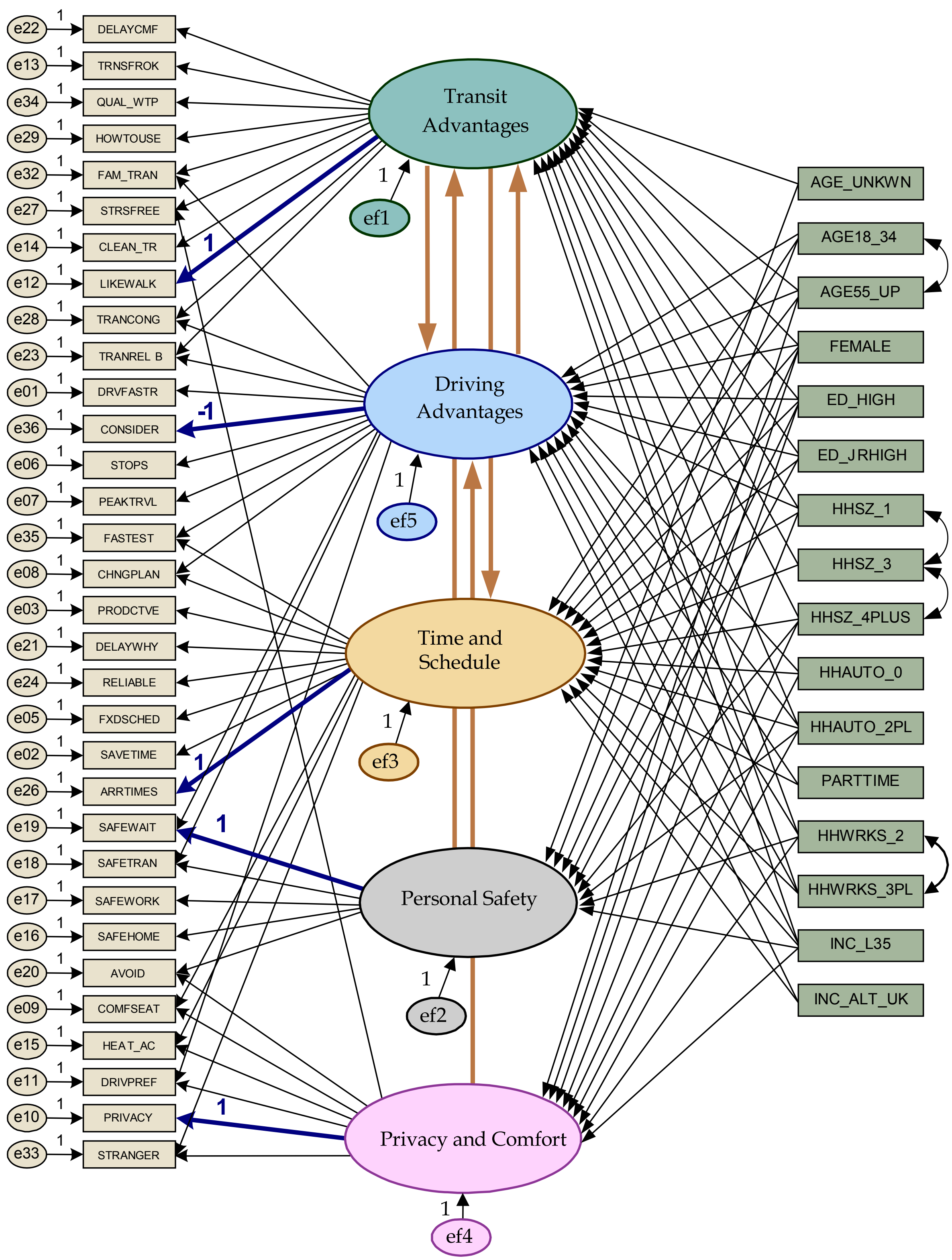


Table 3.5 displays the goodness of fit measures for the model and **Table 3.6** shows regression weight estimates that reflect observed and latent variables along with the multiple square correlations. The selection of the best possible model specification has followed the same strategy as outlined in the previous section. Based on the outputs featured in **Tables 3.5** through **3.10**, we concluded that:

- The existing model reflects a proper balance among the statistical strength of individual variables, measures of overall model fit, interpretation of the findings, and ease of model application; and
- The measures of overall fit for the existing model reflect a good representation of the underlying data and fit well within the existing model structure.

An output of the SEM process is a set of coefficients that are used to calculate the factor scores. These scores are linear combinations of all variables that are connected to that factor either directly or indirectly. The calculated factor scores are used during cluster analysis described in the following section to help define market segments within the study area.

Table 3.5 Goodness of Fit Measures for SEM Model

Measure	Value
N	1,317
NPAR	161
DF	1,015
Chi Square – Zero Model	31,584
Chi Square – Default Model	3,267
GFI	0.897
AGFI	0.880
SRMR	0.067
RMSEA	0.041

Source: Cambridge Systematics, Inc., 2006.

Table 3.6 Regression Weights between Attitudinal Statements and Factors

		Attitudinal Statements and Factors				
		Factors	Estimate	S.E.	C.R.	P
LIKEWALK	←	Transit Advantages	1			
HOWTOUSE	←		0.939	0.077	12.137	0
TRNSFROK	←		0.824	0.074	11.104	0
TRANRELB	←		0.793	0.096	8.267	0
TRANCONG	←		0.715	0.081	8.783	0
QUAL_WTP	←		0.646	0.067	9.585	0
STRSFREE	←		0.628	0.069	9.06	0
FAM_TRAN	←		0.575	0.104	5.544	0
CLEAN_TR	←		0.543	0.056	9.68	0
DELAYCMF	←		0.346	0.067	5.182	0
SAFEWAIT	←	Personal Safety	1			0
SAFETRAN	←		0.935	0.052	17.922	0
SAFEWORK	←		0.636	0.048	13.142	0
SAFEHOME	←		0.361	0.032	11.233	0
AVOID	←		-0.179	0.058	-3.093	0.002
ARRTIMES	←	Time and Schedule	1			0
PRODCTVE	←		0.979	0.116	8.472	0
DELAYWHY	←		0.936	0.091	10.245	0
SAVETIME	←		0.933	0.122	7.648	0
FASTEST	←		0.915	0.151	6.071	0
CHNGPLAN	←		0.776	0.129	6.036	0
COMFSEAT	←		0.756	0.092	8.258	0
RELIABLE	←		0.668	0.07	9.53	0
FXDSCHED	←		0.651	0.13	4.992	0
STRANGER	←		-0.491	0.107	-4.578	0
HEAT_AC	←		0.451	0.098	4.595	0
PRIVACY	←	Privacy and Comfort	1			0
STRANGER	←		0.845	0.085	9.892	0
HEAT_AC	←		0.712	0.077	9.3	0
COMFSEAT	←		0.476	0.059	8.094	0
AVOID	←		0.424	0.082	5.193	0
DRIVPREF	←		0.354	0.083	4.259	0
STRSFREE	←		0.324	0.068	4.765	0
CONSIDER	←	Driving Advantages	-1			0
DRVFASTR	←		0.835	0.055	15.225	0
STOPS	←		0.483	0.051	9.464	0
TRANRELB	←		-0.452	0.059	-7.618	0
SAFETRAN	←		-0.433	0.045	-9.547	0
FASTEST	←		0.409	0.054	7.619	0
SAFEWAIT	←		-0.385	0.047	-8.112	0
CHNGPLAN	←		0.379	0.049	7.678	0
PEAKTRVL	←		-0.375	0.045	-8.279	0
TRANCONG	←		-0.352	0.05	-7.057	0
FAM_TRAN	←		-0.34	0.064	-5.297	0
DRIVPREF	←		0.293	.05	5.926	0

Source: Cambridge Systematics, Inc., 2006.

Table 3.7 Regression Weights between Socioeconomic Variables and Factors

Factors		Factors and Socioeconomic Variables				
		SE Variable	Estimate	S.E.	C.R.	P
Transit Advantages	←	HHWRKS_2	0.435	0.148	2.936	0.003
Transit Advantages	←	HHSZ_1	-0.691	0.237	-2.918	0.004
Transit Advantages	←	HHAUTO_2PL	0.444	0.176	2.52	0.012
Transit Advantages	←	AGE55_UP	-0.33	0.132	-2.505	0.012
Transit Advantages	←	HHWRKS_3PL	0.464	0.193	2.401	0.016
Transit Advantages	←	FEMALE	-0.239	0.102	-2.337	0.019
Transit Advantages	←	AGE18_34	-0.239	0.124	-1.933	0.053
Transit Advantages	←	AGE_UNKWN	-0.585	0.333	-1.759	0.079
Transit Advantages	←	HHSZ_3	0.253	0.144	1.755	0.079
Transit Advantages	←	HHSZ_4PLUS	0.229	0.18	1.276	0.202
Transit Advantages	←	INC_L35	-0.157	0.186	-0.843	0.399
Transit Advantages	←	ED_HIGH	-0.03	0.103	-0.296	0.767
Transit Advantages	←	ED_HIGH	0.014	0.356	0.039	0.969
Personal Safety	←	FEMALE	-0.464	0.137	-3.387	0.001
Personal Safety	←	ED_JRHIGH	-1.51	0.53	-2.85	0.004
Personal Safety	←	ED_HIGH	-0.39	0.138	-2.827	0.005
Personal Safety	←	INC_L35	-0.501	0.251	-1.993	0.046
Personal Safety	←	HHWRKS_2	0.214	0.154	0.139	0.164
Personal Safety	←	HHSZ_4PLUS	0.215	0.172	1.25	0.211
Personal Safety	←	AGE_UNKWN	-0.58	0.5	-1.161	0.246
Personal Safety	←	HHAUTO_2PL	0.21	0.215	0.977	0.328
Personal Safety	←	AGE18_34	-0.155	0.163	-0.95	0.342
Time and Schedule	←	HHAUTO_2PL	-0.768	0.161	-4.766	0
Time and Schedule	←	HHSZ_1	0.832	0.209	3.991	0
Time and Schedule	←	FEMALE	0.29	0.086	3.365	0.001
Time and Schedule	←	HHWRKS_3PL	-0.529	0.161	-3.289	0.001
Time and Schedule	←	HHAUTO_0	0.601	0.185	3.245	0.001
Time and Schedule	←	HHWRKS_2	-0.376	0.127	-2.97	0.003
Time and Schedule	←	HHSZ_3	-0.349	0.126	-2.764	0.006
Time and Schedule	←	AGE55_UP	0.29	0.109	2.668	0.008
Time and Schedule	←	INC_L35	0.403	0.16	2.522	0.012
Time and Schedule	←	HHSZ_4PLUS	-0.359	0.155	-2.324	0.02
Time and Schedule	←	AGE18_34	0.229	0.1	2.287	0.022
Time and Schedule	←	ED_HIGH	0.144	0.083	1.74	0.082
Time and Schedule	←	PART-TIME	0.135	0.104	1.298	0.194
Time and Schedule	←	INC_ALT_UK	-0.096	0.135	-0.713	0.476
Privacy and Comfort	←	HHSZ_1	1.131	0.295	3.835	0
Privacy and Comfort	←	INC_L35	0.856	0.25	3.426	0.001
Privacy and Comfort	←	ED_HIGH	0.375	0.132	2.846	0.004
Privacy and Comfort	←	HHAUTO_2PL	-0.649	0.23	-2.819	0.005
Privacy and Comfort	←	HHSZ_4PLUS	0.47	0.169	-2.777	0.005
Privacy and Comfort	←	FEMALE	0.358	0.133	2.684	0.007
Privacy and Comfort	←	AGE55_UP	0.275	0.162	1.702	0.089
Privacy and Comfort	←	HHAUTO_0	0.496	0.317	1.565	0.118
Privacy and Comfort	←	HHWRKS_2	-0.102	0.157	-0.65	0.516

Table 3.7 Regression Weights between Socioeconomic Variables and Factors (continued)

Factors		Factors and Socioeconomic Variables				
		SE Variable	**Estimate**	**S.E.**	**C.R.**	**P**
Driving Advantages	←	HHAUTO_2PL	1.454	0.323	4.503	0
Driving Advantages	←	HHWRKS_3PL	1.104	0.307	3.597	0
Driving Advantages	←	HHAUTO_0	-1.148	0.395	-2.902	0.004
Driving Advantages	←	HHWRKS_2	0.657	0.259	2.537	0.011
Driving Advantages	←	AGE55_UP	-0.475	0.218	-2.184	0.029
Driving Advantages	←	FEMALE	-0.329	0.186	-1.767	0.077
Driving Advantages	←	PART-TIME	0.372	0.222	1.673	0.094
Driving Advantages	←	AGE18_34	-0.244	0.206	-1.184	0.236
Driving Advantages	←	INC_ALT_UK	0.214	0.284	0.751	0.453
Driving Advantages	←	HHSZ_4PLUS	0.13	0.231	0.562	0.574
Driving Advantages	←	ED_HIGH	0.096	0.177	0.544	0.586
Driving Advantages	←	HHSZ_1	0.212	0.448	0.473	0.636
Driving Advantages	←	INC_L35	-0.133	0.345	-0.384	0.701
Driving Advantages	←	ED_JRHIGH	0.199	0.64	0.311	0.756

Source: Cambridge Systematics, Inc., 2006.

Table 3.8 Regression Weights between Factors

Factors		Factor Interactions				
		Factors	**Estimate**	**S.E.**	**C.R.**	**P**
Transit Advantages	←	Driving Advantages	-0.275	0.05	-5.498	0
Time and Schedule	←	Transit Advantages	0.423	0.05	8.388	0
Transit Advantages	←	Personal Safety	0.381	0.037	10.233	0
Driving Advantages	←	Privacy and Comfort	0.402	0.087	4.612	0
Driving Advantages	←	Transit Advantages	-0.304	0.155	-1.955	0.051

Source: Cambridge Systematics, Inc., 2006.

Table 3.9 Reliabilities of Factors and Attitudinal Statements

Variables	Estimate
Transit Advantages	0.615
Time and Schedule	0.502
Driving Advantages	0.309
Privacy and Comfort	0.137
Personal Safety	0.051
SAFETRAN	0.662
SAFEWAIT	0.62
CONSIDER	0.466
TRANRELB	0.418
TRANCONG	0.413
DRVFASTR	0.379
PRIVCY	0.373
LIKEWALK	0.311
COMFSEAT	0.276
STRANGER	0.261
HEAT_AC	0.245
HOWTOUSE	0.245
SAFEWORK	0.244
DELAYWHY	0.237

Variables	Estimate
ARRTIMES	0.237
RELIABLE	0.213
FAM_TRAN	0.199
TRNSFROK	0.182
SAFEHOME	0.178
PRODCTVE	0.151
STRSFREE	0.148
CLEAN_TR	0.133
QUAL_WTP	0.13
FASTEST	0.129
STOPS	0.127
CHNGPLAN	0.125
SAVETIME	0.112
DRIVPREF	0.102
PEAKTRVL	0.092
AVOID	0.06
DELAYCMF	0.04
FXDSCHED	0.04

Source: Cambridge Systematics, Inc., 2006.

Table 3.10 Factors and Attitudinal Statements

Q Number	Statement	Var Name	Factor	SEM Regression Weight
12	I wouldn't mind walking a few minutes to get to and from a bus or train stop.	LIKEWALK	Transit Advantages	1.000
29	Figuring out how to use public transportation is easy.	HOWTOUSE		0.939
13	I don't mind transferring between buses or between bus and rail service.	TRNSFROK		0.824
23	Riding transit is more reliable than driving during rainy and snowy weather.	TRANRELB		0.793
28	Riding transit is less stressful than driving on congested highways.	TRANCONG		0.715
34	I'm willing to pay a higher fare for higher quality transit service.	QUAL_WTP		0.646
27	Having a stress-free trip is more important than reaching my destination quickly.	STRSFREE		0.628
32	My family and friends use public transportation.	FAM_TRAN		0.575
14	Public transit vehicles in the Chicago area are usually clean.	CLEAN_TR		0.543
22	I don't mind delays as long as I am comfortable.	DELAYCMF		0.346
19	I feel safe while waiting for a bus or train to my workplace.	SAFEWAIT	Personal Safety	1.000
18	I feel safe on a bus or train to my workplace.	SAFETRAN		0.935
17	I feel safe walking near my workplace.	SAFEWORK		0.636
16	I feel safe walking near my home.	SAFEHOME		0.361
20	I avoid traveling through certain areas because they are unsafe.	AVOID		-0.179
26	I want to know when the next bus or train is coming while waiting at a stop or station.	ARRTIMES	Time and Schedule	1.000
3	I like to make productive use of my time when I travel.	PRODCTVE		0.979
21	If my travel is delayed, I want to know the cause and length of the delay.	DELAYWHY		0.936
2	I would change my form of travel if it would save me some time.	SAVETIME		0.933
35	I use the fastest form of transportation to work regardless of the costs.	FASTEST		0.915
8	It's important to be able to change my travel plans at a moment's notice.	CHNGPLAN		0.776
9	It is important to have comfortable seats when I travel.	COMFSEAT		0.756
24	Predictable and reliable travel to work is important to me.	RELIABLE		0.668
5	I need to make work trips according to a fixed schedule.	FXDSCHED		0.651
33	I don't like riding transit with total strangers sitting next to me.	STRANGER		-0.491
15	It is important to be able to control heat and air conditioning when I travel.	HEAT_AC		0.451

Table 3.10 Factors and Attitudinal Statements (continued)

Q Number	Statement	Var Name	Factor	SEM Regression Weight
10	Having my privacy is important to me when I travel.	PRIVACY	Privacy and Comfort	1.000
33	I don't like riding transit with total strangers sitting next to me.	STRANGER		0.845
15	It is important to be able to control heat and air conditioning when I travel.	HEAT_AC		0.712
9	It is important to have comfortable seats when I travel.	COMFSEAT		0.476
20	I avoid traveling through certain areas because they are unsafe.	AVOID		0.424
11	When I travel with others, I prefer to be the driver.	DRIVPREF		0.354
27	Having a stress-free trip is more important than reaching my destination quickly.	STRSFREE		0.324
36	If gas prices increase substantially, I am likely to consider using public transportation to get to work.	CONSIDER	Driving Advantages	-1.000
1	Driving is usually the fastest way to get to work.	DRVFASTR		0.835
6	I need to make stops on the way to or from work.	STOPS		0.483
23	Riding transit is more reliable than driving during rainy and snowy weather.	STRANRELB		-0.452
18	I feel safe on a bus or train to my workplace.	SAFETRAN		-0.433
35	I use the fastest form of transportation to work regardless of the costs.	FASTEST		0.409
19	I feel safe while waiting for a bus or train to my workplace.	SAFEWAIT		-0.385
8	It's important to be able to change my travel plans at a moment's notice.	CHNGPLAN		0.379
7	I need to travel mostly during the morning and afternoon rush hours.	PEAKTRVL		-0.375
28	Riding transit is less stressful than driving on congested highways.	TRANCONG		-0.352
32	My family and friends use public transportation.	FAM_TRAN		-0.340
11	When I travel with others, I prefer to be the driver.	DRIVPREF		0.293

Source: Cambridge Systematics, Inc., 2006.

■ 3.4 Cluster Analysis

The objective of market segmentation was to identify distinct groups within the population that shared the same set of values. Respondents' attitudes towards their everyday travel experience were used to reflect these values and identify a set of "homogeneous" segments that differed as much as possible from the other segments.

Cluster analysis algorithms combine cases into compact groups with respect to certain characteristics. There are two main types of analytical clustering techniques: hierarchical and nonhierarchical.

Hierarchical algorithms start from the most similar pair of cases in the sample and define a new cluster or assign cases to an existing cluster until the list of remaining cases and/or clusters is exhausted. Hierarchical algorithms are often susceptible to linking or chaining effects. In this case, rather than creating new clusters, the algorithm assigns cases to existing clusters.

Nonhierarchical algorithms require the number of clusters as an input. The cases are assigned to the closest cluster and they can be reallocated based on predefined rules. In our analysis, we have adopted the widely used K-Means method of clustering, a nonhierarchical clustering method.

Cluster analysis was based on the output from the SEM that was used to identify patterns that helped group together travelers on the basis of their similar attitudes and socioeconomic characteristics. The three factors that were selected to create the clusters include:

1. Transit Advantages;
2. Time and Schedule; and
3. Privacy and Comfort.

This selection was based on measures of statistical significance and the practicality of defining and positioning clusters. While "Transit Advantages" and "Time and Schedule" had substantial reliabilities as reflected in the Multiple Square Correlations, "Privacy and Comfort" provided a more practical interpretation.

As part of the cluster analysis, we examined four to eight different market segments. The analysis of these results suggested that the best segmentation scheme contained seven distinct clusters that reflected seven distinct market segments in the Pace service area. The interpretation and description of each market segment was based on the following information:

- The size of each cluster in the survey sample;
- The mean value for each of the factor scores underlying the analysis;
- The comparison of the mean factor scores across segments that shows how each segment relates to the other segments along each dimension;
- The distribution of socioeconomic characteristics for each cluster; and
- The current mode choice behavior of members of each market segment and the geography of their home origins and work destinations.

Table 3.11 presents the distribution of factor score means for each cluster. Factor scores are standardized in order to facilitate comparisons across different factors. A comparative analysis across clusters helps to identify how each of the market segments compares to the rest of the clusters on the basis of traveler attitudes. As part of this process, the salient characteristics for each cluster are uncovered and are used to help label each cluster. For example:

- Cluster 7 shows the minimum value for the "Transit Advantages" factor (mean value of -1.898) and contrasts the most with Cluster 6 which has the highest mean value for "Transit Advantages" (0.997).

- In contrast, Cluster 7 has the highest value for the "Driving Advantages" factor (mean value of 1.345) while Cluster 6 has the lowest value for the same dimension (mean value of -0.764).

- The contrast between Clusters 6 and 7 shows a clear difference with respect to the positioning of members of these two market segments and the quite different potential appeal of both existing and proposed transit services to these two markets.

Tables 3.12 to **3.17** provide a summary of socioeconomic characteristics for members of each of the seven clusters, the geography of their travel, and their current mode choice behavior. This information is used to help develop a profile of the most likely members of each cluster. It provides additional insights into the composition of each market segment and the likely impacts of different strategies on the success of any new proposed transit service initiatives.

Table 3.12 shows the composition of each cluster in terms of respondents' demographic characteristics, including gender, age, and household size. **Table 3.13** shows the differences across clusters when comparing education, number of workers, and full- versus part-time employment status for members of each market segment.

Table 3.14 focuses on the levels of automobile ownership and income across the seven clusters. **Table 3.15** features the land use classification of the place of residence and the place of employment for workers in each market segment, as defined in Section 2.2.3. These geographic variables can be used as surrogates that reflect the ease of using highway and transit modes to commute to and from work. The home and work location are used to differentiate among the Chicago central business district (CBD), urban areas, suburban areas, and exurban areas in the six-county region. The CATS definition of the CBD (bounded by Chicago Avenue, Lake Michigan, Roosevelt Road, and Halsted Street) is used to distinguish the CBD from the rest of the Urban area.

Figure 3.5 shows the definitions used for each of these four areas. **Table 3.16** shows how market segments differ by the origin-destination market pairs using these broadly defined areas.

Figure 3.5 Urbanization Classification in Northeastern Illinois

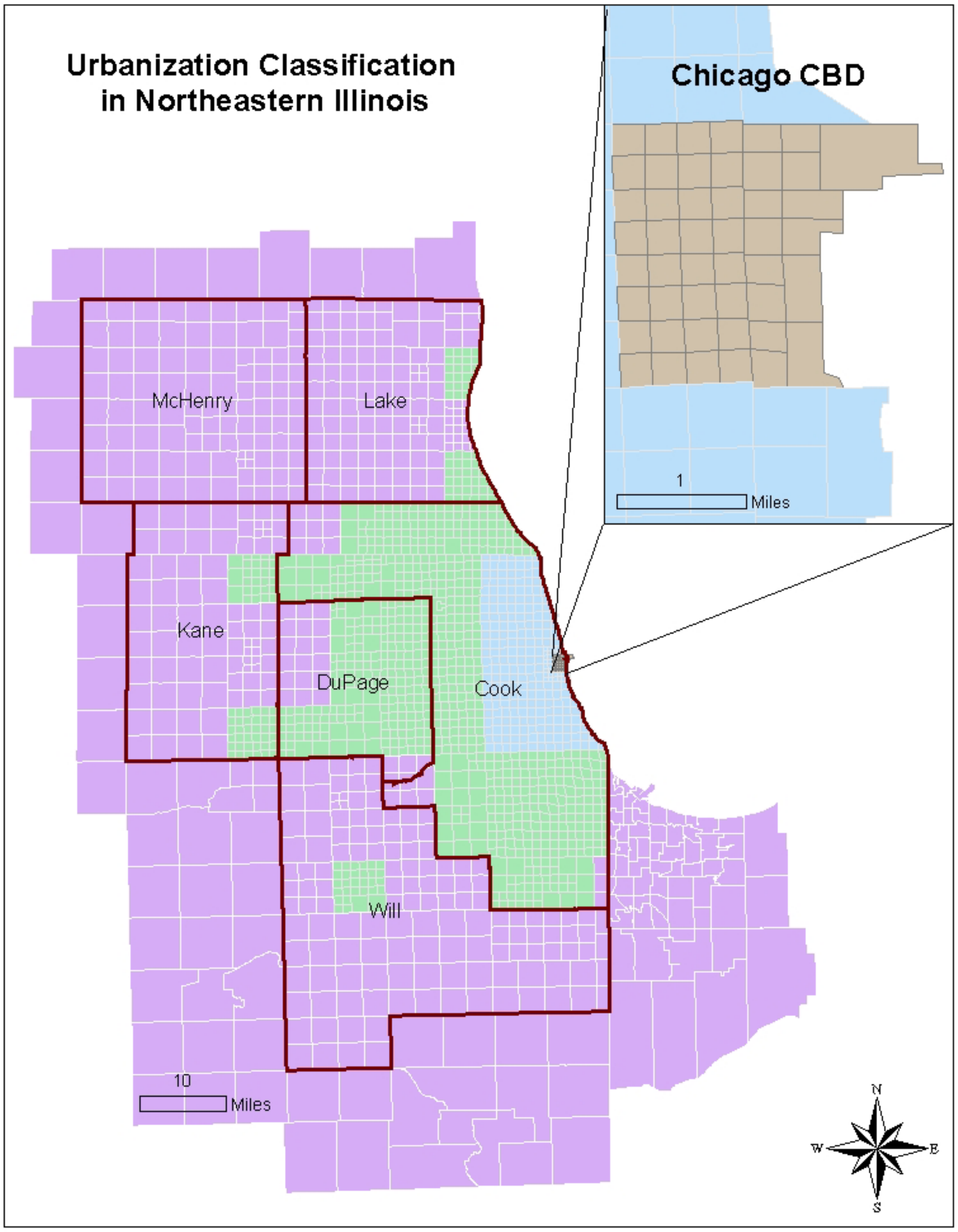


Table 3.17 summarizes the current use of highway and transit modes in respondents' daily travel routines. Differences in the utilization of CTA bus, CTA rail, Metra, and Pace by market segment are used to further characterize the seven clusters in terms of the propensity of their members to use existing and proposed means of public transportation.

Table 3.11 Factor Scores by Cluster Membership

Cluster	Factors		F1 Transit Advantages	F2 Personal Safety	F3 Time and Schedule	F4 Privacy and Comfort	F5 Driving Advantages
1	N		204	204	204	204	204
1	Mean		-0.525	-0.407	-1.101	-0.601	0.483
1	Standard Deviation		0.531	0.842	0.566	0.563	0.700
1	Minimum		-2.122	-2.937	-3.078	-2.493	-1.531
1	Maximum		0.878	1.661	0.291	0.578	2.116
1	Range		3.000	4.598	3.369	3.071	3.647
1	Percentiles	90	0.139	0.700	-0.478	0.050	1.316
1		75	-0.163	0.172	-0.718	-0.186	1.020
1		50	-0.536	-0.413	-1.038	-0.539	0.528
1		25	-0.841	-1.027	-1.463	-0.910	0.067
1		10	-1.210	-1.386	-1.825	-1.399	-0.510
2	N		277	277	277	277	277
2	Mean		0.169	0.105	-0.279	0.348	0.284
2	Standard Deviation		0.431	0.768	0.409	0.488	0.787
2	Minimum		-0.771	-2.120	-1.523	-0.594	-1.785
2	Maximum		1.548	1.880	0.701	2.012	2.072
2	Range		2.319	4.000	2.224	2.606	3.857
2	Percentiles	90	0.732	1.069	0.244	0.956	1.294
2		75	0.445	0.673	0.012	0.637	0.829
2		50	0.162	0.081	-0.284	0.334	0.381
2		25	-0.149	-0.393	-0.522	-0.028	-0.315
2		10	-0.374	-0.974	-0.790	-0.244	-0.852
3	N		124	124	124	124	124
3	Mean		0.450	0.352	1.347	1.214	-0.540
3	Standard Deviation		0.664	0.787	0.676	0.504	0.934
3	Minimum		-1.310	-2.912	0.030	0.129	-2.311
3	Maximum		2.043	1.940	3.017	2.851	1.764
3	Range		3.353	4.852	2.987	2.723	4.075
3	Percentiles	90	1.324	1.297	2.183	1.869	0.738
3		75	0.937	0.956	1.849	1.453	0.198
3		50	0.430	0.372	1.368	1.203	-1.580
3		25	-0.001	-0.180	0.754	0.817	-1.185
3		10	-0.317	-0.568	0.465	0.594	-1.746
4	N		182	182	182	182	182
4	Mean		-1.107	-0.605	0.453	0.764	0.243
4	Standard Deviation		0.534	1.050	0.542	0.715	0.892
4	Minimum		-2.785	-3.721	-0.699	-0.722	-2.276
4	Maximum		-0.209	1.932	2.122	3.018	2.280
4	Range		2.576	5.653	2.822	3.740	4.556
4	Percentiles	90	-0.464	0.610	1.172	1.760	1.391
4		75	-0.704	0.091	0.826	1.160	0.811
4		50	-1.105	-0.474	0.423	0.722	0.204
4		25	-1.449	-1.261	0.083	0.233	-0.276
4		10	-1.844	-2.065	-0.290	-0.097	-0.855

Table 3.11 Factor Scores by Cluster Membership (continued)

Segment	Factors		F1 Transit Advantages	F2 Personal Safety	F3 Time and Schedule	F4 Privacy and Comfort	F5 Driving Advantages
5	N		249	249	249	249	249
5	Mean		0.644	0.442	-0.022	-1.288	-0.444
5	Std. Deviation		0.567	0.684	0.525	0.542	0.857
5	Minimum		-0.700	-2.092	-1.455	-3.186	-2.866
5	Maximum		2.280	1.938	1.154	-0.438	1.770
5	Range		2.980	4.031	3.010	2.748	4.636
5	Percentiles	90	1.367	1.198	0.644	-0.626	0.618
5		75	1.007	0.939	0.350	-0.888	0.185
5		50	0.688	0.534	-0.018	-1.199	-0.450
5		25	0.246	0.065	-0.354	-1.647	-1.083
5		10	-0.163	-0.622	-0.727	-2.026	-1.627
6	N		200	200	200	200	200
6	Mean		0.997	0.604	0.927	-0.108	-0.764
6	Standard Deviation		0.563	0.761	0.547	0.495	0.847
6	Minimum		-0.498	-2.191	-0.328	-1.580	-2.694
6	Maximum		2.227	2.481	2.717	0.899	1.726
6	Range		2.725	4.672	3.046	2.479	4.420
6	Percentiles	90	1.664	1.469	1.672	0.567	0.474
6		75	1.428	1.081	1.249	0.201	-0.231
6		50	1.037	0.695	0.884	-0.094	-0.865
6		25	0.696	0.253	0.531	-0.450	-1.391
6		10	0.229	-0.354	0.287	-0.757	-1.764
7	N		81	81	81	81	81
7	Mean		-1.898	-1.369	-1.573	0.974	1.345
7	Standard Deviation		0.810	1.168	1.894	0.808	0.705
7	Minimum		-4.184	-4.618	-5.208	-1.184	-0.417
7	Maximum		-0.464	1.479	-0.363	3.081	3.104
7	Range		3.720	6.097	4.846	4.265	3.520
7	Percentiles	90	-0.960	-0.170	-0.733	1.909	2.208
7		75	-1.296	-0.595	-0.890	1.559	1.757
7		50	-1.842	-1.353	-1.426	0.929	1.358
7		25	-2.438	-2.017	-2.017	0.417	0.916
7		10	-2.972	-2.840	-2.537	-0.005	0.289

Source: Cambridge Systematics, Inc., 2006.

Table 3.12 Demographic Characteristics by Clusters

		Gender		Household Size				Age				
Clusters	**N**	**Female**	**Male**	**One**	**Two**	**Three**	**Four or More**	**18-24**	**25-34**	**35-54**	**55-64**	**65 and Up**
1	204	71	133	6	66	47	85	7	37	111	35	9
2	277	129	148	9	84	78	106	9	40	176	40	7
3	124	82	42	46	42	18	18	2	22	59	29	11
4	182	124	58	109	42	13	18	7	31	73	59	10
5	249	92	157	12	85	37	115	8	50	145	38	6
6	200	111	89	26	76	33	65	1	31	113	43	11
7	81	56	25	12	30	13	26	2	16	40	18	3
1	204	35%	**65%**	3%	32%	23%	**42%**	3%	18%	**54%**	17%	4%
2	277	47%	53%	3%	30%	28%	**38%**	3%	14%	**64%**	14%	3%
3	124	**66%**	34%	**37%**	34%	15%	15%	2%	18%	48%	**23%**	**9%**
4	182	**68%**	32%	**60%**	23%	7%	10%	4%	17%	40%	**32%**	5%
5	249	37%	**63%**	5%	34%	15%	**46%**	3%	20%	**58%**	15%	2%
6	200	56%	45%	13%	38%	17%	33%	1%	16%	**57%**	22%	6%
7	81	**69%**	31%	15%	37%	16%	32%	2%	20%	49%	22%	4%

Source: Cambridge Systematics, Inc., Pace Traveler Survey, 2006.

Table 3.13 Education and Employment Status by Cluster

		Education				Number of Workers			Employment Status	
Clusters	**N**	**Junior High**	**High**	**College**	**Graduate Degree**	**One**	**Two**	**Three or More**	**Part-Time**	**Full-Time**
1	204	5	54	62	83	55	114	35	20	184
2	277	3	91	105	78	61	167	49	39	238
3	124	4	54	40	26	70	42	12	30	94
4	182	1	67	66	48	143	32	7	30	152
5	249	0	50	99	100	76	138	35	30	219
6	200	2	76	69	53	78	105	17	28	172
7	81	1	37	30	13	27	38	16	13	68
1	204	2%	26%	**30%**	**41%**	27%	**56%**	**17%**	10%	90%
2	277	1%	33%	38%	28%	22%	**60%**	**18%**	14%	86%
3	124	3%	**44%**	32%	21%	**56%**	34%	10%	**24%**	**76%**
4	182	1%	37%	36%	26%	**79%**	18%	4%	16%	84%
5	249	0%	20%	**40%**	**40%**	31%	55%	14%	12%	88%
6	200	1%	38%	35%	27%	39%	53%	9%	14%	86%
7	81	1%	**46%**	37%	16%	33%	47%	20%	16%	84%

Source: Cambridge Systematics, Inc., Pace Traveler Survey.

Table 3.14 Automobile Ownership and Income Levels by Cluster

Clusters	N	Auto Ownership			Household Income					
		Zero	One	Two or More	< 25K	25K-35K	35K-55K	55K-75K	75K-100K	100K or More
1	204	2	17	185	4	2	32	43	45	49
2	277	2	32	243	9	4	30	47	68	79
3	124	27	54	43	25	12	22	13	13	19
4	182	15	110	57	20	20	41	40	21	18
5	249	6	40	203	5	7	27	49	46	82
6	200	14	58	128	10	7	31	45	29	57
7	81	1	18	62	4	5	13	13	14	17
1	204	1%	8%	**91%**	2%	1%	16%	21%	22%	24%
2	277	1%	12%	**88%**	3%	1%	11%	17%	**25%**	**29%**
3	124	**22%**	44%	35%	**20%**	**10%**	18%	10%	10%	15%
4	182	8%	60%	31%	**11%**	**11%**	23%	22%	12%	10%
5	249	2%	16%	**82%**	2%	3%	11%	20%	**18%**	**33%**
6	200	7%	29%	64%	5%	4%	16%	23%	15%	**29%**
7	81	1%	22%	77%	5%	6%	16%	16%	17%	21%

Source: Cambridge Systematics, Inc., Pace Traveler Survey, 2006.

Table 3.15 Place of Residence and Employment of Workers by Clusters

Clusters	N	Home Location				Work Location			
		CBD	Urban	Suburban	Exurban	CBD	Urban	Suburban	Exurban
1	204	-	30	101	73	26	36	97	45
2	277	1	29	135	112	40	37	144	55
3	124	2	35	56	31	27	23	55	19
4	182	2	41	93	46	23	38	91	29
5	249	3	51	134	61	71	29	113	36
6	200	1	52	96	51	74	30	62	34
7	81	-	7	45	29	3	9	46	23
1	204	-	15%	50%	**36%**	13%	18%	**48%**	**22%**
2	277	0%	10%	49%	**40%**	14%	13%	**52%**	**20%**
3	124	2%	**28%**	45%	25%	22%	19%	44%	15%
4	182	1%	**23%**	51%	25%	13%	21%	**50%**	16%
5	249	1%	**20%**	54%	24%	**29%**	12%	45%	14%
6	200	1%	**26%**	48%	26%	**37%**	15%	31%	17%
7	81	-	9%	56%	**36%**	4%	11%	**57%**	**28%**

Source: Cambridge Systematics, Inc., Pace Traveler Survey, 2006.

Table 3.16 Commuting Patterns of Workers by Clusters

		Home to Work Travel Flow Directions														
Clusters	**N**	**CBD-CBD**	**CBD-Exb**	**CBD-Sub**	**Exb-Exb**	**Exb-Sub**	**Exb-Urb**	**Exb-CBD**	**Sub-Exb**	**Sub-Sub**	**Sub-Urb**	**Sub-CBD**	**Urb-Exb**	**Urb-Sub**	**Urb-Urb**	**Urb-CBD**
1	204	-	-	-	27	35	5	6	11	55	20	15	7	7	11	5
2	277	-	-	1	41	51	11	8	11	77	21	26	3	15	5	6
3	124	-	1	1	13	10	3	5	5	27	10	14	-	17	10	8
4	182	-	1	1	14	28	3	1	11	46	22	13	3	16	13	9
5	249	1	-	2	17	24	4	16	11	63	18	42	8	24	7	12
6	200	-	1	-	17	9	5	20	6	36	13	41	10	17	12	13
7	81	-	-	-	14	13	2	-	8	29	6	2	1	4	1	1
1	204	-	-	-	13%	17%	2%	3%	5%	27%	10%	7%	3%	3%	5%	2%
2	277	-	-	0%	**15%**	**18%**	4%	3%	4%	28%	8%	9%	1%	5%	2%	2%
3	124	-	1%	1%	10%	8%	2%	4%	4%	22%	8%	11%	-	**14%**	8%	6%
4	182	-	1%	1%	8%	15%	2%	1%	6%	25%	12%	7%	2%	**9%**	7%	5%
5	249	0%	-	1%	7%	10%	2%	6%	4%	25%	7%	**17%**	3%	**10%**	3%	5%
6	200	-	1%	-	9%	5%	3%	**10%**	3%	18%	7%	**21%**	5%	**9%**	6%	7%
7	81	-	-	-	**17%**	**16%**	2%	-	**10%**	**36%**	7%	2%	1%	5%	1%	1%

Source: Cambridge Systematics, Inc., Pace Traveler Survey, 2006.

Table 3.17 Mode Preference for Work Trips by Clusters

		Primary Mode			Mode of Travel -Detailed							
Clusters	**N**	**Automobile**	**Transit**	**Unknown**	**Drive Alone**	**Carpool**	**CTA-Bus**	**CTA-Rail**	**Metra**	**Pace - Bus**	**Van Pool**	**Other**
1	204	175	22	7	170	5	4	1	12	5	-	7
2	277	219	52	6	206	13	9	3	28	12	-	6
3	124	61	60	3	56	5	4	12	19	24	1	9
4	182	141	36	5	136	5	7	9	11	9	-	8
5	249	144	98	7	139	5	18	3	62	14	1	12
6	200	83	111	6	80	3	11	8	71	21	-	13
7	81	77	4	-	73	4	-	1	3	-	-	6
1	204	**86%**	11%	3%	**83%**	2%	2%	0%	6%	2%	-	3%
2	277	**79%**	19%	2%	**74%**	**5%**	3%	1%	10%	4%	-	2%
3	124	49%	**48%**	2%	45%	4%	3%	**10%**	15%	**19%**	1%	7%
4	182	**77%**	20%	3%	**75%**	3%	4%	5%	6%	5%	-	4%
5	249	58%	**39%**	3%	56%	2%	**7%**	1%	**25%**	6%	0%	5%
6	200	42%	**56%**	3%	40%	2%	**6%**	4%	**36%**	**11%**	-	7%
7	81	**95%**	5%	-	**90%**	5%	-	1%	4%	-	-	7%

Source: Cambridge Systematics, Inc., Pace Traveler Survey, 2006.

The factor scores were first used to "label" each market segment and describe its relative positioning as compared to the other market segments along the factors of interest. The socioeconomic characteristics, geography of travel, and observed mode choice behavior also were used to develop the most likely profile of members of each market segment. Names for each segment were developed in coordination with Pace to reflect distinguishing characteristics of each group.

Cluster 1 – Million Milers

The respondents in this market segment gave low to average ratings on every factor except the "Driving Advantages" factor where they gave above average ratings. Members of this market segment are mostly men, are highly educated, live in larger households with the highest percentage of two or more workers. This market segment lives and works primarily in exurban and suburban areas. The predominant mode of travel is by automobile (83 percent) which is reflected in the respondents' attitudes, their home and work locations, and their automobile ownership patterns.

Cluster 2 – Great Middle

The members of the largest market segment exhibit generally average ratings for each of the five factors defined for the Pace study. Their socioeconomic characteristics, home location, and commuting patterns are similar to Million Milers. They also belong to large households, have a high percentage of two or more workers, and have high incomes. They live and work primarily in suburbs and exurbs, have a high automobile ownership, and mostly use their automobile to travel to work. However, they are more transit-oriented and less automobile-friendly than Million Milers, as reflected in a somewhat higher incidence of transit usage (just under 20 percent).

Cluster 3 – Demanding Survivors

The respondents in this market segment gave the highest ratings in the "Time and Schedule" and in the "Privacy and Comfort" factors. They also feel secure using transit and have positive attitudes towards "Transit Advantages." Two-thirds of the members are women and live in small households generally supported by one worker. This segment has the lowest level of education and automobile ownership and a higher incidence of incomes less than $35,000 per year. Respondents in this segment have varying commute patterns with the second highest use of transit (48 percent), the highest usage of CTA rail and Pace bus (10 and 19 percent, respectively), and the highest incidence of reverse commute (15 percent of all work trips).

Cluster 4 – Cautious Individuals

The members of this segment are particularly sensitive to questions related to "Personal Safety." Otherwise, they have similar attitudes in the "Time and Schedule" and "Privacy and Comfort" dimensions as Demanding Survivors, and are more oriented towards automobile rather than transit. They share similar socioeconomic characteristics as Demanding Survivors – two-thirds are women, most live in one-person households, and they have relatively lower incomes. Unlike the Demanding Survivors, three out of four Cautious Individuals use their own car for their work commute. The travel patterns in this group vary considerably with no single origin-destination pattern emerging.

Cluster 5 – Educated Professionals

Members of this market segment gave higher than average scores on "Transit Advantages" and "Personal Safety" factors reflecting their positive attitudes toward transit use. On the other hand, their lowest ratings on "Privacy and Comfort" and the lower than average ratings on "Driving Advantages" were consistent suggesting that they are not all that interested in the advantages associated with driving one's own automobile. Members of this group have the highest education level, live in large households, are mostly males, and have at least two cars available. Nearly half of the members reside in the suburbs. This market segment has the highest percentage of workers traveling to the CBD (29 percent) with almost half of their members working in suburban locations. This makes the suburb-to-suburb and suburb-to-CBD the strongest work travel markets. Automobile usage is the third lowest among the market segments (58 percent) while transit usage is the third highest (39 percent) and Metra has the second highest market share among all segments with 25 percent.

Cluster 6 – Downtown Commuters

Members of this market segment have very demanding schedules with the highest score on "Time and Schedule," the highest "Personal Safety" score, and show the most positive attitudes toward "Transit Advantages." They also show average concerns about "Privacy and Comfort" and negative attitudes toward "Driving Advantages." While the socioeconomic profile in this market segment showed great variability, respondents belonged primarily to high-income households. More importantly, this segment is characterized by the highest percentage of work locations in the Chicago CBD. As a result, suburb-to-CBD and exurbs-to-CBD travel patterns were the strongest among all market segments and were reflected in the primary travel mode being transit with a market share of 56 percent. Reflecting the origin-destination markets served, this segment also had the highest levels of Metra usage with 36 percent while Pace also had a sizeable market with 11 percent of the total work travel.

Cluster 7 – Determined Drivers

The ratings of members in this segment are almost the opposite of those provided by Downtown Commuters. Members of this market segment are concerned with their "Privacy and Comfort" to the greatest extent, while they do not feel safe and secure in using transit ("Personal Safety"). Although their schedule is not highly demanding (low average ratings for "Time and Schedule"), they are strongly inclined towards using their own automobile for commuting. While the socioeconomic profile varies, nearly 70 percent of this market segment consists of female commuters. In general, respondents in this cluster live in, work in, and commute between exurban and suburban locations. This helps explain in part why this segment of the market shows a very low market penetration by transit with automobile being the dominant mode with a 95 percent market share.

3.5 Cluster Membership Modeling

This section describes the method for analyzing the size and distribution of each market segment in the region as a function of the socioeconomic characteristics of market segment members. The study area is the six-county Chicago metropolitan region. This analysis was conducted at the Census block group level of geographic detail, as this is the most finely grained level at which detailed Census socioeconomic data is available.

Since the only pieces of information available at Census block group level are the demographic and socioeconomic data of residents (no information on traveler attitudes, for example), a link between cluster membership and socioeconomic characteristics was needed to estimate segment membership for each block group. A discrete outcome model predicting cluster membership based on socioeconomic characteristics of the survey respondents was estimated.

Table 3.18 features model performance and the parameter estimates. The selected cluster membership model is a multinomial logit model which is commonly used for modeling mode choice. The model predicts probability of each respondent belonging to each of the market segments. The probability of being in one cluster is defined as the ratio of the exponent of the utility of being in that segment to the summation of exponents of utilities of each of the clusters. Therefore, probability of being a member of *Cluster 1* is expressed in Equation 3.1.

Table 3.18 Cluster Choice Model Parameter Estimates

Measures of Fit	
Observations	1097
Final log (L)	-1856.1
D.O.F.	66
Rho^2(0)	0.125
Rho^2(c)	0.104

Parameter Estimates			
Constants		**Is age between 18 and 34 years?**	
Cluster 1	-2.37 (-4.6)	Cluster 1	0 (*)
Cluster 2	-2.03 (-4.3)	Cluster 2	0 (*)
Cluster 3	0 (*)	Cluster 3	0 (*)
Cluster 4	-1.08 (-2.6)	Cluster 4	0 (*)
Cluster 5	-1.37 (-3.1)	Cluster 5	0 (*)
Cluster 6	-0.950 (-2.2)	Cluster 6	0 (*)
Cluster 7	-3.09 (-4.6)	Cluster 7	0 (*)
Is HH Income less than 35K?		**Is age between 35 and 55 years?**	
Cluster 1	0 (*)	Cluster 1	-0.471 (-1.4)
Cluster 2	0 (*)	Cluster 2	-0.144 (-0.5)
Cluster 3	0 (*)	Cluster 3	0 (*)
Cluster 4	0 (*)	Cluster 4	-0.0311 (-0.1)
Cluster 5	0 (*)	Cluster 5	-0.241 (-0.8)
Cluster 6	0 (*)	Cluster 6	0.158 (0.5)
Cluster 7	0 (*)	Cluster 7	-0.232 (-0.6)

Table 3.18 Cluster Choice Model Parameter Estimates (continued)

Is HH Income between 35 and 75K?	
Cluster 1	2.11 (5.6)
Cluster 2	1.53 (4.7)
Cluster 3	0 (*)
Cluster 4	0.477 (1.7)
Cluster 5	1.31 (4.1)
Cluster 6	1.41 (4.5)
Cluster 7	0.859 (2.1)
Is HH Income between 75 and 125K?	
Cluster 1	2.30 (5.2)
Cluster 2	2.03 (5.2)
Cluster 3	0 (*)
Cluster 4	-0.297 (-0.7)
Cluster 5	1.59 (4.1)
Cluster 6	1.62 (4.1)
Cluster 7	1.05 (2.1)
Is HH Income over 125K?	
Cluster 1	2.38 (4.2)
Cluster 2	2.39 (4.6)
Cluster 3	0 (*)
Cluster 4	-0.564 (-0.9)
Cluster 5	1.95 (3.8)
Cluster 6	1.97 (3.7)
Cluster 7	1.45 (2.3)
Vehicles per Worker	
Cluster 1	1.20 (4.9)
Cluster 2	1.14 (4.9)
Cluster 3	0 (*)
Cluster 4	0.907 (4.1)
Cluster 5	0.989 (4.2)
Cluster 6	0.761 (3.2)
Cluster 7	0.935 (3.2)
Is Female?	
Cluster 1	-1.06 (-3.9)
Cluster 2	-0.679 (-2.7)
Cluster 3	0 (*)
Cluster 4	0.102 (0.4)
Cluster 5	-1.07 (-4.2)
Cluster 6	-0.190 (-0.7)
Cluster 7	0.393 (1.1)

Is age over 55 years?	
Cluster 1	-1.02 (-2.7)
Cluster 2	-1.39 (-3.7)
Cluster 3	0 (*)
Cluster 4	-0.139 (-0.4)
Cluster 5	-0.806 (-2.3)
Cluster 6	-0.416 (-1.2)
Cluster 7	-0.606 (-1.3)
College Education or Higher?	
Cluster 1	0.539 (1.8)
Cluster 2	0.127 (0.5)
Cluster 3	0 (*)
Cluster 4	0.697 (2.7)
Cluster 5	0.837 (3.0)
Cluster 6	0.0232 (0.1)
Cluster 7	-0.0153 (-0.0)
Residence Zone is in CBD Area?	
Cluster 1	0 (*)
Cluster 2	0 (*)
Cluster 3	0 (*)
Cluster 4	0 (*)
Cluster 5	0 (*)
Cluster 6	0 (*)
Cluster 7	0 (*)
Residence Zone is in Urban Area?	
Cluster 1	0 (*)
Cluster 2	0 (*)
Cluster 3	0 (*)
Cluster 4	0 (*)
Cluster 5	0 (*)
Cluster 6	0 (*)
Cluster 7	0 (*)
Residence Zone is in Suburban Area?	
Cluster 1	0.580 (1.6)
Cluster 2	0.943 (2.7)
Cluster 3	0 (*)
Cluster 4	0.274 (0.9)
Cluster 5	0.450 (1.4)
Cluster 6	-0.481 (-1.6)
Cluster 7	0.975 (1.9)
Residence Zone is in Exurban Area?	
Cluster 1	0.617 (1.5)
Cluster 2	1.05 (2.7)
Cluster 3	0 (*)
Cluster 4	-0.0556 (-0.2)
Cluster 5	-0.0466 (-0.1)
Cluster 6	-0.497 (-1.4)
Cluster 7	1.29 (2.3)

Source: Cambridge Systematics, Inc., 2006.

$$Pb(CL_1) = \frac{\exp(U_{CL_1})}{\sum_{i=1}^{n} \exp(U_{CL_i})} \quad [3.1]$$

where ***n*** is the number of clusters. Utilities are expressed in linear functions of input variables (socioeconomic variables in this application). For example, utility of belonging to *Cluster 1* can be expressed as follows:

U_{CL1} =-2.37 + 0****(Income Less than 35K)*** + 2.11****(Income between 35K and 75K)*** + 2.30****(Income between 75K and 125K)*** + 2.38****(Income Higher than 125K)*** + 1.20****(Vehicles per Worker)*** - 1.06****(Female)*** + 0****(Ages between 18 and 34)*** - 0.471****(Ages between 35 and 54)*** – 1.02****(Ages 55 and up)*** + 0.539****(College Education or Higher)*** + 0****(Residence in Urban Area)*** + 0.580* ***(Residence in Suburban Area)*** + 0.617****(Residence in Exurban Area)*** [3.2]

The probability of a given respondent belonging to a given cluster can then be expressed as:

$$Pb_{CL1} = \frac{\exp(U_{CL1})}{\left(\exp(U_{CL1}) + \exp(U_{CL2}) + \exp(U_{CL3}) + \exp(U_{CL4}) + \exp(U_{CL5}) + \exp(U_{CL6}) + \exp(U_{CL7})\right)} \quad [3.3]$$

To estimate the incidence of each cluster in a given block group, the joint distributions of all the variables in Table 3.18 were first obtained from the Census data at the block group level. So, for instance, the number of males aged between 18 and 34 years, with college education or higher, with an income between 35,000 and 75,000 dollars, and living in a household, in which one vehicle is available for each worker and located in a suburban area was obtained for each block group. The relevant coefficients from Table 3.18 were then applied as indicated in Equation 3.1 and the probabilities of membership in each cluster were computed. This process is repeated for each possible combination of gender, age, income level, education level, vehicle ownership level, and area of residence. The probabilities thus obtained are multiplied by the total number of workers in the block group to yield the number of workers in each cluster.

As described in Section 5.1, block group results were then transformed into estimates of cluster membership at the Census traffic analysis zone (TAZ) level of detail for analysis of travel patterns.

4.0 Mode Choice Models

A major objective of the Initiative was to conduct an analysis of travelers' mode choice behavior to better understand the trade-offs travelers make when considering whether to ride transit to work. Survey respondents completed a *customized experiment* that took into account the respondent's origin and destination and the corresponding levels of service that they experience both on highway and transit modes serving their own market.

Service characteristics were varied across experiments to assess travelers' trade-offs among:

- The travel time spent on the highway;
- The in-vehicle travel time spent while riding transit;
- The frequency of transit service available;
- The need to transfer and the time spent waiting while transferring;
- The reliability of traveling by highway and by transit;
- The access and egress characteristics of transit service; and
- The costs of traveling by different modes, including transit fares, out-of-pocket costs, and parking costs.

The stated-preference mode choice model has been developed using as a basis the origin-destination work-related travel that was described in the survey by each respondent. Using the origin-destination information, the corresponding levels of service for highway and transit modes were calculated for each individual origin-destination pair.

These levels of service reflect currently available transit modes and the observed highway level of service. As a result, they provide a realistic level of service for proposed transit modes that would serve each individual origin-destination market.

Values for the Rapid Bus alternative were generated to provide respondents with realistic alternatives among which to make a choice. The analysis of these choices allows us to assess trade-offs between existing and proposed transit services in terms of schedules, travel times, access and egress times, need to transfer, and fare levels. A detailed description of the process used to generate the level of service data for Rapid Bus was provided in Section 2.2.3.

Table 4.1 shows an example of a stated-preference exercise for a respondent who travels between Calumet Park and Lake Bluff. Each of the offered modes is described in terms of its own levels of service. The respondent was then asked to make a choice among the available modes described in the page.

Table 4.1 Choice Exercise

Suppose these were your transportation options for your trip from:
16,101 SOUTH LOOMIS, Calumet Park to ABBOTT LABS at 1401 SHERIDAN ROAD, Lake Bluff

Your choices are…	OPTION A	OPTION B	OPTION C
Method of travel	You **drive by yourself** from your home to a parking place at or near where you work. You walk from that parking place to your workplace.	You **walk to the Rapid Bus System and ride** to a stop at or near where you work. You do not need to make any transfers. You walk from the final transit stop to your workplace.	You **ride in a Vanpool with up to six other people** from your home to a parking place at or near where you work. You walk from that parking place to your workplace.
Service frequency	–	Every 60 minutes	–
Time to get to transit	–	8 minutes	–
Time in vehicle(s)	66 minutes	60 minutes	83 minutes
Time spent transferring between buses or trains	–	0 minutes	–
Time to walk from your car or transit stop to your workplace	1 minute	1 minute	1 minute
Gas cost	$7.20	–	–
Fare cost	–	$1.25	$1.00
Parking cost	Free parking	–	–
Reliability: You will be more than 15 minutes late…	Twice a month	Once every 3 months	Twice a month
Which of the three options above would you choose? (Please circle one)	**OPTION A**	**OPTION B**	**OPTION C**

Following this first experiment and the respondent's stated choice, a second set of alternatives was described to the respondent in a second experiment where he/she was again asked to make a similar selection. The process was repeated for a third time to elicit three responses in three choice situations. These choice data were then processed and analyzed using Alogit, a discrete choice software package.

■ 4.1 A Model of Mode Choice Behavior

The empirical analysis presented in this section presents and interprets the relative importance of service attributes that influence travelers' choice behavior and identifies important differences among market segments. Since the observed transit ridership reflects travelers' choices among highway and transit modes at various service and price levels, the policy-sensitive results from the choice analysis can be used by decision-makers to help design transit service that is more likely to attract a higher market share.

We first describe the mode structure and the alternatives that were evaluated in the experiment. We discuss how the mode choice model is used to assess the probability of choosing a mode and its corresponding market share.

We then focus on the utility of each mode to provide the background for the interpretation of the mode choice model. The discussion of modal utility focuses on the individual components of utility using the drive alone and Rapid Bus modes as examples.

4.1.1 Model Structure and Alternatives

An extensive analysis of travelers' choice behavior by market segment was undertaken to explore differences in travelers' sensitivity to different aspects of transit and highway service. Differences by market segment were examined by focusing on policy-related variables and their relative importance.

The mode choice model and trade-offs were based on the stated-preference survey where individual travelers were presented with three origin-destination travel scenarios for work travel. Given the focus of the study on different configurations of transit service, both the existing bus and rail transit and the proposed Rapid Bus alternatives were included as potential options in the choice experiment.

In each comparison, travelers were presented with three alternatives selected from the following five modes based on available transit options:

1. Driving alone;
2. Sharing a ride;
3. Riding conventional transit that currently is available;
4. Riding the proposed Rapid Bus service; and
5. Using a vanpool service.

The mathematical expression used to calculate the probabilities and corresponding market shares of each mode under a multinomial logit model formulation is given by the following equation:

$$P_{Mode\ 1} = \frac{\exp(U_{Mode\ 1})}{\sum_{i=1}^{N} \exp(U_i)}$$

Where:

P_{mode1} = Probability of selecting mode 1;

U_{mode1} = Utility function for mode 1;

U_i = Utility function for all five modes (i); and

N = The five modes used in the model.

A set of three customized choice experiments was offered to each respondent using the observed highway and transit levels of service as a basis for reference. The different dimensions of level of service (such as headways, access and egress times, in-vehicle travel times, and costs) were varied using an experimental design process.

Different specifications of the mode choice models were developed based on the survey responses to capture the attributes most important to individual travelers and to help predict their travel choices under different highway and transit level of service scenarios. The estimated models helped us understand how the highway modes compete with transit service by quantifying the trade-offs that individuals make between the "bundles" of service that were offered to them.

The highway and transit times (in-vehicle times, access times, egress times, need to transfer, wait times at each stop, and fares/cost of travel) that were used in model estimation reflect the levels of service currently faced by individual travelers. These values were customized for each individual O-D pair, reflect travelers' current experience, and are derived from the CATS regional travel demand model.

These "bundles" of service were characterized by policy-sensitive service attributes revealing differences in sensitivity across segments and trip purposes for:

- In-vehicle travel times by highway and transit modes;
- Access, egress, and wait times for transit service;
- The extent of transferring activity while riding transit;
- Egress time and the time spent searching for parking; and
- Parking costs and transit fares.

4.1.2 Utility Function for the Drive Alone Mode

The utility functions in a discrete choice model describe the attractiveness of each competing mode as discussed in the equation above. The utility functions are usually linear combinations of variables that affect travelers' choices. For the multinomial logit model estimated for this analysis, a utility equation for drive alone was expressed as follows:

$$
\begin{aligned}
U_{drive} = \; & \alpha * Constant_{drive} + \\
& \beta_1 * \text{In-vehicle } Time_{drive} + \\
& \beta_2 * Cost_{drive} + \\
& \beta_3 * Distance_{drive} + \\
& \beta_4 * Reliability_{drive}
\end{aligned}
$$

The constant for driving alone reflects the preference for driving alone. Since drive alone is used as a base mode, all other mode constants are compared to the drive alone constant. Therefore, the automobile constant is set to zero and we expect all other constants to be negative to reflect the general preference for driving alone.

The coefficients for in-vehicle time and cost of travel are expected to be negative to reflect the disutility of driving longer and paying more to reach one's final destination.

The reliability variable was presented to respondents as the "probability of being late" when using the highway. As a result, we expect the reliability coefficients to be negative to reflect the disutility of frequent delays. The relative magnitude of these coefficients also should reflect the increasingly negative impact of more frequent highway delays.

Finally, there was no strong prior expectation for the sign and magnitude of the distance coefficients. Overall, we would expect that distance coefficients would be negative to reflect the more limited attractiveness of the automobile over longer commute distances. A similar utility function was specified for the shared ride mode and to a large extent for the vanpool mode in the few experiments where it was offered as an option.

4.1.3 Utility Function for the Rapid Bus Mode

The utility function for the Rapid Bus mode is much more complicated since it aims to reflect all the individual components of transit disutility and attractiveness. A similar utility function was specified for existing transit service provided by CTA, Metra, and Pace. The utility of Rapid Bus was expressed as follows:

$$
\begin{aligned}
U_{\text{Rapid Bus}} = \; & \alpha_1 * \text{Constant}_{\text{Rapid Bus}} + \\
& \alpha_2 * \text{Constant by Gender}_{\text{Rapid Bus}} + \\
& \alpha_3 * \text{Constant by Car Ownership}_{\text{Rapid Bus}} + \\
& \alpha_4 * \text{Constant by Cluster}_{\text{Rapid Bus}} + \\
& \beta_1 * \text{Frequency}_{\text{Rapid Bus}} + \\
& \beta_2 * \text{In-vehicle Time}_{\text{Rapid Bus}} + \\
& \beta_3 * \text{Access Time}_{\text{Rapid Bus}} + \\
& \beta_4 * \text{Egress Time}_{\text{Rapid Bus}} + \\
& \beta_5 * \text{Transfers}_{\text{Rapid Bus}} + \\
& \beta_6 * \text{Transfer Time}_{\text{Rapid Bus}} + \\
& \beta_7 * \text{Fare}_{\text{Rapid Bus}} + \\
& \beta_8 * \text{Density of Service}_{\text{Rapid Bus}} + \\
& \beta_9 * \text{Reliability}_{\text{Rapid Bus}}
\end{aligned}
$$

The set of constants controls for the attractiveness of Rapid Bus as compared to the automobile mode which is set as the base. We generally expect transit constants to be negative to reflect the overall attractiveness of driving alone when compared to a transit mode in markets not well served by transit.

- The gender-specific constants are used to explore any differences in the attractiveness and potential appeal of Rapid Bus to men versus women.
- The car-ownership constants are used to control for the potential impact of low automobile availability on the attractiveness of transit and Rapid Bus in particular.
- Finally, the cluster-specific constants are used to reflect the differential appeal of Rapid Bus to each of the seven clusters described in the previous section. We expect these coefficients to differ to reflect the different propensity of each market segment to find transit appealing for their daily work travel routine.

4.2 Model Evaluation

The constants and parameter coefficients are estimated by a maximum likelihood algorithm that attempts to replicate the observed choice patterns in the dataset.[1] There are two broad measures of statistical significance for discrete choice models and an important set of relative measures. First, the value of the log-likelihood function reflects the performance of the model as a whole and its ability to explain the travelers' mode choice behavior. Second, the t-statistic values for individual coefficients reflect the statistical robustness of components of the utility function for each alternative. Last, but equally importantly, a critical quality control check for any model is that the signs of the variables need to reflect prior analyst expectations, and the relative magnitudes of the level of service and cost coefficients need to be reasonable.

The **log-likelihood value** at zero assumes that all modes have the same probability of being selected; in our experiments, this translates into a uniform probability of 20 percent for each mode. The log-likelihood value at market shares assumes that the model's point of reference is the market share of each mode as observed in the survey. The log-likelihood at convergence reflects the ability of the model to explain "over and above" the log-likelihood at zero and at market shares. The rho-square measure is similar to the R-square in linear regression and reflects the extent to which the model explains the existing variance. A measure of 0.20 or greater for rho-square reflects a very good performance for discrete choice models.

Values of **t-statistic** reflect the statistical robustness of individual coefficients that correspond to measures of service. A t-statistic value of 1.96 suggests that this coefficient is statistically different than zero at the 95 percent confidence level. This measure and cutoff point are often used to classify coefficients as "highly significant" suggesting that there is a high level of confidence in the value estimated for this specific coefficient. Coefficients with t-statistic higher than 1.65 also are significant, but at the 90 percent level of confidence. This measure and cutoff point are generally considered as the "low end" of statistically significant coefficients.

Last, the **signs and relative magnitudes** of explanatory variables reflect analysts' expectations and serve as important quality control checks for a mode choice model. For example:

- Variables that reflect the disutility of travel should have a negative sign associated with them. This suggests that an increase in travel time, cost, and the time spent while transferring will have a negative impact on the utility of this alternative and on its probability of being selected.

[1] A key reference is *Discrete Choice Analysis: Theory and Application to Travel Demand* by Ben-Akiva and Lerman, MIT Press, Cambridge, Massachusetts, 1985. This textbook provides an in-depth discussion of discrete choice theory and its application to estimating travel demand.

- Variables that enhance the appeal of any mode are expected to have a positive sign. Increased reliability should enhance a mode's attractiveness and its probability of being selected and should, therefore, have a positive impact on its utility.

The estimated mode choice model provides us with interesting insights into travelers' sensitivity towards service attributes for different transit and highway modes and highlights some important differences by market segment. **Table 4.2**[2] presents the utility equations for each mode as outlined and discussed in Section 4.2. The detailed presentation of the model provides information about the coefficients for each individual variable and shows the differences in sensitivity by market segment. Overall:

- The estimated coefficients reflect the best statistical fit for the observed and stated mode choice behavior by survey respondents;

- This model formulation represents a partially segmented model with important differences by market segment represented in the model specification by different coefficients while a single coefficient was used in cases where these differences were not statistically significant;

- The model exhibits a very good overall fit with a rho-square value of 0.29 when compared to the zero model and a rho square value of 0.20 when compared to the market shares model; and

- The coefficients for the majority of the variables are statistically significant, have the proper signs, and reflect the expected trade-offs and patterns of importance across modes and market segments.

In the following sections, we discuss each of the variables that appear in Table 4.2 starting with the mode constants in Section 4.4 and then focusing on level of service coefficients in Section 4.5. In both sections, we first discuss important differences by mode and then highlight any important differences across market segments that are implicit in the estimated model.

[2] The presentation of the mode choice model follows the format adopted in the discrete choice modeling literature.

Table 4.2 Specification of Final Model for Pace Market Research

Observations	3,824.00	
Final Log Likelihood	-2,959.50	
Degrees of Freedom	67	
Rho-square with respect to zero market shares	0.294	
Rho-square with respect to observed market shares	0.201	
Constants by Mode		
Drive Alone	0	
Shared Ride – Cluster 1	-0.0097	(-0.0)
Shared Ride – Cluster 2	-0.840	(-3.3)
Shared Ride – Cluster 3	-1.28	(-4.4)
Shared Ride – Cluster 4	-2.41	(-7.0)
Shared Ride – Cluster 5	-0.610	(-1.9)
Shared Ride – Cluster 6	-1.44	(-4.6)
Shared Ride – Cluster 7	-0.735	(-1.2)
Existing Transit – Cluster 1	0.672	(2.3)
Existing Transit – Cluster 2	1.02	(3.4)
Existing Transit – Cluster 3	0.714	(2.1)
Existing Transit – Cluster 4	0.277	(0.9)
Existing Transit – Cluster 5	1.54	(5.4)
Existing Transit – Cluster 6	1.21	(4.0)
Existing Transit – Cluster 7	-0.590	(-1.2)
Rapid Bus – Cluster 1	0.523	(1.8)
Rapid Bus – Cluster 2	0.270	(0.9)
Rapid Bus – Cluster 3	0.539	(1.6)
Rapid Bus – Cluster 4	-0.0820	(-0.3)
Rapid Bus – Cluster 5	0.977	(3.5)
Rapid Bus – Cluster 6	0.749	(2.5)
Rapid Bus – Cluster 7	0.0209	(0.1)
Van Pool	-1.22	(-8.1)
Constant Components by Socioeconomics		
Existing Transit – Zero Vehicle Respondents	1.11	(4.0)
Existing Transit – Female Respondents	-0.321	(-2.9)
Rapid Bus – Zero Vehicle Respondents	0.738	(2.5)
Rapid Bus – Female Respondents	-0.167	(-1.7)

Table 4.2 Specification of Final Model for Pace Market Research (continued)

Constant Components by Work Location		
Transit – CBD Work Location	0	
Transit – Urban Work Location	-1.06	(-6.4)
Transit – Suburban Work Location	-1.32	(-8.6)
Transit – Exurban Work Location	-1.56	(-5.5)
Rapid Bus – CBD Work Location	0	
Rapid Bus – Urban Work Location	-0.912	(-5.1)
Rapid Bus – Suburban Work Location	-1.20	(-7.9)
Rapid Bus – Exurban Work Location	-0.852	(-5.0)
Constant Components by Travel Distance		
Drive Alone – Distance of 5 miles or less	0	
Drive Alone – Distance of 5+ to 10 miles	-0.162	(-1.3)
Drive Alone – Distance of 10+ to 20 miles	-0.414	(-2.6)
Drive Alone – Distance of 20+ to 30 miles	-0.648	(-2.9)
Drive Alone – Distance of 30+ miles	-0.855	(-2.6)
Costs of Travel		
Cost for Drive Alone/Shared Ride	-0.151	(-3.2)
Transit Fares	-0.188	(-6.2)
Access Time to Transit		
Access Time by Walking to Station/Stop	-0.0245	(-2.0)
Access Time by Driving	-0.0234	(-2.4)
Access Time via Shuttle to Rapid Bus	-0.0139	(-0.5)
Headway of Transit Service		
Headway – Clusters 1, 5, and 7	-0.0076	(-2.4)
Headway – Clusters 3 and 6	-0.0051	(-1.8)
Headway – Clusters 2 and 4	-0.0123	(-3.4)
In-Vehicle Travel Time for Highway Modes		
Highway In-Vehicle Time – Clusters 1, 5, and 7	-0.0186	(-5.2)
Highway In-Vehicle Time – Clusters 3 and 6	-0.0226	(-5.7)
Highway In-Vehicle Time – Clusters 2 and 4	-0.0230	(-5.6)

Table 4.2 Specification of Final Model for Pace Market Research (continued)

In-Vehicle Travel Time for Transit Modes		
Transit In-Vehicle Time – Clusters 1, 5, and 7	-0.0231	(-8.1)
Transit In-Vehicle Time – Clusters 3 and 6	-0.0245	(-8.3)
Transit In-Vehicle Time – Clusters 2 and 4	-0.0285	(-8.8)
Number of Transfers for Transit Modes		
Transfers – Clusters 1, 5, and 7	-0.152	(-1.5)
Transfers – Clusters 3 and 6	-0.202	(-2.0)
Transfers – Clusters 2 and 4	0.131	(1.2)
Time Spent While Transferring for Transit Modes		
Transfer Time – Clusters 1, 5, and 7	-0.0263	(-2.6)
Transfer Time – Clusters 3 and 6	-0.0073	(-0.6)
Transfer Time – Clusters 2 and 4	-0.0377	(-3.5)
Egress Walk Time for Transit		
Egress Time	-0.0348	(-3.5)
Density of Existing Transit Service		
Number of Transit Providers within .5 miles of Residence Location	0.252	(5.1)
Reliability for Travel by Transit		
Probability of being late …		
… less often	0	
… every three months	-0.221	(-1.9)
… every two months	-0.265	(-2.1)
… once a month	-0.219	(-1.8)
… twice a month	-0.382	(-2.3)
… once a week	-0.345	(-2.1)
Reliability for Highway Travel		
Probability of being late …		
… less often	0	
… once a month	-0.146	(-1.5)
… twice a month	-0.152	(-1.5)
… once a week	-0.237	(-2.4)

■ 4.3 Model Constants

Mode-specific constants for shared ride, existing transit, vanpool, and Rapid Bus were included in the mode choice model to control for the various competing modes evaluated and chosen by the respondents. The constant for the drive alone mode is set to zero to serve as a basis of comparison against the constants for the other four modes.

In interpreting the constants, one needs to focus on their relative values and needs also to recognize that constants represent *"what is left unexplained by the model."* Therefore, a positive constant for a mode suggests that everything else being equal in terms of the variables included in the model, there is an implicit preference for that mode relative to the base mode, which is the drive alone mode in our case. With that in mind, the comparison of the various constants suggests the following:

- The constant for the vanpool mode (-1.22) was negative and statistically significant reflecting its much lower attractiveness when compared to the drive alone option.

- The constants for the share ride mode by cluster were all negative (-0.001 to -2.41) and most were statistically significant. The constants for *Demanding Survivors*, *Cautious Individuals,* and *Downtown Commuters* (Clusters 3, 4, and 6) were larger in magnitude (-1.28, -2.41, and -1.44, respectively). This reflects their higher sensitivity to "Time and Schedule" and the difficulty of coordinating schedules while sharing a ride to work.

- The overall constants for the existing transit modes were positive with the exception of the automobile-oriented segment of *Determined Drivers* (Cluster 7). This pattern applies only to work trips with destinations in the CBD and clearly suggests that existing transit service is perceived as competitive to the automobile in cases where automobile and transit offer comparable levels of service. This pattern is very reasonable in Chicago which is characterized by prolonged congestion in the highway system and the high level of CBD-oriented transit service.

- However, this pattern of preference toward transit does not hold in cases where the work destination is outside the Chicago CBD. (See Figure 3.16). In these cases, transit constants are negative and strongly significant and the automobile emerges as the preferred mode. Transit constants are:

  - Lowered by 1.06 when the destination is a non-CBD urban area;
  - Reduced further by 1.32 when the destination is a suburb; and
  - Are lowered even further by 1.56 when the destination is an exurban location.

- Transit constants also are large and positive for households without a car available (value of 1.11) reflecting their degree of captivity and preference for transit.

- Transit constants are smaller and negative among women suggesting a lower preference among women toward transit (value of -0.32).

The values for the Rapid Bus constants generally followed a similar pattern. Although such a mode currently is not available in the Chicago area, the stated-preference survey described its salient characteristics to survey respondents and elicited their likely usage of Rapid Bus. These constants should be viewed with caution given the innovative nature of the proposed transit service. In this context, the constants for Rapid Bus provide the following interesting insights:

- Rapid Bus appears to be least appealing to *Cautious Individuals* and *Determined Drivers* (Clusters 4 and 7). Members of these two market segments are clearly more automobile-oriented in terms of their attitudes compared to all other segments (constant values of -0.08 and 0.02). Personal safety was a major concern for *Cautious Individuals*. Therefore, the introduction of a new bus transit mode with a higher level of service may not necessarily address the safety concerns of this particular group. As a result, Rapid Bus may not appear as attractive to this segment relative to other segments.

- In contrast, Rapid Bus is most appealing to *Educated Professionals* and *Downtown Commuters* (constant values of 0.98 and 0.75), reflecting transit-friendly attitudes of these market segments, low automobile usage, and the comparatively high transit market share, including Metra and Pace service.

- Respondents without a vehicle available to them are more likely to ride the proposed Rapid Bus than the rest of the population (constant value of 0.74).

- The preference towards Rapid Bus also was highly dependent on the work location. Similar to existing transit, Rapid Bus had the highest constants when the work destination was in the Chicago CBD. For other work destinations, Rapid Bus constants are negative:

  – These constants are less negative than they are for existing transit. This suggests the potential appeal of Rapid Bus in serving markets that currently are not well served by existing transit.

  – The difference between existing transit and Rapid Bus is greater when considering exurban work locations. The Rapid Bus constant is still negative (value of -0.85) but much smaller than existing transit which has a constant of -1.56. This contrast clearly suggests the potential appeal of Rapid Bus in serving exurban work locations better than existing transit.

- The appeal of Rapid Bus is again smaller to female respondents but the gap is not as large as for traditional transit which was much less appealing to women (constant values of -0.17 against -0.32).

4.4 Impact of the Level of Service

The sensitivity of respondents to the individual level of service characteristics also is summarized in Table 4.2. In this section, we discuss how the sensitivity of travelers varies for different service characteristics and identify cases where the modeled sensitivity to a particular service attribute varies across market segments.

Travelers' sensitivity to ***in-vehicle travel time*** was explored in a number of different formulations to test the hypothesis that there were important differences by highway versus transit mode and across market segments. In the preferred specification, a total of six coefficients were estimated, three for each mode and for three groups of market segments.

- All in-vehicle travel-time coefficients were strongly significant and negative as expected;
- The highway time coefficients for *Demanding Survivors*, *Downtown Commuters*, *Great Middle*, and *Cautious Individuals* were larger reflecting a greater Time and Schedule sensitivity and transit orientation; and
- In-vehicle travel-time coefficients were generally comparable across market segments when considering transit service options.

A component of in-vehicle travel time that is not often included in mode choice models is the impact of ***reliability*** on the attractiveness of highway and transit modes. In this model, we have estimated the impact of being late more than 15 minutes for both modes:

- On the highway side, there is a negative disutility associated with being late more often than once a month, which increases somewhat when the delays happen once a week;
- On the transit side, the patterns are stronger. Respondents' reaction to delays is significant and almost doubles when the delays occur twice a month or once a week.

There was a very strong pattern of ***travel distance*** impact on the attractiveness of the drive alone mode. This stepwise pattern clearly shows the role that transit plays in serving longer distance commute trips in the Chicago area. Using a short commute of less than five miles as a base of comparison, the utility of drive alone was lower but comparable for distances between 5 and 10 miles (value of -0.16), but became strongly more negative for longer distances.

- The negative coefficients increased to -0.41 for distances between 10 and 20 miles;
- A negative value of -0.65 corresponded to travel distances between 20 and 30 miles; and
- A value of -0.86 applied to the attractiveness of driving alone for travel distances longer than 30 miles.

The ***cost*** of driving and taking transit had the expected negative impact on the utility of each mode. Respondents appeared to be somewhat more sensitive to the out-of-pocket costs associated with transit compared to the greater but often hidden costs of driving. The coefficient values of -0.15 for the highway modes and -0.19 for all transit modes were strongly significant.

Individual components of out-of-vehicle travel time also were taken into account to reflect the disutility of travel. These individual components are important policy variables since they can be tied to service design for proposed service improvements.

Access time to transit modes differentiated between access modes: walking to a station or bus stop, driving or being dropped off, or taking a shuttle service to the proposed Rapid Bus service. The walk and drive access coefficients were strong statistically, negative, and had similar values. There were no important differences among market segments. Furthermore, the sensitivity to taking a shuttle service to access Rapid Bus service could not be conclusively assessed given the very low statistical significance for this variable.

The ***headway of transit service*** and the corresponding wait time for transit riders is an important service design consideration. The headway coefficients were negative and statistically significant across all market segments. A comparison across segments suggested a greater sensitivity to headways among the *Great Middle* and *Cautious Individuals*.

Respondents' sensitivity to ***transit transfers*** also was explored by including two variables – one to account for the number of transfers needed to complete each transit trip and one to account for the time spent transferring. With the exception of two insignificant variables, the negative values reflect the "transfer penalty" associated with each transfer. The negative coefficients are in agreement with accepted practice and reflect the advantages of a one-ride transit trip. The observed differences across market segments suggest that:

- Members of the transit-oriented segments of *Great Middle* and *Cautious Individuals* are the most sensitive to transferring between transit modes reflecting their preference for a one-seat ride; and

- Members of automobile-oriented segments *Million Milers* and *Determined Drivers* also are very sensitive to a transfer reflecting their overall preference for driving alone. The similar sensitivity shown by *Educated Professionals* suggests the advantages of a one-seat ride to suburban transit riders.

The ***egress time*** for transit was negative as expected and more onerous than the in-vehicle travel-time coefficient. There were not large differences by market segment leading to a single coefficient value.

Finally, the ***density of transit*** service was used as a surrogate for respondents' exposure to and knowledge of transit service in the Chicago region. The variable that was used measures the number of transit providers (CTA bus, CTA rail, Metra, and Pace) available within half a mile of the respondent's residence. The positive coefficient for this variable reflects the higher likelihood of riding both existing and proposed transit service in areas with available transit service.

4.5 Model Calibration

As the mode choice model is implemented in the Service Planning Tool, the model will be calibrated to more accurately reflect observed mode shares. The calibration process involves adjustment of the constants for each mode. Therefore, the constants that are presented in this report are subject to change. More detail on the calibration process is provided in the *SPT User Manual.*

4.6 Summary

The mode choice model discussed in this section was estimated using the set of three choice experiments that were provided to travelers in the six-county Pace service area. The stated preference provided by the respondents was related to the varying levels of service for each of the five modes that were considered.

The proposed Rapid Bus service was one of the alternatives that was provided to respondents to elicit their stated-preference. The other four modes included driving alone, sharing a ride, riding transit that is already available by CTA, Metra, or Pace, and participating in a vanpool.

The model results reflect the implicit trade-offs that travelers make when comparing both existing and proposed modes of travel for their daily commute. The discussion of the model focuses on trade-offs among service components and interesting findings related to the Rapid Bus alternative.

Finally, the model differentiates among the choice behavior of different market segments. Where applicable, differences in sensitivity among market segments are discussed and tied to the attitudinal and behavioral characteristics of the segments as described in Section 3.0. The estimated mode choice models along with the market segments developed are combined in Section 5.0 to discuss the competitive positioning options for transit in the region.

5.0 Competitive Positioning

5.1 Cluster Incidence

Cluster incidence was computed for each block group by applying the cluster membership model described in Section 3.5.

5.1.1 Translation to Traffic Analysis Zone Geography

The cluster membership model relies on socioeconomic information from Census block group data. However, the Competitive Positioning analysis and the Transit Service Sketch Planning Tool (SPT) calculations are both performed the Census Transportation Planning Package (CTPP) Journey-to-Work Traffic Analysis Zone (TAZ) level. Block groups generally are different from CTPP TAZs. **Figure 5.1** shows an example of a CTPP TAZ that does not have a 1:1 correspondence to a Census block group. Therefore, in order to apply the cluster membership model results to CTPP data on work travel patterns, it was necessary to translate the results of the cluster membership model (provided at the Census block group level) into results at the CTPP TAZ level.

The correspondence between Census block groups and CTPP TAZs is mixed. In some cases, there is a one-to-one correspondence. In other cases, there are either many block groups to one TAZ, or vice versa. To overcome this, a correspondence between block groups and TAZs was developed based on the shared area. This area was calculated systematically using ArcGIS software. The resulting correspondence was used to calculate the percentage of workers residing in each TAZ who belong to the different market segments. Next, the number of workers by segment moving between each O-D pair was calculated based on the percentage by segment at the origin zone.

The specific example shown in **Figure 5.1** and **Table 5.1** illustrates this process. This example is based on CTPP TAZ 17940031293211. Figure 5.1 shows this TAZ as well as each of the block groups that overlap that TAZ. For each block group, Step 1 of Table 5.1 presents the percentage of the block group's area that overlaps the TAZ. Step 2 shows the number of adult residents by cluster in each block group. Step 3 shows the process of transferring the residential data from the block groups to the TAZ based on shared area. Step 4 illustrates the cluster percentage calculation, and Step 5 demonstrates the application of these percentages to the CTPP TAZ data.

Figure 5.1 Illustration of Converting Census Block Group Data to the CTPP TAZ Level

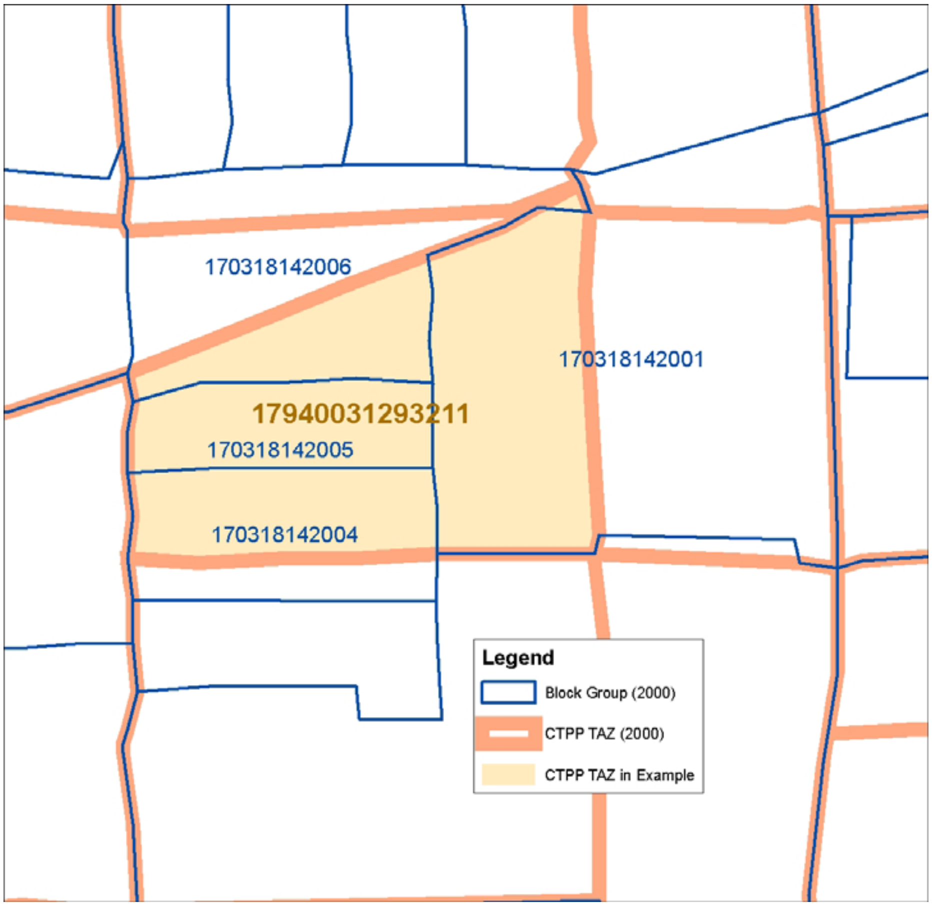


Table 5.1 Illustration of Converting Census Block Group Data to the CTPP TAZ Level

Step 1. Calculate percentage of area overlap between Block Groups and CTPP TAZs.

BG	Block Group (BG) ID	CTPP TAZ ID	Area Proportion	Description
1	170318142001	17940031293211	0.35	35% of data from 170318142001 will be assigned to TAZ 17940031293211.
2	170318142004	17940031293211	0.68	68% of data from 170318142004 will be assigned to TAZ 17940031293211.
3	170318142005	17940031293211	1.00	100% of data from 170318142005 will be assigned to TAZ 17940031293211.
4	170318142006	17940031293211	0.30	30% of data from 170318142006 will be assigned to TAZ 17940031293211.

Step 2. Input block group population data.

Population Over 18 in Block Group, by Cluster (Census Block Group Data)

BG	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Total
1	74	87	234	180	115	240	30	959
2	70	85	258	196	114	239	31	993
3	65	69	142	137	102	179	21	715
4	66	74	133	130	94	186	23	706

Step 3. Calculate number of block group residents over 18 who live in selected TAZ.

Block Group Data to Assign to TAZ, by Cluster

BG	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Total
1	35% * 74 = 26	31	82	63	40	84	10	337
2	68% * 70 = 47	58	176	133	78	163	21	676
3	100% * 65 = 65	69	142	137	102	179	21	715
4	30% * 66 = 20	22	40	39	28	56	7	212
	Total: 158	180	440	373	248	482	59	1,940

Step 4. Calculate cluster percentages for workers residing in CTPP TAZ.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Total
	158/1,940 = 8%	9%	23%	19%	13%	25%	3%	100%

Step 5. Apply cluster percentages to JTW data.

Note: This CTPP TAZ has 1,663 workers that travel to a workplace within the six counties

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6	Cluster 7	Total
	1,663 * 8% = 135	154	377	320	213	413	51	1,663

5.1.2 Geographic Distribution of Market Segments

In order to display the distribution of market segments throughout the six-county region, a series of GIS maps was developed. These maps (**Figures 5.2 to 5.9**) are based on where workers within each segment live. The first seven maps show the percentage of workers within the given segment in a given TAZ.

In this map series, TAZs are classified by their standard deviation from the average percentage of cluster membership across all TAZs. Dark brown TAZs have a value more than 1.5 standard deviations below the mean. Light brown TAZs have a value between 1.5 and 0.5 standard deviations below the mean. White zones have a value that falls with 0.5 standard deviations of the mean. Light blue zones have a value that falls between 0.5 and 1.5 standard deviations above the mean, and dark blue zones have a value greater than 1.5 standard deviations above the mean. In other words, white zones have a fairly typical representation of a given customer type while brown zones have fewer and blue zones have more. A GIS Definition Query is used to ensure that TAZs with a population of zero are not included (represented in gray).

Million Milers (shown in **Figure 5.2**) also tend to be concentrated outside of Chicago. The area around Plainfield and parts of Kane County have high incidence of Million Milers. Joliet and Chicago Heights are examples of areas with lower than average representation of this segment. The average share of Million Milers in a TAZ is 13.4 percent. Across the entire six-county region, Million Milers represent about 12 percent of adult workers. In the suburban portion of the region (not including the City of Chicago), they represent about 11 percent of all workers.

The Great Middle (shown in **Figure 5.3**) has a similar distribution pattern to the Million Milers. They are represented in low numbers in Chicago and other urban areas. The Plainfield area and parts of Kane County again show high incidence of this customer type. The average share of Great Middle in a TAZ is 18.9 percent. Across the entire six-county region, Great Middle represents about 16 percent of adult workers. In the suburbs, they represent about 19 percent of all workers.

Demanding Survivors (shown in **Figure 5.4**) have a significant presence in Chicago. Joliet and the Village of Matteson are a few of the additional areas where this segment is concentrated. Most of the suburban region has slightly below average representation. The exurban region has fairly typical representation. The average share of Demanding Survivors in a TAZ is 13.5 percent. Across the entire region, Demanding Survivors represent about 15 percent of adult workers. In the suburbs, they represent about 16 percent of all workers.

Cautious Individuals (shown in **Figure 5.5**) have an urban-focused distribution pattern. In addition to the City of Chicago, there is a high proportion of Cautious Individuals in Aurora, Joliet, and the southeast portion of the region. Across the entire region, Cautious Individuals represent about 18 percent of adult workers. In the suburbs, they represent about 16 percent of all workers.

Educated Professionals (shown in **Figure 5.6**) are generally concentrated in suburban areas, particularly suburban Cook County and DuPage County. The Lake Forest-Highland Park suburban area north of Chicago also has a high proportion of this customer type. The Wilmington area stands out as having particularly low representation. The average share of Educated Professionals in a TAZ is 15.9 percent. Across the entire region, Educated Professionals represent about 16 percent of adult workers. In the suburbs, they represent about 17 percent of all workers.

Not surprisingly, Downtown Commuters (shown in **Figure 5.7**) are the most concentrated in the City of Chicago. The exurban portions of the region generally have average representation of Downtown Commuters while suburban areas, such as most of DuPage and parts of Cook County, are below average. The average share of Downtown Commuters in a TAZ is 14.9 percent. Across the entire region, Downtown Commuters represent about 17 percent of adult workers. In the suburbs, they represent about 14 percent of all workers.

Determined Drivers (shown in **Figure 5.8**) are located in the greatest abundance in exurban areas. Urban areas such as Chicago show a much lower incidence of this customer type. The southeastern corner of the region, the Sauk Village area, and the City of Harvard all have high concentrations of Determined Drivers. The average share of Determined Drivers in a TAZ is 6.2 percent. Across the entire region, Determined Drivers represent about 5 percent of adult workers. In the suburbs, they also represent about 5 percent of all workers.

Another view of these results, the plurality by TAZ (or segment with the highest share), is shown in the final map of the series, **Figure 5.9**. Because of their large proportion of the population in general, the Great Middle tends to be dominant, especially in exurban areas. Demanding Survivors also have a presence in exurban areas, as well as parts of Chicago. The maximum share in suburban areas is most frequently Cautious Individuals and Educated Professionals. In Chicago, Downtown Commuters tend to have the maximum share.

Figure 5.2 Million Milers Incidence by TAZ

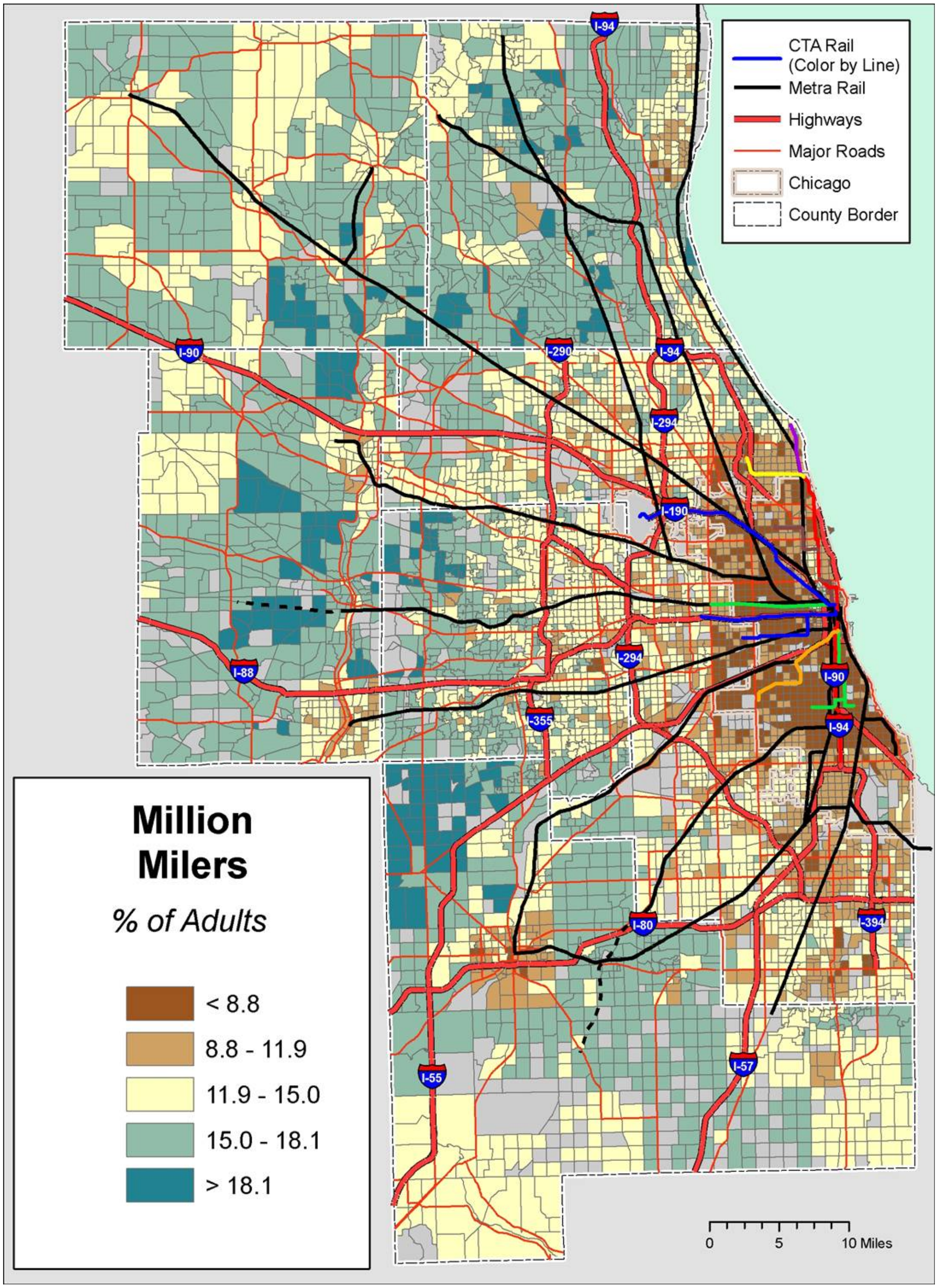


Figure 5.3 Great Middle Incidence by TAZ

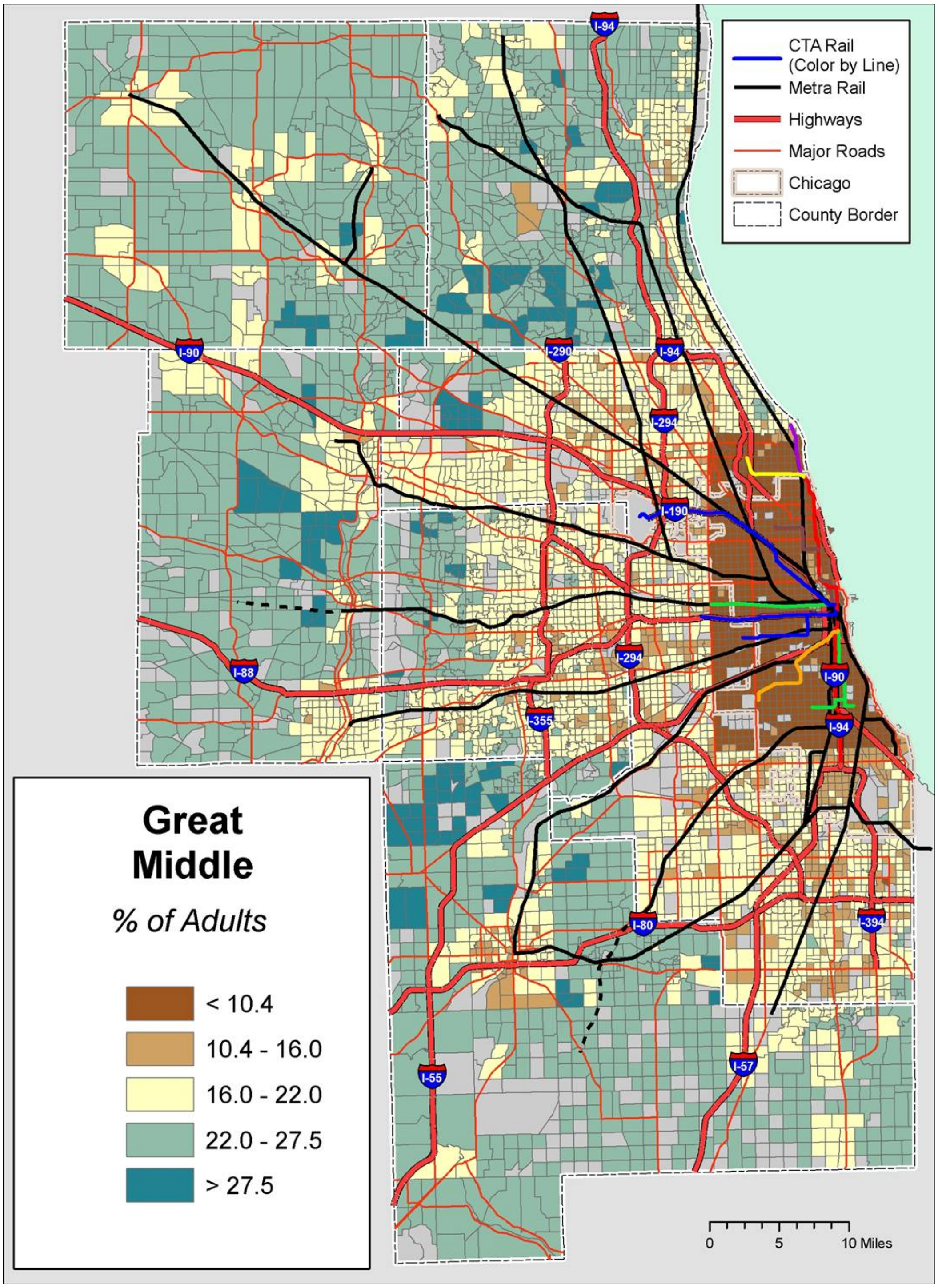


Figure 5.4 Demanding Survivors Incidence by TAZ

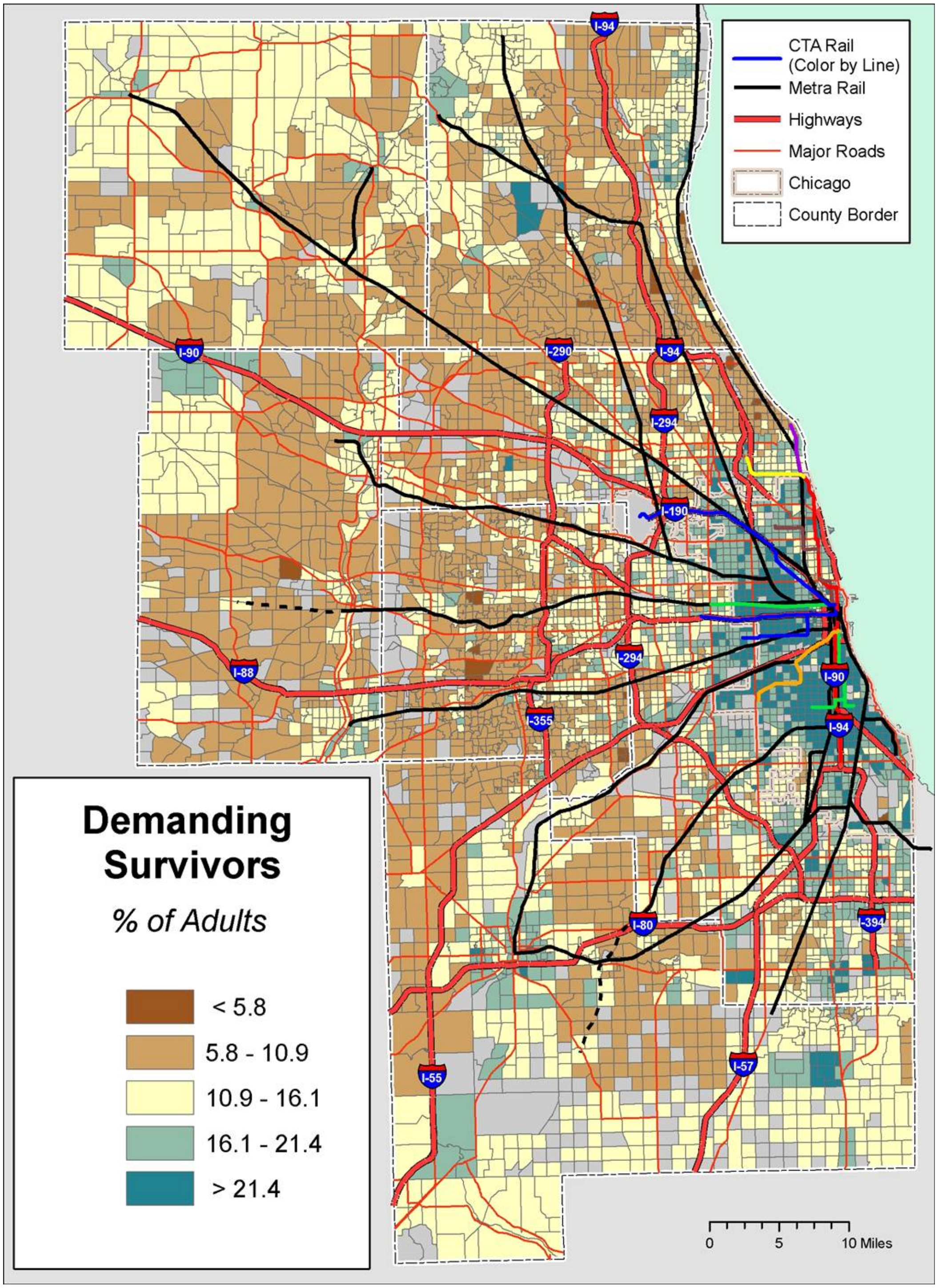


Figure 5.5 Cautious Individuals Incidence by TAZ

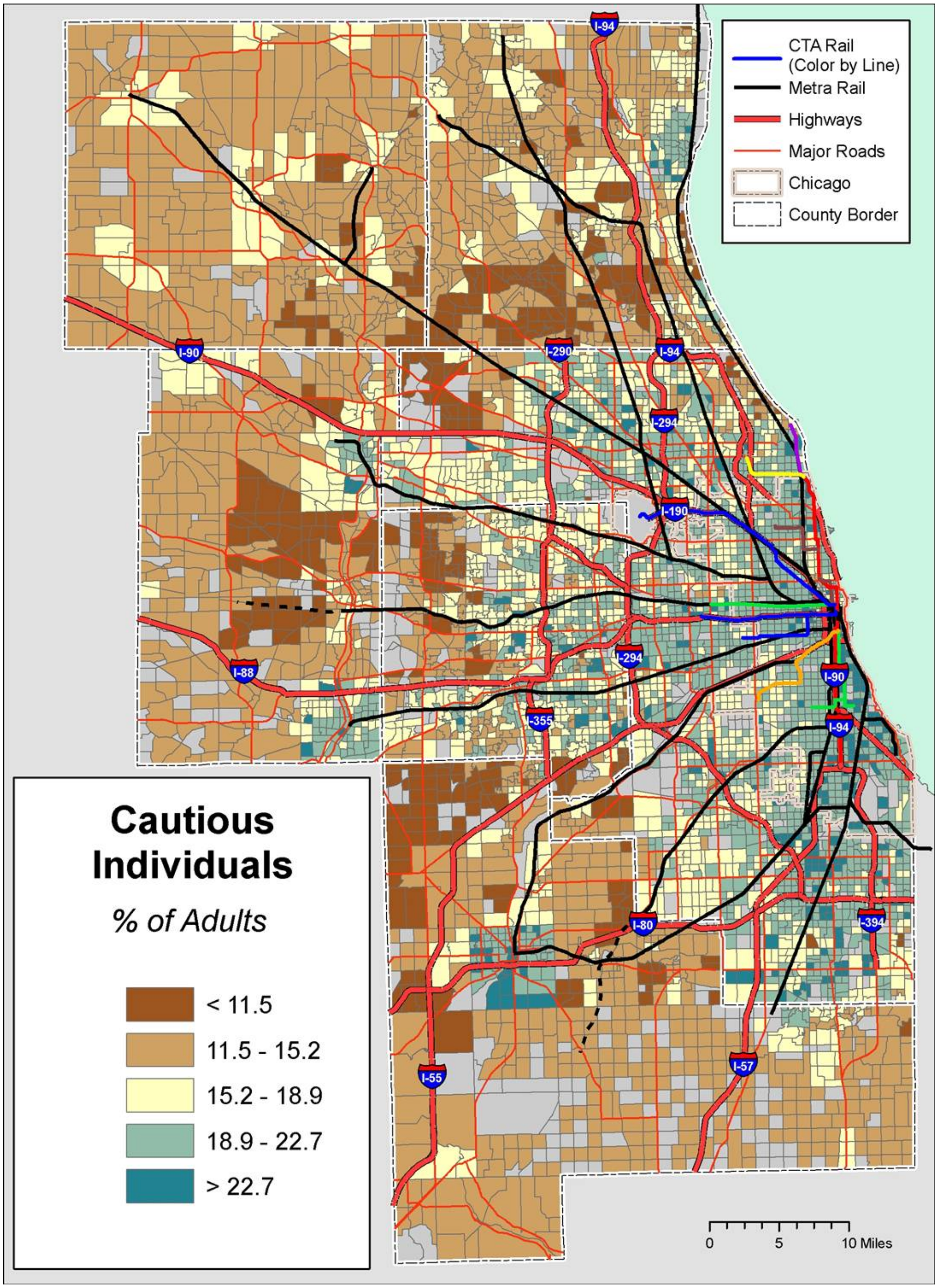


Figure 5.6 Educated Professionals Incidence by TAZ

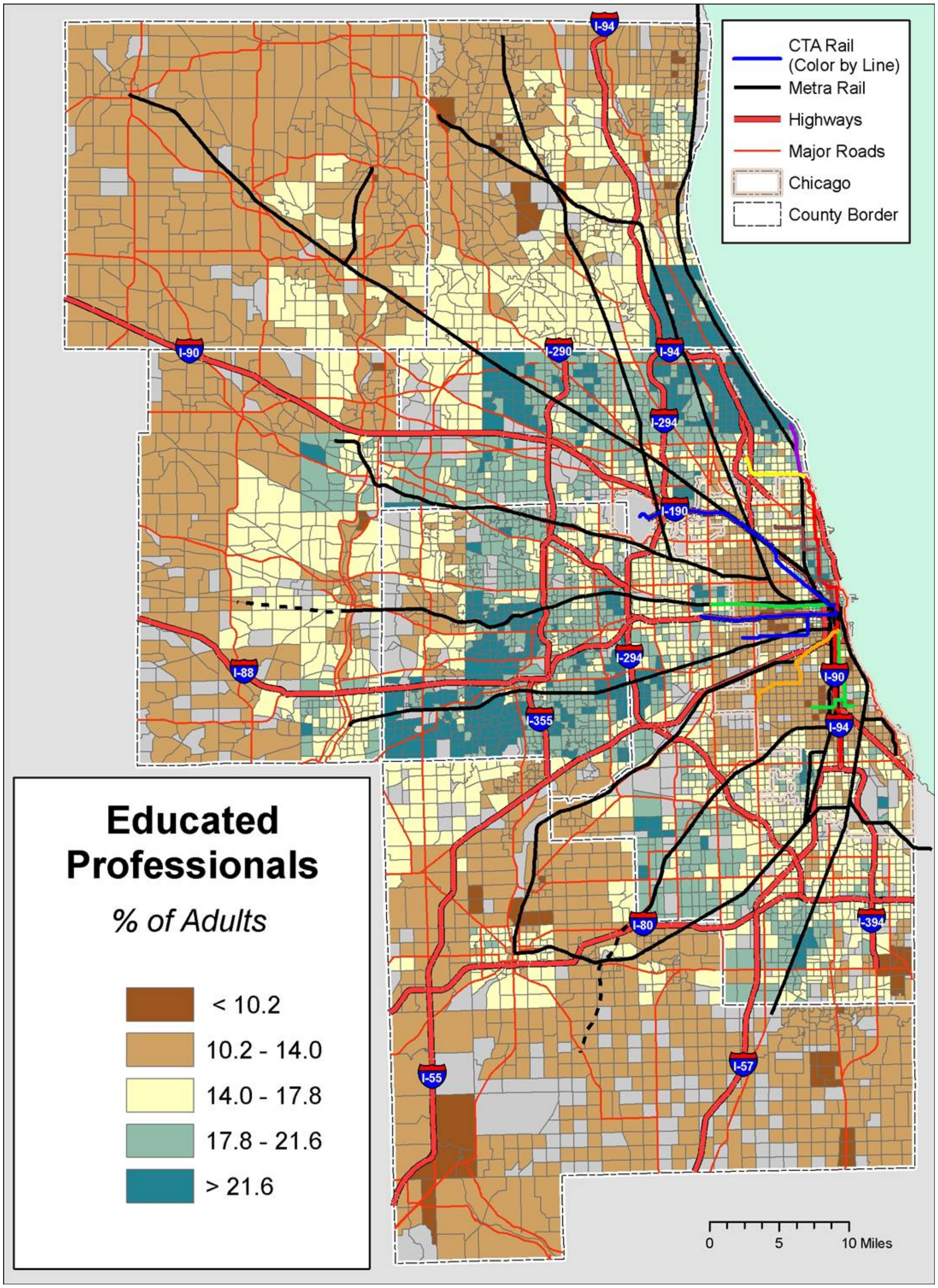


Figure 5.7 Downtown Commuters Incidence by TAZ

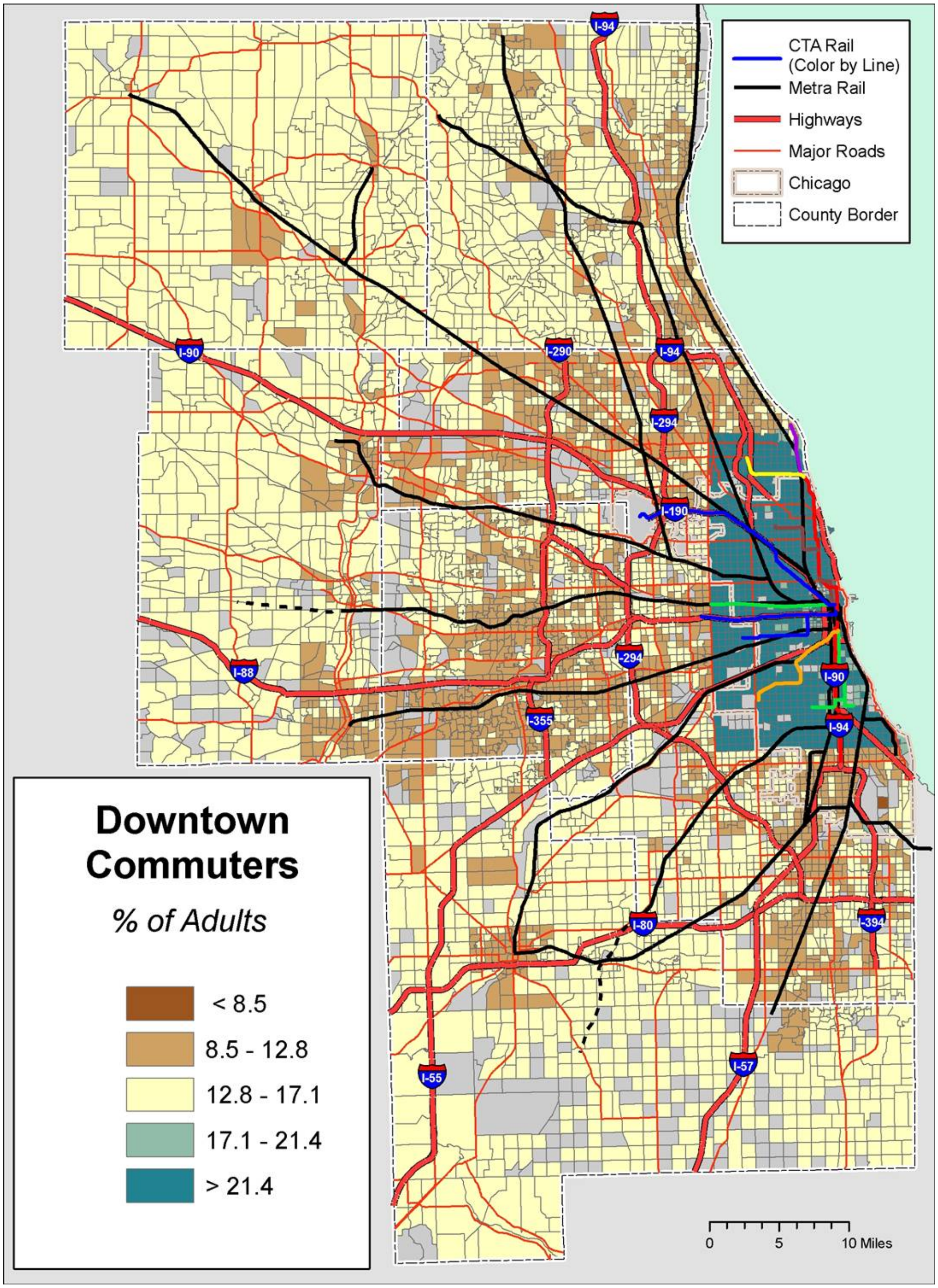


Figure 5.8 Determined Drivers Incidence by TAZ

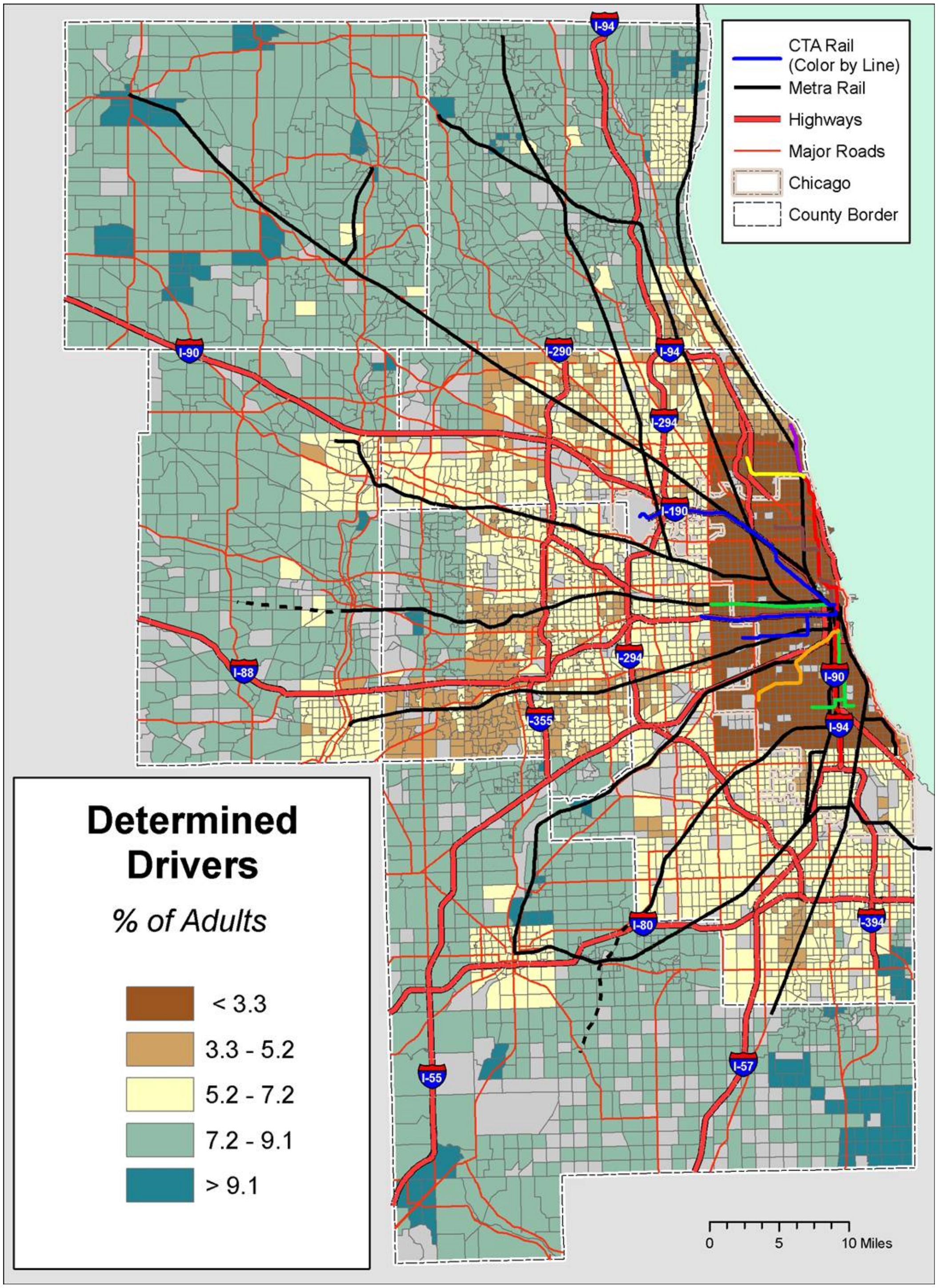
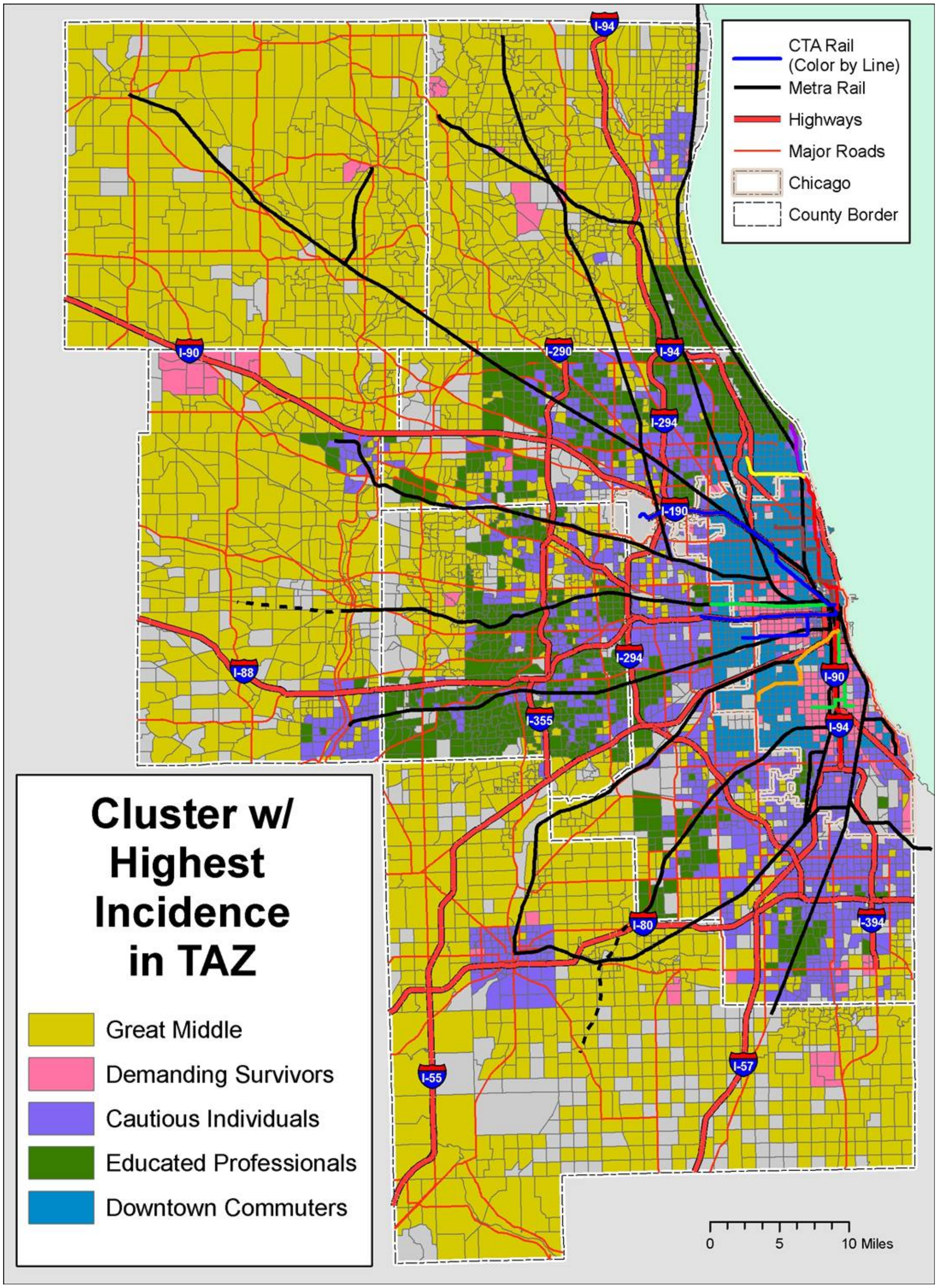


Figure 5.9 Customer Type Clusters with Highest Incident in TAZ



5.2 Transit Competitiveness Analysis

Transit competitiveness analysis is a market-based look at the relative transit potential of origins and destination locations. Analysis is conducted at the CTPP Traffic Analysis Zone (TAZ) level throughout the six-county region. Each TAZ is assigned two indices that describe the relative market ability of transit to compete with automobiles for customers. One index quantifies the ability of transit to compete for trip productions or origins. The other index quantifies the ability of transit to compete for trip attractions or destinations. The goal of each index, referred to as the Transit Competitiveness Factor (TCF) analysis is to identify opportunity markets for all forms of transit by combining customer type characteristics together with transportation, land use, socioeconomic, and demographic information. All of these factors are combined with weights based on the mode choice model to describe their relative ability to increase transit ridership. Similar to the consumer price index, TCF analysis gives a single number to describe the overall transit competitiveness of a place. This number can then be further broken down and analyzed to identify what drives the transit competitiveness of a place and assess how customers may respond to different service strategies. A detailed explanation of the equations used in calculating TCF is included in Appendix E.

Demand, rather than supply, drives TCF analysis. Existing conditions for automobile work trips are considered, but existing transit provision and characteristics are not. The intention of TCF analysis is not to identify how well customers currently are served by existing transit, but to assess what the market potential for transit is given the existing pattern of land use, population, and employment and travel patterns. In service planning and resource allocation planning, the results of the TCF analysis are applied to consider market demands alongside current and future transit supplies and identify opportunity areas that are being underserved or overserved by transit.

The TCF analysis can be distinguished from other transit planning and transit market research methods by its scale, level of detail, and flexibility. Most transit market research conducted in Chicago is either limited to a smaller study area (a subregion of the six-county transit market) or uses a larger-scale unit of analysis, such as the roughly 1,600 CATS TAZs that make up the six-county region. This analysis focuses on the Census TAZ level, providing detailed results for 6,320 zones with an average area of about 0.6 square miles (or 380 acres).

A high level of detail is captured in TCF analysis. Typical transit market research considers numerous land use, socioeconomic, and transportation components and applies the resulting predicted ridership metric to the population of a given area. TCF analysis captures the influence of these components but applies them to the market segmentation research results for each TAZ. Each customer type has a different response to the input components as well as service provisions and amenities, all of which is captured in the results of TCF analysis. Relative trade-offs between congestion and costs, for example, depend on what kinds of customers live in a given region rather than a regionwide average.

TCF analysis provides a bridge between market segmentation analysis and service planning. While the incidence of segments in each zone, as shown in Section 5.1, provides some insight into service strategies, TCF indices add information on land use, socio-economic, and transportation components to describe the relative merits of providing transit service at origin and destination locations across the region. By analyzing the components that contribute to the TCF results, more detailed insights on service strategies between particular origins and destinations can be gained. This next step will be conducted for the most highest rated origins and destinations in the South Cook County – Will County Initiative area in Task 5 (Preliminary Service Concepts).

5.2.1 Approach

TCF results are given in the form of two indices, one for the competitiveness of transit versus automobile in a given TAZ for productions (trips from an origin place of residence), and the other for competitiveness of transit versus automobiles in a given TAZ for attractions (trips to a destination place of work). Values that are 100 and higher are generally transit competitive. Values lower than 100 fall below the competitive level. The index is designed to reflect research and literature review of transportation and land use about critical transit thresholds. Transit mode share tends to rise rapidly at certain employment and household densities. A wide range of values is found in the transportation and land use literature for the critical transit thresholds. For the purposes of this analysis, densities of eight dwelling units per gross acre and 30 employees per gross acre were used. The TCF level of 100 corresponds roughly to these critical transit thresholds. The scale was developed so that numbers of 100 or higher can be generally considered transit competitive. The TCF is constructed to be proportional to transit market potential. In other words, transit ridership potential would be double for a TAZ with a TCF of 200 as compared to a TAZ with a TCF of 100.

A wide variety of components is considered in calculation of TCF results. Transportation and land use components include trip density at origin, trip density at destination, level of congestion, marginal automobile operating costs, and parking costs. The data selected for the analysis reflects availability and dependability. Socioeconomic inputs include household vehicle ownership and male/female ratio from the 2000 Census. Work trip travel patterns between each residence (origin zone) and workplace (destination zone) are from the 2000 Census Transportation Planning Package Journey-to-Work data.

Parking costs were based on the 2000 Downtown Parking Inventory by CATS, and supplemented by anecdotal data on parking costs in suburban locations developed with Pace. Downtown parking costs varied by TAZ, and ranged from zero at the periphery of the CBD to up to $13 (2000 dollars), adjusted with the consumer price index (CPI). Parking costs in suburban locations where the typical worker would likely experience at least some parking cost were defined in current dollars based on personal experience as:

- **Aurora** (approximately the downtown area bounded by New York Street, Broadway, Benton Street, and River Street) – average parking cost of $1 per day;
- **Downers Grove** (approximately the downtown area bounded by Rogers Street, Maple Avenue, and Forest Avenue) – average parking cost of $2 per day;
- **Evanston** (approximately the downtown area bounded by Emerson Street, Chicago Avenue, Lake Street, and Ridge Avenue) – average parking cost of $4 per day;
- **Joliet** (approximately the downtown area bounded by Cass Street, Eastern Avenue, Washington Avenue, and Ottawa Street) – average parking cost of $1 per day; and
- **Waukegan** (approximately the area bounded by Grand Avenue, Sheridan Road, Washington Street, and Martin Luther King Jr. Avenue) – average parking cost of $1 per day.

Parking costs at the CTPP TAZ level were modified in situations where the district with parking costs did not cover the whole TAZ. For instance, the area of downtown Waukegan considered to have a nonzero average parking cost represented only a small portion of two CTPP TAZs, therefore, the parking cost was reduced accordingly by the approximate proportion of shared area.

Automobile operating cost per mile was derived based on marginal costs represented in the annual "Your Driving Costs 2006" report by the American Automobile Association. The average value used is 16.5 cents per mile, which is a rough average of operating costs for sedans (15 cents per mile), minivans (17 cents per mile), and SUVs (20 cents per mile).

These inputs were weighted according to ability to generate transit trips. To develop the proper weights, each factor included in the TCF calculation was related to a specific variable in the mode choice mode described in Section 3.6. The mode choice models differ for every cluster. For example, density at the origin is related to access time, density at the destination is related to egress time, congestion is related to in-vehicle travel time, and parking cost is related to out-of-pocket travel cost. Coefficients are applied to the input data and the results are weighted by customer type incidence. The total is summed to get the TCF.

Results of the TCF analysis are described in two components, attractions (destinations) and productions (origins). As Journey-to-Work data were used for analysis, these components and results apply only to work trips. The following section describes components of the TCF analysis first for attractions, then for productions.

5.2.2 Results for Destinations

A series of GIS-generated maps (**Figures 5.10 to 5.13**) display the components that contribute to the overall TCF for trips destined to each TAZ (attractions). For all maps in the attraction series, a GIS Definition Query has been applied in order to only display TAZs with an attraction density of greater than 0.05 trips per acre. TAZs with less than or equal to 0.05 trips per acre are shown in gray to avoid misrepresentation due to small values.

The first map (**Figure 5.10**) displays the relative transit competitiveness of each destination location, as defined by the TCF for attractions. TAZs in blue have a TCF value of 100 or greater and are considered transit competitive. These zones represent markets with high transit potential. Generally, transit competitive zones are better targets for investment while noncompetitive zones, colored yellow/green, may be potential targets for disinvestment. Noncompetitive zones should not be eliminated from further analysis or considered undesirable for service investment, but rather should be considered relative to each other. A darker green zone indicates more transit potential than a lighter green zone and this can inform service decisions.

About one-third (34 percent) of the six-county region's total work trips are destined to a transit competitive attraction zone. Transit competitive zones are concentrated in Chicago. Other competitive areas include Oak Brook, the Warrenville Road corridor, Schaumburg, and downtown Evanston. Within the South Cook County – Will County Initiative area, there are a limited number of transit competitive zones, such as Orland Park and downtown Joliet. In addition, two isolated transit competitive TAZs in the area coincide with hospital facilities, namely the Provena St. Joseph Hospital in West Joliet and St. James Hospital and Health Center in Chicago Heights.

Of the components of TCF for attractions, the one that contributes the most to transit competitiveness is trip attraction density, shown in **Figure 5.11**. This map shows how many trips go to a TAZ (per acre). The critical transit threshold is about 15 trips per acre, which is approximately the number of work trips associated with an employment density of 30 jobs per gross acre, a figure based on literature review of transit-supportive employment densities. The literature review is described in more detail in Appendix D. This has the most significant contribution to overall TCF for attractions. The map shown has many similarities to the TCF for attractions map due to the strong positive influence of trip attraction density on overall TCF for attractions.

Parking Cost is another component with a positive influence on overall TCF for attractions. **Figure 5.12** displays the average parking cost for work trips attracted to a TAZ. The area of the blue circle indicates the average parking cost per trip. Downtown Chicago has the largest cost for parking. Other areas with significant parking costs include downtown Evanston, Oak Brook, Joliet, Aurora, and Waukegan. For most destinations, parking is free. This tends to contribute to the overall TCF for attractions of areas outside of downtown Chicago, Evanston, and other destinations with measurable parking costs.

Average delay for attractions, a measure of congestion, is shown in **Figure 5.13**. Delay is measured as the difference between a.m. peak-period highway travel times and off-peak travel times as reflected in the CATS regional travel demand model multiplied by the number of trips to a given destination zone from each origin zone. This value is summed across all origin zones that send work trips to the given destination zone and divided by the total number of trips destined to the zone to compute average delay for each zone.

For display purposes, blue TAZs are above the regional average of 4.5 minutes of delay per work trip and green/yellow TAZs are below. Delay has a positive influence on overall TCF for attractions, as it indicates automobile work trip congestion that may frustrate commuters, particularly those with high sensitivity to time and schedule. The map also can serve to represent the ability of a location to attract workers from distant locations, as people who encounter more delay are generally involved in longer trips. TAZs in places like Oak Brook with major employers that draw workers from long distances tend to show greater delay. Not surprisingly, trips going into downtown Chicago experience significant delay. There are pockets in suburban areas where attracted work trips experience significant delay such as the southeastern Villages of Homewood, Lynwood, and Flossmoor. DuPage County generally experiences less congestion than may be expected. This may be explained as a function of the county's large employment level, which allows many jobs to be filled by residents of the county who thus do not experience as much delay due to the relatively short trip lengths.

Median production density for trips attracted is shown in **Figure 5.14**. This component of overall TCF for attractions is a measure of the median production density (or the density of the TAZ in which a trip originated) for trips attracted to a given TAZ.[1] It has a positive influence on overall TCF for attractions. An attraction may be of high density and, therefore, have a high TCF, but it also is important to consider the other end of the trip, which may not come from a high-density location. Assume there are two TAZs, identical in all other factors, one of which draws a significant amount of work trips from Chicago, the other which draws most work trips from a low-density suburb. The TAZ that draws people from Chicago will be more transit competitive. TAZs displayed in blue tend to draw trips from dense zones. Blue zones reflect densities above a transit competitive threshold of six work trips produced per gross acre, a figure based on literature review of transit-supportive residential densities. Six work trips produced per gross acre is approximately the level expected from a housing density of eight dwelling units per net acre. The literature review is described in more detail in Appendix D. Blue zones outside of Chicago may have potential for a city-to-suburb transit market. Some highlights in the South Cook County – Will County Initiative area include locations in Hickory Creek, Argonne National Laboratory, and Country Club Hills.

[1] The median attraction density for trips produced is used rather than the average attraction density for trips produced to eliminate the undue effect of a small number of work trips to a very dense attraction such as downtown Chicago.

Figure 5.10 Transit Competitiveness Factor for Attractions

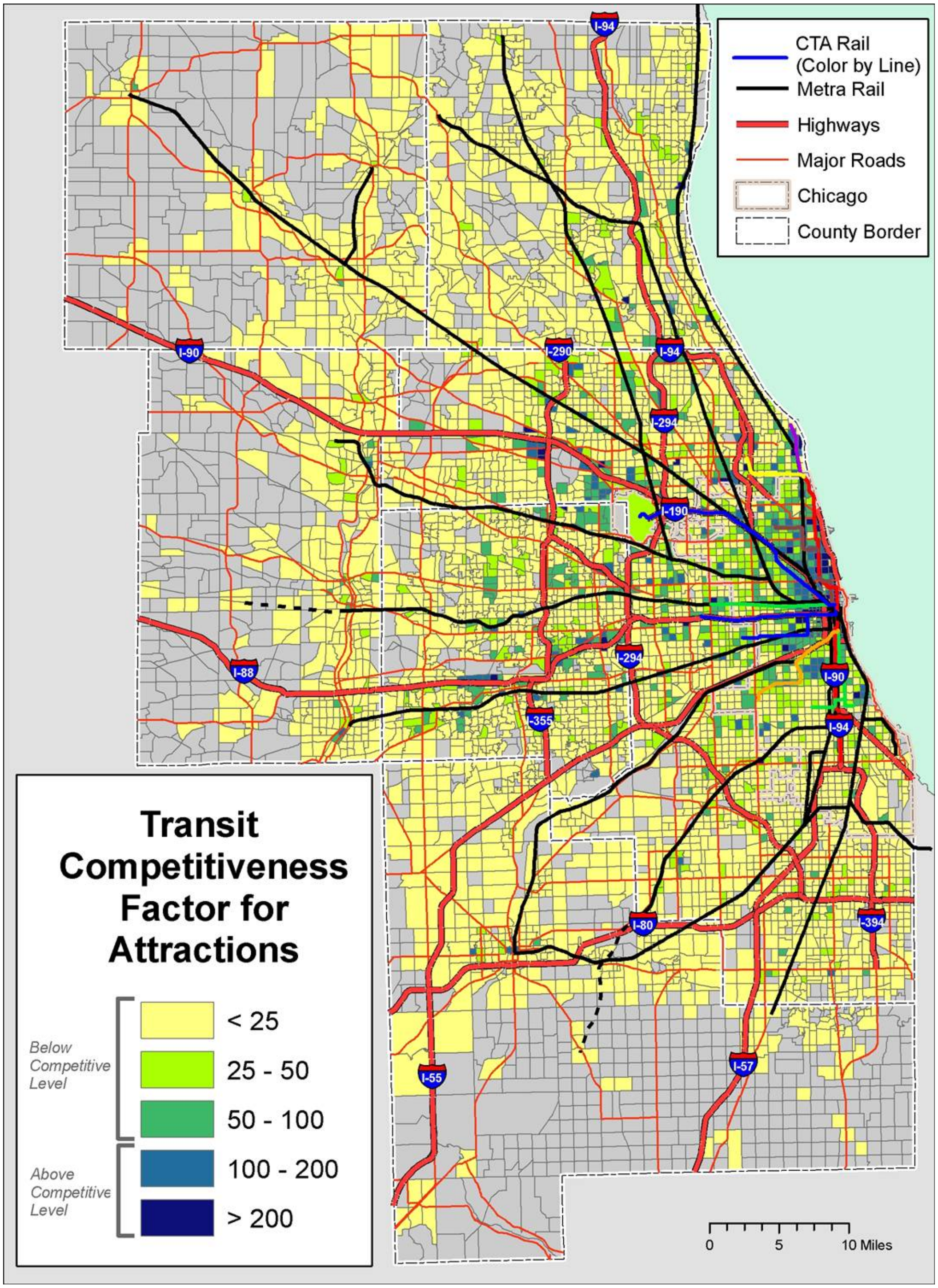


Figure 5.11 Transit Attraction Density

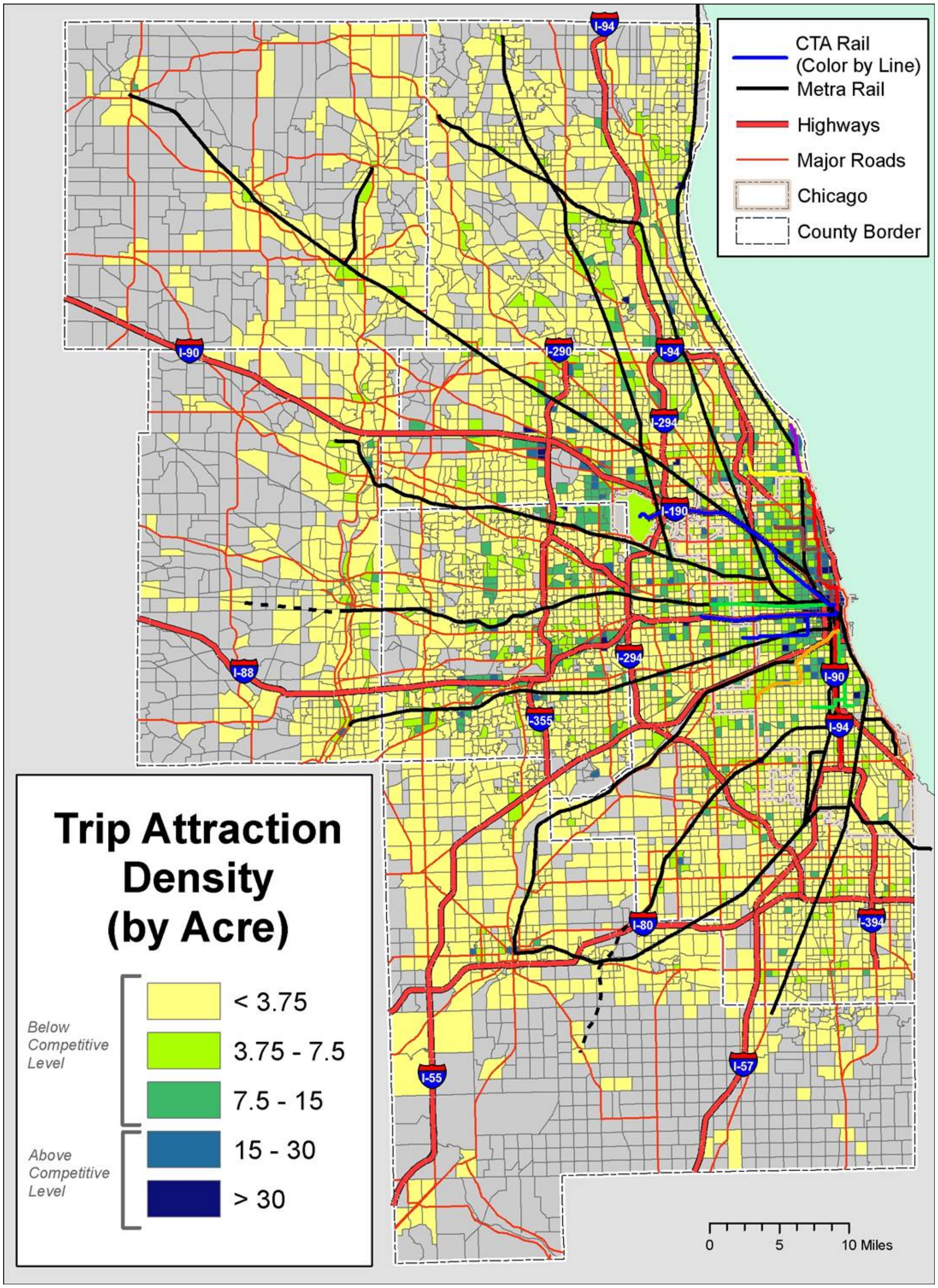


Figure 5.12 Average Parking Cost for Attractions

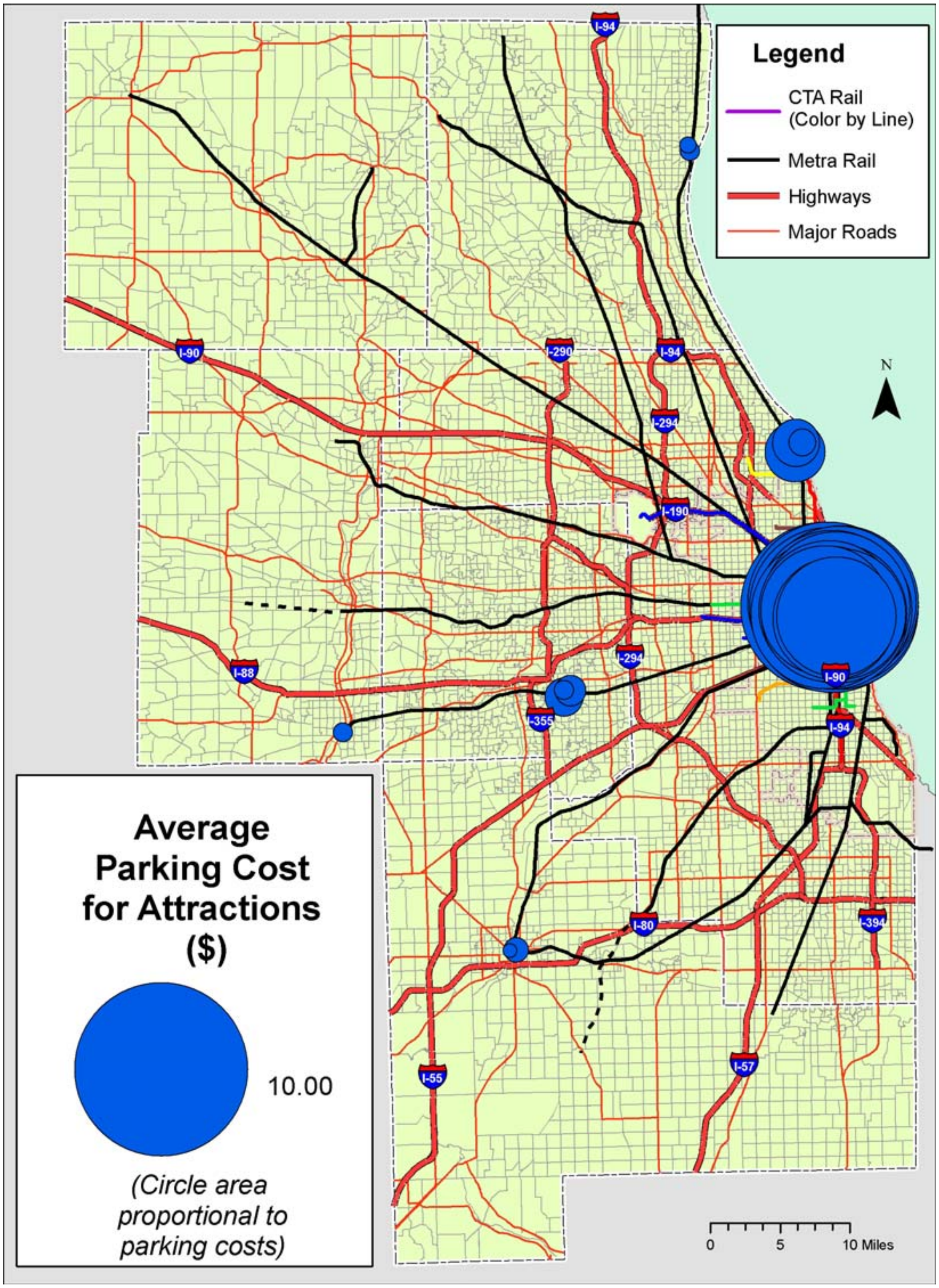


Figure 5.13 Average Delay for Attractions

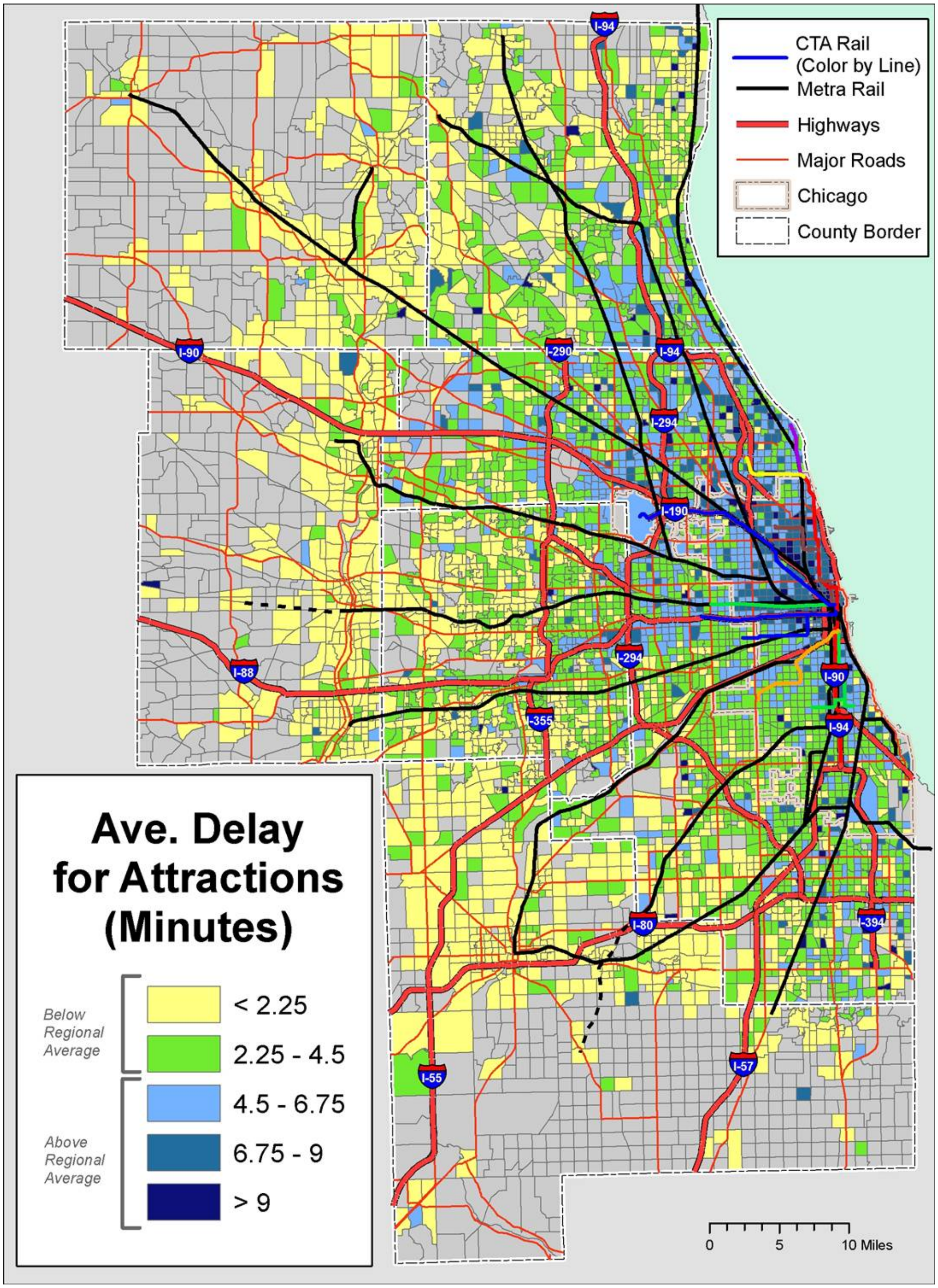
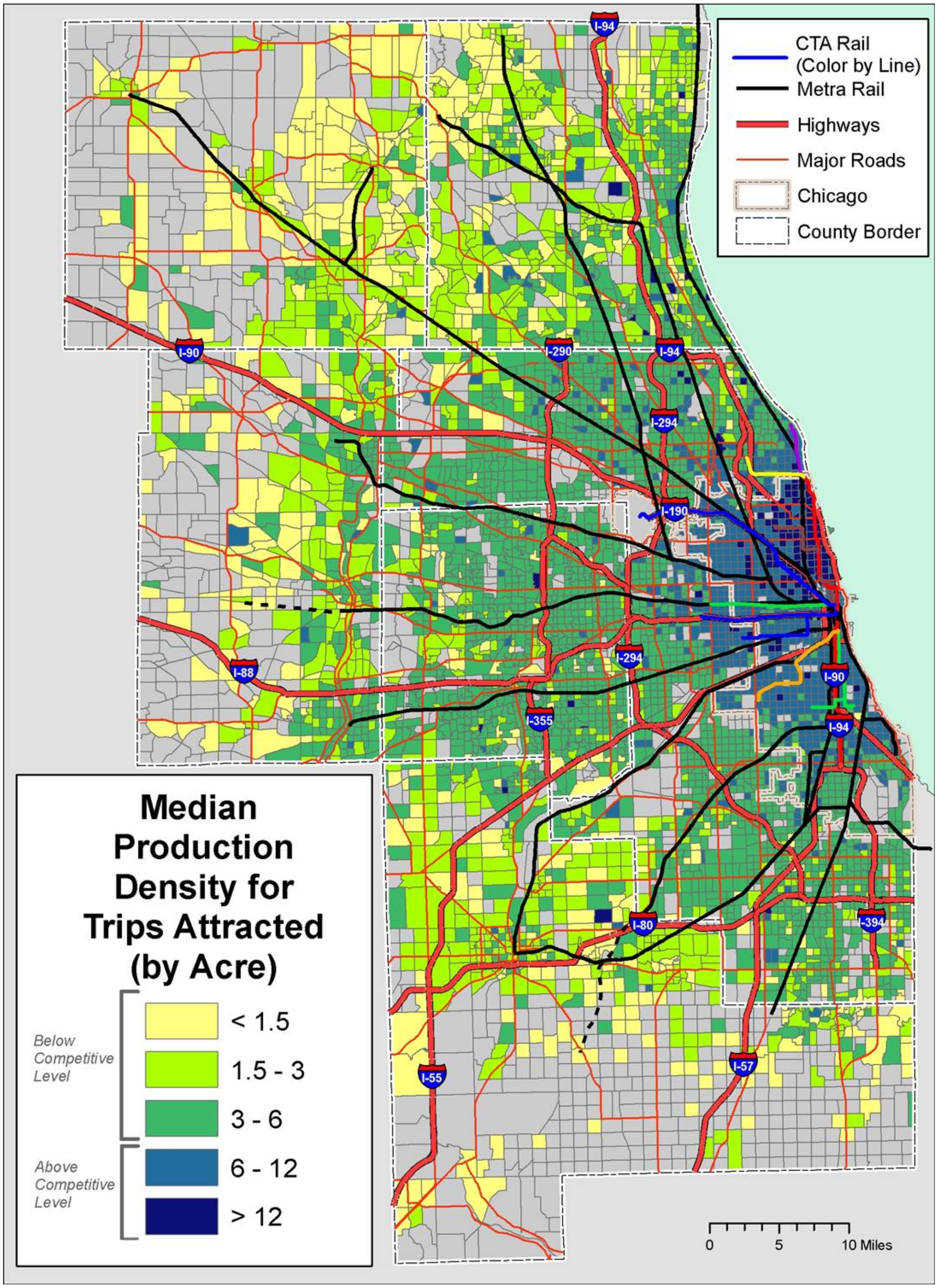


Figure 5.14 Median Production Density for Trips Attracted



In **Figure 5.15**, the light blue bars represent the percentage of all work trips sorted by destination county. About 34 percent of all work trips go to Chicago and an equal percentage of all work trips go to suburban Cook County. Transit competitive trips (defined as having a destination in a transit competitive zone) are represented by the dark blue bars. The City of Chicago attracts the largest proportion of transit competitive trips (about 62 percent), making transit service to Chicago (or to intermediate destinations that connect with services to Chicago) a significant transit market opportunity. Suburban Cook County is another attractive travel market with about 26 percent of all transit competitive trips destined there. Only about 12 percent of transit competitive trips are destined to a location in the collar counties, with the majority of those in DuPage County.

Figure 5.15 Transit Potential by Destination County

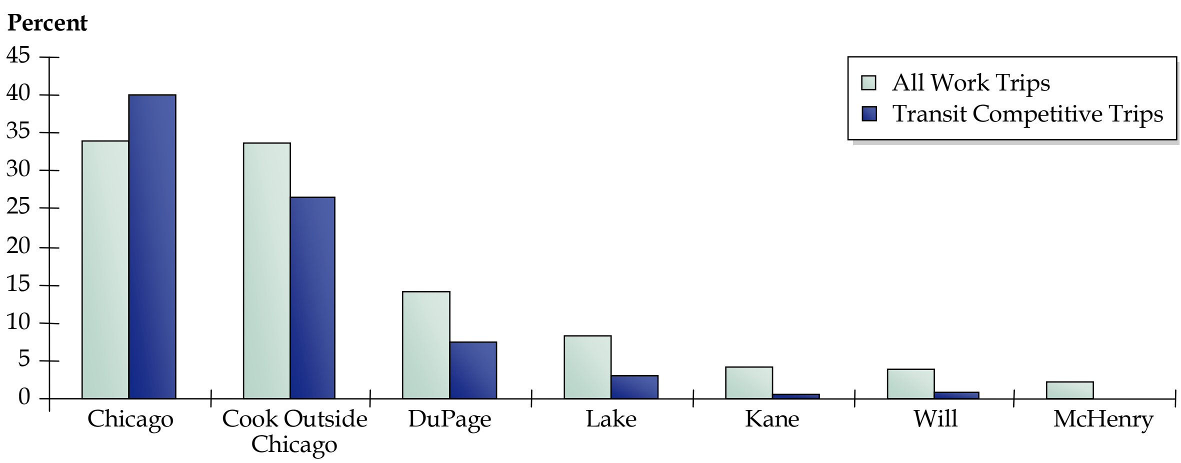
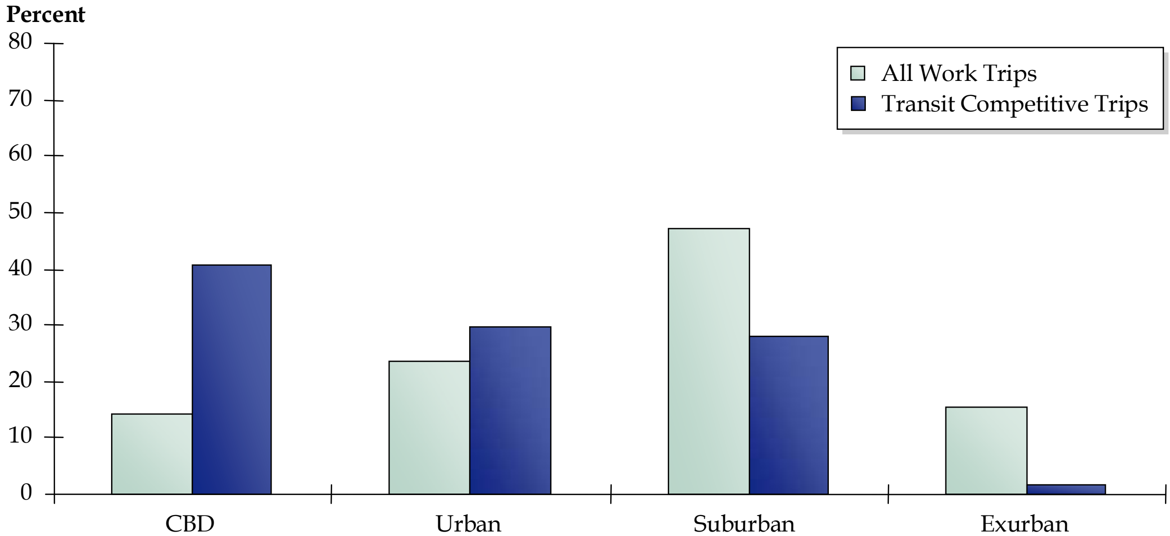


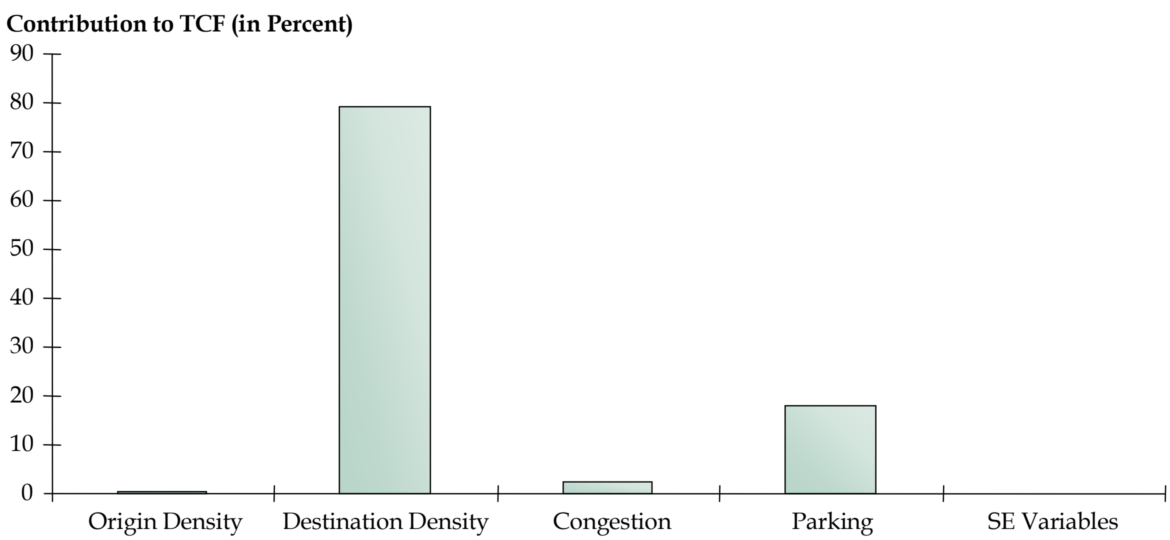
Figure 5.16 shows a similar breakdown but groups results by area type, using the land use classifications described in Section 2.2.3. About 12 percent of all work trips are attracted to the central business district (CBD), but about 42 percent of all transit competitive trips are attracted there. About 28 percent of transit competitive trips have suburban destinations which represents a potential transit market.

Figure 5.16 Transit Potential by Destination Area Type



For transit competitive TAZs (TAZs with TCF for attractions greater than 100), a variety of components contribute to the end result. **Figure 5.17** breaks down the factors that contribute to TCF for attractions by component. Destination density is clearly the largest contributor to TCF. Parking cost also is a significant contributor. Congestion plays a fairly small role in transit competitiveness, because this is a function of in-vehicle travel time, a trip component to which travelers generally show less sensitivity than other components.

Figure 5.17 Destination Transit Potential by Component
Transit Competitive TAZs Only



5.2.3 Results for Origins

A second series of GIS-generated maps (**Figures 5.18 to 5.23**) displays the components that contribute to the overall TCF for productions for each TAZ. For all maps in the production series, a GIS Definition Query has been applied in order to only display TAZs with a production density of greater than 0.05 trips per acre. TAZs with less than or equal to 0.05 trips per acre are shown in gray to avoid misrepresentation due to small values.

The first map in the production series (**Figure 5.18**) shows the overall TCF for productions in the six county region. As in the TCF for attractions map, transit competitive zones (TCF greater than 100) are shown in blue. About 43 percent of the six-county region's work trips come from a transit competitive TAZ. The City of Chicago has the largest concentration of transit competitive TAZs. Other areas with concentrations of TAZs include Aurora, Oak Park, and Schaumburg.

Trip production density is the biggest contributor to the overall TCF for production, shown in **Figure 5.19**. This map shows how many trips originate in each TAZ (per acre). Blue zones are considered above the transit competitive threshold of six trips produced per gross acre. The distribution is similar to that of the overall TCF for productions map. This is because of the importance of this component to the overall TCF.

One socioeconomic factor that positively contributes to overall TCF for productions is the percentage of households with zero vehicles, displayed in **Figure 5.20**. The regional average is 12 percent of households. TAZs shown in blue have a higher than average percentage of households with zero vehicles. Chicago has the largest concentration of transit competitive TAZs. There also are scattered areas throughout the six-county region, particularly in central Joliet and southeastern cities such as Harvey and Chicago Heights.

Average parking costs for productions has a positive impact on TCF as parking costs increase the relative cost of driving and make transit more attractive as an alternative. **Figure 5.21** displays the average parking cost for productions within a TAZ, what the average commuter (who begins his/her trip in the given TAZ) pays in parking costs at his/her destination. The regional average parking cost for a work trip in the six-county region is 65 cents. TAZs in blue have higher than average parking costs. The high parking costs in downtown Chicago have a significant impact on average parking costs so TAZs in blue are likely to send a higher proportion of trips into downtown Chicago than green/yellow TAZs.

Average delay for productions is another component with a positive impact on TCF, shown in **Figure 5.22**. Delay is computed for automobile work trips originating from each zone in a similar manner as described above. Higher values for delay can increase the competitiveness of transit as an alternate mode to driving. Delay also is influenced by trip length. As described above, TAZs with above average delay for productions are shown in blue and are concentrated in Chicago, as well as to the north and south of the City. The southeastern portion of the region experiences significant delays in places such as South Holland and Calumet City.

The median attraction density for trips produced is shown in **Figure 5.23**. This component of overall TCF for productions is a measure of the median attraction density (or the density of the TAZ in which each trip ends) for work trips originating in a given TAZ. It has a positive influence on overall TCF for productions. An origin location may be of high density and, therefore, have a high TCF, but it also is important to consider the other end of the trip, which may not end in a high-density location. TAZs displayed in blue tend to have work trips going to dense zones. Blue zones are considered above the transit competitive threshold of 15 work trips attracted per acre, a figure based on literature review. This component has a relatively low positive contribution to overall TCF. The highest attraction density for trips produced is found in Chicago and the northern suburbs of Winnetka, Kenilworth, and Wilmette.

Figure 5.18 Transit Competitiveness Factor for Productions

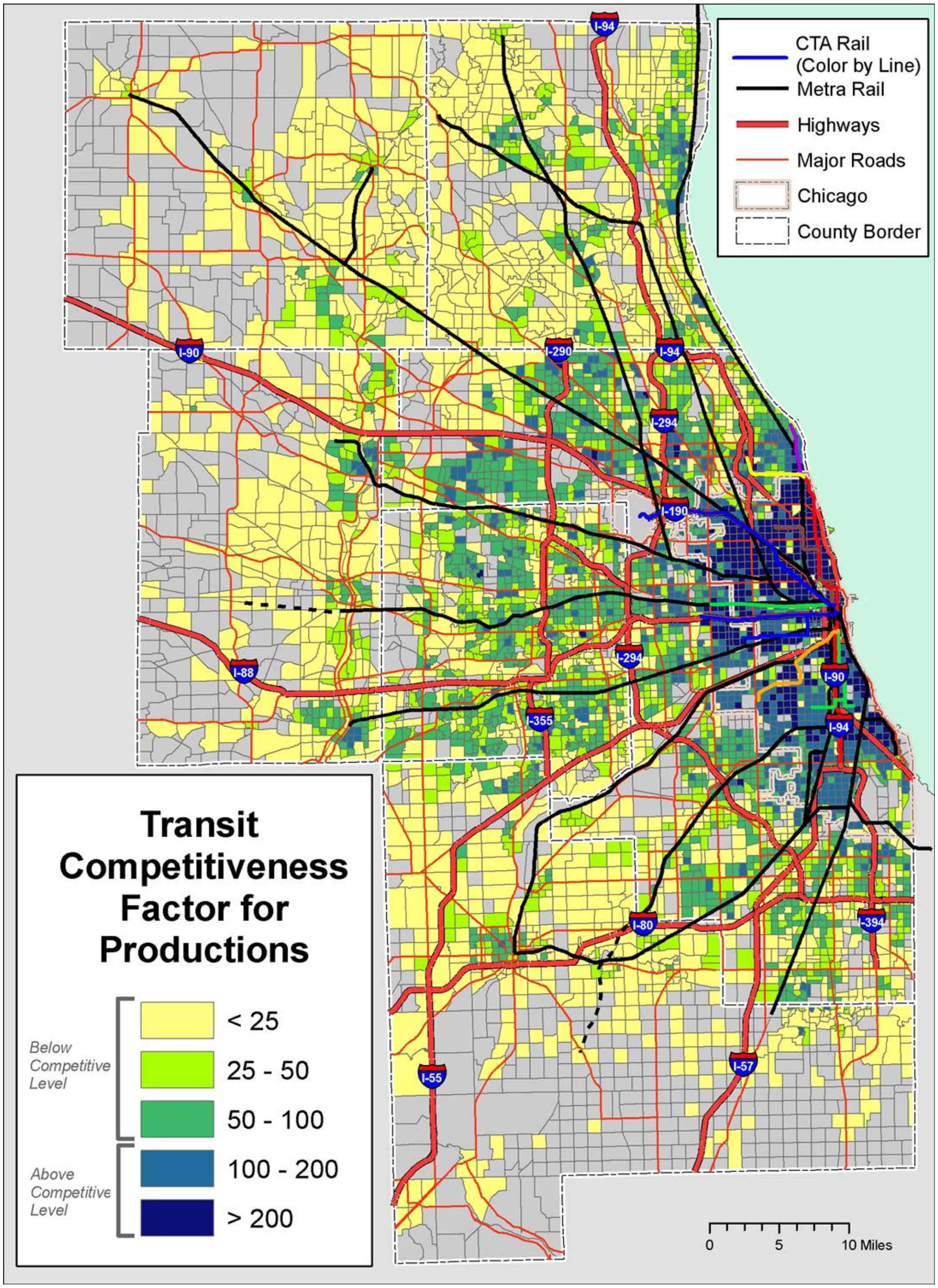


Figure 5.19 Trip Production Density

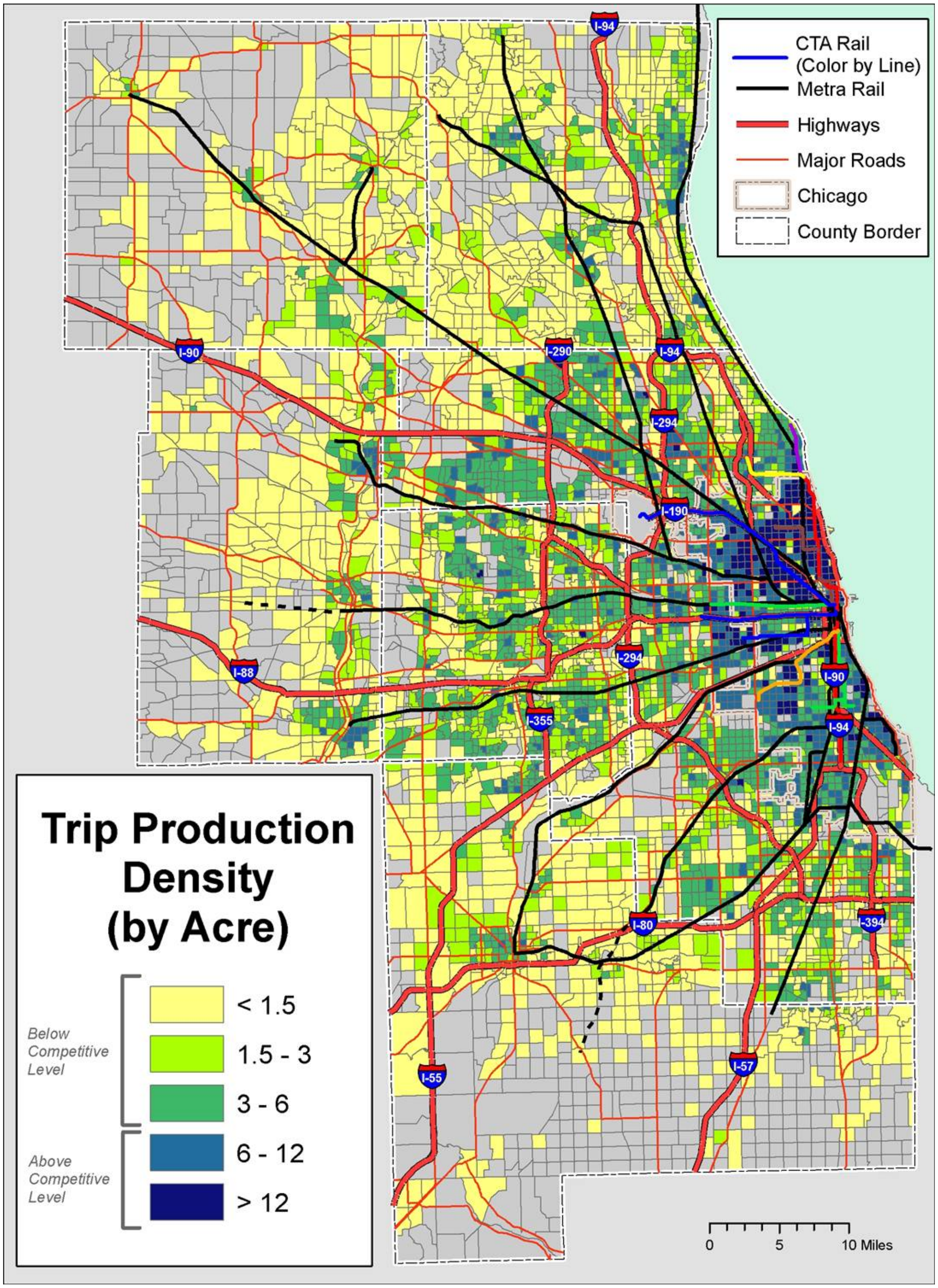


Figure 5.20 Percentage of Households with Zero Vehicles

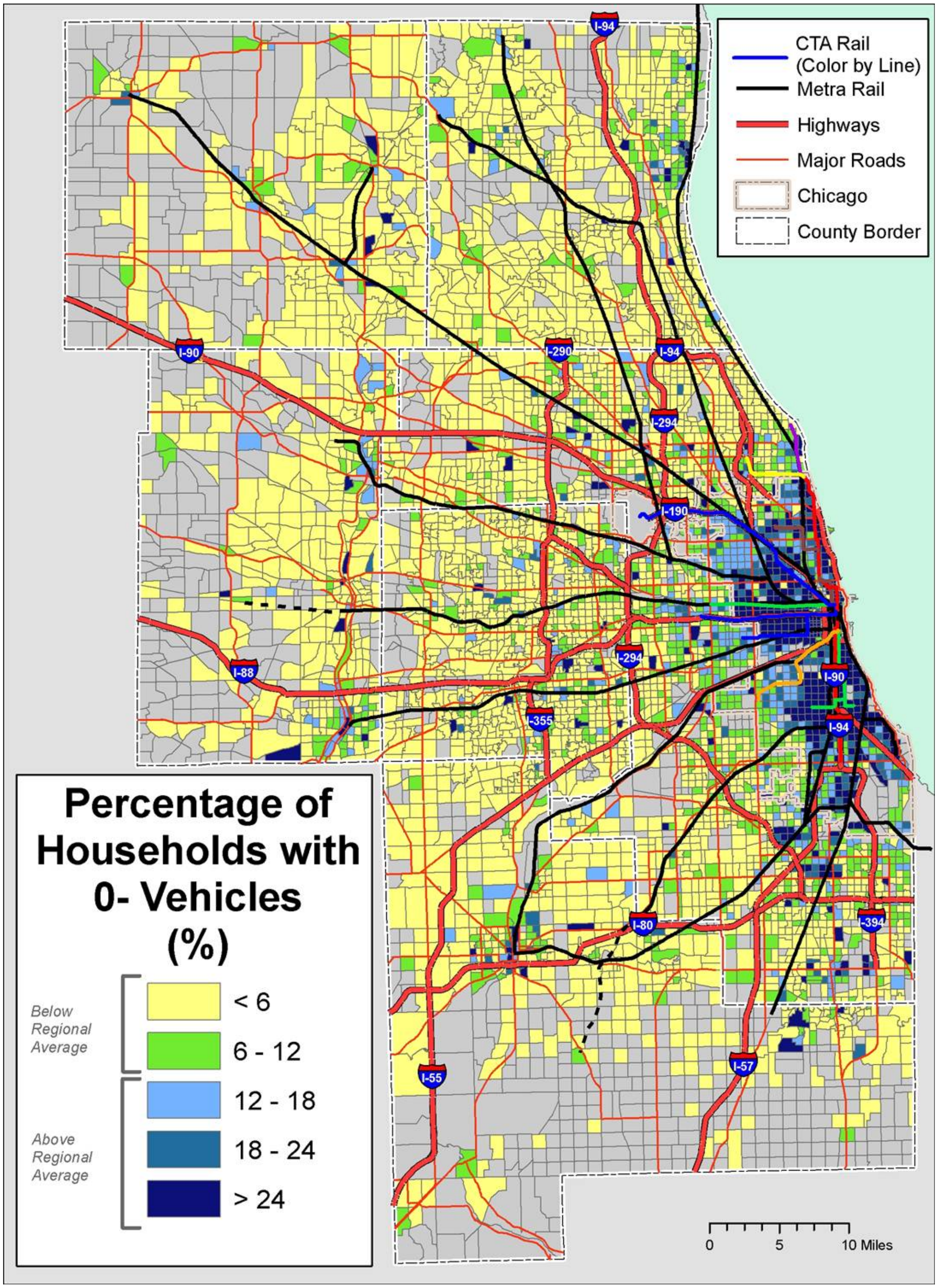


Figure 5.21 Average Parking Cost for Productions

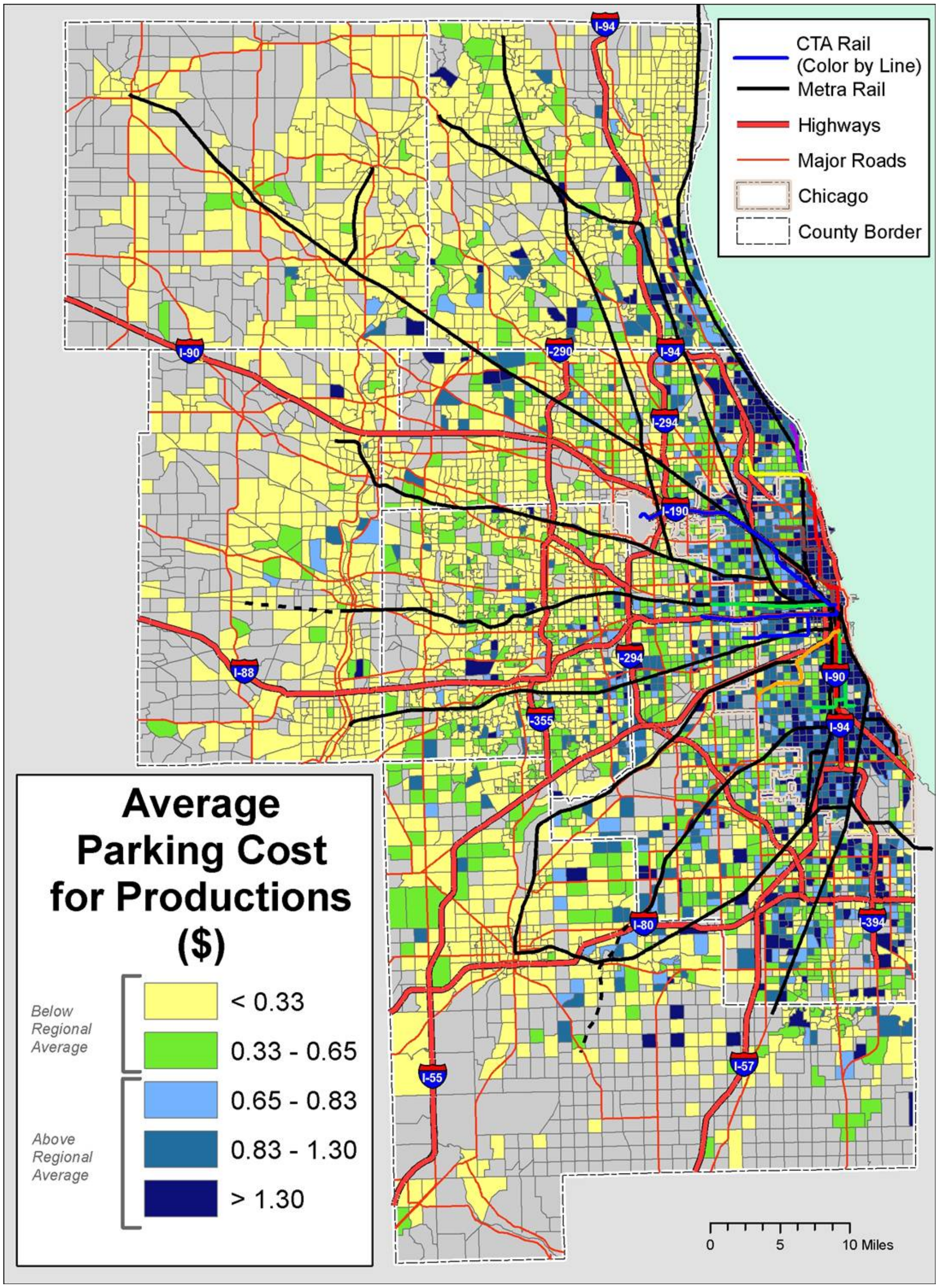


Figure 5.22 Average Delay for Productions

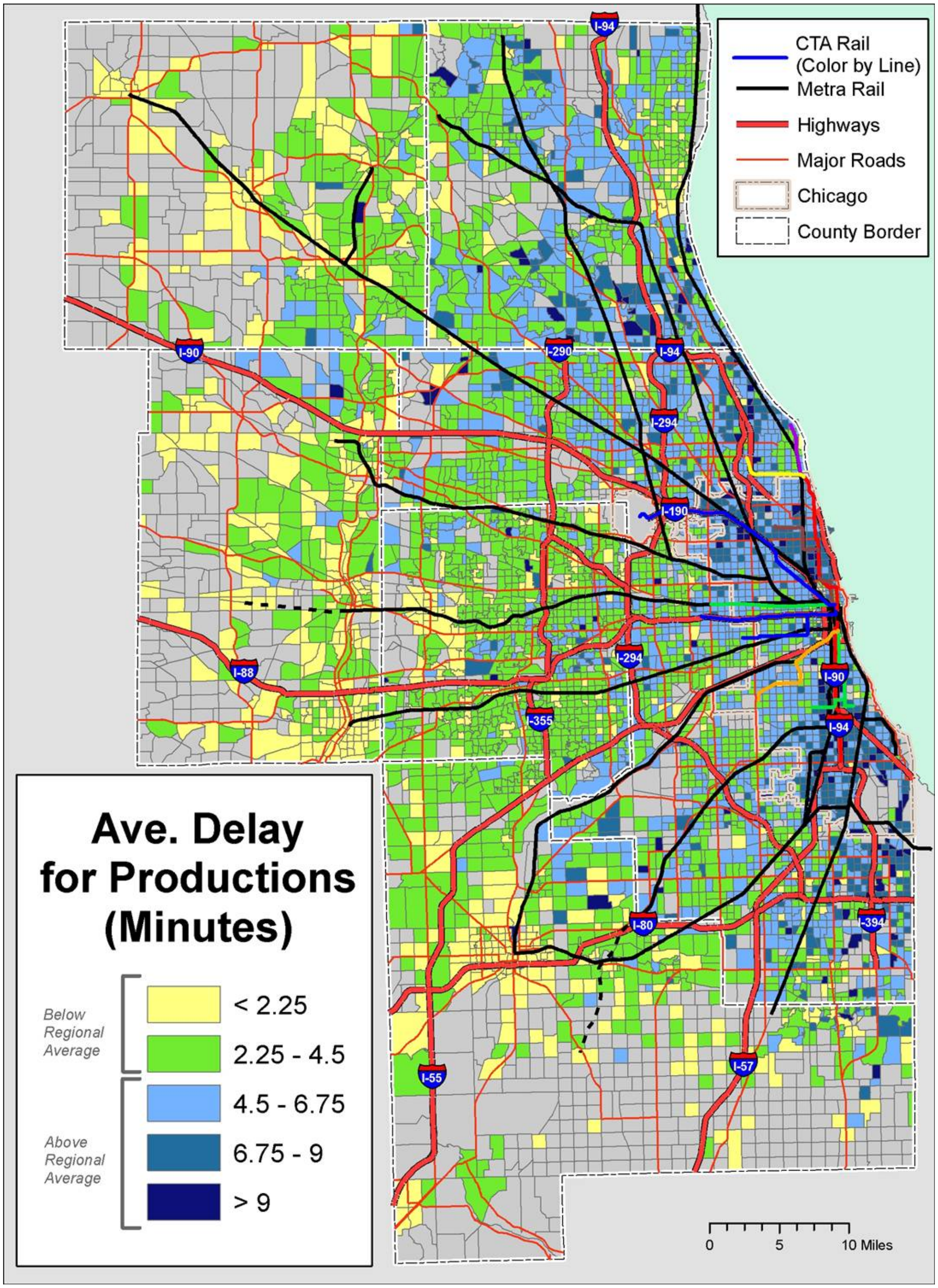
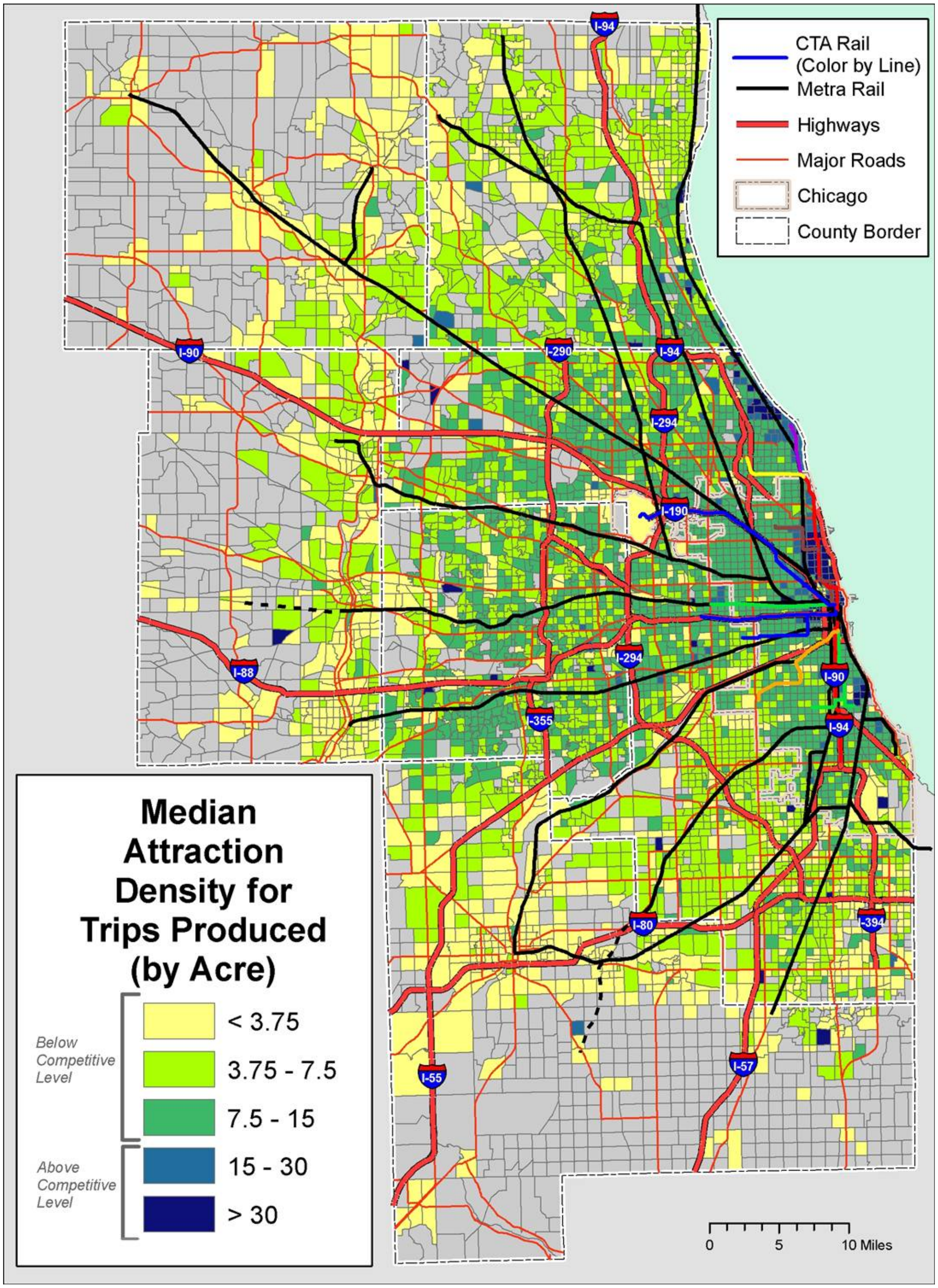


Figure 5.23 Median Attraction Density for Trips Produced



In **Figure 5.24**, the light blue bars represent the percentage of all work trips sorted by origin county. About 32 percent of all work trips go to Chicago and an equal percentage of all work trips go to suburban Cook County. Transit competitive trips (defined as having an origin in a transit competitive zone) are represented by the dark blue bars. As with destination county results, the City of Chicago dominates the market for production of transit competitive trips with 67 percent. Suburban Cook County produces about 26 percent of all transit competitive trips.

Figure 5.24 Transit Potential by Origin County

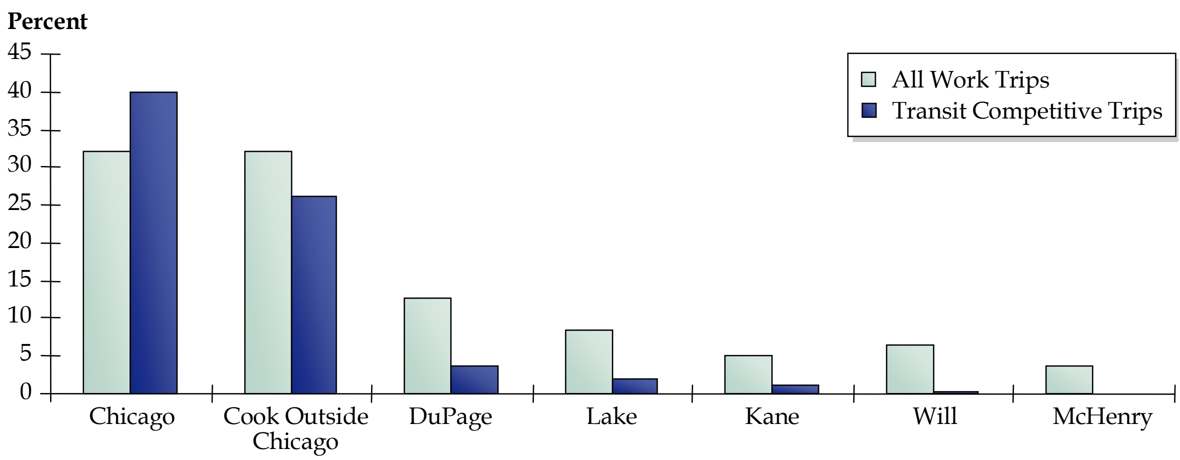
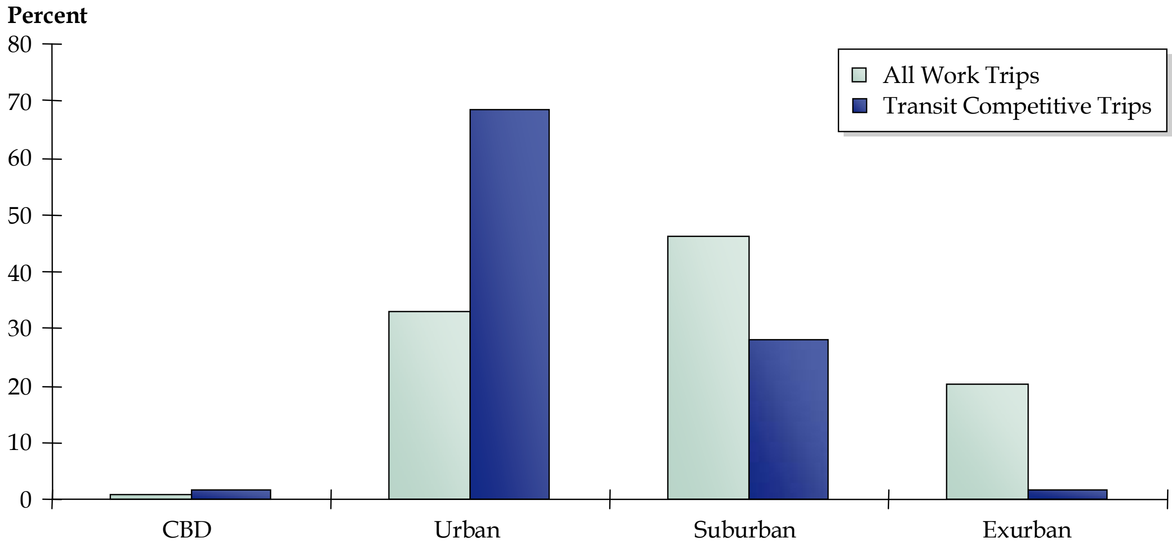


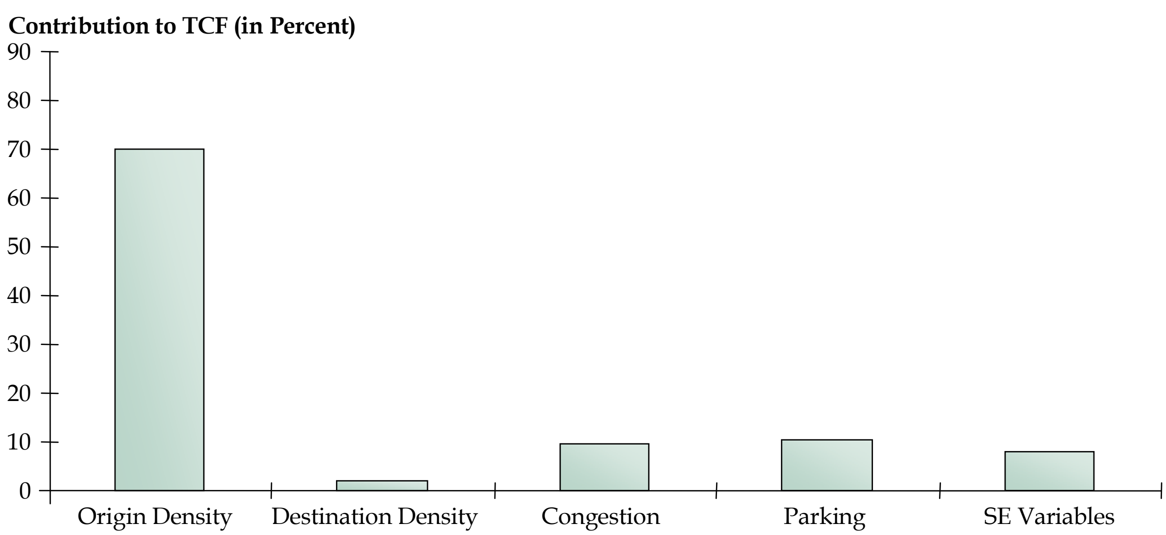
Figure 5.25 shows a similar breakdown but groups results by area type. Very few trips originate in the CBD. The largest share of work trips, about 46 percent, comes from the suburbs. Urban areas attract a significant portion of transit competitive trips, more than double the proportion of all work trips that originate in this area type.

Figure 5.25 Transit Potential by Origin Area Type



For transit competitive TAZs (TAZs with TCF for productions greater than 100), a variety of components contribute to the end result. **Figure 5.26** breaks down the factors that contribute to TCF for productions by component. Origin density is the largest contributor to TCF. Parking cost also is a significant contributor. Congestion, parking costs, and socio-economic components also play a role in transit competitiveness.

Figure 5.26 Origin Transit Potential by Component
Transit Competitive TAZs Only



5.2.4 Implications for the South Cook County – Will County Area

The results of the TCF analysis conducted in this section are largely contained within **Figures 5.10** and **5.18**, the maps of TCF for attractions (destinations) and TCF for productions (origins). The results indicate that there are relatively few transit competitive production and attraction TAZs within the South Cook County – Will County area.

However, each transit competitive TAZ represents an opportunity for Pace to compete with autos for work trip mode share. Additionally, it is important to note that relative TCF levels can be an important indicator of service responsiveness even in nontransit competitive TAZs. When comparing service options, patterns of relative TCF levels should be considered even when zones fall below the competitive threshold.

As part of the development of Preliminary Service Concepts in Task 5, further analysis is being conducted for each TAZ or group of TAZs within the South Cook County – Will County area that are transit competitive. This analysis is described in the *Market Research Report*. In addition, the Transit Service Sketch Planning Tool (SPT) applies similar market research results not only for origin and destination locations themselves, but for specific travel markets between selected origins and destinations. This tool is described in the *SPT User Manual*.

Appendix A

Sample Size

Sample Size

Memorandum **DRAFT**

TO: Ben Owen

FROM: Kimon Proussaloglou, Chris Kopp, and Chris Wornum

DATE: May 11, 2006

RE: Discussion of Sample Size

The objective of this memo is to review and briefly analyze data from the 1,162 observations collected to date as part of the Pace market research study and to summarize some key findings. This discussion and the data summarized will help Pace decide whether to use the sample "as is," wait until approximately 1,300 observations are collected, or seek ways to meet the original objective of collecting 1,500 observations.

The sample design for the Pace market research study has the objective of collecting a random sample of respondents in the Pace service area in order to be able to make inferences about the study area's population. The sample includes both current and potential users of Pace service within the areas where Pace provides bus service. It also includes specific segments of the market such as respondents of Hispanic origin and reverse commuters.

In the first section, we discuss how the precision of income and transit market share are affected by the three different sample sizes. In the second section, we summarize the preliminary analysis of attitudinal statements and present the mean and standard deviations obtained with the current sample. We also discuss how ethnicity accounts for important and statistically significant differences in attitudes among respondents in the current sample. In the third section, we present important differences by market segment that affect choice behavior that were identified using a sample size of 700 to 750 observations. We conclude by summarizing the sample size implications of our preliminary analysis.

1. Income and Transit Market Share

When a sample is drawn to make inferences about a population, there is a discrepancy between the "true value" of a variable in the population and its value in the sample. These discrepancies reflect the reliability and validity of the collected data and reflect primarily sampling errors, relating primarily to the sampling method and sample size, and non-sampling errors that reflect factors such as response biases.

Tables A.1 and A.2 show the relative and absolute *precision* that is expected for two key variables that were used in our September 19, 2005 memo to guide decisions on sample design. In this memo, we use sample sizes of 1,162 observations, 1,300 observations, and 1,500 observations and three confidence levels of 80, 90, and 95 percent. The precision estimate is used to assess how much we expect to deviate from the true mean for each variable of interest. Census data are used to provide the mean income and transit market share in the study area.

Table A.1 examines the precision (and the expected +/- deviation from the true mean) of the income values in the sample. If we use the existing sample of 1,162 observations, we expect a precision of +/- 5.9 percent relative to the true mean at the 95 percent confidence level. What this means is that if 100 samples were drawn, 95 percent of the time the average income that would be calculated from each sample would be within 5.9 percent of the true income value (or within $3,990 from the true mean value of $68,100).

Table A.1 Precision of Income Variable for Different Sample Sizes

Mean (m)	Standard Deviation (σ)	Confidence Level (1-α)	z-Statistic (z)	Sample Size (n)	Relative Precision (d)	Absolute Precision (D)
$68,102.20	$69,380.50	80.0%	1.282	1,162	3.8%	$2,608
$68,102.20	$69,380.50	80.0%	1.282	1,300	3.6%	$2,466
$68,102.20	$69,380.50	80.0%	1.282	1,500	3.4%	$2,296
$68,102.20	$69,380.50	90.0%	1.645	1,162	4.9%	$3,348
$68,102.20	$69,380.50	90.0%	1.645	1,300	4.6%	$3,165
$68,102.20	$69,380.50	90.0%	1.645	1,500	4.3%	$2,947
$68,102.20	$69,380.50	95.0%	1.960	1,162	5.9%	$3,989
$68,102.20	$69,380.50	95.0%	1.960	1,300	5.5%	$3,771
$68,102.20	$69,380.50	95.0%	1.960	1,500	5.2%	$ 3,511

By increasing sample size, the precision will improve to a smaller 5.2 percent deviation from the true mean income. The expected absolute precision with which we could estimate incomes in the sample would improve from +/- $3,990 to a range of +/- of $3,500 from the true mean income.

Table A.2 highlights a similar pattern when we focus on transit market share in the study area of interest. At the 95 percent confidence level and relying on the 1,162 observations collected to date, we will be able to estimate the study area transit market share of 12.8 percent with a relative precision of 15 percent and an absolute precision of 1.9 percent. This means that the estimate of the transit market share based on the sample may vary between a market share of 10.9 and 14.7 percent of the market. If we collect additional observations for a total of 1,500, the precision will increase with an expected deviation of 1.7 percent of the true transit market share.

Table A.2 Precision of Transit Market Share for Different Sample Sizes

Mean (m)	Standard Deviation (σ)	Confidence Level (1-α)	z-Statistic (z)	Sample Size (n)	Relative Precision (d)	Absolute Precision (D)
12.8%	33.4%	80.0%	1.282	1,162	9.8%	1.3%
12.8%	33.4%	80.0%	1.282	1,300	9.3%	1.2%
12.8%	33.4%	80.0%	1.282	1,500	8.6%	1.1%
12.8%	33.4%	90.0%	1.645	1,162	12.6%	1.6%
12.8%	33.4%	90.0%	1.645	1,300	11.9%	1.5%
12.8%	33.4%	90.0%	1.645	1,500	11.1%	1.4%
12.8%	33.4%	95.0%	1.960	1,162	15.0%	1.9%
12.8%	33.4%	95.0%	1.960	1,300	14.2%	1.8%
12.8%	33.4%	95.0%	1.960	1,500	13.2%	1.7%

Both of these comparisons suggest the robustness of the sample at each of the three levels of data collection. Additional observations will result in additional gains in precision but with a decreasing rate of return.

2. Attitudinal Statements

We also have conducted a **preliminary analysis** of the attitudinal statements using the 1,162 observations collected. First, we examine if gender, reported income, ethnicity, and current mode used can help explain observed differences in respondents' attitudes and whether these differences in ratings are statistically significant for the sample that has already been collected. We also briefly present the mean values for each statement and how much each statement varies in the sample.

Table A.3 summarizes the preliminary analysis of important and statistically significant differences in attitudes. The socioeconomic and travel variables are used as a first-cut attempt to help identify significant differences across the respondents in the Pace service area. More detailed market segmentation analyses will follow when the data collection is over.

Each of the four variables contributes to explaining significant differences in attitudes within the population. As one would expect, the mode that currently is used helps shape strong opinions among respondents and accounts for statistically significant differences for 27 of the 36 statements. Importantly, differences in ethnicity accounts for statistically significant differences for 16 of the 36 statements, gender is a critical factor in differences in 15 statements, and income accounts for significant differences in 11 attitudinal statements.

Table A.3 Attitudinal Questions with Statistically Significant Differences

Variable	Label	Gender	Income	Ethnic Group	Mode
Att1	Driving is usually the fastest way to get to work.				●
Att2	I would change my form of travel if it would save me some time.			●	●
Att3	I like to make productive use of my time when I travel.	●			●
Att4	I am usually in a hurry when I make a trip to work.	●			
Att5	I need to make work trips according to a fixed schedule.	●			●
Att6	I need to make stops on the way to or from work.	●		●	●
Att7	I need to travel mostly during the morning and afternoon rush hours.	●	●		●
Att8	It is important to be able to change my travel plans at a moment's notice.				●
Att9	It is important to have comfortable seats when I travel.			●	●
Att10	Having my privacy is important to me when I travel.	●	●		
Att11	When I travel with others, I prefer to be the driver.	●			●
Att12	I wouldn't mind walking a few minutes to get to and from a bus or train stop.			●	●
Att13	I don't mind transferring between buses or between bus and rail service.	●	●		●
Att14	Public transit vehicles in the Chicago area are usually clean.			●	●
Att15	It is important to be able to control heat and air conditioning when I travel.			●	●
Att16	I feel safe walking near my home.		●	●	
Att17	I feel safe walking near my workplace.	●		●	●
Att18	I feel safe on a bus or train to my workplace.	●			●
Att19	I feel safe while waiting for a bus or train to my workplace.	●			●
Att20	I avoid traveling through certain areas because they are unsafe.	●		●	
Att21	If my travel is delayed, I want to know the cause and length of the delay.				
Att22	I don't mind delays as long as I am comfortable.			●	●
Att23	Riding transit is more reliable than driving during rainy and snowy weather.		●		●
Att24	Predictable and reliable travel to work is important to me.				
Att25	I often commute before or after the rush hour to avoid highway congestion.	●	●		●
Att26	I want to know when the next bus or train is coming while waiting at a stop or station.				●
Att27	Having a stress-free trip is more is more important than reaching my destination quickly.		●	●	●
Att28	Riding transit is less stressful than driving on congested highways.				●
Att29	Figuring out how to use public transportation is easy.			●	●
Att30	When driving, I worry about my vehicle breaking down.		●	●	
Att31	When traveling, I like to talk and visit with other people.		●	●	
Att32	My family and friends use public transportation.	●		●	●
Att33	I don't like riding transit with other people.				
Att34	I'm willing to pay a higher fare for higher quality transit service.	●	●		●
Att35	I use the fastest form of transportation to work regardless of the costs.				●
Att36	If gas prices increase substantially, I am likely to consider using public transportation.		●	●	●

Table A.4 shows the mean and standard deviation for each statement and the relative and absolute precision that is expected for each statement given the current sample size and a 95 percent confidence level. The precision for each statement ranges between 0.9 and 4 percent of the mean value of each statement highlighting the overall high precision with which these ratings are estimated.

Table A.4 Analysis of Attitudinal Questions and Estimates of Precision

Question	Mean (m)	Standard Deviation (σ)	Confidence Level (1-α)	z-Statistic (z)	Sample Size (n)	Relative Precision (d)	Absolute Precision (D)
1	7.863	3.060	95.0%	1.960	1,162	2.2%	0.18
2	7.017	2.727	95.0%	1.960	1,162	2.2%	0.16
3	7.535	2.289	95.0%	1.960	1,162	1.7%	0.13
4	6.490	2.618	95.0%	1.960	1,162	2.3%	0.15
5	6.600	3.028	95.0%	1.960	1,162	2.6%	0.17
6	5.408	3.056	95.0%	1.960	1,162	3.2%	0.18
7	7.524	2.737	95.0%	1.960	1,162	2.1%	0.16
8	6.953	2.539	95.0%	1.960	1,162	2.1%	0.15
9	8.124	1.846	95.0%	1.960	1,162	1.3%	0.11
10	6.629	2.414	95.0%	1.960	1,162	2.1%	0.14
11	5.791	2.950	95.0%	1.960	1,162	2.9%	0.17
12	7.448	2.442	95.0%	1.960	1,162	1.9%	0.14
13	5.004	2.794	95.0%	1.960	1,162	3.2%	0.16
14	5.953	2.052	95.0%	1.960	1,162	2.0%	0.12
15	6.788	2.309	95.0%	1.960	1,162	2.0%	0.13
16	9.046	1.507	95.0%	1.960	1,162	1.0%	0.09
17	8.286	2.147	95.0%	1.960	1,162	1.5%	0.12
18	7.275	2.447	95.0%	1.960	1,162	1.9%	0.14
19	7.112	2.516	95.0%	1.960	1,162	2.0%	0.14
20	6.082	2.976	95.0%	1.960	1,162	2.8%	0.17
21	8.582	1.797	95.0%	1.960	1,162	1.2%	0.10
22	4.517	2.611	95.0%	1.960	1,162	3.3%	0.15
23	6.890	2.819	95.0%	1.960	1,162	2.4%	0.16
24	9.171	1.398	95.0%	1.960	1,162	0.9%	0.08
25	5.495	3.213	95.0%	1.960	1,162	3.4%	0.18
26	8.652	1.826	95.0%	1.960	1,162	1.2%	0.10
27	6.007	2.464	95.0%	1.960	1,162	2.4%	0.14
28	7.776	2.381	95.0%	1.960	1,162	1.8%	0.14
29	6.304	2.593	95.0%	1.960	1,162	2.4%	0.15
30	4.182	2.884	95.0%	1.960	1,162	4.0%	0.17
31	4.607	2.646	95.0%	1.960	1,162	3.3%	0.15
32	5.016	2.996	95.0%	1.960	1,162	3.4%	0.17
33	4.360	2.580	95.0%	1.960	1,162	3.4%	0.15
34	6.102	2.512	95.0%	1.960	1,162	2.4%	0.14
35	6.250	2.908	95.0%	1.960	1,162	2.7%	0.17
36	5.754	3.313	95.0%	1.960	1,162	3.3%	0.19

The relatively low variability of the attitudinal statements results in very sharp estimates of the mean value in the sample. For example, the statement *"My family and friends use public transportation"* with a mean of 5.016 could vary from a low of 4.84 to a high of 5.19 at the 95 confidence level.

As is the case with the other variables examined so far, increasing the sample size to 1,300 and 1,500 observations will increase the precision for each statement. For example, a sample size of 1,300 will increase the precision of the first statement (*"Driving is usually the fastest way to get to work"*) from 2.2 to 2.1 percent of the mean value (or from +/- 0.18 units to +/- 0.17 units on the rating scale). A sample size of 1,500 will further increase precision to 2 percent of the mean value or +/- 0.15 units on the rating scale.

A preview of the mean ratings highlights the **range** of the average value of the attitudinal statements. The statement *"Predictable and reliable travel to work is important to me"* received the highest rating with a value of 9.17 reflecting the uniform importance of travel reliability. At the same time, the statement *"When driving I worry about my vehicle breaking down"* received the lowest level of agreement with a low rating of 4.18.

It also is interesting to note the **degrees of variability** for different statements as reflected in the measure of standard deviation. The statement *"Predictable and reliable travel to work is important to me"* had the lowest standard deviation confirming the broad agreement with the statement. The statement *"If gas prices increase substantially, I am likely to consider using public transportation"* had the highest standard deviation suggesting strong differences in opinion among survey respondents that may reflect in part the travel options available to them and their perceptions of highway and transit service.

These preliminary results suggest the robustness of the attitudinal statements. They also suggest that the ethnic and racial mix currently in the Pace survey (912 Caucasians, 86 African Americans, 92 Hispanic Americans, and 29 Asian Americans) provides enough observations to help identify statistically significant differences by ethnic and racial group in the study area.

3. Mode Choice Analysis

Although we will not conduct an analysis of mode choice behavior until much later in this project, we briefly discuss prior efforts in mode choice modeling and relate them to sample size requirements to help support Pace's decision-making.

Table A.5 presents the results of a mode choice model estimated with the San Diego MTDB sample. There are significant differences in key level of service variables by market segment as reflected in the different coefficients for in-vehicle travel time, wait time, and walk time. These statistically significant differences were observed with a sample of 750 observations from the San Diego area.

Table A.6 presents the mode choice model estimated for San Mateo. In this model, there are significant differences by market segment or groups of market segments in almost all of the variables examined. This table highlights the different sensitivities to travel time, peak and off-peak service frequency, cost of travel, drive access time, and walk access and egress times among different segments of the travel market. This model was estimated based again on a sample of about 680 completed choice experiments.

These results clearly suggest that these sample sizes were enough for identifying important differences by market segment that are of interest or pertain to this study as well. Although the mode choice model for the Pace project will not be identical to these two mode choice models, it is expected that the model will produce robust sensitivities to level of service attributes and highlight differences among segments with a sample size of 1,100 observations or higher.

4. Summary and Recommendations

We believe that we have already collected a robust sample that can be used for the various analyses under way when considering the entire service area that is under study. In the tally released by MORPACE today, it appears that the sample size has increased significantly since the dataset used for the analysis above was released. The sample now stands at more than 1,220 completes, including more than 150 completes in the reverse commuter sample frame. Across all frames, the reverse commuter goal of 200 responses appears to have been substantially achieved. Despite MORPACE's continued efforts, the Hispanic sample remains around one-half of the goal.

If we are able to begin work next week on the market segmentation analysis, we believe that it may be possible to complete the remainder of the study in time for the summer 2007 picks, despite the time that has elapsed since the planned survey completion date of April 30. Any further delays are likely to make it impossible to meet this goal. Therefore, it is our preference to begin work with the current sample as soon as possible.

If Pace determines that it is imperative to increase the representation of the Hispanic population in the sample, we are prepared to discuss strategies for recruiting and collecting additional surveys, the likely time frame and its impacts on the overall project schedule, and the budget implications of the work. We must emphasize, however, that our scope of work does not include any additional analysis of this data. Of much greater practical importance, we believe it would be highly unlikely that differences between the attitudes and tradeoffs (i.e., mode choice coefficients) of Hispanics and the other market segments would be sufficient to warrant unique transit service targeted at this ethic group. The more likely scenario, which was the case in our work in San Mateo County (SamTrans), was that special populations are distributed in two or three of the general population market segments and thus their needs and preferences for transit service are addressed through the mainstream market segmentation and mode choice models.

Table A.5 San Diego MTDB Mode Choice Model Overview

	Coefficient	t-Statistic
Modal Constants		
Carpool	-0.789	-8.0
Bus	-0.681	-3.4
Express Bus	-0.725	-3.7
Shuttle Bus	-0.580	-2.6
Trolley	-0.505	-2.6
Commuter Rail	-0.451	-2.3
Train on Tires	-0.325	-1.6
Seat Availability and Transfers – Transit Mode		
Seat Availability (in percent of time)	0.001	1.1
Number of Transit Transfers	-0.142	-2.1
Automobile Ownership – Auto Modes		
Cars per Adult – Drive Alone Alternative	0.440	4.2
Cars per Adult – Share Ride Alternative	0.267	2.6
In-Vehicle Travel Time – Auto Modes		
In-Vehicle Time – Commute Travel – Road Runners	-0.073	-4.3
In-Vehicle Time – Commute Travel – Cautious Runabouts	-0.051	-4.8
In-Vehicle Time – Commute Travel – Intrepid Trekkers and Flexible Flyers	-0.043	-5.5
In-Vehicle Time – Commute Travel – Conventional Cruisers and Easy Goers	-0.040	-6.2
In-Vehicle Time – Non-Commute Travel – Road Runners	-0.057	-4.5
In-Vehicle Time – Non-Commute Travel – Cautious Runabouts	-0.024	-4.1
In-Vehicle Time – Non-Commute Travel – Intrepid Trekkers and Flexible Flyers	-0.016	-4.9
In-Vehicle Time – Non-Commute Travel – Conventional Cruisers and Easy Goers	-0.017	-6.0
In-Vehicle Travel Time – Transit Mode		
In-Vehicle Time – Commute Travel – Road Runners	-0.067	-2.9
In-Vehicle Time – Commute Travel – Cautious Runabouts	-0.035	-3.4
In-Vehicle Time – Commute Travel – Intrepid Trekkers and Flexible Flyers	-0.034	-4.5
In-Vehicle Time – Commute Travel – Conventional Cruisers and Easy Goers	-0.022	-3.5
In-Vehicle Time – Non-Commute Travel – Road Runners	-0.047	-3.5
In-Vehicle Time – Non-Commute Travel – Cautious Runabouts	-0.020	-3.5
In-Vehicle Time – Non-Commute Travel – Intrepid Trekkers and Flexible Flyers	-0.012	-3.3
In-Vehicle Time – Non-Commute Travel – Conventional Cruisers and Easy Goers	-0.016	-5.7
Time Looking for Parking		
Time Searching for Parking – Commute Travel	-0.072	-5.0
Time Searching for Parking – Non-commute Travel	-0.041	-4.1

Table A.5 San Diego MTDB Mode Choice Model Overview (continued)

		Coefficient	t-Statistic
Wait Time – Transit Mode			
Wait Time – Commute Travel – Road Runners and Cautious Runabouts		-0.138	-3.3
Wait Time – Commute Travel – Intrepid Trekkers and Flexible Flyers		-0.044	-2.8
Wait Time – Commute Travel – Conventional Cruisers and Easy Goers		-0.097	-6.2
Wait Time – Non-Commute Travel – Road Runners and Cautious Runabouts		-0.031	-2.5
Wait Time – Non-Commute Travel – Intrepid Trekkers and Flexible Flyers		-0.011	-1.2
Wait Time – Non-Commute Travel – Conventional Cruisers and Easy Goers		-0.016	-2.1
Walk Times			
Walk To/From Transit Time – Road Runners, Cautious Runabouts, Intrepid Trekkers, and Flexible Flyers		-0.062	-4.6
Walk To/From Transit Time – Conventional Cruisers		-0.069	-4.3
Walk To/From Transit Time – Easy Goers		-0.025	-1.8
Walk Time – Drive Alone and Share Ride		-0.056	-6.6
Travel Costs			
Parking Cost – No response on Income question		-0.056	-3.7
Parking Cost/Log (Income) – Commute Travel		-0.978	-9.8
Parking Cost/Log (Income) – Non-commute Travel		-0.854	-12.3
Transit Fare (paid by employer)		0.063	1.9
Transit Fare – Commute Travel		-0.150	-5.6
Transit Fare – Non-Commute Travel		-0.091	-5.8
Attitudes towards Everyday Travel Auto Modes			
Need for Flexibility and Speed		0.052	1.6
Concern for the Natural Environment		-0.114	-3.9
Sensitivity to Personal Travel Experience		-0.091	-3.1
Sensitivity to Personal Safety		0.031	1.0
Sensitivity to Transportation Costs		-0.302	-3.4
Sensitivity to Crowds		0.052	1.0
Summary Statistics			
Likelihood with Zero Coefficients	-4555.8		
Likelihood with Zero Coefficients	-4555.8		
Likelihood with Constants Only	-4215.3		
Initial Likelihood	-4555.8		
Final Value of Likelihood	-3505.1		
“Rho-Squared” w.r.t. Zero	0.23		
“Rho-Squared” w.r.t. Constants	0.17		

Table A.6 San Mateo Model Mode Choice Estimation

	Mode Choice Model Estimation Results							
	Segment							
	Diligent Chargers	**Intrepid Amblers**	**Rigid Flyers**	**Brave Runabouts**	**Shy Cruisers**	**Outgoing Multitaskers**	**Solo Ramblers**	**Tense Trekkers**
Local Transit Constant	-1.32	-1.32	-1.32	-1.32	-1.32	-1.32	-1.32	-1.32
Enhanced Transit Constant	-1.224	-1.224	-1.224	-1.224	-1.224	-1.224	-1.224	-1.224
Level of Service Variables								
In-Vehicle Travel Time (Minutes)	-0.035	-0.007	-0.024	-0.013	-0.013	-0.007	-0.007	-0.007
Cost of Travel ($)	-0.119	-0.07278	-0.092	-0.1145	-0.1145	-0.073	-0.073	-0.073
Drive Access to the Station (Minutes)	-0.02	-0.007	-0.02	-0.057	-0.057	-0.007	-0.007	-0.007
Walk Access and Egress (Minutes)	-0.084	-0.021*	-0.084	-0.141	-0.141	-0.021*	-0.021*	-0.021*
Peak Frequency	-0.014	-0.004	-0.014	-0.004	-0.004	-0.014	-0.004	-0.014
Off-Peak Frequency	-0.001	-0.003	-0.001	-0.003	-0.003	-0.001	-0.003	-0.001
Transfers – Continuous Variable	-0.262	-0.065	-0.262	-0.262	-0.262	-0.065	-0.065	-0.065
Parking Search Time at Destination (Minutes)	-0.105	-0.021	-0.072	-0.039	-0.039	-0.021	-0.021	-0.021
Seat Available (0/1): 1 if Seat Guaranteed	0.1958	0	0.1958	0.1958	0.1958	0	0	0
Shuttle Bus for Transit Service (0/1)	0.05955	0.05955	0.05955	0.05955	0.05955	0.05955	0.05955	0.05955
Real-Time Information (0/1)	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004

Appendix B

Recruit Survey

Recruit Survey

INTRODUCTION

Record Telephone Exchange

Hello, I'm __________, calling on behalf of a regional transportation agency. We are not selling anything. We are conducting a survey about travel to work in your area. Responses will be used to plan transportation improvements. All answers are strictly confidential.

RECRUITING OF RESIDENTS WITH WORK-RELATED TRAVEL

If Telephone Number From Pace List Ask

PS_PACE: Is this [Insert NAME from Pace namelist]?
(IF RESPONDENT ASKS WHERE WE GOT THEIR NAME, SAY IT WAS FROM A PACE BUS CUSTOMER SATISFACTION SURVEY.)

1. Yes (GO TO PS_COUNTY)
2. No ("Can I please speak to [insert NAME from Pace namelist] GET [NAME] OR ARRANGE CALLBACK. IF [NAME] NOT AVAILABLE, AND NO CALLBACK CAN BE SCHEDULED, TERMINATE.)
9. Refused (THANK AND TERMINATE.)

(IF TELEPHONE NUMBER NOT FROM PACE LIST ASK) (IF RESPONDENT ASKS WHERE WE GOT THEIR NAME, SAY THEY WERE RANDOMLY SELECTED.)

For this survey, I need to speak with someone who is 16 years or older who travels to work at least three days a week.

PS_16: Are you 16 years or older?

1. Yes
(GO TO PS_COUNTY)

2. No
("Can I please speak to someone who is 16 or older?" GET PERSON 16 YRS+ AND CONTINUE OR ARRANGE CALLBACK. IF NO ONE 16+YRS IS AVAILABLE AND NO CALLBACK CAN BE SCHEDULED, TERMINATE.)

3. Refused
(THANK AND TERMINATE)

PS_COUNTY: What County do you live in?

1. Cook **(GO TO PS_COOK)**
2. DuPage **(GO TO PS_ZIPCODE)**
3. Lake **(GO TO PS_ZIPCODE)**
4. McHenry **(GO TO PS_ZIPCODE)**
5. Kane **(GO TO PS_ZIPCODE)**
6. Will **(GO TO PS_ZIPCODE)**
7. Other **(THANK AND TERMINATE)**

(IF PS_COUNTY=1, ASK:)

PS_COOK: Do you live inside or outside the city of Chicago?

1. Chicago
2. Outside Chicago

PS_ZIPCODE: What is your zip code?

__ __ __ __ __ Sample zip codes in Cook County north of I55

__ __ __ __ __ Sample zip codes in Cook County south of I55

__ __ __ __ __ Other sample zip codes

__ __ __ __ __ Other zip codes not in sample area
(THANK AND TERMINATE)

PS_WORK: Are you employed full-time or part-time?

1. Full-time **(GO TO PS_FREQUENCY)**
2. Part-time **(GO TO PS_FREQUENCY)**
3. No **("Can I please speak to someone 16 or older who travels to work three or more days a week?" GET PERSON 16 YRS+ AND EMPLOYED AND REPEAT PS_WORK OR ARRANGE CALLBACK. IF NO ONE 16+YRS AND EMPLOYED OUTSIDE THE HOME IS AVAILABLE AND NO CALLBACK CAN BE SCHEDULED, TERMINATE.)**
4. No one in household is employed **(THANK AND TERMINATE)**
9. Refused **(THANK AND TERMINATE)**

PS_FREQUENCY: Do you usually travel to work three or more days a week?

1. Yes **(GO TO PS_DURATION)**
2. No **("Is there someone else 16 or older who travels to work three or more days a week?" GET PERSON 16 YRS+ AND EMPLOYED AND REPEAT PS_WORK OR ARRANGE CALLBACK. IF NO ONE 16+YRS AND EMPLOYED OUTSIDE THE HOME 3+ DAYS PER WEEK IS AVAILABLE AND NO CALLBACK CAN BE SCHEDULED, TERMINATE.)**
3. No one in household travels to work three or more days a week **(THANK AND TERMINATE)**
9. Refused **(THANK AND TERMINATE)**

PS_DURATION Does your trip to work usually take more than 10 minutes?

1. Yes **(PS_PARTICIPATE)**
2. No **("Is there someone else 16 or older who travels to work more than 10 minutes, three or more days a week?" GET PERSON 16 YRS+ AND EMPLOYED 3+ DAYS PER WEEK AND REPEAT PS_WORK OR ARRANGE CALLBACK. IF NO ONE 16+YRS AND EMPLOYED OUTSIDE THE HOME 3+ DAYS PER WEEK IS AVAILABLE AND NO CALLBACK CAN BE SCHEDULED, TERMINATE.)**
9. Refused **(THANK AND TERMINATE)**

INVITATION TO PARTICIPATE IN SURVEY

This survey is being conducted to understand travel choices within the region. We are interested in talking to you regardless of what type of transportation you use. After this call, we will mail you a survey form. Then we will call you back to take your responses over the telephone. This will not take more than 10 to 15 minutes of your time. All of your answers are strictly confidential.

(IF PARTICIPATE/HOUSEHOLD MEETS RARE POPULATION SAMPLE CRITERIA [To be determined by MORPACE as data collection progresses]) INCENTIVE IS ONLY FOR HISPANIC SAMPLE, NOT RDD.

PS_INCENTIVE: To show that we appreciate your participation, once we have your answers, we will send you a check for $15.

PS_PARTICIPATE: Are you willing to participate?

1. Yes **(CONTINUE)**
2. No **(THANK AND TERMINATE)**

We will be sending you the survey materials in an envelope that says "Chicago Regional Transportation Study." There will be a toll-free number for you to call if you have any questions.

So that we can mail the survey to you, would you spell your name and give me your home address?

PS_NAME: What is your first name? _________
And your last name? ____________

PS_STADDRESS: What is your street address? ________________________

PS_CITY: And the city? (See list) ____________________

PS_CROSSST: What are the nearest cross streets?

RECORD: Street 1 & Street 2 ____

WORK COMMUTE TRIP INFORMATION

Before we send you the survey, we need to know where you travel to work.

WK_NAME:

1. What is the name of the place where you work? ________________________
2. NO ONE DESIGNATED WORK SITE **(GO TO WK_TYPICAL)**
9. REFUSED **(THANK AND TERMINATE)**

(IF WK_NAME =2, ASK:)

WK_TYPICAL: Where did you go for work most often last week? ____________________

WK_TYPE: What type of business is this? **(MORPACE GEOCODING AID LIST)**

WK_STADDRESS: What is the address of this work place? __________________________

WK_CITY: What city is it in? **(SEE CITY LIST)**

WK_ZIP: What is the zip code?

WK_CROSSST: What are the **nearest** cross streets?

RECORD: Street 1 & Street 2 ___________________

WK_LEAVE: What time of the day do you usually leave for work?

HOURS__ __ MINUTES__ __

AM/PM

WK_RETURN: What time of the day do usually leave work for home?

HOURS__ __ MINUTES__ __

AM/PM

WK_WKENDS: Do you usually work on weekends?

1. Yes
2. No

WK_FLEXIBILITY: Which of these statements best describes your working hours or the times you have to be at work? **(READ LIST)**

1. I have no flexibility in the times I have to be at work.
2. I can vary my starting and finishing times a bit, but not more than 30 minutes.
3. I'm pretty much free to adjust my starting and finishing times as I like.
8. Don't know.
9. Refused.

WK_PMODE: For your trip to work, what is usually your primary means of transportation? **(NOTE: <u>Primary</u> means is the mode you spent most of your time on.)** Is it: **(READ LIST)**

WK_OMODE: When not using (INSERT WK_PMODE) for your trip to work, what other means of transportation do you usually use? **(READ LIST) (CHECK ALL THAT APPLY) (Stress that this other form of transportation is not what they use to get to or from the primary means of transportation, but is what they use on days when they don't use the primary mode at all.)**

	(Check only one)	**(Check all that apply)**
	WK_PMODE	WK_OMODE
Driving alone in a private vehicle (car, pick-up, SUV, motorcycle, etc.)	1	1
Driving or riding with someone else in a private vehicle	2	2
CTA Train	3	3
CTA Bus	4	4
Metra Train	5	5
Pace Bus	6	6
Vanpool	7	7
Taxi	8	8
Walk	9	Do not ask
Other (specify):___________	996	996
No other mode used	10	10
(For WK_OMODE) No other mode used		997

(IF WK_PMODE >2 AND WK_PMODE< 7, ASK:)

MO_ACCESS: How do you usually get from your home to (INSERT WK_PMODE)? (Do not read responses, but prompt and clarify, as necessary) (CHECK All THAT APPLY)

1. Drove and parked at the station/near the stop
2. Was dropped off by someone else at station/near the stop
3. Walked to station/stop
4. Used CTA bus
5. Used CTA train
6. Used Metra train
7. Used Pace bus
8. Used Vanpool
9. Taxi
10. Bicycle
11. Shuttle

996. Other

(IF WK_PMODE >2 AND WK_PMODE< 7, ASK:)

MO_EGRESS: And how do you usually get from (INSERT WK_PMODE) to work? (Do not read responses, but prompt and clarify, as necessary) (CHECK ALL THAT APPLY)

1. Drove a car that was parked at the station / near the stop
2. Was picked up by someone else at station/near the stop
3. Walked from station/stop
4. Used CTA bus
5. Used CTA train
6. Used Metra train
7. Used Pace bus
8. Used Vanpool
9. Taxi
10. Bicycle
11. Shuttle

996. Other

MO_FREQUENCY: Approximately, how many days a week do you use (INSERT AND REPEAT FOR EACH MODE MENTIONED IN WK_PMODE, WK_OMODE) to get to work? **(READ RESPONSES)**

	a. Drive Alone?	b. Drive or Ride with Others?	c. Use CTA Train?	d. Use CTA Bus?	e. Use Metra?	f. Use Pace Bus?	g. Use a Vanpool?	h. Taxi?
Six or more days a week								
Five days a week								
Four days a week								
Three days a week								
Two days a week								
One day a week								
Less than once a week								

(IF WK_PMODE >2 AND WK_PMODE< 7, ASK:)

MO_TRANSFERS: During your usual trip from home to work using (WK_PMODE), how many times do you transfer to a different bus or train? **(If necessary, say:** **"**If you only rode on a bus and a train or two buses, that would be one transfer." (If more than 3 transfers, verify that those transfers are only on the trip from home to work, and NOT a combination of both daily commutes.)

6. Zero
1. One transfer
2. Two transfers
3. Three transfers
4. Four transfers
5. Five or more transfers

(IF MO_TRANSFERS >1 AND <6, ASK:)

MO_DTRANSFERS: What is the longest time you have to wait during a single transfer?

HOURS__ __ MINUTES__ __

WK_DURATION: What is your best estimate of the **total door-to-door time** it takes you to travel from your home in (INSERT PR_CITY) to your workplace in (INSERT WK_CITY)?

HOURS__ __ MINUTES__ __

(IF WK_PMODE=3 OR WK_PMODE=4)

MO_COSTCTA: How do you usually pay for the (INSERT WK_PMODE)? Is it with: **(READ RESPONSES)**

1. Cash/Single Ticket
2. 1-Day Full Fare Pass
3. 7-Day Full Fare Pass
4. CTA/Pace 30-Day Pass
5. Visitor Pass
6. Chicago Card
7. Chicago Card Plus
8. Transit Card

996. Other *(Please specify)*__________________

(IF WK_PMODE=5)

MO_COSTMETRA: How do you usually pay for the (INSERT WK_PMODE)? Is it with: **(READ RESPONSES)**

1. Cash/Single Ticket
2. 10-Ride Ticket
3. Monthly Ticket

996. Other *(Please specify)*__________________

(IF WK_PMODE=6)

MO_COSTPACE: How do you usually pay for the (INSERT WK_PMODE)? Is it with: **(READ RESPONSES)**

1. Cash/Single Ticket
2. 10-Ride Ticket
3. Commuter Club Card
4. Pace/CTA 30-Day Pass
5. Chicago Card

6. Chicago Card Plus
7. ADA Paratransit Book
8. Transit Card
9. Link-Up Sticker
10. PlusBus Sticker
11. College Student Campus Connection
12. Student Haul Pass

996. Other *(Please specify)*__________________

(IF WK_PMODE>6 AND WK_PMODE<9)

MO_COST: How do you usually pay for the (INSERT WK_PMODE)? Is it with: **(READ RESPONSES)**

1. Cash

996. Other *(Please specify)*__________________

(IF WK_PMODE>2 AND WK_PMODE<9)

MO_COST_RED: And was the fare you paid a regular fare, or a reduced fare?

1. Regular
2. Reduced

996. Other *(Please specify)*__________________

(IF [WK_PMODE>2 AND < 11 ASK:)

MO_AUTO: Is there usually a private vehicle available that you could have used for making your trip by (WK_PMODE)?

1. Usually yes
2. Usually not
3. Sometimes

(IF WK_PMODE>2 AND WK_PMODE< 9, ASK:)

TRANSIT_SUB: Does your employer pay any part of your costs for getting to and from work?

1. Yes
2. No

(IF WK_PMODE=1 OR WK_PMODE=2 OR WK_PMODE=7, ASK:)

MO_PARK: Do you or any other person in your vehicle usually pay to park at your workplace?

1. Yes
2. No

(IF MO_PARK=1,ASK:)

MO_COSTPARK: How much in total do you usually pay to park at your workplace?

DOLLARS __ __ CENTS __ __

1. Per day
2. Per week
3. Every two weeks
4. Per month
5. Per year

996. Other___________

(IF MO_PARK=1, ASK:)

PARK_SUB: Does your employer pay for any part of your parking costs at work?

1. Yes
2. No

(IF MO_PARK=2, ASK:)

PARK_NOPAY: You said that you don't pay anything for parking. Is that because

1. There is free parking available
2. Your employer pays all of the parking

(IF [WK_PMODE< 3 OR >6] AND [WK_OMODE <3 OR >6] AND [MO_ACCESS <4 OR >7] AND [MO_EGRESS <4 OR>7], AS:)

TRANSIT_AWARE: Are you familiar with how to get from home to your workplace using public transportation?

1. Yes
2. Somewhat familiar
3. No
4. Not sure/Don't know

(IF [WK_PMODE< 3 OR >6] AND [WK_OMODE <3 OR >6] AND [MO_ACCESS <4 OR >7] AND [MO_EGRESS <4 OR>7], ASK:)

TRANSIT_TIME: If you were to take public transportation, what is your best estimate of the **total door-to-door time** it would take you to travel from your home in (INSERT PR_CITY) to your workplace in (INSERTWK_CITY)?

HOURS__ __ MINUTES __ __

98. Don't Know
99. Refused

(IF [WK_PMODE< 3 OR >6] AND [WK_OMODE <3 OR >6] AND [MO_ACCESS <4 OR >7] AND [MO_EGRESS <4 OR>7], ASK:)

TRANSIT_ CONS: On a 10-point scale where 1 is very unlikely and 10 is very likely, how likely are you to consider using public transportation to get to work from home?

1. Very unlikely
2.
3.
4.
5.
6.
7.
8.
9.
10. Very likely
98. Don't Know
99. Refused

(IF [{WK_PMODE <3 OR >6} AND {TRANSIT_CONS<6}] OR [{MO_FREQUENCY <3}], ASK:)

TRANSIT_WHYNOT: What is the main reason you do not use public transportation more often to get to work from your home? ***(Do not read responses, but prompt and clarify, as necessary)*** **(If respondent provides more than one reason, prompt for most important reason.)**

1. Need my car for my job
2. Need to make stops on the way to or from work
3. Service is too infrequent
4. Too far to the station/stop from my house

5. Too far to work from the station/stop where I would get off
6. Travel time is too long
7. Parking is a problem at the station/stop
8. Too many transfers are required to reach my destination
9. Buses are not on time
10. Concerned about security on public transit
11. Seats on the bus or train are not available
12. Public transit doesn't go to my work place
13. Bus/train does not run early or late enough
14. I am not sure how I would take public transit to work
15. Lack of control over on-board atmosphere
16. Lack of control of heat or air conditioning
996. Other (*Specify)*

____

____

(IF [WK_PMODE< 3 OR >6] AND [WK_OMODE <3 OR >6] AND [MO_ACCESS <4 OR >7] AND [MO_EGRESS <4 OR>7], ASK:)

TRANSIT_USE: When was the last time you used public transportation to get to work?

1. Within the last week
2. One week to one month ago
3. One month to three months ago
4. Three months to six months ago
5. More than six months ago
6. Never

SOCIOECONOMICS

Now, just a few last questions for statistical purposes... We are very interested in the travel needs and choices of individuals of certain ages.

AGE: How old are you? __ ___

DISABILITY: Do you have a physical or health condition that affects the travel choices you make in the Chicago metropolitan area?

1. Yes
2. No

EDUCATION: What is the highest level of education that you have completed? **(Read responses, if necessary. Check one only)**

1. Some high school or less (Grade 1-11)
2. High school graduate or equivalent
3. Some college or technical school
4. College graduate
5. Graduate or Professional Degree
9. (DO NOT READ) Refuse

HHSIZE: Including yourself, how many people live in your household?

1. One person
2. Two persons
3. Three persons
4. Four persons
5. Five persons
6. Six or more persons

HHAUTOS: How many cars, trucks, or vans are available to your household for general transportation use?

1. One vehicle
2. Two vehicles
3. Three or more vehicles
4. Zero vehicles

HHWRKS: Including yourself, how many people in your household, age 16 or older, are employed full- or part-time, at least three days per week?

1. One worker
2. Two workers
3. Three or more workers
4. Zero workers

We are also very interested in the travel needs and choices of individuals from different ethnic groups and income levels.

ETHNIC: What is your primary ethnic background?

1. White/Caucasian
2. African American
3. Hispanic/Latin American
4. Asian American
5. Other

INCOME_35: Was your total household income last year under or over $35,000?

1. Under $35,000 **(GO TO INCOME1)**
2. Over $35,000 **(GO TO INCOME2)**

98. Don't know
99. Refused

INCOME 1: Was your household income:

1. Below $15,000
2. $15,000 to below $25,000
3. $25,000 to below $35,000

98. Don't know
99. Refused

INCOME2:

1. $35,000 to below $55,000
2. $55,000 to below $75,000
3. $75,000 to below $100,000
4. $100,000 to below $125,000
5. $125,000 or more

98. Don't know
99. Refused

Thank you. We will mail you the follow-up survey on travel choices. Please have your survey form available when we call you back. We greatly appreciate your participation in this study. **(IF INCENTIVE=1, "A check for $15 with be mailed to you after the second part of the survey is complete.")** INCENTIVE IS ONLY FOR HISPANIC SA

Appendix C

Attitudinal Survey

Attitudinal Survey

INTRODUCTION

Hello, my name is ______________________, and I'm calling you back on behalf of a regional transportation agency about the work travel survey. May I please speak with ___________ **(NAME OF RECRUITED INDIVIDUAL)? (GET RESPONDENT ON THE TELEPHONE AND REPEAT INRODUCTION)**

TELEPHONE: For verification purposes, can I please have your telephone number?

Thank you for agreeing to participate in this study. However, we have not yet received your responses. We are offering a $10 incentive if you complete by April 30th. Can we take your responses now, over the phone? **(IF NOT, "If you don't have the survey form in front of you now, I can wait while you get it.")**

(If necessary, explain: no sales, follow-up, or telemarketing is involved) [INTERVIEWER NOTE: This survey will take about 10 minutes to complete.]

RE-MAIL: If you don't have the survey anymore, we can mail you a new copy.

1. Re-mail
2. No longer wishes to participate (Thank and Terminate)

(IF RE-MAIL=1)

You should receive your survey in 3 to 5 days. Please don't mail the survey back to us until AFTER we have called you to take your answers. We will call you about 1 week from now to collect your responses.

Respondent has mailed in survey

1. Yes **(THANK "We will callback if we need any further information.")**

(IF INCENTIVE=1, SAY :)

"We will mail your check for $10 when your survey is complete. Thank you for your participation."

VERSION: There are several different versions of this survey, and I need to verify which version you have. There is a number on the second page of your attitude questions **(IF NEEDED, "the attitude questions are the pages with gray and**

white stripes.”). The number I’m looking for should start with an “A.” Can you please tell me what number you have?

Enter number 1-4____

ATTITUDINAL SURVEY

Now I would like to ask you about your ***day-to-day work trips***. I am going to read you a number of statements as they relate to these trips.

There are no right or wrong answers. I would like you to indicate ***your*** level of agreement or disagreement with each statement. Please indicate your rating level on a scale of 1 to 10, where

1 means that you strongly disagree

10 means that you strongly agree

1. Driving is usually the fastest way to get to work
2. I would change my form of travel if it would save me some time
3. I like to make productive use of my time when I travel
4. I am usually in a hurry when I make a trip to work.
5. I need to make work trips according to a fixed schedule.
6. I need to make stops on the way to or from work
7. I need to travel mostly during the morning and afternoon rush hours
8. It’s important to be able to change my travel plans at a moment’s notice
9. It is important to have comfortable seats when I travel
10. Having my privacy is important to me when I travel
11. When I travel with others, I prefer to be the driver
12. I wouldn’t mind walking a few minutes to get to and from a bus or train stop
13. I don’t mind transferring between buses or between bus and rail service
14. Public transit vehicles in the Chicago area are usually clean
15. It is important to be able to control heat and air conditioning when I travel
16. I feel safe walking near my home
17. I feel safe walking near my workplace
18. I feel safe on a bus or train to my workplace
19. I feel safe while waiting for a bus or train to my workplace
20. I avoid traveling through certain areas because they are unsafe
21. If my travel is delayed, I want to know the cause and length of the delay

22. I don't mind delays as long as I am comfortable
23. Riding transit is more reliable than driving during rainy and snowy weather
24. Predictable and reliable travel to work is important to me
25. I often commute before or after the rush hour to avoid highway congestion
26. I want to know when the next bus or train is coming while waiting at a stop or station
27. Having a stress-free trip is more important than reaching my destination quickly
28. Riding transit is less stressful than driving on congested highways
29. Figuring out how to use public transportation is easy
30. When driving, I worry about my vehicle breaking down
31. When traveling, I like to talk and visit with other people
32. My family and friends use public transportation
33. I don't like riding transit with total strangers sitting next to me
34. I'm willing to pay a higher fare for higher quality transit service
35. I use the fastest form of transportation to work regardless of the costs
36. If gas prices increase substantially, I am likely to consider using public transportation to get to work

(ASK FOLLOW UP QUESTIONS (FROM INTRO TO ATTCLEAR) FOR EVERY 10TH RESPONDENT)

INTRO: You are one of the first people to take this survey, and we would like your feedback so we can improve our questions.

UNDATT: Did you understand the questions and descriptions in this part of the survey?

1. Yes **(GO TO CE_INTRO)**
2. No **(GO TO ATTHARD)**

ATTHARD: Which words or phrases were hard to understand?

(OPEN END – ALLOW UP TO 5 RESPONSES)

(ASK FOR EACH RESPONSE IN ATTHARD)

ATTCLEAR: Do you have any suggestions to make it more clear?

(OPEN END)

(GO TO CE_INTRO)

CHOICE EXPERIMENTS

CE_INTRO: Now I would like to record your choices from the choice exercises.

CE_1: Which option did you choose for exercise 1?

1. A
2. B
3. C

CE_2: And for exercise 2?

1. A
2. B
3. C

CE_3: and lastly for exercise 3?

1. A
2. B
3. C

(ASK FOLLOW UP QUESTIONS (FROM GLOS TO SHUTTLE) FOR EVERY 10TH RESPONDENT)

GLOS: Were the descriptions of public transportation options in the Guide to Survey Terms easy to understand?

1. Yes **(GO TO UNDCHX)**
2. No **(GO TO GLOSHARD)**

GLOSHARD: Which descriptions were difficult to understand?

(OPEN END – ALLOW UP TO 5 RESPONSES)

(ASK FOR EACH RESPONSE IN CHXHARD)

GLSCLEAR: Do you have any suggestions to make it more clear?

(OPEN END)

UNDCHX: Did you understand the questions in this part of the survey?

1. Yes **(GO TO TRANSFER)**
2. No **(GO TO CHXHARD)**

CHXHARD: Which parts of the choice exercises were difficult to understand?

(OPEN END – ALLOW UP TO 5 RESPONSES)

(ASK FOR EACH RESPONSE IN CHXHARD)

CHXCLEAR: Do you have any suggestions to make it more clear?

(OPEN END)

REAL: Did your travel choices seem realistic?

TRANSFER: For public transportation options, were the transfers clearly explained?

1. Yes
2. No

BRT: Did you understand how the proposed Rapid Bus system would work?

1. Yes
2. No

SHUTTLE: Did you understand how the Shuttle Service would work?

1. Yes
2. No

PACE BUS IMAGE

Consider Use Questions

(ONLY ASKED OF NON-TRANSIT USERS)

1. If safe and convenient PACE Bus service was available from near your home to your workplace, how likely would you be to use this service?

1 means that you strongly disagree

10 means that you strongly agree

2. If safe and convenient Metra Rail service was available from near your home to your workplace, how likely would you be to use this service?

1 means that you strongly disagree

10 means that you strongly agree

3. If safe and convenient CTA service was available from near your home to your workplace, how likely would you be to use this service?

1 means that you strongly disagree

10 means that you strongly agree

4. If safe and convenient PACE Rapid Bus service was available from near your home to your workplace, how likely would you be to use this service?

1 means that you strongly disagree,

10 means that you strongly agree.

Overall Satisfaction Questions

(ONLY ASKED OF TRANSIT USERS) [All respondents will get either the 4 Consider Use Questions, or the 4 Satisfaction Questions, depending on whether or not they use transit]

In this section of the survey, we would like to understand your satisfaction level with different travel options. Please rate each of the following statements on a scale of 1 to 10, where 1 means that you very unsatisfied (or dissatisfied) and 10 means that you are very satisfied with the service.

1. How would you rate your overall satisfaction with Pace Bus on a 10 point scale?

1 means that you are very unsatisfied

10 means that you are very satisfied

2. How would you rate your overall satisfaction with Metra Rail on a 10 point scale?

1 means that you are very unsatisfied

10 means that you are very satisfied

3. How would you rate your overall satisfaction with CTA Bus Service on a 10 point scale?

1 means that you are very unsatisfied

10 means that you are very satisfied

4. How would you rate your overall satisfaction with CTA Rail Service on a 10 point scale?

1 means that you are very unsatisfied

10 means that you are very satisfied

CLASSIFICATION QUESTIONS

Finally, for verification purposes, can you please give me your first name?

____

(IF NEEDED ADD: "Information from this survey will help to shape transportation planning decisions within the Chicago region.")

(IF INCENTIVE=1, SAY :)

"We will mail your check for $15 within the next week. Thank you for your participation."

Respondent Comments (VOLUNTEERED): ___________________________________

(Record gender)

1. Male
2. Female

Lastly, would you be willing to participate in future transportation studies conducted in the Chicago area?

1. Yes **(CONTINUE)**
2. No **(THANK AND TERMINATE)**

Could I please have your e-mail address so we can contact you in the future?

E-mail:_______________________

[MOVED FROM AFTER FNAME]

Those are all the questions we have! Thank you so much for your help.

(THANK AND TERMINATE)

Appendix D

Density Thresholds for Transit Competitiveness Analysis

Density Thresholds for Transit Competitiveness Analysis

A Note on Defining Density

- What is meant by "per acre"?
  - When hear "X residential units per acre" or "X employees per acre," this usually refers to gross area
  - When hear "X population density" or "X employment density," this usually refers to total area
- What is difference between gross area and total area?
  - Total area = all land area, regardless of use
  - Gross area = total developed area = total area less public rights-of-way (i.e., roads, sidewalks, schools, parks, other neighborhood facilities)
- Relationship between gross and total land area, based on reviews of aerial maps of typical locations, confirmation of aerial results using field measurements, and discussions with experts in land use, real estate, and urban economics
  - For most places, gross area is anywhere between about 50 to 75 percent of total area
  - For typical residential areas, gross area is roughly 60 to 65 percent of total area

Transit Competitive Density – Production End

- www.envstudies.brown.edu/classes/es201/2003/TOD/What%20Is%20TOD/What%20Is%20TOD.htm
  - Transit-Oriented Development generally requires seven residential units per acre, and twice that for premium quality transit, such as rail service
- www.crcog.org/Publications/TCSP/Ch05_Fact%20Sheet_TOD.pdf
  - Minimum residential density required to support regular bus service is six to eight units per acre. For express bus service, minimum densities should be 15 units per acre. Sharp increases (tripling) in ridership as residential densities approach 30 units per acre.

- www.sfu.ca/geog/geog496spring03/1B_SUDLD.html
  - Pushkarev and Zupan, Cervero and Bernick, 1977
    - Twelve dwelling units per acre (dua) necessary to support moderate levels of rail transit service
  - John Holtzclaw
    - Bus every 30 minutes becomes feasible above 7 dua, and every 10 minutes at 15 dua
    - Light rail service is feasible above 9 dua
    - Rapid transit above 12 dua
  - Peter Calthorpe
    - Fifteen dua in urban TODs
  - Smart Growth British Columbia
    - Minimum density necessary to support transit use at 8 dua
- www.vtpi.org/tdm/tdm45.htm
  - Pushkarev and Zupan, 1977; Ewing, 1999; Robert Cervero, et al, 2004
    - Six residential units per acre
    - Twice above for premium quality transit, such as rail
- www.wcel.org/issues/urban/sbg/Part3/transitsupportive/
  - Ten units per acre in residential areas
- FTA, Guidelines and Standards for Assessing Transit-Supportive Land Use
  - Population density
    - High rating: > 15,000 people per square mile (> 23.4 per acre)
    - Medium-High rating: 10,000-15,000 per square mile (15.6-23.4 per acre)
    - Medium rating: 6,667-10,000 per square mile (10.4-15.6 per acre)
    - Low-Medium rating: 3,333-6,667 per square mile (5.2-10.4 per acre)
    - Low rating: < 3,333 per square mile (< 5.2 per acre)
  - Residential dua
    - High rating: > 25 dua
    - Medium-High rating: 15-25 dua

    - Medium rating: 10-15 dua
    - Low-Medium rating: 5-10 dua
    - Low rating: < 5 dua

- MTC Resolution 3434 TOD Policy for Regional Transit Expansion Projects, 27 July 2005
  - Dwelling units within one-half mile of stations
    - Heavy rail: 3,850 (7.66 du per acre of total area)
    - Light rail: 3,300 (6.57 du per acre of total area)
    - BRT: 2,750 (5.47 du per acre of total area)
    - Commuter rail: 2,200 (4.38 du per acre of total area)

Transit Competitive Density – Attraction End

- www.envstudies.brown.edu/classes/es201/2003/TOD/What%20Is%20TOD/What%20Is%20TOD.htm
  - Transit-Oriented Development generally requires 25 employees per acre in commercial centers, and twice that for premium quality transit, such as rail service
- www.brookings.edu/es/urban/publications/belzertod.pdf
  - Frank, Lawrence and Gary Pivo, Impacts of Mixed Use and Density on Utilization of Three Modes of Travel: Single-Occupant Vehicle, Transit, and Walking; Issues in Land Use and Transportation Planning, Models, and Applications; Transportation Research Record No. 1466, TRB, 1994
    - Relationship between mode choice and employment density is non-linear, with significant improvements resulting from raising density above two key thresholds: between 20 and 50 employees per acre at the low end and 75 employees per acre at the high end
- www.crcog.org/Publications/TCSP/Ch05_Fact%20Sheet_TOD.pdf
  - In the downtown area, a minimum density of 50 employees per acre is necessary to support regular transit service, and people do not switch from driving to transit until employment densities reach about 50 to 75 employees per acre
- www.universityunited.com/TOD.pdf
  - Met Council, Planning More Livable Communities with Transit-Oriented Development
    - Minimum jobs per acre: 100 for commercial development at transit stop

    - The Transportation Policy Plan states that employment and education goals should be at least 50 employees or students per acre
    - New Jersey guidelines state minimum commercial development of 150 employees per acre to support rail or other high-capacity service, and 40 employees per acre to support local bus service

- www.vtpi.org/tdm/tdm45.htm
  - Pushkarev and Zupan, 1977; Ewing, 1999; Robert Cervero, et al, 2004
    - Twenty-five employees per acre in commercial centers
    - Twice above for premium quality transit, such as rail
- www.wcel.org/issues/urban/sbg/Part3/transitsupportive/
  - Twenty-eight employees per acre in commercial centres
- Puget Sound Regional Council, R. Ewing, Pedestrian and Transit-Friendly Design: A Primer for Smart Growth, 1999
  - Employment densities of 25 jobs per gross acre will support frequent, high-transit service. For light-rail service, employment densities of 50 jobs per gross acre are needed.

Transit Competitive Densities Used for this Analysis

As reflected in the wide range of densities cited in the references above, there is no precise, universally accepted threshold at which a development becomes transit competitive. The various literature citations provide an overview of the range of values used for the threshold. We selected values that fall within the range cited above, generally near the low end of the range to provide some benefit of doubt.

- Production End
  - Assume transit competitive if 8 dwelling units per gross acre or more
  - Convert above to total area assuming gross area = 60 percent of total area
    - Transit competitive if more than 4.8 dwelling units per acre of total area
  - For Chicago six-county metro area, 1.22 work trips per household. Use this to convert above.
    - Transit competitive if more than 6 work trips per acre of total area

- Attraction End
  - Assume transit competitive if 30 jobs per gross acre or more
  - Convert above to total area assuming gross area = 60 percent of total area
    - Transit competitive if more than 18 jobs per acre of total area
  - For Chicago six-county metro area, 0.83 work trips per job. Use this to convert above.
    - Transit competitive if more than 15 work trips per acre of total area

Appendix E

Transit Competitiveness Factor Calculations

Transit Competitiveness Factor Calculations

An essential element in designing an effective transit system is to locate origin and destination markets where transit service can be competitive relative to auto and to determine what type of transit service would be most effective in serving those markets. To do this, we designed an index called the Transit Competitiveness Factor (TCF) that rates places in the Chicago region for their relative transit competitiveness. This index is a single number that provides a quantitative measure of the potential for transit ridership. The TCF incorporates many of the demand-side components that contribute to successful transit service, including density at the origin, density at the destination, congestion, and parking cost. Compared to other efforts to create indices rating places for their transit potential, the TCF combines each of these components with weighting factors that are proportional to each component's ability to generate transit trips. This is accomplished by using weighting factors based on coefficients from the market segmentation-based mode choice models.

As a result, the TCF incorporates the extensive market research done in the Chicago region by taking into account the different attitudes of different customer types with respect to transit service. This information is brought into the TCF by using travel demand mode choice model coefficients that are specific to each customer type.

The TCF is developed so that it can be deconstructed to determine which of the underlying components (i.e., origin density, destination density, etc.) and customer types are the primary contributors to a place's transit competitiveness. With this information, a transit agency can determine what type of transit service will be most effective in attracting ridership.

The TCF is designed to locate places where the potential exists for a high density of transit trip ends. This is done by combining travel demand model mode choice coefficients and structure with information on origin density, destination density, congestion, and parking cost. To simplify the analysis, we compare one transit mode with one auto mode to get a sense of how competitive transit is relative to auto. In reality, a variety of transit modes and auto modes could be available. Representing the range of possible modes with one representative mode should still provide a reasonable assessment of the relative competitiveness of transit versus auto. For the representative modes for this study, we selected the transit mode with the highest volume (i.e., the "existing transit" mode in the travel demand mode choice model) and the auto mode with the highest volume (i.e., the "drive alone" mode in the travel demand mode choice model).

Definitions

P = Probability of using particular mode of travel
U = Utility of particular mode of travel
<X> = Average X over all trips produced by or attracted to TAZ
<<X>> = Average X over all trips regionwide
[X] = Median X over all trips produced by or attracted to TAZ
[[X]] = Median X over all trips regionwide

Subscripts

t = existing transit
a = drive alone
i = production TAZ
j = attraction TAZ

Base Utilities – Attractions

The first step in the development of the TCF is to calculate the utilities for transit and automobile travel assuming a "base" situation that represents typical conditions in the Chicago region. This is done by using regionwide average values for variables such as transit access time, transit headway, and so forth in the travel demand model mode choice utility equations. The base utilities are developed for each of the customer types. The following equations show how this is done for an attraction zone. The equations for a production zone are similar.

Base existing transit utility for attraction zone j = U_{tj}
= Modal constant for existing transit
+ Coeff for walk time • <<Existing transit access time>>
+ Coeff for ivtt • <Drive alone congested ivtt> • <<Existing transit ivtt>>/<<Drive alone congested ivtt>>
+ Coeff for walk time • <<Existing transit egress time>>
+ Coeff for out-of-pocket cost • <<Existing transit out-of-pocket cost>>
+ Coeff for headway • <<Existing transit headway>>
+ Coeff for transfer • <<Existing transit number of transfers>>
+ Coeff for transfer wait • <<Existing transit transfer wait>>
+ Attraction area type constant
+ Coeff for # of transit providers within ½ mile • <<# of transit providers within ½ mile>>
+ Reliability constant for late twice per month
+ Coeff for % zero vehicle • <<% population with no vehicle>>
+ Coeff for % female • <<% female>>

Base drive alone utility for attraction zone j = U_{aj}
= Modal constant for drive alone
+ Coeff for ivtt • <Drive alone congested ivtt>
+ Coeff for out-of-pocket cost • <<Drive alone out-of-pocket cost>>
+ Drive-alone constant for 5- to 10-mile trips
+ Reliability constant for late twice per month

Adjusted Utilities – Attractions

The next step in the development of the TCF is to adjust the base utilities for location-specific attributes. For example, a particular attraction zone might have a higher than typical density of attracted trips. To account for this, an adjustment factor is applied to the appropriate term in the base utility equation. For trip attraction density, the factor [[Trip attraction density]]/Trip attraction density is applied to the transit egress time term. The rationale for this adjustment is that if a zone has twice the density of trips, it can effectively support twice the amount of transit service. This, in turn, halves the typical transit egress time. The correspondence between different location attributes and utility equation terms is shown in Table 1. The adjustment terms are shown in **bold** in the following equation.

Table 1. Adjusting Utility for Location-Specific Attributes

Attribute	Utility Equation Term
Density of trips produced	Transit access time
Density of trips attracted	Transit egress time
Congestion	Drive in-vehicle time
Parking cost	Drive out-of-pocket cost

Adjusted existing transit utility for attraction zone j = U_{tj}
= Modal constant for existing transit
+ Coeff for walk time • <<Existing transit access time>> • **[[Trip production density for trips attracted]]/ [Trip production density for trips attracted]**
+ Coeff for ivtt • <Drive alone congested ivtt> • <<Existing transit ivtt>>/<<Drive alone congested ivtt>>
+ Coeff for walk time • <<Existing transit egress time>> • **[[Trip attraction density by customer type]]/ [Trip attraction density by customer type]**

+ Coeff for out-of-pocket cost • <<Existing transit out-of-pocket cost>>
+ Coeff for headway • <<Existing transit headway>>
+ Coeff for transfer • <<Existing transit number of transfers>>
+ Coeff for transfer wait • <<Existing transit transfer wait>>
+ Attraction area type constant
+ Coeff for # of transit providers within ½ mile • <<# of transit providers within ½ mile>>
+ Reliability constant for late twice per month
+ Coeff for % zero vehicle • <<% population with no vehicle>>
+ Coeff for % female • <<% female>>

Adjusted drive alone utility for attraction zone j = U_{aj}
= Modal constant for drive alone
+ Coeff for ivtt • <Drive alone congested ivtt> • **<Drive alone congested ivtt>/ <Drive alone free-flow ivtt>**
+ **Coeff for out-of-pocket cost • <Parking cost for trips attracted>**
+ Coeff for out-of-pocket cost • <<Drive alone out-of-pocket cost>>
+ Drive-alone constant for 5- to 10-mile trips
+ Reliability constant for late twice per month

Unscaled Attraction TCF

Once adjusted utilities for transit and auto are developed, the probability of using transit can be calculated using the standard form for the mode choice model:

Probability of using transit for attraction zone j = P_{tj}

$= \exp(U_{tj})/[\exp(U_{tj}) + \exp(U_{aj})]$

The TCF is the potential density of transit trips attracted, and equals the probability of using transit multiplied by the density of trips attracted:

Unscaled attraction TCF for attraction zone j

= P_{tj} • Trips attracted to zone j/Area of zone j

The above equation gives the TCF for a specific customer type or market segment. To create an overall attraction TCF for attraction zone j, we sum over all market segments.

Scaled Attraction TCF

The above equations results in a quantitative TCF score for each attraction zone in the Chicago area. To assist with interpreting them, it is useful to scale the results. We chose to rescale such that a TCF score of 100 corresponds to a place that is at the threshold of being transit competitive. To do this, we generated a hypothetical zone with the attributes of a place that would be considered just competitive from the point of view of transit service.

From the general literature on transit usage versus land use density, we find that transit usage tends to turn noticeably upward at a threshold land use density. For attraction zones, this threshold is generally cited as between 25 and 75 jobs per gross acre. For this study, we used 30 jobs per gross acre. While there is no precise, universally accepted threshold at which a development becomes transit competitive in the literature, we selected a value that falls within the range cited above, near the low end of the range to provide some benefit of doubt.

This value can be converted to work trips attracted per acre of total land by: 1) converting gross acres – which do not include public lands such as roads, sidewalks, parks, schools, etc. – to acres of total land; and 2) applying a work trips attracted per job factor for the Chicago area. We used 0.6 gross acres per acre of total land and 0.83 work trips per job to derive a transit competitive trip density threshold of 15 work trips attracted per acre of total land.

To calculate the unscaled attraction TCF corresponding to the transit competitive threshold, make the following substitutions into the equations in the previous sections:

Trips attracted to zone j = Area of zone j • Threshold trips attracted per area
Trip attraction density →Threshold trips attracted per area
[Trip production density for trips attracted]→[[Trip production density for trips attracted]]
<Drive alone congested ivtt>→<<Drive alone congested ivtt>>
<Drive alone free-flow ivtt>→<<Drive alone congested ivtt>>
Attraction area type constant→Suburban attraction area type constant
Parking cost for trips attracted→0

Once the unscaled TCF corresponding to the transit competitive threshold is calculated, we rescale all TCF values so the threshold TCF is set equal to 100. Our intention is to calculate the raw TCF score for a place that is "transit competitive" and then rescale all TCF scores so that this place has TCF score = 100. We define a transit competitive place to be one that has the employment density defined above, but in every other way is typical. So, we set

<Drive alone congested ivtt> = <<Drive alone congested ivtt>> (regionwide average)

Parking cost for trips attracted = 0

Attraction area type = suburban.

Base Utilities – Productions

The calculation of TCFs for productions is similar to that for attractions. The equations for the base transit and auto utilities for each customer type are:

Base existing transit utility for production zone i = U_{ti}
= Modal constant for existing transit
+ Coeff for walk time • <<Existing transit access time>>

+ Coeff for ivtt • <Drive alone congested ivtt> • <<Existing transit ivtt>>/<<Drive alone congested ivtt>>
+ Coeff for walk time • <<Existing transit egress time>>
+ Coeff for out-of-pocket cost • <<Existing transit out-of-pocket cost>>
+ Coeff for headway • <<Existing transit headway>>
+ Coeff for transfer • <<Existing transit number of transfers>>
+ Coeff for transfer wait • <<Existing transit transfer wait>>
+ Suburban attraction area type constant
+ Coeff for # of transit providers within ½ mile • <<# of transit providers within ½ mile>>
+ Reliability constant for late twice per month
+ Coeff for % zero vehicle • % population with no vehicle
+ Coeff for % female • % female

Base drive alone utility for production zone i = U_{ai}
= Modal constant for drive alone
+ Coeff for ivtt • <Drive alone congested ivtt>
+ Coeff for out-of-pocket cost • <<Drive alone out-of-pocket cost>>
+ Drive-alone constant for 5- to 10-mile trips
+ Reliability constant for late twice per month

Adjusted Utilities – Productions

The equations for the utilities adjusted for location-specific attributes follow. As above, The adjustment terms are shown in **bold**.

Existing transit utility for production zone j = U_{ti}
= Modal constant for existing transit
+ Coeff for walk time • <<Existing transit access time>> • **[[Trip production density by customer type]]/ Trip production density by customer type**
+ Coeff for ivtt • <Drive alone congested ivtt> • <<Existing transit ivtt>>/<<Drive alone congested ivtt>>
+ Coeff for walk time • <<Existing transit egress time>> • **[[Trip attraction density for trips produced]]/[Trip attraction density for trips produced]**
+ Coeff for out-of-pocket cost • <<Existing transit out-of-pocket cost>>
+ Coeff for headway • <<Existing transit headway>>
+ Coeff for transfer • <<Existing transit number of transfers>>
+ Coeff for transfer wait • <<Existing transit transfer wait>>
+ Suburban attraction area type constant
+ Coeff for # of transit providers within ½ mile • <<# of transit providers within ½ mile>>
+ Reliability constant for late twice per month
+ Coeff for % zero vehicle • % population with no vehicle
+ Coeff for % female • % female

Drive alone utility for production zone i = U_{ai}
= Modal constant for drive alone
+ Coeff for ivtt • <Drive alone congested ivtt> • **<Drive alone congested ivtt>/<Drive alone free-flow ivtt>**
+ **Coeff for out-of-pocket cost • <Parking cost for trips produced>**
+ Coeff for out-of-pocket cost • <<Drive alone out-of-pocket cost>>
+ Drive-alone constant for 5- to 10-mile trips
+ Reliability constant for late twice per month

Unscaled Production TCF

The probability of using transit for a production zone is calculated as below:

Probability of using transit for production zone i = P_{ti}

= $\exp(U_{ti})/[\exp(U_{ti}) + \exp(U_{ai})]$

The TCF for each production zone is calculated as:

Unscaled production TCF for production zone i

= P_{ti} • Trips produced from zone i/Area of zone i

To develop the overall production TCF for production zone i, we sum the above over all customer types.

Scaled Production TCF

For production zones, the threshold is usually cited as between 8 and 15 dwelling units per gross acre. For this study, we used 8 dwelling units per gross acre. As above, because there is no precise, universally accepted threshold at which a development becomes transit competitive in the literature, we selected a value that falls within the range cited above, near the low end of the range to provide some benefit of doubt. Using conversion factors of 0.6 gross acres per acre of total land and 1.22 work trips produced per household, this is equivalent to a transit competitive trip density threshold of 6 work trips produced per acre of total land.

To calculate the unscaled production TCF corresponding to the transit competitive threshold, we make the following substitutions into the equations in the previous sections:

Trips produced from zone i = Area of zone i • Threshold trips produced per area
Trip production density → Threshold trips produced per area
[Trip attraction density for trips produced] → [[Trip attraction density for trips produced]]
% population with no vehicle → <<% population with no vehicle>>
% female → <<% female>>

<Drive alone congested ivtt> → <<Drive alone congested ivtt>>
<Drive alone free-flow ivtt> → <<Drive alone congested ivtt>>
Parking cost for trips produced → 0

Once the unscaled TCF corresponding to the transit competitive threshold is calculated, we rescale all TCF values so the threshold TCF is set equal to 100. As above, our intention is to calculate the raw TCF score for a place that is "transit competitive" and then rescale all TCF scores so that this place has TCF score = 100. We define a transit competitive place to be one that has the residential density defined above, but in every other way is typical. So, we set

<Drive alone congested ivtt> = <<Drive alone congested ivtt>> (regionwide average)

Parking cost for trips produced = 0

% population with no vehicle → <<% population with no vehicle>> (regionwide average)

% female → <<% female>> (regionwide average)

Contributions to TCF from Different Components

As described above, the TCF includes contributions from production density, attraction density, congestion, and parking cost. The contribution of each of these components individually can be determined by recalculating the TCF with the appropriate adjustment factor in the adjusted utility equations removed and seeing how much this changes the result. Recall that the adjustment factors are shown in **bold** in the equations above. For example, to determine the contribution of congestion to attraction TCF, recalculate the TCF with the factor <Drive alone congested ivtt>/<Drive alone free-flow ivtt> removed.

One additional replacement needs to be made in two special cases: 1) determining the contribution of attraction density to attraction TCF; and 2) determining the contribution of production density to production TCF. For the first case, in addition to making the replacement described above, we also need to replace Trips attracted to zone j/Area of zone j with <<Trips attracted to zone j/Area of zone j>> in the equation for the unscaled attraction TCF, in the ***italicized bold*** font above. A similar procedure is needed for the second case.

Contributions to TCF from Different Customer Types

As described above, the overall TCF is calculated as the sum over the TCFs for each individual customer type. The contribution of each customer type to the overall TCF is determined by calculating the percentage of the total that comes from each individual customer type.

Limitations of TCF Methodology

The TCF methodology uses existing travel demand model data and the existing structure and coefficients from the travel demand mode choice model as inputs. So, the first limitation is that the results are only as good as the input data and the travel demand mode choice model are accurate.

The TCF methodology as developed for the Chicago region incorporates the effects of production density, attraction density, congestion, and parking cost on transit competitiveness. However, a location's transit competitiveness may depend on other components such as how pedestrian friendly a place is, how much time is required to locate parking, and so forth. These additional components could be incorporated into the TCF methodology if the data were available and the mode choice model included them.

On the production end, the TCF methodology accounts for the varying mix of customer types by TAZ and their different attitudes toward using transit. However, on the attraction end, good information on the mix of customer types by TAZ is not available. For the Chicago region, we addressed this deficiency to some degree by making coarse assumptions about the travel patterns of different customer types. The effect of these assumptions is that the variation in the mix of customer types by TAZ on the attraction end is small. This deficiency on the attraction end could be addressed by developing a synthetic population to model the travel patterns of individual people in the Chicago area.

The TCF methodology does its calculations at a fairly high level of granularity. For example, all work trips are considered similar in their transit competitiveness. In reality, it could be that certain types of work trips are more transit competitive than others. For example, work trips to places with a regular work schedule (e.g., industrial facilities) are likely more transit competitive than those to places with an irregular schedule (e.g., medical facilities). This shortcoming could be addressed if the mode choice model differentiated between different types of work trips.

Finally, the TCF methodology evaluates productions and attractions for their transit competitiveness separately. However, transit serves production-attraction pairs. Thus, the TCF could misrepresent the transit competitiveness of some production-attraction pairs because their endpoints are considered separately.