# TCRP

## REPORT 119

TRANSIT COOPERATIVE RESEARCH PROGRAM

Sponsored by the Federal Transit Administration

# Improving ADA Complementary Paratransit Demand Estimation

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

TRANSIT COOPERATIVE RESEARCH PROGRAM

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# Improving ADA Complementary Paratransit Demand Estimation

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## TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), Transportation 2000, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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COOPERATIVE RESEARCH PROGRAMS




## AUTHOR ACKNOWLEDGMENTS

The research that produced this report was performed under TCRP Project B-28. David Koffman of Nelson\Nygaard Consulting Associates was the Principal Investigator and principal author of the report. David Lewis of HDR|HLB Decision Economics was senior advisor on econometric methods and demand forecasting and oversaw much of the regression analysis for the project. May Raad-Young of HDR|HLB Decision Economics carried out many of the regression runs. David Chia of Planners Collaborative was responsible for collecting the data from representative systems. Jon Burkhardt of Westat prepared the chapter about long-term trends, and Mark Bradley prepared the chapter about options for disaggregate analysis. Richard Weiner of Nelson\Nygaard contributed to the early phases of the research, especially a survey of paratransit practitioners. Mapping specialists at Nelson\Nygaard, including Christine Celsor and Anneka Imkamp, carried out the detailed demographic analysis of the representative system service areas.

Dianne Schwager, TCRP Project Officer, assembled and directed the Oversight Panel. The Panel, in addition to crafting the project statement that guided the research, provided numerous suggestions that greatly improved the final product. Staff of 28 representative transit systems gave generously of their time, responding to a detailed questionnaire and multiple follow-up requests for data, on which the demand estimation tools are based.

# FOREWORD

By Dianne S. Schwager
Staff Officer
Transportation Research Board

*TCRP Report 119: Improving ADA Complementary Paratransit Demand Estimation* will be of interest to public transportation systems that provide ADA complementary paratransit services; regional, state, and federal agencies that oversee, plan, or finance public transportation; and disability advocates. This report provides a handbook for estimating ADA paratransit demand together with a research report that presents the findings and conclusions of TCRP Project B-28. The handbook is accompanied by an on-line spreadsheet tool, which is available at http://www.trb.org/news/blurb_detail.asp?id=8246.

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The Americans with Disabilities Act of 1990 (ADA) created a requirement for complementary paratransit service for all public transit agencies that provide fixed-route service. Complementary paratransit service is intended to complement the fixed-route service and serve individuals who, because of their disabilities, are unable to use the fixed-route transit system. The methods presented are designed to predict demand for service that complies with legal requirements for level of service as specified by the ADA and implementing regulations. The methods are also designed to exclude demand for services that exceed requirements for ADA complementary paratransit.

The tools presented in this handbook are based on a statistical model that was estimated using data from 28 "representative systems." The representative systems were selected from an initial list of 88 systems suggested by respondents to a survey about factors that influence the demand for paratransit. All of the representative systems appeared to be in compliance with ADA paratransit requirements regarding capacity constraints and generally provided quality service as of the time data were collected.

The tools for estimating the demand for ADA complementary paratransit include (1) an Excel spreadsheet that calculates demand estimates using user-entered data indicating a system's policies and service area characteristics (the spreadsheet is available on-line); (2) a series of graphs for determining factors with which demand estimates can be calculated by hand; and (3) elasticities and change factors for quick calculations about small differences between systems and the impacts of small changes to service policies.

The research report that accompanies the handbook presents the data sources, preliminary data analysis, model development, long-term trends that may affect paratransit demand, options for disaggregate analysis, and a research agenda.

# CONTENTS

# Handbook for Estimating ADA Paratransit Demand

## Introduction

The Americans with Disabilities Act of 1990 (ADA) created a requirement for complementary paratransit service for all public transit agencies that provide fixed-route service. Complementary paratransit service is intended to complement the fixed-route service and serve individuals who, because of their disabilities, are unable to use the fixed-route transit system. In fulfilling their ADA obligations, transit operators have a responsibility to consider current and probable future demand for complementary paratransit service and to plan and budget to meet all of the expected demand. The tools presented in this handbook are intended to improve transit operators' ability to estimate the probable future demand for complementary paratransit service.

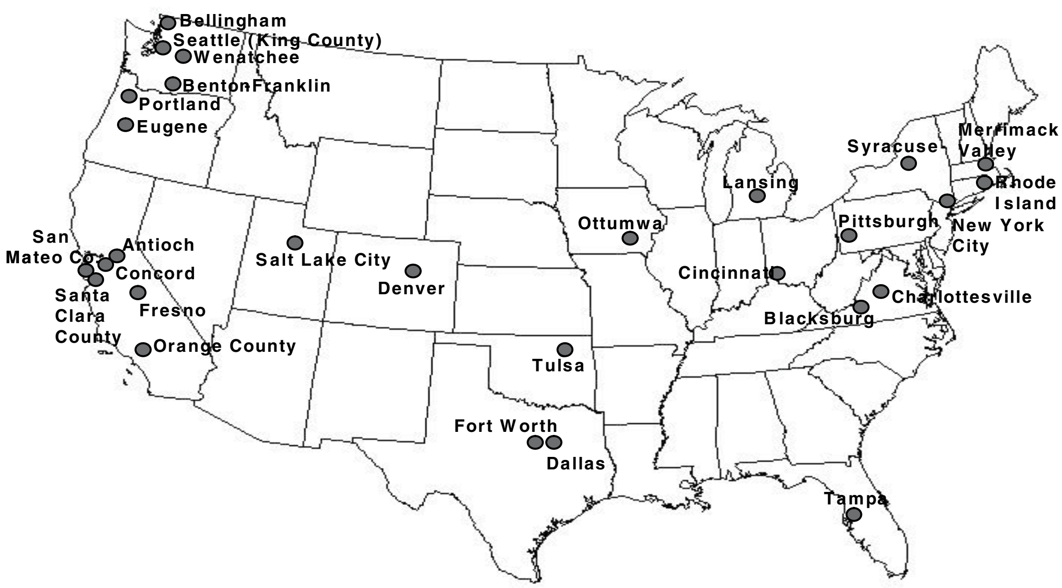
In keeping with the intent of the ADA law and regulations, the methods presented are designed to predict demand for service that complies with requirements for level of service. The methods are also designed to exclude demand for services that exceed requirements for ADA complementary paratransit. Of particular importance, demand is predicted only for service by ADA-eligible individuals, for trips within three-quarters of a mile of fixed-route service, based on reservations taken from one to fourteen days in advance. Demand is predicted for service that is not capacity constrained by significant numbers of denials, unreliable service, or excessive telephone wait times to reach a reservations agent. To the extent possible, demand is predicted only for trips that ADA-eligible individuals are unable to make by fixed-route service.

The tools presented in this handbook are based on a statistical model that was estimated using data from 28 "representative systems" (Figure 1). The representative systems were selected from an initial list of 88 systems suggested by respondents to a survey about factors that influence the demand for paratransit. The selection process included interviews with transit agency staff, advocates, and ordinary riders of each candidate system. All of the representative systems appeared to be in compliance with ADA paratransit requirements regarding capacity constraints and generally provided quality service as of the time data were collected.

Within the framework established by the ADA regulations, the representative systems have a great variety of policies about on-time performance, fares, and other issues. In general, standards for service quality and users' perceptions of service quality may vary greatly. As a result, the levels of demand estimated by the tools in this handbook are intended to correspond to realistic levels of quality service, meeting ADA requirements, but not necessarily meeting the expectations of all users.

The demand estimation tools take account of six key variables that impact ridership. For many reasons, some variables that are known to impact demand are not included.

**Figure 1 Representative Systems**




Reasons for this include lack of data, lack of reliable measures, and the small sample size that was available. The fact that a variable is not included in the demand estimation tools is not intended to suggest that it is not important or that transit operators should ignore it in planning for future demand. Despite these limitations, the tools represent a major advance in understanding the factors that drive demand for ADA paratransit and a major advance in transit operators' ability to plan for the future.

## Overview of the Demand Estimation Tools

The tools for estimating the demand for ADA complementary paratransit include:

1. An Excel spreadsheet that calculates demand estimates using user-entered data indicating a system's policies and service area characteristics.
2. A series of graphs for determining factors with which demand estimates can be calculated by hand.
3. Elasticities and change factors for quick calculations about small differences between systems and the impacts of small changes to service policies.

4. A formula based on the regression model that was used to create the first three tools.

5. Tables with representative system data to use for comparison purposes.

These tools calculate expected annual ADA paratransit ridership (including attendants and companions) when a system operates without capacity constraints as defined by the ADA regulations. The demand estimates are based on six factors:

1. ADA paratransit service area population.

2. Base fare for ADA paratransit.

3. Percent of applicants for ADA paratransit eligibility found conditionally eligible.

4. Whether or not trip-by-trip eligibility determination based on conditions of eligibility is used.

5. Percent of service area population with household incomes below the poverty line.

6. The effective window used to determine on-time performance (i.e., the window from the passenger's point of view including requirements to be ready early and adjustments made in the scheduling process that may not be communicated to passengers).

## How the Factors Affect Demand

Briefly stated, the six factors affect demand as follows:

- Population: Demand increases directly in proportion to the total population of the area served.
- Base Fare: Demand is highly sensitive to fares, possibly even more sensitive than general public transit demand.
- Conditional Eligibility: Systems that have higher percentages of applicants found conditionally eligible (rather than "fully eligible" or eligible without conditions) have lower demand.
- Conditional Trip Determination: Systems that conduct trip-by-trip determination based on conditions of eligibility have much lower demand.
- Poverty Level: High levels of poverty in a service area significantly depress demand.
- Effective Window: Demand is highly sensitive to standards for on-time pick-ups. Systems that define "on-time" for pick-ups using a wider window have lower demand.

Numerical values for these impacts, in the form of elasticities, are provided in the presentation of the third demand estimation tool. All of these factors are considered highly significant in a statistical sense. The technical report that accompanies this handbook provides additional detail about the reliability of the tools and a discussion of the mechanisms that may be responsible for the observed impacts.

# Appropriate Uses of the Demand Estimation Tools

As with any model, the demand estimation tools need to be used with caution. Suggested uses include:

**Planning for elimination of capacity constraints:** For systems that are still experiencing difficulties with capacity constraints, the tools provide a way of estimating how much ridership may increase as these capacity constraints are removed. The calculated demand can be taken as an estimate of where growth is likely to level off, at least in the short run. In other words, the demand estimation tools provide one indication of "latent demand" in a capacity-constrained system.

**Benchmarking:** The tools can also be used for benchmarking a system's performance in comparison to peers. For example, if System A has ridership of 500,000 per year and System B has ridership of 750,000 in an area of twice the population, the tools provide a way of comparing these two systems with adjustments for the effects of service area and service characteristics.

**Assessment of compliance:** Comparing the demand estimate from these tools with current actual demand provides one piece of evidence about how close a paratransit system is to full compliance with the ADA requirement for no capacity constraints. Since there are many factors not included in the tools, this comparison is not conclusive. In fact, many of the representative systems used to estimate the model have ridership significantly above or below the model predictions. If current demand is considerably below the level estimated by the demand estimation tools, the possibility of capacity constraints should be examined in light of other available information.

**Predicting the impact of policy changes:** To a limited degree, the tools may also predict how ridership will respond to changes in policies. However, the model's "predictions" may be accurate only in the long term and might not be completely reflected in actual ridership for several years.

**Service planning:** The impact of expanding or contracting the fixed-route service area (and therefore the ADA paratransit service area) can be estimated based on total population and poverty rate data for the modified service area. If predictions of population and economic conditions are available, these can be used to create long-range ridership predictions.

**Policy development and advocacy:** By showing how sensitive paratransit demand is to various factors, the demand estimation tools can be useful in developing policies about the need for paratransit services, and for making the case for high-quality paratransit services.

# Cautions

**Policy changes within a system:** Because the demand estimation tools are based on a comparison of systems at one point in time, they can only be used with great caution for predicting the impact of policy changes within a system. For example, the model indicates that a system with 10% higher fares than another system will have 7% lower ridership. However, these differences reflect the entire history of fares at the two systems and the adjustments that riders have made to these fares over many years. In the short run, meaning one or two years, the impact of a fare change may be much less. Similar considerations apply to all of the other variables in the model.

**Cost management and compliance:** It may be tempting to use the demand estimation tools as a guide to minimizing the cost of service, for example by adopting a wider pick-up window for defining on-time performance. This is not the intended use of the tools. In fact, the predictions of the model could be taken as an indication of the extent to which this type of deliberate service degradation would amount to a prohibited capacity constraint, that is, a practice that limits the availability of service. These issues should be resolved through the public participation process at each system.

**Eligibility practices:** The research showed a strong relationship between demand and use of trip-by-trip eligibility determination, as well as findings of conditional eligibility in the eligibility determination process. These results certainly point to the value of these tools. However, the paramount consideration in the eligibility process should be making use of best practices to achieve the most accurate and fairest determinations possible. Simply maximizing findings of conditional eligibility and screening out as many trips as possible would be inappropriate and probably illegal.

**Decreasing accuracy with time:** The tools are based on observed demand and system characteristics in 2005 plus population data from the 2000 U.S. Census. No more recent population data were available at the time the research was conducted. It is likely that demand at the representative systems will increase over time. At a minimum, as populations grow, demand is likely to grow. In addition, it is possible that demand will grow for other reasons that are not captured in the demand estimation tools. This may be particularly true where systems have only recently eliminated denials or other capacity constraints. For these reasons, predictions from the demand estimation tools will be most meaningful within the next few years. By the time of the 2010 Census, the usefulness of the demand estimation tools will be greatly diminished.

**Statistical accuracy:** The predictions of the demand estimation tools have a degree of inherent uncertainty. This uncertainly comes from: 1) factors that influence demand but were not captured in the model; and 2) the chances that the 28 "representative systems" do not exactly represent the entire set of paratransit systems that are meeting ADA requirements. The statistical model on which the demand estimation tools are based succeeded in explaining 96% of the observed variation in total ADA paratransit demand among the representative systems. Controlling for total population, the model explained 74% of the variation in ADA paratransit trips per capita among the representative systems. From this statistic, it is estimated that actual demand should be no higher than 19% more than the predicted demand using the tools and no lower than 16% less than the predicted demand in 95% of cases. (A 95% confidence interval for the predictions is -16% to +19%.)

# Variables Not in the Model

A number of factors commonly believed to influence demand for paratransit are not in the demand estimation tools. Some of the notable cases include:

**Population in older age groups:** The research found that the percentage of the population that is above the age of 65 or 75 did not significantly affect paratransit demand at the representative systems. This outcome may reflect the fact that younger people with disabilities ride more frequently than older people. As a result, even though older people tend to account for a majority of ADA eligible people, they do not necessarily account for a majority of demand. The model result could also, at least in part, stem from limitations of ADA paratransit from the perspective of older people.

**Incidence of disability:** Census data indicate that the percentage of the population with a disability varies greatly among metropolitan areas. However, the research found no statistically significant relationship between paratransit demand and Census measures of the population with a disability. This may be a result of the fact that none of the questions about disability in the Census measures ability to use public transportation.

**Availability of human service transportation:** The availability of human service transportation almost certainly has a major impact on ADA paratransit demand. An attempt was made to measure the overall availability of human service transportation at the representative systems. However, this effort produced only partial and inexact results that were not statistically related to ADA paratransit demand. The absence of a factor related to human service transportation is a limitation of the demand estimation tools that users should address through knowledge of local conditions.

**Availability and quality of accessible fixed-route transit:** It is widely assumed that high levels of accessible transit service or high levels of transit service in general will reduce the demand for ADA paratransit. However, the research did not find a statistically significant relationship between paratransit demand and availability of accessible transit or availability of transit service overall. In fact, contrary to expectations, the research showed that paratransit demand may be higher in places that have extensive transit service (including accessible transit service) than in places with less extensive transit service. This topic is addressed at length in the technical report.

**Telephone access:** Difficulty getting through on the telephone to make a reservation almost certainly affects paratransit demand. An attempt was made to capture this effect by requesting data about telephone hold times. However, nine of the 28 representative systems were not able to provide a quantitative measure of telephone hold time. As a result of this data limitation, the observed relationship between hold times and demand was not statistically significant, although it was nearly so and in the expected direction. The technical report provides more detail. Systems where customers face long hold times or frequent busy signals should assume that remedying this situation may well result in higher demand levels (other factors being equal) even though the demand estimation tools do not provide a quantitative estimate of this effect.

**Ethnicity and language:** It is possible that certain ethnic groups may use paratransit less than others because of traditions about taking care of family members. The research did not find any statistically significant impact, but did not rule it out. In communities where numerous languages are spoken, lack of marketing and multilingual reservations staff may reduce paratransit demand. Language issues were not investigated. As communities become more diverse, these issues may become particularly important in some areas.

## Policy and Planning Implications

The demand estimation tools may be useful for developing policies and plans for the future. Issues that may be informed by the research include how demand will grow in the future and how systems' policies limit demand.

**Long-term demand growth:** The research results imply that demand will grow in proportion to total population and is not related to the proportion of the population in older age groups. If this result is correct, the anticipated graying of America may have much less impact on ADA paratransit demand than expected. The result could also indicate that responding to needs of older people will require developing solutions other than ADA paratransit.

**Eligibility:** The research finding that conditional eligibility and use of trip-by-trip eligibility determination have significant impacts on demand points to a need for continued work to provide transit operators with the best possible eligibility assessment tools. The widespread adoption of functional assessment for eligibility determination has aroused concern among some in the disability community about the fairness and accuracy of the implementation of these methods in some systems. The state of the art with respect to trip-by-trip determination is still very rudimentary. The results of this research suggest that trip-by-trip determination has a much greater impact on demand than previously suspected. This points to an urgent need to spread the use of existing best practices and to improve the state of the art in this area.

**On-time performance:** While ADA regulations prohibit "substantial numbers of significantly untimely pick-ups" as one type of capacity constraint that "limits the availability of complementary paratransit service" (49 CFR 37.131(f)), standards for what amounts to an untimely pick-up vary among systems. The findings of the research about how these standards impact demand may be useful in formulating policy about the point at which overly loose on-time standards begin to limit the availability of service.

**Economic conditions:** The research showed that high levels of poverty in a community depress demand. Communities that are able to raise overall standards of living will mostly like see an increase in demand for paratransit services. Unfortunately, the research was not able to identify the likely impact of improving the economic condition of people with disabilities.

**Fixed-route transit and paratransit demand:** The research did not find any tendency for high levels of fixed-route transit service (including accessible transit service) to reduce paratransit demand. This tentative result suggests a need for further research about how people with disabilities make choices regarding how they travel.

# Instructions for Using the Demand Estimation Tools

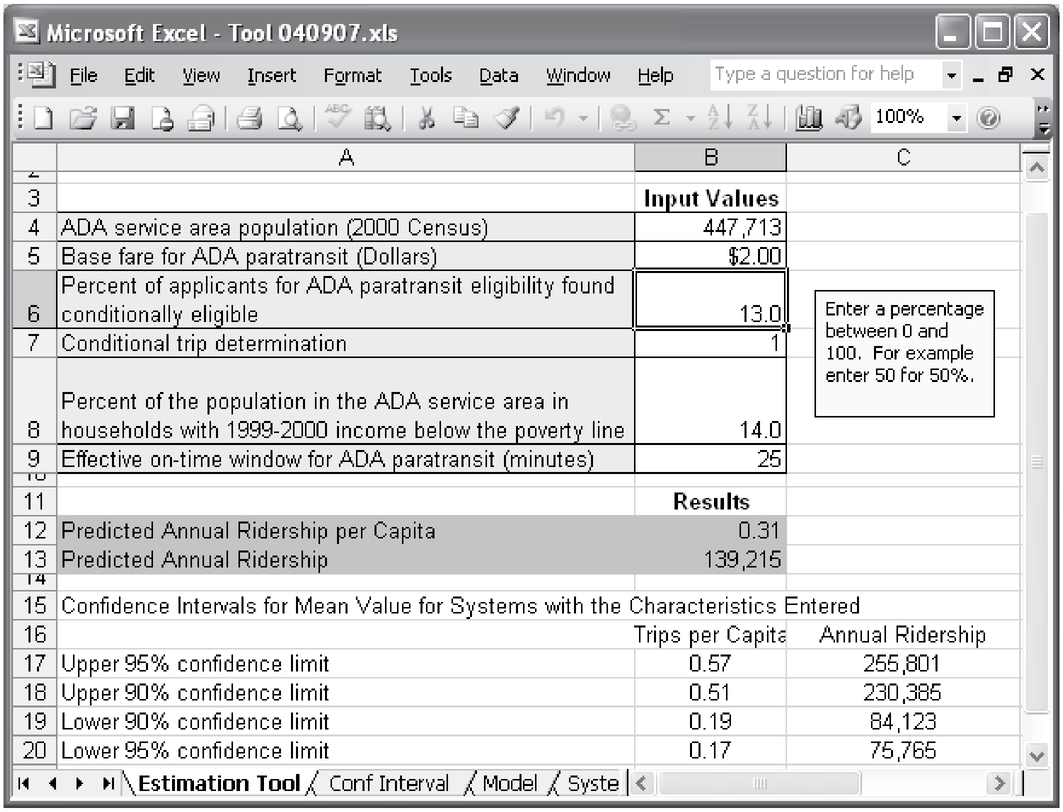
## Spreadsheet Tool

An Excel spreadsheet is provided that calculates expected annual ADA paratransit ridership per capita and total ridership when a system operates without capacity constraints as defined by the ADA regulations. The spreadsheet can be downloaded from the TCRP website along with the electronic version of this report. Pop-up instructions provide guidance about how to enter variables where there could be confusion. Cells that require values in specific ranges (i.e., 0 to 100 for percentages, and 0 or 1 for conditional trip determination) have validation rules that prevent other values from being entered. Figure 2 shows the tool with pop-up instructions for a sample cell.

The inputs needed to use the spreadsheet are as follows:

- ADA service area population = total population according to the 2000 U.S. Census for the actual area served by ADA paratransit. Depending on service policies, this may be just the area three-quarters of a mile around fixed-route service or a larger area. It is critical that the actual ADA service area be used, or an area as close as possible to the actual ADA service area.
- Base Fare = the full cash fare for an ADA paratransit trip before any discounts for advance purchase or use of a monthly pass, and before adding any zone charges.
- The percent of applicants found conditionally eligible = 100 x (the number of people found eligible with conditions) ÷ (the number of people who apply for ADA paratransit eligibility). The most recent full year of eligibility statistics should be used.
- Conditional trip determination = 1 if trip-by-trip determination based on conditions of eligibility is done, 0 otherwise.
- Percent below the poverty rate = 100 x (the number of people in households with incomes below the poverty rate in the area actually served by ADA paratransit as reported in the 2000 U.S. census) ÷ (the ADA service area population from the first bullet).
- Effective on-time window = the total variation in pick-up time, before or after the last time that was given to the customer, before the trip is no longer counted as being "on-time." For example, if a vehicle is considered late beginning 20 minutes after the promised time, but customers are expected to be ready 10 minutes before the promised time, then the "effective window" is 30 minutes. Similarly, if pick-up times can be changed by up to 10 minutes without informing the customer, then the effective window may need to be adjusted.

## Figure 2 Spreadsheet Tool for Estimating ADA Paratransit Demand



| | A | B | C |
|---|---|---|---|
| 3 | | **Input Values** | |
| 4 | ADA service area population (2000 Census) | 447,713 | |
| 5 | Base fare for ADA paratransit (Dollars) | $2.00 | |
| 6 | Percent of applicants for ADA paratransit eligibility found conditionally eligible | 13.0 | Enter a percentage between 0 and 100. For example enter 50 for 50%. |
| 7 | Conditional trip determination | 1 | |
| 8 | Percent of the population in the ADA service area in households with 1999-2000 income below the poverty line | 14.0 | |
| 9 | Effective on-time window for ADA paratransit (minutes) | 25 | |
| 11 | | **Results** | |
| 12 | Predicted Annual Ridership per Capita | 0.31 | |
| 13 | Predicted Annual Ridership | 139,215 | |
| 15 | Confidence Intervals for Mean Value for Systems with the Characteristics Entered | | |
| 16 | | Trips per Capita | Annual Ridership |
| 17 | Upper 95% confidence limit | 0.57 | 255,801 |
| 18 | Upper 90% confidence limit | 0.51 | 230,385 |
| 19 | Lower 90% confidence limit | 0.19 | 84,123 |
| 20 | Lower 95% confidence limit | 0.17 | 75,765 |

The spreadsheet gives predicted annual ridership and annual ridership per capita, as well as confidence limits for these. A separate tab provides a graphical representation of the confidence limits.

The spreadsheet also includes data from the representative systems used to develop the demand estimation tool. Information for each system includes service characteristics, measures of service quality, eligibility statistics, and area demographics, Users can use this data to look for systems that are similar to their own, or to explore the possible influence of variables that were not included in the demand estimation tool itself.

## Graphical Demand Estimation Tool

A form is given in Figure 3 that can be used for hand calculations. There is one row for each factor of the estimation tool. In the boxes to the right, enter values for each factor by reading from the graphs in Figures 5 through 8. For each graph, users locate the value along the horizontal axis that applies to their system and read the factor from the vertical axis. The inputs needed to use the graphs are the same ones described for the spreadsheet tool.

A worked-out example is provided in Figure 4, using the same input values illustrated for the spreadsheet tool in Figure 2.

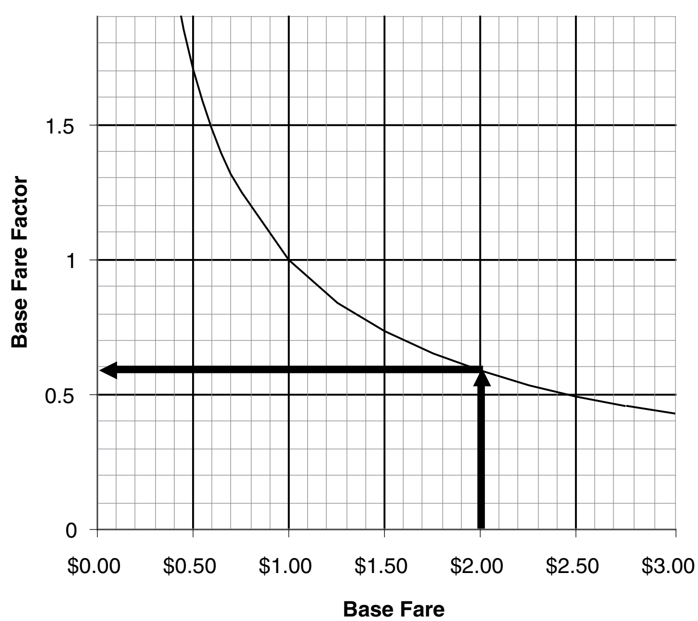
- In the first row, the service area population is entered, rounded to three significant figures.
- In the second row, the constant of 31.91 is carried over.
- In the third row, the fare of $2.00 is located on the horizontal scale of the "Factor for Base Fare" graph, then a line is traced up to the curve and read across to the vertical scale, giving a factor of 0.59.
- The process is repeated for the remaining factors.
- The result is rounded to three significant figures as 139,000 annual trips, approximately matching the result from the spreadsheet tool.

### Figure 3 Calculation Form for Use with Graphical Tools

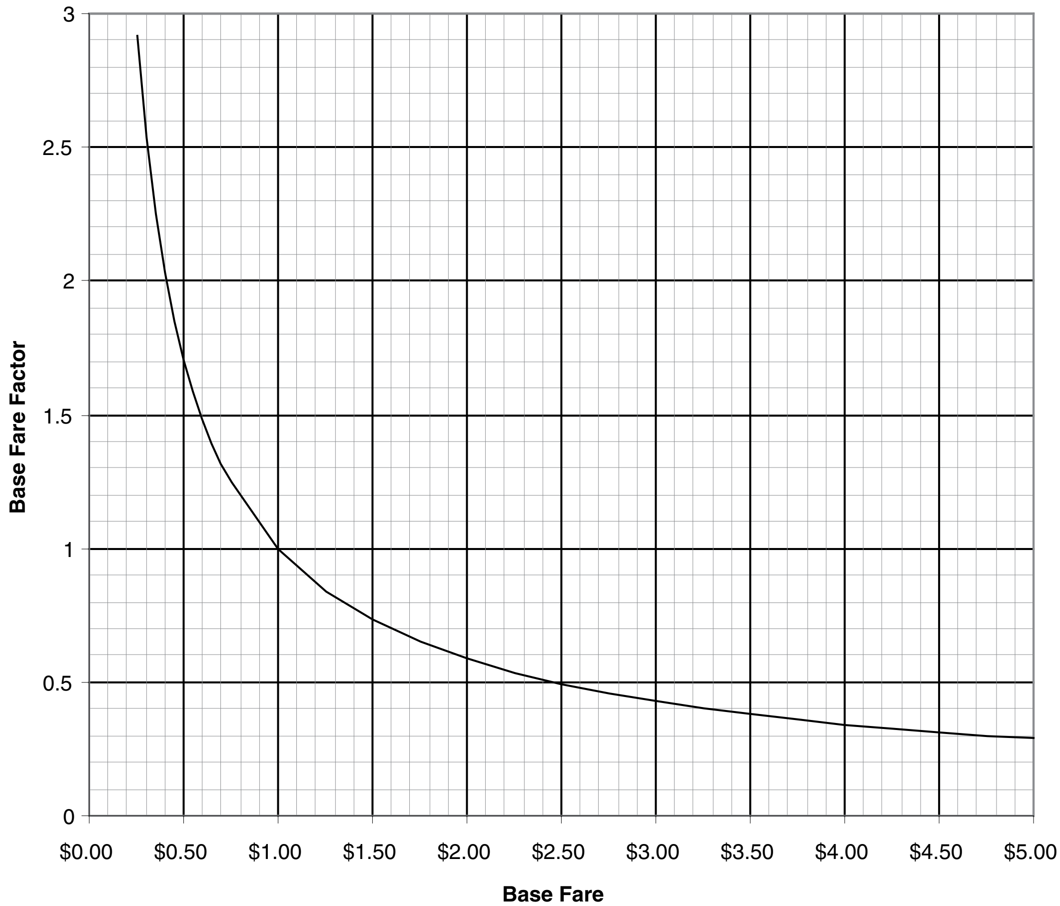
| | |
|---|---|
| **Total ADA Service Area Population** | |
| X | X |
| 31.91 | |
| X | X |
| Base Fare Factor | |
| X | X |
| Eligibility Factor | |
| X | X |
| Conditional Trip Screening Factor:<br>0.52 if trips are screened<br>1.0 if trips are not screened | |
| X | X |
| Poverty Factor | |
| X | X |
| On-time Window Factor | |
| = | = |
| ADA Paratransit Trips per Year<br>(Including Attendants and Companions) | |

## Figure 4 Example Calculation with Graphical Tools

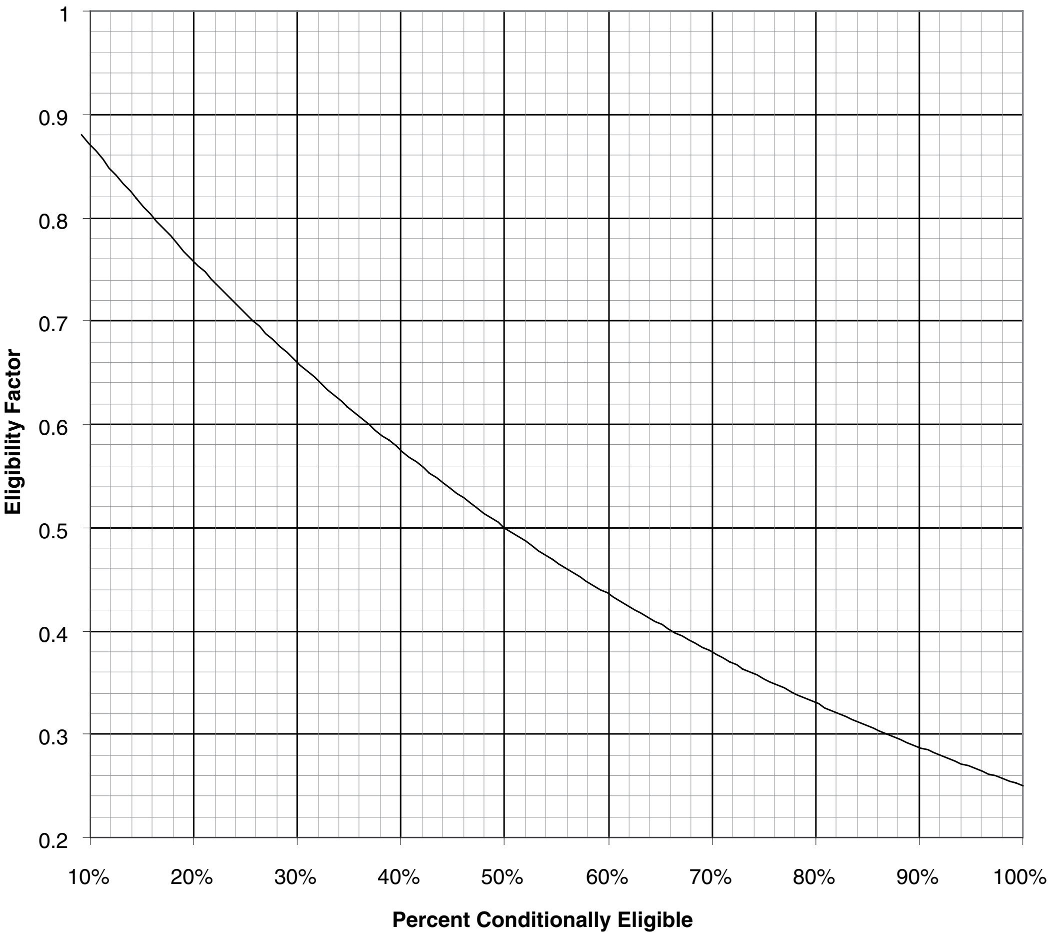
| | |
|---|---|
| **Total ADA Service Area Population** | **448,000** |
| X | **X** |
| 31.91 | **31.91** |
| X | **X** |
| Fare Factor | **0.59** |
| X | **X** |
| Eligibility Factor | **0.84** |
| X | **X** |
| Conditional Trip Screening Factor:<br>0.52 if trips are screened<br>1.0 if trips are not screened | **0.52** |
| X | **X** |
| Poverty Factor | **0.39** |
| X | **X** |
| On-time Window Factor | **0.098** |
| = | = |
| ADA Paratransit Trips per Year<br>(Including Attendants and Companions) | **139,000** |



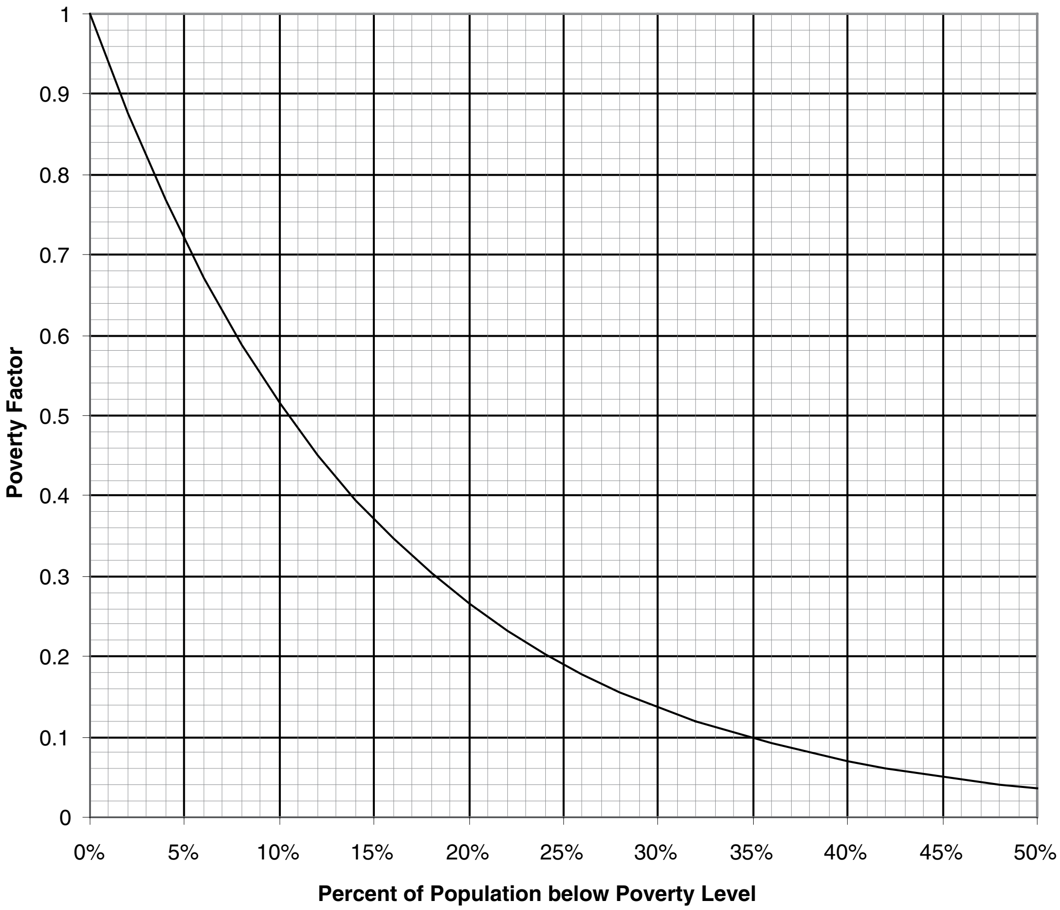
## Figure 5 Factor for Base Paratransit Fare



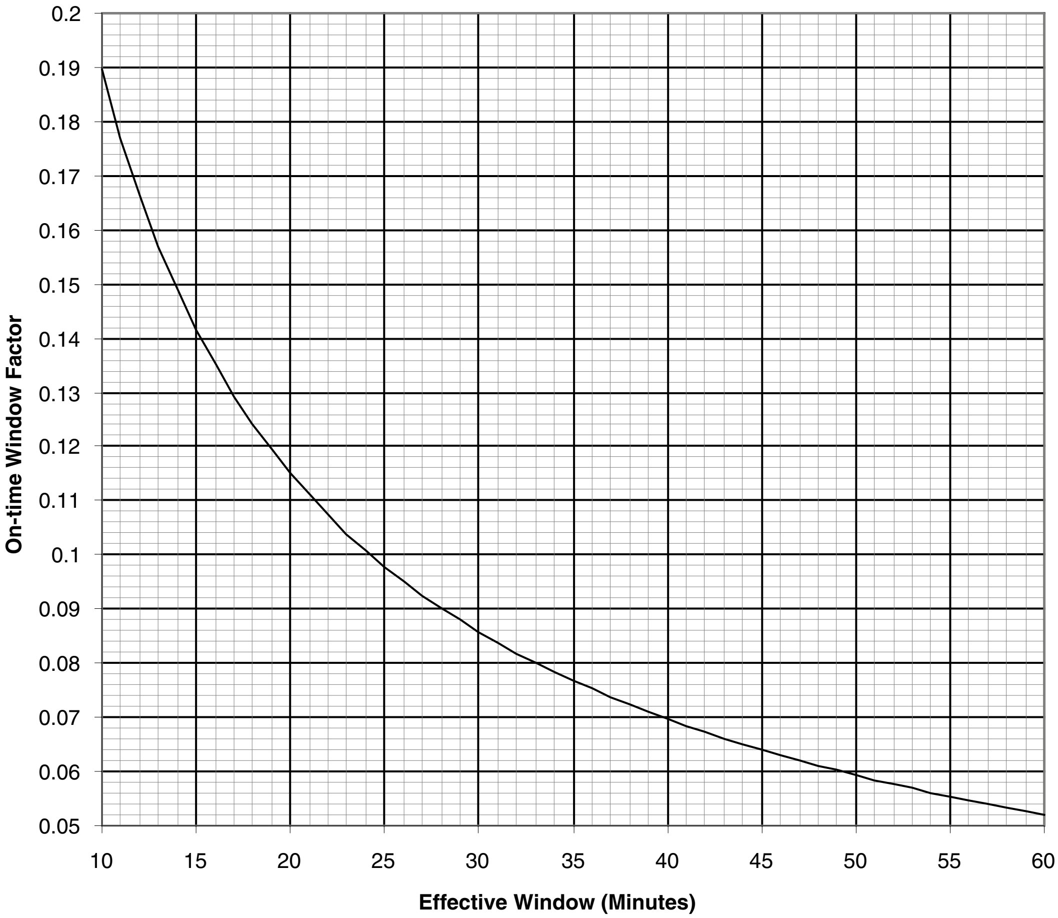
## Figure 6 Factor for Percent Found Conditionally Eligible



## Figure 7 Factor for Percent Below Poverty Level



## Figure 8 Factor for On-time Window



## Elasticities and Difference Factors

The demand model provides elasticities for some variables and “difference factors” that function in a similar way for others. These can be used to help compare two systems or, in some cases, to estimate the effect of small changes. Figure 9 shows how these factors apply to differences between systems or changes of 1%. However, applying these factors to differences much greater than 1% requires application of exponentials. It is recommended that users consult the graphs in Figures 5 through 8. For example, ridership with a $1.50 fare and ridership with a $2.00 fare can be compared as follows:

From Figure 4, the factor for a base fare of $1.50 is 0.73.

From the same figure, the factor for a base fare of $2.00 is 0.59.

All else being equal, a system with a $2.00 base fare would be expected to have ridership 0.59/0.73 = 0.81 times that of a system with a $1.50 base fare.

**Figure 9 Elasticities and Different Factors**

| Variable | Elasticity | Factor | Interpretation |
|---|---|---|---|
| Base Factor | -0.77 | | A 1% higher base fare (e.g., $2.02 vs. $2.00) corresponds to 0.77% less demand. |
| Percent Conditionally Eligible | -0.29 at the mean | | A 1% higher percent found conditionally eligible compared to the mean value of 21% (21.21% vs. 21%) corresponds to 0.29% less demand. |
| | | 1.39 | A 1% greater percentage of applicants found conditionally eligible (e.g., 31% vs. 30%) corresponds to 1.39% less demand. |
| Conditional Trip Screening | | 48% | Systems that use conditional trip screening have 48% lower demand than other systems. |
| Percent below Poverty | -0.90 at the mean | | A 1% higher poverty rate compared to the mean value of 13% (13.13% vs. 13%) corresponds to 0.90% less demand. |
| | | -6.6 | A 1% higher percentage of the population below the poverty level (e.g., 16% vs. 15%) corresponds to 6.6% less demand. |
| Effective Window | -0.72 | | A 1% wider effective window (e.g., 30.3 minutes vs. 30 minutes) corresponds to 0.72% less demand. |

## Formula-Based Estimation

For those who are comfortable with mathematics, a formula is provided that is the basis of the other tools. Most users will probably prefer to use the graphical tools, the spreadsheet provided with the handbook, or the elasticities and difference factors.

Based on the experience of 28 representative systems, a formula that predicts demand for ADA complementary paratransit trips as of 2005 is given in Figure 10.

- In this formula, "exp" refers to exponentiation, that is, "e" (the base of the natural logarithms) raised to the power of the term in parenthesis.
- All of the population data should be from the 2000 U.S. Census.
- All of the population data should be for the actual area served by ADA paratransit. Depending on service policies, this may be just the area three-quarters of a mile around fixed-route service or a larger area. It is critical that the actual ADA service area be used, or an area as close as possible to the actual ADA service area.
- Base Fare = the full cash fare for an ADA paratransit trip before any discounts for advance purchase or use of a monthly pass, and before adding any zone charges.
- The percent of applicants found conditionally eligible = 100 x (the number of people found eligible with conditions) ÷ (the number of people who apply for ADA paratransit eligibility). The most recent full year of eligibility statistics should be used.
- Conditional trip determination = 1 if trip-by-trip determination based on conditions of eligibility is done, 0 otherwise.
- Percentage below the poverty rate = 100 x (the number of people in households with incomes below the poverty rate in the area actually served by ADA paratransit as reported in the 2000 U.S. census) ÷ (the ADA service area population).
- Effective On-time Window = the total variation in pick-up time, before or after the last time that was given to the customer, before the trip is no longer counted as being "on-time." For example, if a vehicle is considered late beginning 20 minutes after the promised time, but customers are expected to be ready 10 minutes before the promised time, then the "effective window" is 30 minutes. Similarly, if pick-up times can be changed by up to 10 minutes without informing the customer, then the effective window may need to be adjusted.

**Figure 10 Formula for Predicting Demand**

ADA Paratransit Trips per Year = (Total ADA Service Area Population)

x 3.463

x (Base Fare)$^{-0.772}$

x exp (1.385 x (Percent of Applicants Found Conditionally Eligible/100))

x exp (-0.662 x (Conditional Trip Determination))

x exp (-6.633 x (Percent of Population below Poverty/100))

x (Effective On-time Window)$^{-0.722}$

CHAPTER 1

# Introduction and Highlights

This report presents a "sketch planning model" of ADA paratransit demand, based on aggregate, cross-sectional modeling of system-level data. This model predicts total system ridership from factors such as population, fare levels, and so forth. The report also describes a process of exploring data needs and availability for producing a disaggregate model, whether in a future project or in a continuation of this one. Such a disaggregate model would use travel data from individual people, including paratransit riders and others, to estimate equations that predict individual travel choices.

The project panel approved the sketch planning approach because of (a) the difficulty and expense of obtaining sufficient data for a disaggregate model and (b) the need to produce a usable tool as an immediate product of this research. The sketch planning model is a first step in understanding the travel behavior of people with disabilities. At the same time, it is understood that many smaller communities will use only the sketch planning model since any eventual disaggregate model may require data and technical abilities that are beyond their resources.

The sketch modeling process has produced a regression model for annual ADA paratransit trips that appears stable and likely to provide useful predictions. The model includes the effects of six variables:

1. ADA paratransit service area population.
2. Base fare for ADA paratransit.
3. Percentage of applicants for ADA paratransit eligibility found conditionally eligible (i.e., with conditions).
4. Whether or not trip-by-trip screening based on conditions of eligibility is used.
5. Percent of service area population with household incomes below the poverty line.
6. The effective window used to determine on-time performance (i.e., the window from the passenger's point of view including requirements to be ready early and adjustments made in the scheduling process that may not be communicated to passengers).

The model shows how strongly each of these variables influences paratransit demand. Some results of interest include the following:

- Paratransit demand appears to be sensitive to fares, possibly more so than is fixed-route transit ridership.
- Areas with higher poverty rates have much less ridership than areas with lower poverty rates. The strength of this factor is surprisingly high, but it is statistically very significant and does not appear to be due to any unusual cases in the sample.
- Conditional trip screening is connected with significantly lower ridership.

Intensity of fixed-route transit service, measured as revenue vehicle miles (RVM) of service per capita, was nearly significant. Greater intensity of transit service is associated with higher levels of paratransit ridership. This effect, while not clear enough for use in a demand estimation tool, is important because of its implications for research.

Telephone hold time could not be included in the model because many systems do not measure it. However, exploratory analysis indicates that long average hold times are probably connected with lower ridership.

A variety of tools have been developed for applying the model results, including a spreadsheet, a calculation form using factors read from graphs, and elasticities and difference factors for all of the variable.

The report includes a detailed discussion of long-term factors that are likely to affect demand for ADA paratransit and options for developing more disaggregate tools than the ones that this project has produced. A research agenda is provided that suggests further exploration in several areas, including some of the more surprising results of the regression analysis.

CHAPTER 2

# Data Sources

The sketch planning model is based on actual paratransit demand and other data for 28 "representative systems." This section describes the process for selecting these systems, the specific service area and paratransit system data that were used, and the process for collecting the data.

## Representative Systems

The original project concept called for using data from "transit systems considered exemplary for providing transit services in accordance with ADA requirements and best practices in the transit industry." As the team investigated candidate systems for use in the research and discussed these systems with riders and advocates, the term "exemplary" came into question.

The systems used in the model development are definitely much above average, and all are believed to be in compliance with ADA paratransit requirements regarding capacity constraints. Systems were sought where demand is representative of demand that will occur when a system is in compliance and doing a good job of providing service. However, it is entirely possible that to some members of the eventual audience for this research, the term "exemplary" would imply a degree of excellence that goes beyond actual performance at some of the systems. A system can be meeting the letter and spirit of the law yet be providing a service that falls short of many users' desires for public transportation.

Further, some of the systems may not be using state-of-the-art eligibility methods, and the status of fixed-route accessibility may vary considerably among systems. It was also recognized that passenger perceptions of on-time performance may vary considerably, especially considering the variations in on-time windows in use. Finally, the investigations of the systems done for this research are necessarily limited in scope, so the possibility cannot be ruled out that service or compliance issues exist that have not been identified.

Twenty-nine representative systems were chosen for use in model development. These 29 were chosen after beginning with 88 candidate systems identified by respondents to a preliminary survey about factors influencing the demand for ADA paratransit. Candidate systems were contacted to determine their interest in participating in the research. Forty-eight systems either declined to participate or never responded to inquiries.

The research team investigated whether the remaining 40 candidate systems met the criterion of "no significant capacity constraints." This investigation emphasized obtaining input from ordinary riders as well as advocates. The transit systems were asked to provide names and contact information for riders. In addition, contact information was obtained independently using referral by panel members, local disability organizations, and contacts developed by the research team in previous work.

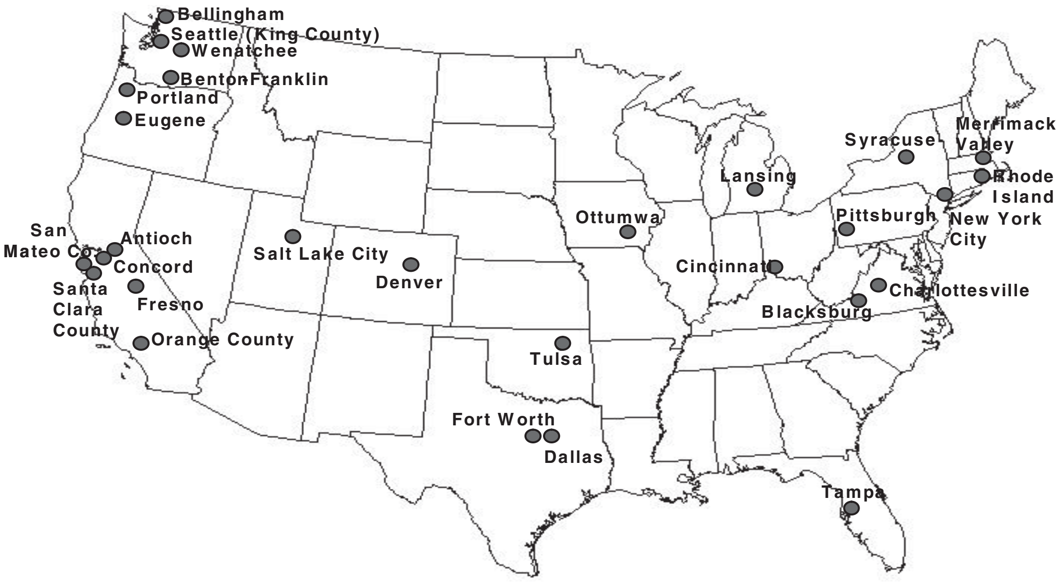
Using these sources, the researchers interviewed at least one and often two or three riders (and in one case, six riders) from each candidate system. The riders were asked about ability to get through on the phone to make reservations, trip denials, trip purpose rules, and on-time performance. In discussing trip denials, riders were specifically asked about trips negotiated over an hour from the requested time and ability to get a trip in response to a request 1 day in advance. In the case of transit systems that operate ADA and other paratransit services (for example, coordinated human service transportation), the riders were asked to distinguish ADA service from other service. As a result of this process, 11 candidate systems were removed from the list, leaving 29 "representative systems." One system was eliminated later after no data were obtained to use in modeling.

Exhibit 2-1 is a list of the 28 representative systems used in the research. Exhibit 2-2 shows the location of all the representative systems. The Midwest and South are somewhat under-represented. To remedy this, the team attempted to add one more system in Florida, one in Illinois, one more in Iowa, two in Kansas, two more in Michigan, three in North Carolina, one more in Ohio, one in South Carolina, one more in Texas, one more in Virginia, and two in Wisconsin. All these systems either declined, did not respond to multiple calls, or were eliminated after investigation.

**Exhibit 2-1. List of representative systems.**

| | | | |
|---|---|---|---|
| 1. | Ben Franklin Transit | Richland | WA |
| 2. | BT Access - Blacksburg Transit | Blacksburg | VA |
| 3. | Capital Area Transportation Authority | Lansing | MI |
| 4. | Central Contra Costa Transit Authority | Concord | CA |
| 5. | Dallas Area Rapid Transit (DART) | Dallas | TX |
| 6. | Eastern Contra Costa Transit Authority | Antioch | CA |
| 7. | Fort Worth Transportation Authority (The T) | Fort Worth | TX |
| 8. | Fresno Area Express | Fresno | CA |
| 9. | Hillsborough Area Regional Transit Authority | Tampa | FL |
| 10. | JAUNT | Charlottesville | VA |
| 11. | King County Metro | Seattle | WA |
| 12. | Lane Transit District | Eugene | OR |
| 13. | Link Transit | Wenatchee | WA |
| 14. | Merrimack Valley RTA | Lawrence-Haverhill | MA |
| 15. | Metropolitan Tulsa Transit Authority | Tulsa | OK |
| 16. | New York City Transit | New York | NY |
| 17. | Orange County Transportation Authority | Anaheim | CA |
| 18. | Ottumwa Transit System | Ottumwa | IA |
| 19. | Port Authority of Allegheny County (Access) | Pittsburgh | PA |
| 20. | Regional Transportation District | Denver | CO |
| 21. | Rhode Island Public Transit Authority | Providence | RI |
| 22. | San Mateo County Transit District (SamTrans) | San Mateo County | CA |
| 23. | Southwest Ohio Regional Transit Authority / The Metro | Cincinnati | OH |
| 24. | Central New York Regional Transportation Authority | Syracuse | NY |
| 25. | Tri-Met | Portland | OR |
| 26. | Utah Transit Authority | Salt Lake City | UT |
| 27. | Valley Transportation Authority | San Jose | CA |
| 28. | Whatcom Transportation Authority | Bellingham | WA |

**Exhibit 2-2. Location of representative systems.**




## Measures and Data Sources

The principal sources of data for the sketch planning model were a questionnaire sent to the representative systems and the U.S. Census. Because of the small number of systems to be used in this analysis, it was understood that it would be possible to include only the most important and clearly measurable factors in the model. Initially 37 factors were identified that could potentially be included in a system-level model. A shorter list of factors, shown in Exhibit 2-3, was selected for data collection along with specific measures and data sources based on the following:

- Ratings from a survey of 160 paratransit professionals, researchers, advocates, and riders about factors that affect demand for ADA paratransit (see Appendix C).
- Theoretical considerations and empirical evidence obtained from a comprehensive literature review.
- Data availability.
- Input from the project panel.

Non-ADA paratransit trips (Factor 2) include (1) subsidized taxi trips, even if they are limited to ADA-eligible individuals, that do not comply with ADA service criteria such as limits on number of trips, fare, etc.; and (2) trips provided using eligibility criteria other than ADA eligibility, for example, under senior transportation programs.

Human service trips (Factors 3 and 4) include trips sponsored by Medicaid, workshops and training programs serving people with developmental disabilities, adult day care and adult day health care, and senior meal programs.

The Census questions about disability mentioned in the last item (Factor 18) are as follows:

Question 16. Does this person have any of the following long-lasting conditions:

a. Blindness, deafness, or a severe vision or hearing impairment?
b. A condition that substantially limits one or more basic physical activities such as walking, climbing stairs, reaching, lifting, or carrying?

**Exhibit 2-3. Factors to be used in system-level modeling.**

| | Factor | Measure | Data Sources |
|---|---|---|---|
| 1. | ADA paratransit demand | Annual ADA complementary paratransit trips provided | Representative system questionnaire |
| 2. | Non-ADA paratransit (including subsidized taxis) provided or administered by the transit agency or a broker | Annual trips provided that are not part of ADA complementary paratransit | Representative system questionnaire |
| 3. | Overall level of human service transportation | Proportion of human service transportation needs served by human service agencies | Estimates of transit agency and state level staff |
| 4. | Human service transportation provided or administered by the transit agency or a broker | Annual trips provided for human service agencies, whether or not under a formal arrangement | Representative system questionnaire |
| 5. | Accessible public transit service | Annual vehicle miles of transit service<br>Percentage of revenue vehicles that are ADA accessible<br>Wheelchair boardings, if available | Representative system questionnaire |
| 6. | ADA paratransit on-time performance | Percent of pick-ups after the window<br>Length of on-time window | Representative system questionnaire |
| 7. | ADA paratransit telephone access | Average hold time to make a reservation | Representative system questionnaire |
| 8. | ADA paratransit eligibility process | Percent of applicants interviewed or tested in-person | Representative system questionnaire |
| 9. | ADA paratransit fare | Average fare per passenger | Representative system questionnaire |
| 10. | Length of time since significant denials were eliminated | Months from the last significant denials to the middle of the fiscal year for which data is provided | Representative system questionnaire |
| 11. | Exact geographic definition of the ADA paratransit service area | Maximum extent of service at peak hours | Transit system GIS data or maps |
| 12. | Total service area population | Total population in the service area | Geographic definition of service area combined with U.S. Census |
| 13. | Age and sex distribution of the service area population | Male and female population in the service area age 65+ and age 75+ | Geographic definition of service area combined with U.S. Census |
| 14. | Ethnic composition of the service area population | Non-white or Hispanic population in the service area | Geographic definition of service area combined with U.S. Census |
| 15. | Climate | Mean annual snowfall or days with measurable snowfall | National Climatic Data Center |
| 16. | Household income | Total population in the service area with 1999 household income below the poverty level | Geographic definition of service area combined U.S. Census |
| 17. | Density and/or car ownership | Population per square mile within the service area<br>Percent of housing units in the service area with no vehicle available | Geographic definition of service area combined U.S. Census |
| 18. | Disability | Census long form questions 16a and b, 17a | Geographic definition of service area combined U.S. Census |

Question 17. Because of a physical, mental, or emotional condition lasting 6 months or more, does this person have any difficulty in doing any of the following activities:

a. Learning, remembering, or concentrating?

As with all the Census disability questions, there is no way to know for sure how answers are related to degrees of disability. These three questions do cover the principal functional abilities for transit use. They also include some issues that generally do not result in ADA paratransit eligibility, such as deafness and difficulty lifting. Still, it is likely that incidence of disability as measured by these questions is highly correlated with ADA paratransit eligibility, at least at the level of large geographic areas.

In addition to the questions listed, the Census included a question about "go outside the home disability." Panel members questioned the relevance of this question, noting that it was intended to measure the need for in-home care. In addition, Census staff have determined that go outside the home disability appears to have been substantially overstated in the 2000 Census, most likely as a result of a confusing skip pattern in the mail-back version of the long form.[1]

All of the population measures were for an area corresponding as closely as possible to the actual ADA paratransit service area. In a few cases, this area may correspond closely to a division, such as a city or county, for which published Census tabulations are available. In most cases, the area served, consisting of points within three-quarters of a mile of transit routes, corresponds to some combination of numerous Census tracts or block groups. If maps of the ADA service area are available, ideally as geographic files from a geographic information system (GIS), these can be combined with Census data sets to compute the desired measures. This process can be somewhat time consuming, but it is very important, since the population of the ADA service area may be very different than the population of the urbanized area normally reported by transit systems to the National Transit Database.

## Data Collection

The data collection process began in October 2005. A data collection form for the representative transit systems was created in Microsoft Word. The form was designed so that transit agency staff could complete the form within Word and return it as an e-mail attachment. On October 20, 2005, a draft of the form was provided to the panel for comment. After obtaining comments from one panel member, a draft of the form was provided to two agencies to obtain their comments and their estimate of the time that it would take to complete. Based on their input, further refinements were made, after which the Principal Investigator sent an e-mail to all 29 representative systems, reminding them about the project and alerting them to expect a form from Planners Collaborative that would take about 2 hours to complete. Planners Collaborative sent the form on November 2, 2005, requesting responses by November 18.

The first response came the following day. However, by November 18 only 13 completed forms had been received, with promises of five more. At this point, the process began of sending reminder e-mails and making phone calls. Follow-up contacts also began at this time, in particular to obtain the best possible information about service area, which is critical to developing usable demographic information for the modeling process. As of the end of December 2005, responses had been received from 28 of the 29 representative systems, including three systems that provided data for multiple years. The data collection process was completed over the next

[1] Sharon Stern and Matthew Brault, "Disability Data from the American Community Survey: A Brief Examination of the Effects of a Question Redesign in 2003," Feb. 2005. At http://www.census.gov/hhes/www/disability/ACS_disability.pdf.

**Exhibit 2-4. Methods used for creating GIS files.**

| Methods Used | Number of Transit Systems |
|---|---|
| Sent GIS layers that could be matched to Census data. | 15 |
| Provided a list of jurisdictions from which it was possible to compute the necessary population measures. | 7 |
| Sent maps of their service area in pictorial form from which approximate GIS layers could be created. | 3 |
| Described their service areas as consisting of one jurisdiction plus areas around one or two routes, for which it was necessary to create an approximate GIS layer. | 2 |
| One system sent screen prints from its scheduling system. These were not usable, but a paper copy of the bus route book was available from which it was possible to create an approximate GIS layer. | 1 |
| **Total:** | **28** |

3 months, resulting in usable data from 28 of the 29 representative systems, including three systems that provided data for multiple years. Activities included the following:

- Creating GIS files to describe the ADA service area of each system. As described below, some systems sent GIS files, some sent lists of jurisdictions, and some sent graphics of their service area. Some of these required interpretation and personal follow-up with the respondents. Eventually, GIS files were created for all 28 systems.
- Analyzing Census data to calculate values for all the desired demographic variables specific to each system's ADA paratransit service area.
- Working with the respondents to clarify responses, in particular with respect to definitions of on-time performance. Follow up inquiries were made about 33 data items from 16 systems.
- Sending a supplementary questionnaire concerning human service transportation and non-ADA paratransit to all 28 systems. This questionnaire was sent to the panel for their review and comment at the end of January 2006. One panel member responded with several suggestions that were incorporated into the supplemental questionnaire. Several systems responded that they did not have the information requested. In these cases information was sought from other contacts, typically in state government. Only one of these non-transit agency contacts yielded a response.
- Compiling information about snowfall from the National Climatic Data Center.

As expected, a particularly time-intensive activity was obtaining a description of the ADA paratransit service area suitable for estimating the size of the population served and the number of people in various subcategories. The methods used are summarized in Exhibit 2-4.

In some cases, the GIS layers were specific to paratransit, while in others they were for the fixed-route system, from which three-quarter-mile buffers were created. In one case the layer was approximate and needed to be adjusted based on knowledge of the area.

As described in the section about model development, further data collection was necessary after preliminary regression analysis led to identifying data that was incomplete or incorrect.

CHAPTER 3

# Preliminary Data Analysis

Before estimating regression equations, the data to be used are reviewed. This section provides summary statistics for all the data items collected and identifies issues that could affect the modeling process. These issues include data items that could not be obtained from some representative systems, data items that needed to be modified or combined in some way in order to be suitable for regression analysis, and data items that are correlated with each other in ways that could affect the regression analysis.

## Summary Statistics

Exhibits 3-1 through 3-6 provide summary statistics for the data items that were collected and are potentially relevant to estimating a system-level model of ADA paratransit ridership. (Contact data, non-quantitative data, and data about possible disaggregate modeling are not included.) "Base fare" was not part of the original list of required items, but was added after problems with the data for "average fare per passenger" were discovered. It is the full cash fare for an ADA paratransit trip before any discounts for advance purchase or use of a monthly pass, and before adding any zone charges. A number of data items were not obtained from a significant number of respondents and therefore cannot be used for modeling without unacceptably reducing the size of the already-small sample. These include the following:

- Total ADA-certified rider trips. This differs from "total ADA paratransit trips" by excluding trips by attendants and companions.
- Agency ADA trips. These are trips included within the count of total ADA paratransit trips that bring clients to agency services. Many agencies keep no records about this, even though trips to agency programs do account for much of their demand.
- Average time on hold. Smaller systems that do not have automatic call distributors either do not have this information or provided only rough estimates. Although this variable could not be included in the model, an exploratory analysis was conducted, which is described at the end of Chapter 4.
- Length of time since significant denials were eliminated.
- Whether human service agencies provide at least 25% of the transportation needs of clients to come to agency services. Many agencies either never responded to the supplemental questionnaire on this topic or answered "don't know" to the questions. Attempts to gather the same data from state-level contacts were not successful.

Many respondents also did not provide any data about non-ADA services such as supplementary taxi service or paratransit available to seniors regardless of disability. In this case, however, it was assumed that no response meant that no such service was provided, so a total of non-ADA service was computed for all representative systems. Note, however, that, in each category of non-ADA service, one-fourth or less of representative systems reported providing any trips. A

**Exhibit 3-1. Trip data.**

| | Valid N | Non-Zero N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Total ADA paratransit trips | 28 | 28 | 11,327 | 3,982,892 | 469,028 | 753,715 |
| ADA paratransit trips per capita | 28 | 28 | 0.08 | 1.86 | 0.60 | 0.48 |
| Total ADA certified rider trips | 21 | 28 | 11,131 | 2,877,476 | 394,591 | 631,876 |
| Agency ADA trips | 13 | 13 | 1,562 | 764,000 | 101,087 | 206,682 |
| Agency non-ADA trips | 27 | 8 | 0 | 1,137,128 | 93,399 | 260,687 |
| Taxi non-ADA trips | 18 | 4 | 0 | 50,314 | 7,498 | 16,403 |
| Senior non-ADA trips | 16 | 6 | 0 | 524,642 | 35,564 | 130,524 |
| Other non-ADA trips | 15 | 7 | 0 | 117,004 | 21,022 | 34,986 |
| Total non-ADA Trips | 28 | 12 | 0 | 524,642 | 36,405 | 102,182 |

**Exhibit 3-2. Fare and service quality data.**

| | Valid N | Non-Zero N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Total ADA fare revenue | 28 | 28 | $2,700 | $5,903,677 | $805,548 | $1,297,631 |
| Fare per passenger | 28 | 28 | $0.18 | $4.35 | $1.78 | $1.04 |
| Base fare | 28 | 28 | $0.50 | $3.50 | $1.81 | $0.84 |
| Effective on-time window* | 28 | 28 | 10 | 60 | 30.4 | 10.0 |
| Percent of pick-ups on-time | 28 | 28 | 79.8% | 99.1% | 92.2% | 4.9% |
| Do they track drop-off on-time performance? | 28 | | | | 25.0% | |
| Average time on hold (m:ss) | 24 | 24 | 0:15 | 3:00 | 1:08 | 0:38 |

*Effective On-time Window = the total variation in pick-up time, before or after the last time that was given to the customer, before the trip is no longer counted as being "on-time." For example, if a vehicle is considered late beginning 20 minutes after the promised time, but customers are expected to be ready 10 minutes before the promised time, then the "effective window" is 30 minutes. Similarly, if pick-up times can be changed by up to 10 minutes without informing the customer, then the effective window may need to be adjusted. This measure was determined by combining responses about the advertised window and about scheduling practices.

**Exhibit 3-3. Eligibility data.**

| | Valid N | Non-Zero N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Percent tested | 28 | 20 | 0% | 100% | 52% | 45% |
| Percent fully eligible | 28 | 28 | 13% | 100% | 72% | 25% |
| Percent conditionally eligible | 28 | 21 | 0% | 79% | 21% | 23% |
| Percent not eligible | 28 | 26 | 0% | 15% | 5% | 4% |
| Do they do conditional trip screening?* | 28 | | | | Yes = 46% | |

* Examples of specific conditions of eligibility used for trip-by-trip screening at the representative systems are given in Appendix B.

**Exhibit 3-4. Fixed-route service data.**

| | Valid N | Non-Zero N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Fixed-route revenue vehicle miles | 28 | 28 | 313,640 | 443,483,860 | 26,447,402 | 81,247,775 |
| RVM per capita | 28 | 28 | 3.0 | 55.4 | 14.9 | 9.5 |
| Active fixed-route fleet | 28 | 28 | 11 | 9040 | 625 | 1687 |
| Active ADA-accessible fixed-route fleet | 28 | 28 | 11 | 9040 | 620 | 1688 |
| Do they track wheelchair boardings? | 28 | | | | Yes = 46% | |

**Exhibit 3-5. ADA service area data.**

| | Valid N | Non-Zero N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|---|
| Total ADA service area population | 28 | 28 | 19,503 | 8,008,278 | 1,041,089 | 1,563,730 |
| Pct males age 65+ | 28 | 28 | 2% | 7% | 5% | 1% |
| Pct males age 75+ | 28 | 28 | 1% | 3% | 2% | 1% |
| Pct females age 65+ | 28 | 28 | 3% | 11% | 7% | 2% |
| Pct females age 75+ | 28 | 28 | 2% | 6% | 4% | 1% |
| Pct non-white or Hispanic | 28 | 28 | 6% | 65% | 32% | 17% |
| Pct population below poverty line | 28 | 28 | 3% | 33% | 13% | 6% |
| Pct of housing units with no vehicle | 28 | 28 | 5% | 56% | 11% | 9% |
| Pct with sensory disability | 28 | 28 | 1% | 5% | 3% | 1% |
| Pct with physical disability | 28 | 28 | 2% | 12% | 7% | 2% |
| Pct with mental disability | 28 | 28 | 1% | 8% | 5% | 1% |
| Service land area (square miles) | 28 | 28 | 16 | 1,803 | 357 | 375 |
| Population per square mile | 28 | 28 | 280 | 26,402 | 3,111 | 4,679 |
| Days with >.1" of snowfall | 28 | 21 | 0 | 31 | 6.6 | 7.6 |

**Exhibit 3-6. Human service agency transportation data.**

| | Valid N | Percent "Yes" |
|---|---|---|
| Do agencies provide some DD/MR trips? | 20 | 85% |
| Do agencies provide some ADC trips? | 20 | 65% |
| Do agencies provide some senior meal trips? | 20 | 55% |
| Do agencies provide some dialysis trips? | 18 | 39% |
| Do agencies provide some Medicaid trips? | 17 | 76% |

small number of non-zero observations is a concern for regression analysis. Results based on such variables are, in effect, based on a very small number of observations. All of these variables, except for those about human service agency transportation, have been excluded from further analysis.

The summary data about human service agency transportation are a compilation of responses. Respondents were asked, "Thinking of human service agencies in your ADA paratransit service area, to the best of your knowledge, what portion of the transportation needed by their clients to agency programs or services do the agencies provide or pay for?" They were asked to respond using categories of 0%, 25%, 50%, 75%, and 100%.

A preliminary statistical analysis was conducted to determine how to use these responses using regression on total ADA paratransit trips per capita. It was found that systems that gave non-zero responses have significantly higher ADA paratransit trips per capita than systems that gave zero responses (i.e., agencies serve none of their clients' transportation needs). The differences were significant with 95% confidence for Developmental Disabilities/Mental Retardation (DD/MR) and Adult Day Care (ADC) trips and 90% confidence for Senior Meals and Dialysis trips. However, there was no discernable difference based on the specific non-zero responses (i.e., whether respondents believe that the agencies provide 25%, 50%, 75%, or 100% of the needed trips). The full analysis is shown in Exhibit 3-7.

**Exhibit 3-7. Exploratory analysis of human service agency transportation variables.**

| *Y* variable = Total ADA trips per capita | R-squared | Parameter Estimate | Standard Error | *t* value | Pr > \|*t*\| | Pr > F |
|---|---|---|---|---|---|---|
| Full Model | 0.2439 | | | | | 0.2562 |
| Percent of DD/MR_0 | | 1.33392 | 0.5662 | 2.36 | 0.0278 | |
| Percent of DD/MR_25 | | 0.40957 | 0.32554 | 1.26 | 0.2215 | |
| Percent of DD/MR_50 | | 0.03963 | 0.5662 | -0.07 | 0.9448 | |
| Percent of DD/MR_75 | | 0.07713 | 0.48285 | -0.16 | 0.8745 | |
| Percent of DD/MR_100 | | 0.04344 | 0.76346 | 0.06 | 0.9551 | |
| Full Model | 0.2804 | | | | | 0.1731 |
| Percent of Adult Day Care _0 | | 0.91312 | 0.37241 | 2.45 | 0.0226 | |
| Percent of Adult Day Care _25 | | 0.06093 | 0.34334 | 0.18 | 0.8608 | |
| Percent of Adult Day Care _50 | | 0.08728 | 0.74482 | -0.12 | 0.9078 | |
| Percent of Adult Day Care _75 | | 0.24394 | 0.47106 | -0.52 | 0.6097 | |
| Percent of Adult Day Care _100 | | 0.02009 | 0.74482 | -0.03 | 0.9787 | |
| Full Model | 0.2001 | | | | | 0.2533 |
| Percent of Senior Meals _0 | | 0.71651 | 0.35404 | 2.02 | 0.0548 | |
| Percent of Senior Meals _25 | | 0.22775 | 0.38401 | 0.59 | 0.5589 | |
| Percent of Senior Meals _50 | | 0 | . | . | . | |
| Percent of Senior Meals _75 | | 0.05928 | 0.56958 | -0.1 | 0.918 | |
| Percent of Senior Meals _100 | | 0.18518 | 0.48574 | -0.38 | 0.7065 | |
| Full Model | 0.1539 | | | | | 0.2518 |
| Percent of Dialysis _0 | | 0.58255 | 0.32053 | 1.82 | 0.0817 | |
| Percent of Dialysis _25 | | 0.30373 | 0.47782 | 0.64 | 0.531 | |
| Percent of Dialysis _50 | | 0.12674 | 0.42833 | -0.3 | 0.7698 | |
| Percent of Dialysis _75 | | 0 | . | . | . | |
| Percent of Dialysis _100 | | 0 | . | . | . | |
| Full Model | 0.0928 | | | | | 0.8085 |
| Percent of Other Medicaid _0 | | 0.43946 | 0.6026 | 0.73 | 0.4735 | |
| Percent of Other Medicaid _25 | | 0.25861 | 0.50816 | 0.51 | 0.6159 | |
| Percent of Other Medicaid _50 | | 0.14943 | 0.6026 | 0.25 | 0.8065 | |
| Percent of Other Medicaid _75 | | 0.44547 | 0.50816 | -0.88 | 0.3902 | |
| Percent of Other Medicaid _100 | | 0.19752 | 0.4175 | -0.47 | 0.6408 | |
| Full Model | 0.0298 | | | | | 0.6852 |
| Percent of Other_0 | | 0 | . | . | . | |
| Percent of Other_25 | | 0 | . | . | . | |
| Percent of Other_50 | | –0.41326 | 0.78491 | -0.53 | 0.6032 | |
| Percent of Other_75 | | 0 | . | . | . | |
| Percent of Other_100 | | 0.37964 | 0.56559 | 0.67 | 0.5082 | |

Despite the prevalence of missing data, the human service agency transportation variables were kept in the analysis because of their obvious importance from a policy point of view. In order to avoid unacceptable loss of sample size, systems which did not respond or which responded "don't know" were grouped with those that gave responses of 0%. This admittedly rough assumption is based on the reasoning that, if human service agencies were organized to provide significant amounts of transportation, paratransit staff would be likely to know about it.

The data were examined for extreme values that would tend to skew model results. Three variables were identified as problematic, even after normalizing observations on a per-capita basis:

- Percent of housing units with no vehicle available.
- RVM of fixed-route service per capita.
- Non-ADA trips per capita.

The most extreme situation involves "percent of housing units with no vehicle available." The mean value for this variable is 11%. The maximum is 56% represented by New York City. The next highest observation is 16%, represented by the Port Authority of Allegheny County (Pittsburgh) and the Southwest Ohio Regional Transit Authority (Cincinnati). If this variable is included in the model, the coefficient that is estimated for it will mainly show the difference between New York City and all other systems, rather than differences among the majority of systems.

For "revenue vehicle miles of fixed-route service per capita," New York City is again the extreme case with a value of 55.4 compared to a mean of 14.9. The situation is not as extreme as for the no-vehicle variable, since there are four systems with values of 20 or more (King County, WA; Wenatchee, WA; Pittsburgh, PA; and Portland, OR). In addition, this variable is one that lends itself to transformation using logarithms; when this is done, the problem of extreme values is greatly reduced.

For "Non-ADA trips per capita" Ottumwa, IA and Charlottesville, VA (JAUNT) stand out from the rest (as shown below):

| System | Non-ADA Trips per Capita |
|---|---|
| Ottumwa Transit Authority | 1.75 |
| JAUNT, Inc. | 1.14 |
| Port Authority of Allegheny County | 0.38 |
| Capital Area Transportation Authority | 0.23 |
| Eastern Contra Costa Transit Authority | 0.11 |
| King County Metro Transit | 0.10 |
| Merrimack Valley Regional Transit Authority | 0.10 |
| Central New York Regional Transportation Authority | 0.09 |
| Lane Transit Agency | 0.04 |
| Regional Transportation District | 0.02 |
| Southwest Ohio Regional Transit Authority | 0.02 |
| All others (17 systems) | 0 |

## Correlation Analysis

As a next step, Exhibit 3-8 shows how each variable of interest correlates with total ADA paratransit trips per capita. Trips per capita is used because of the great variation in population among the representative systems, ranging from Ottumwa, Iowa, with a population of 19,503 to New York City with a population of 8,008,278. Other variables that are clearly related to city size

**Exhibit 3-8. Correlation of potential variables with total ADA paratransit trips per capita.**

| Variable | Pearson Correlation | Significance (2-tailed)** |
|---|---|---|
| Non-ADA trips per capita | 0.21 | 0.28 |
| **Fare per passenger** | **-0.57** | **0.00** |
| **Base fare** | **-0.47** | **0.01** |
| Effective window | -0.25 | 0.21 |
| Pct on-time | -0.09 | 0.64 |
| Pct tested | -0.06 | 0.76 |
| **Pct fully eligible** | **0.47** | **0.01** |
| **Pct conditionally eligible** | **-0.42** | **0.03** |
| Pct not eligible | -0.21 | 0.28 |
| Conditional trip screening* | -0.34 | 0.08 |
| RVM per Capita | 0.14 | 0.47 |
| ADA fleet per capita | -0.04 | 0.82 |
| Track wheelchair boardings* | 0.05 | 0.80 |
| Pct males 65+ | -0.10 | 0.61 |
| Pct males 75+ | -0.06 | 0.76 |
| Pct females 65+ | -0.16 | 0.42 |
| Pct females 75+ | -0.13 | 0.50 |
| Pct non-white or Hispanic | -0.26 | 0.19 |
| Pct below poverty | -0.11 | 0.58 |
| Population per square mile | -0.15 | 0.45 |
| Pct no vehicle | -0.14 | 0.49 |
| Pct with sensory disability | 0.13 | 0.53 |
| Pct with physical disability | -0.11 | 0.59 |
| Pct with mental disability | -0.09 | 0.66 |
| Days with >-0.1" of snowfall | -0.04 | 0.83 |
| Agenda provide some DD/MR trips* | -0.13 | 0.50 |
| Agencies provide some ADC trips* | -0.25 | 0.20 |
| Agencies provide some Senior Meal trips* | -0.14 | 0.47 |
| Agencies provide some Dialysis trips* | 0.02 | 0.92 |
| Agencies provide some Medicaid trips* | 0.00 | 1.00 |

*1 = Yes, No = 0

**Shaded rows are significant at 95% (?5% probability that the true correlation = 0 ) using a two-tailed test.

have been similarly stated in per capita terms, including RVM of fixed-route service, fixed-route ADA accessible fleet, and non-ADA paratransit trips.

At this preliminary stage, only four variables are significantly correlated with ADA paratransit trips per capita. They are highlighted with gray in Exhibit 3-8 and are as follows:

- Fare per passenger
- Base fare
- Percent fully eligible
- Percent conditionally eligible

In addition, whether or not conditional trip screening is used has a nearly significant correlation.

The variables that show no significant correlation all have possible relevance based on experience and theory, so they could not be eliminated. For example, it is possible that correlations not

**Exhibit 3-9. Correlations among variables.**

| Variable of Interest | Correlated Variables | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Non-ADA trips per capita | Pct non-white or Hispanic | -.44 | | | | | | |
| Fare per passenger | Base fare | .64 | Pct fully eligible | -.46 | Pct conditionally eligible | .41 | Conditional trip screening | .40 |
| Base fare | Fare per passenger | .64 | Pct below poverty | -.42 | | | | |
| Effective window | Percent on-time | .40 | | | | | | |
| Pct on-time | Effective window | .40 | All age variables | .52 - .59 | Pct with sensory disability | .53 | Pct with physical disability | .38 |
| Pct tested | None | | | | | | | |
| Pct fully eligible | Fare per passenger | -.46 | Pct conditionally eligible | -.95 | Pct not eligible | -.41 | | |
| Pct conditionally eligible | Pct fully eligible | -.95 | Fare per passenger | .41 | Pct fully eligible | -.95 | | |
| Pct not eligible | Pct fully eligible | -.41 | RVM per capita | .41 | Pct no vehicle | .39 | | |
| Conditional trip screening | Fare per trip | .40 | All age variables | .45 - .46 | | | | |
| RVM per Capita | Pct no vehicle | .81 | Total or ADA fleet per capita | .83 - .85 | Population per square mile | .80 | | |
| ADA fleet per capita | RVM per capita | .85 | Pct no vehicle | .60 | Population per square mile | .57 | | |
| Track wheelchair boardings | None | | | | | | | |

seen at this level of analysis may become evident once other factors are controlled for. To provide additional basis for considering these variables, correlations among the variables were examined.

Exhibits 3-9 and 3-10 show all the correlations among variables that were found significant with 95% significance. The correlations fall into three categories:

- **Probably Meaningful Correlations**: These correlations appear to indicate important connections among variables that would be important to include in a model. These correlations could help to explain why some variables that would be expected to show a significant impact on demand appeared not to in Exhibit 3-8.
- **Possibly Chance Correlations**: These correlations, while statistically significant, have no apparent explanation and may indicate problems with the data. With a small sample and a large number of variables, it would be expected that, on average, 5% of the possible variable combinations would have some apparent correlation in the sample, even though there is no correlation in the total population from which the sample was drawn. Such chance correlations represent a pitfall for model development, since they could result in a model that is not generalizable to systems other than those in the sample.
- **Closely Related Measures**: These correlations show that some obviously related variables are so closely connected that they should not be used together in a model. Instead one of them should be selected or they should be combined.

Examples in each of these categories are discussed next.

## Probably Meaningful Correlations

**Fare per passenger with eligibility variables:** Systems with higher than average fare per passenger tend to have fewer fully eligible riders, have more conditionally eligible riders, and are more likely to use conditional trip screening. All of these would be expected in systems that have

**Exhibit 3-10. Correlations among variables, Part 2.**

| Variables of Interest | Correlated Variables | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pct males 65+ | Pct on-time | .59 | Conditional trip screening | .45 | All age variables | >.90 | All disability variables | .61 - .74 | | |
| Pct males 75+ | Pct on-time | .54 | Conditional trip screening | .46 | All age variables | >.90 | All disability variables | .57 - .73 | Pct non-while or Hispanic | -.38 |
| Pct females 65+ | Pct on-time | .56 | Conditional trip screening | .46 | All age variables | >.90 | All disability variables | .63 - .76 | | |
| Pct females 75+ | Pct on-time | .52 | Conditional trip screening | .45 | All age variables | >.90 | All disability variables | .60 - .73 | Some senior meals | .40 |
| Pct non-white or Hispanic | Non-ADA trips per capita | -.44 | Pct males 75+ | -.38 | Population per square mile | .51 | Days with >-.1" of snowfall | -.46 | Some Medicaid | -.40 |
| Pct below poverty | Base fare | -.42 | | | | | | | | |
| Population per square mile | Pct non white or Hispanic | .51 | RVM per capita | .79 | ADA fleet per capita | .57 | Pct no vehicle | .92 | | |
| Pct no vehicle | Pct not eligible | .39 | RVM per capita | .80 | ADA fleet per capita | .60 | Population per square mile | .92 | | |
| Pct with sensory disability | Pct on-time | .53 | All age variables | .71 - .77 | All disability variables | .80 - .86 | Some Medicaid | .37 | | |
| Pct with physical disability | Pct on-time | .38 | All age variables | .57 - .63 | All disability variables | .67 - .86 | | | | |
| Pct with mental disability | Some Medicaid | .39 | All age variables | .71 - .76 | All disability variables | .67 - .80 | | | | |
| Days with >-.1" of snowfall | Pct non-white or Hispanic | -.46 | | | | | | | | |
| Some DD/MR* | All human svc vars* | -.38 -.60 | | | | | | | | |
| Some ADC* | All human svc vars* | -.37 -.60 | | | | | | | | |
| Some Senior Meals* | All human svc vars* | -.46 -.57 | Pct females 75+ | .40 | | | | | | |
| Some Dialysis* | All human svc vars* | -.37 to -.54 | | | | | | | | |
| Some Medicaid* | All human svc vars* | -.53 to -.57 | Pct with sensory disability | .37 | Pct with mental disability | .39 | Pct non-white or Hispanic | -.40 | | |

*Agencies provide some of these trips. Correlation is Kendall's Tau b focused strongly on controlling costs. However, none of these eligibility variables is correlated with the base fare.

**Base fare with poverty:** Systems in places with higher rates of poverty tend to have lower-than-average paratransit base fares. The correlation between poverty rate and the average fare per passenger is somewhat weaker and significant with only 91% confidence. These connections are reasonable and might be expected as a response to affordability issues. Since both poverty and fares are expected to influence paratransit demand, these negative correlations suggest that it is important to have both fare and poverty variables in a model. Otherwise the excluded variable could result in biased estimates for the remaining variable. The correlations, while significant, are too weak to cause unreliability in the model results.

**Effective window with percent of on-time pick-ups:** It is to be expected that systems with longer windows that define which trips can be considered on-time would be able to report a higher percentage of on-time pick-ups than systems that hold themselves to a tighter standard.

## Possibly Chance Correlations

**Percent of on-time pick-ups with age and disability variables:** Systems with higher percentages of older people or people with sensory or physical disabilities in their service areas tend to report a higher percent of on-time pick-ups. Conceivably, systems in areas with high percentages of older people or people with disabilities are more concerned with providing high-quality service. However, reported on-time performance is subject to great variation in reliability. Some systems rely entirely on driver reports or passenger complaints, while others use automated, on-board monitoring equipment. Note that the age and disability variables are not correlated with effective window, suggesting that it may perform better in a model than reported on-time performance.

**Conditional trip screening with age variables:** Systems where there are more older people are somewhat more likely to use conditional trip screening.

## Closely Related Measures

**Eligibility variables:** Percent of applicants found fully eligible is very highly correlated with the percent found conditionally eligible. This is to be expected, since most applicants will be in one of these two categories: that is, the two add up to close to 100% less those found not eligible. These two variables should not be used together. The remaining eligibility variables (percent found not eligible and whether or not conditional trip screening is used) are weakly correlated or not correlated with the others.

**Fixed-route transit and urbanization variables:** RVM of fixed-route service per capita, active fleet per capita, ADA accessible fleet per capita, population density, and the percentage of households without access to a vehicle are all strongly correlated. Lack of access to a vehicle, when measured at the level of an entire metropolitan area, appears to be more closely connected to urbanization than it is poverty. Total active fleet per capita and ADA accessible fleet per capita are very highly correlated since all but six of the systems reported 100% accessible fleets, and only three have less than 90% accessible fleets.

**All age and disability variables:** There are strong correlations among all of these variables. This suggests that the age variables, if used, should be combined—for example, as total percent of population age 65 and older. There is no easy way to combine the disability variables.

CHAPTER 4

# Model Development

The modeling process requires a choice of mathematical forms to be used in the regression procedure. This section describes the advantages and disadvantages of several mathematical forms, leading to a recommendation for the most promising ones. The results of the regression analysis are then presented. A model that predicts annual ADA paratransit trips per capita produces the best results.

## Appropriate Mathematical Forms

We have explored two principal types of regression models:

Linear:

(1) Trips = a + b (Population) + c (Factor 1) + d (Factor 2) + . . .

Logarithmic:

(2) log(Trips) = a + b(log(Population)) + c(log(Factor 1)) + d(log(Factor 2)) + . . .

In this equation, "log(Trips)" represents taking the logarithm of trips. The logarithmic form is equivalent to a multiplicative form as follows:

(3) $\text{Trips} = a \times (\text{Population})^{b} \times (\text{Factor 1})^{c} \times (\text{Factor 2})^{d} \times \ldots$

Both linear and logarithmic forms can also be used for models that predict not total trips, but trips per capita:

Linear per capita:

(4) Trips/Population = a + b (Factor 1) + c (Factor 2) + . . .

Logarithmic per capita:

(5) log(Trips/Population) = a + b(log(Factor 1)) + c(log(Factor 2)) + . . .

The logarithmic-per-capita form is equivalent to:

(6) $\text{Trips/Population} = a \times (\text{Factor 1})^{b} \times (\text{Factor 2})^{c} \times \ldots$

Notice that (3) and (6) are equivalent except for the exponent b on the Population term in (3). If b = 1 in equation (3), then the two forms are exactly equivalent. It is also possible to have mixed forms, in which some of the factors on the right-hand side appear without logarithms. Before proceeding to presentation of model specifics, some discussion of these possible forms is provided.

## Linear Model of Trips

Of the possible models, the linear form with trips (1) was eliminated. The enormous spread of values for many variables would give undue influence to a handful of cases. For example, Exhibit 4-1 shows service area population and total ADA paratransit trips for the 28 representative systems. Fitting a line to these points would essentially just connect New York City to the clump of other systems to the lower left. The position of the line would be almost entirely due to the values for New York and would tell us nothing about differences among the other systems. Eliminating New York from the analysis, in addition to losing a valuable data point, would only partially solve the problem, since a number of other large population areas would still exert undue influence.

This linear form is undesirable for other reasons as well. For example, suppose a model is produced similar to this one:

$$\text{Trips} = 0.47 \times \text{Population} - 10{,}000 \times \text{Fare}$$

The value of 10,000 for the fare term is chosen purely for the sake of illustration. This equation would say that raising fares by $1.00 would reduce ridership by 10,000 trips per year regardless of the size of the service area or the initial ridership level. But 10,000 trips would be close to a 100% change in the smallest representative systems and less than a 1% change in the four largest systems. The impact would also be same regardless of whether the fare was raised from $0.50 to $1.50 (i.e., tripled) or from $3.00 to $4.00 (a 33% increase).

## Logarithmic Model of Trips

The logarithmic model form has many advantages. One advantage is that the logarithmic transformation reduces the problem of extreme variation and extreme values in the data. For example, Exhibit 4-2 shows the same trip and population data just presented in Exhibit 4-1, except using a logarithmic scale that is equivalent to graphing log (trips) against log (population). There are still a few extreme cases, but the problem is much reduced.

**Exhibit 4-1. ADA trips and service area population (linear).**

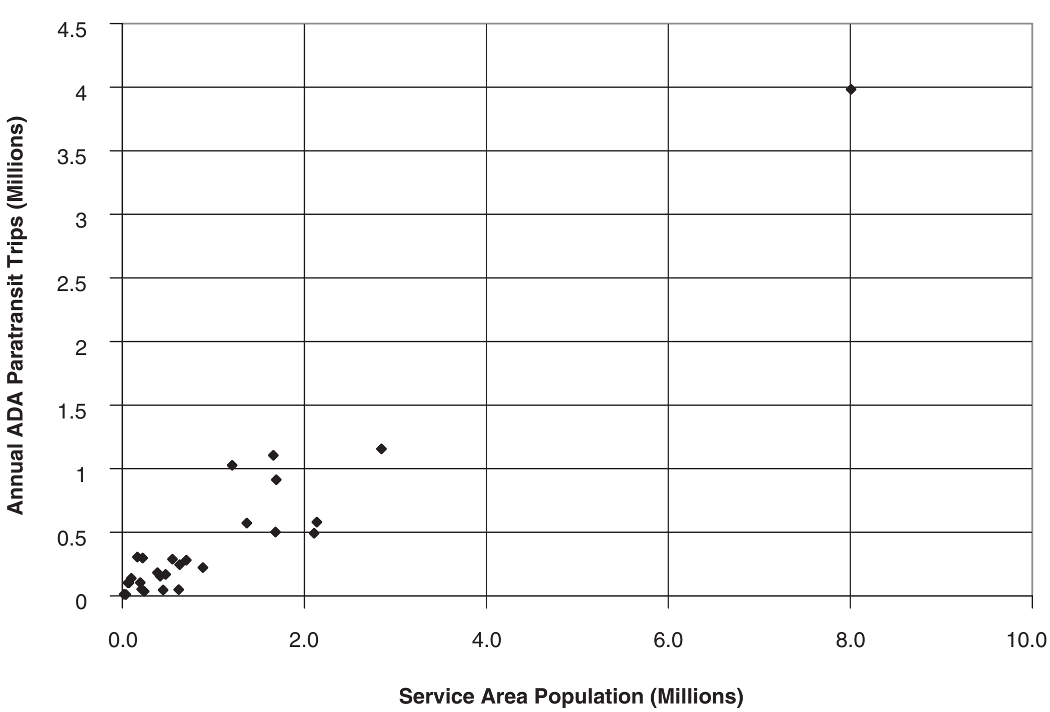
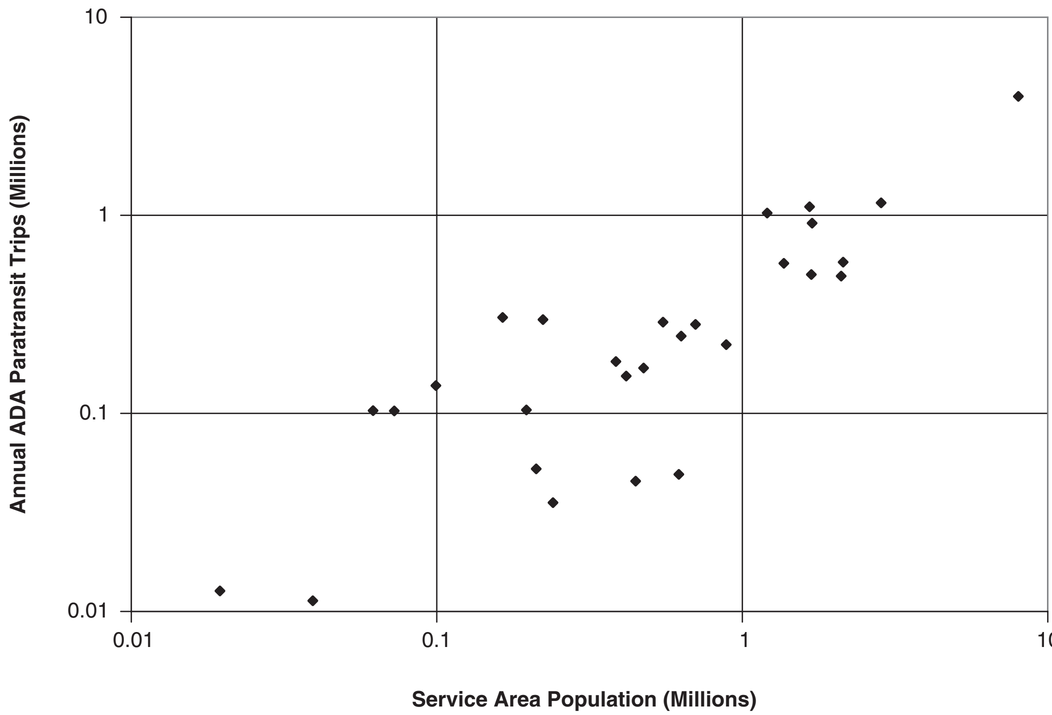


**Exhibit 4-2. ADA trips and service area population (logarithmic).**




The other major advantage of the logarithmic form is that the impacts of coefficients are, in effect, percentage increases or decreases in trips. Using the example of fare again, suppose a model is produced similar to this one:

$$\text{Log(Trips)} = 0.9 \times \log(\text{Population}) - 0.5 \times \log(\text{Fare})$$

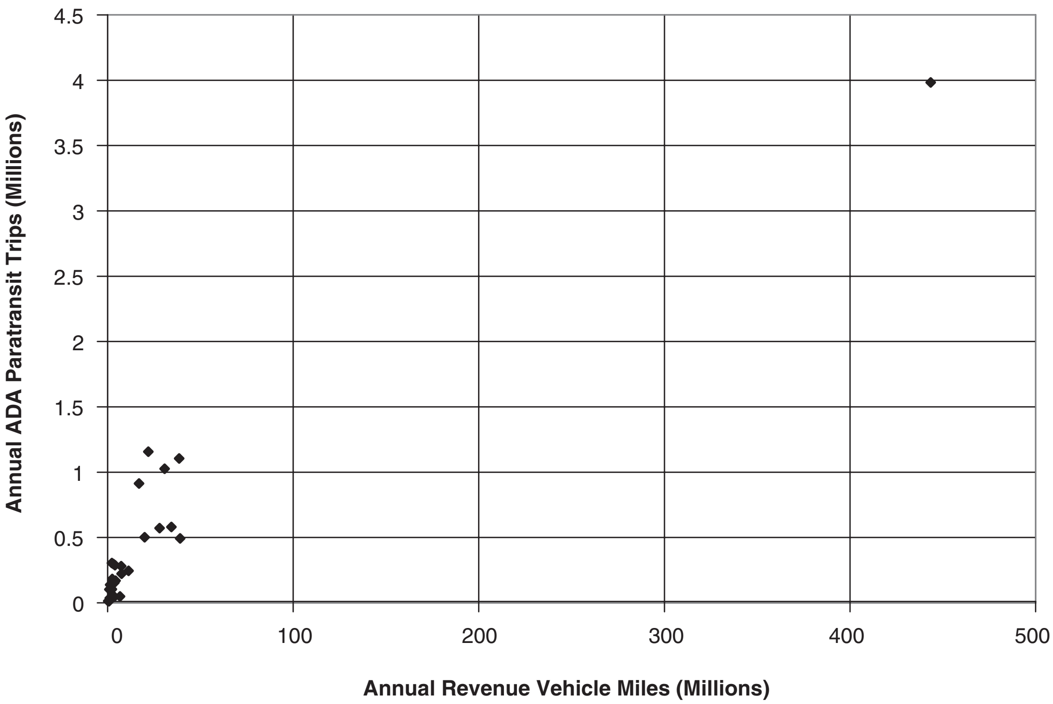
This would mean that a 10% increase in fare would result in approximately a 5% reduction in ridership. (More precisely, ridership would fall by $1 - (1.1)^{-0.5}$ or 4.7%.) This percentage change would apply equally regardless of the initial ridership level, the service area population, or the initial fare level. In other words, the model would mean that the elasticity of ridership with respect to fare is –0.5.

Either the "natural logarithm" or a base-10 logarithm can be used, but the natural logarithm is usual because it is easier to prove the interpretation of coefficients as elasticities that way.

## Per Capita Models

Transforming trips and some other variables to per capita form is also useful. Exhibits 4-3 and 4-4 illustrate this using the example of total ADA paratransit trips and revenue vehicle miles of fixed-route service. Both of these variables have one extreme case, a lot of cases clustered at lower values, and a handful of cases that are less extreme but still very different from the small systems. Plotting per-capita versions of both variables creates a much clearer view. There is still a noticeable difference between small systems, large systems, and the one very large system, but the differences are much less extreme and variation among the systems is now much easier to see. Note that population variables such as the number of people age 65 and older and the number of people in poverty become percentages of population when expressed in per-capita form—for example, the percentage of the population with incomes below the poverty line.

**Exhibit 4-3. ADA trips and revenue vehicle miles.**

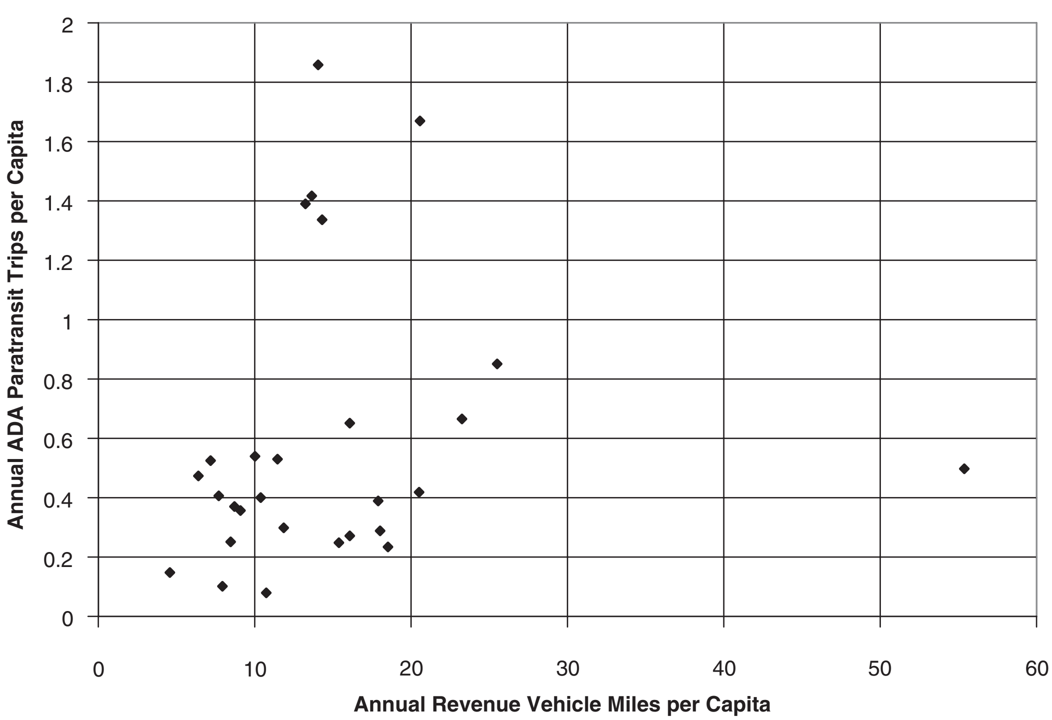



Some variables, such as fare, do not need to be put in per-capita form. Models that predict ADA trips per capita would probably have no population term, for example, (purely for illustration) a model could take the form:

ADA Trips per Capita = 0.6 × RVM per Capita − 0.2 Base Fare

This would say that a $1.00 fare increase would cause trips to fall by 0.2 trips per capita. This is much more reasonable than the simple linear form, since it adjusts for the population of the

**Exhibit 4-4. ADA trips per capita and revenue vehicle miles per capita.**



service area. However, it produces the same impact regardless of the initial ridership level. Since initial ridership levels among the representative systems range from a low of 0.08 trips per capita to a high of 1.86 trips per capita, this would still be very awkward. The model would probably predict negative ridership for possible fare changes at some systems.

### Logarithmic per Capita Models

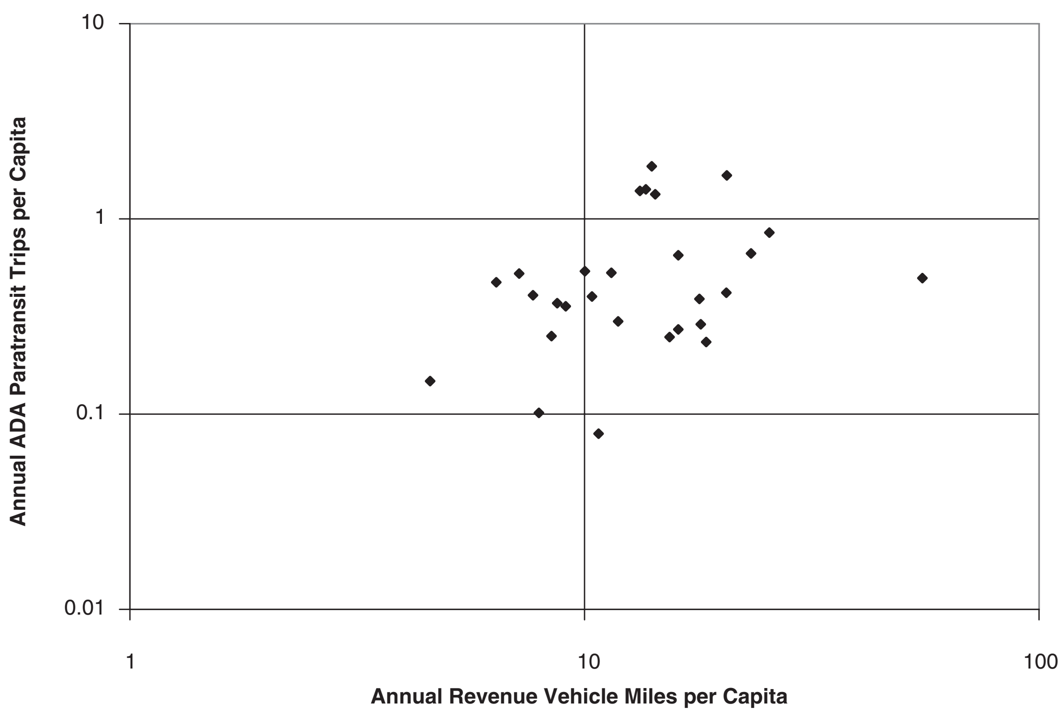
Using logarithms of per-capita data combines the advantages of both of these transformations. Exhibit 4-5 illustrates this using the same RVM data and paratransit trip data as in the previous two exhibits. Compared with the pure linear form or the linear per-capita form, analysis using logarithms of per-capita data greatly reduces the problems of extreme values or skewed distributions of values. As in the pure logarithmic form, the coefficients indicate percentage changes and can be interpreted as elasticities. This type of model assumes that, all other things being equal, ADA paratransit trips per capita are about the same regardless of population size. In other words, holding constant factors such as fares, intensity of transit service, and income levels, ADA paratransit trips are about proportional to service area population. This cannot be assumed, but needs to be tested by analysis of the data.

## Testing Possible Models

The considerations described in the preceding section lead to the following plan of attack for testing possible models:

1. Estimate a model using logarithms of total values (i.e., a model of total ADA paratransit trips per year).
2. If the model results show that ADA paratransit ridership is proportional to population as long as other factors are held constant, then estimate a model using logarithms of per-capita values (i.e., a model of annual ADA paratransit trips per capita).
3. As a fall-back, consider a model of per-capita values without logarithms.

**Exhibit 4-5. ADA trips per capita and revenue vehicle miles per capita (Logarithmic).**



## Logarithmic Model of Total ADA Paratransit Trips

The preliminary data analysis identified a number of possible problems with variables, including some variables that clearly cannot be present together in a model. However, only a handful of variables were initially excluded from consideration:

- Separate age variables by sex were not used because they are so highly correlated. Instead, percent of population age 65 or older and percent of population age 75 or older were tested.
- Average fare per passenger (i.e., total ADA paratransit fare revenue divided by total ADA paratransit passengers) was replaced by base fare (the full cash fare for an ADA paratransit trip before any discounts for advance purchase or use of a monthly pass, and before adding any zone charges). Average fare per passenger would clearly be preferable, since many systems have monthly passes, discounts for pre-paid tickets, or zone charges, and these could have a big impact on ridership. However, after preliminary model testing indicated possible problems with the fare revenue data, further investigation determined that a number of systems had provided only cash fare revenue, leaving out revenue from pass or ticket sales. Attempts to correct this were only partially successful. At least one system known to have missing fare revenue has still not provided the requested data. Other cases of missing data are suspected and would require further investigation before average fare per passenger could be used with confidence.
- Percent of housing units with no vehicle available was not used because, as described earlier, it acts essentially as an indicator variable for New York City. This remains true even with transformation by logarithms.
- Data with missing values as described previously.

Also, even in a model of total ADA paratransit trips, it is necessary to express some variables in per-capita form. Without this transformation, all variables related to size of the area would be highly correlated including total population, population age 65 and older, population below the poverty line, fixed-route fleet size, fixed-route RVM, and so on. Therefore, only one of these variables can be included as an explanatory variable and the rest would need to be expressed in per-capita form (or percent of population). Total population, population age 65 and older, population age 75 and older were all tested as candidates for inclusion as totals. The disability variables can only be used as percentages since any one alone is insufficient and they cannot be added together. Percentage variables were tested using logarithms and without.

The candidate variables were tested using stepwise regression (forward and backward), with the data issues kept in mind for examination of difficulties that could come of this procedure. Some initial experiments led to examination of the data, which discovered coding or other errors that were then corrected. Where the stepwise method produced models with closely correlated variables, each variable was tested separately to determine which was better. These experiments converged on the candidate model shown in Exhibit 4-6. None of the other candidate variables are significant if added to this model. The variables are listed in approximate descending order of statistical significance, with the most significant variables first. Examining the regression results shows that

- All of the coefficients are significant at better than 95% confidence level.
- The model has excellent goodness of fit as measured by R Squared, with 96% of variation in total ADA paratransit explained.
- None of the variables are highly correlated with each other.

Note that because three variables are not in logarithmic form, their coefficients cannot be interpreted directly as elasticities. (This is explained further below.)

Examining the results for each variable we see

- The significant *constant* gives the predicted number of trips when all the other variables are set to zero. Because of the logarithm form, this would occur when population = 1, base fare = $1,

**Exhibit 4-6. Logarithmic model of total ADA paratransit trips.**

**Regression 1**
**Dependent Variable: Log of Total ADA Paratransit Trips**

| | Unstandardized Coefficients | Standard Error | *t*-Statistic | Probability* |
|---|---|---|---|---|
| (Constant) | 3.628 | 1.260 | 2.879 | 0.009 |
| Log of Service Area Population | 0.984 | 0.073 | 13.512 | 0.000 |
| Log of Base Fare | -0.759 | 0.181 | -4.194 | 0.000 |
| Percent found conditionally eligible/100[a] | -1.373 | 0.395 | -3.474 | 0.002 |
| Conditional Trip Screening | -0.658 | 0.186 | -3.543 | 0.002 |
| Percent below Poverty/100[b] | -6.686 | 1.909 | -3.502 | 0.002 |
| Log of Effective Window | -0.712 | 0.265 | -2.685 | 0.014 |

| | |
|---|---|
| R Squared | 0.957 |
| Standard Error of the Estimate | 0.450 |

* Probability that the estimated coefficient is due to chance.
[a] The coefficient implies an elasticity of –0.29 at the mean observed conditional eligibility percentage.
[b] The coefficient implies an elasticity of –0.90 at the mean observed poverty rate.

percent found conditionally eligible = 0%, conditional trip screening is not used, and effective window = 1 minute. This has no practical meaning.

- The estimated coefficient for *total population* is very close to 1.0, meaning that if other factors are kept constant, ADA paratransit trips are proportional to total population. This indicates that a per-capita model of trips should be tested.
- The model gives a *fare* elasticity of –0.76. This value may indicate that paratransit trip making is more sensitive to fares than is general transit ridership. In the survey of practitioners conducted for this research, fares were rated quite low as a factor that influences demand. Low sensitivity to fares would be expected in paratransit systems that are capacity constrained, since only the most necessary trips would be made and only trips for which no other alternatives were available. However, in paratransit systems without capacity constraints, a greater level of fare sensitivity would be expected given the general low income of people with disabilities and the relatively high fares that characterize many paratransit systems. Because the model uses cross-sectional data, the estimated elasticity shows long-term effects that would be expected to be greater than short-term effects estimated by commonly cited fare elasticities. Note that base fare and poverty rate have a weak negative correlation, so leaving out either one would cause biased results.
- Trips decrease with the *percent* of applicants found *conditionally ADA eligible*, which accords with expectations. The coefficient of –1.373 is equivalent to an elasticity of –0.29 at the mean value of the percentage of applicants found conditionally eligible at the representative systems.
- *Conditional trip screening* reduces paratransit usage. The coefficient indicates that systems that use conditional trip screening have 48% less ridership[2] than systems that do not use conditional trip screening. Given experience in the field, it is extremely unlikely that systems with conditional trip screening are actually screening out 48% of trip requests based on conditions of eligibility. In fact, respondents to the survey of practitioners ranked trip-by-trip eligibility screening lower than many other variables as a factor influencing demand. However, it is possible that riders reduce their requests based on the conditions they have been given or based on experi-

[2] Calculated as $1 - e^{-.658}$.

ences when they have requested trips and been turned down for trip-specific eligibility reasons. It is also likely that systems that use conditional trip screening also have more rigorous eligibility screening practices in general in ways not captured by the percentage of applicants found fully or conditionally eligible. Note that there is no significant correlation between use of conditional trip screening and any of the eligibility outcome variables. (This is desirable, since it means that both variables can be included in the model without difficulty.) As noted earlier, conditional trip screening is weakly correlated with average fare per trip (0.40 correlation) and with the percentage of the population age 65 or older or age 75 or older (0.45 to 0.46 correlation).

- The coefficients indicate that trip making decreases at higher *poverty rates*. It might have been expected that lower income would be reflected as lack of access to other modes and therefore higher paratransit usage. However, the variable in question is total area-wide poverty rate, not the rate of poverty among people with disabilities. In general, people with higher incomes travel more than people with lower incomes. It is also likely that communities with higher poverty rates will have fewer available activities that generate travel than more affluent communities. The coefficient of –6.686 for poverty rate is equivalent to an elasticity of –0.90 at the mean value of poverty rate for the representative systems.
- Longer *effective windows* for defining on-time pick-ups reduce trip making. The direction of this effect is as expected, although its strength is surprising compared with expectations of the practitioners surveyed for this research. Note that the measured on-time percentage was not found to be significant. This may be explained by the great variation in methods for measuring on-time performance, which result in very accurate data for some systems and less accurate data for others.

A number of variables did not prove significant and are not included in the model. These included the percentage of the population with various disabilities, the percentage age 65 and older or age 75 and older, and various measures of the availability of fixed-route transit service.

One measure of transit service that was very nearly significant was RVM per capita. Because of its implications for further research, the regression with this variable included is shown in Exhibit 4-7. The other variables have coefficients very similar to those in Regression 1. The coefficient for RVM per capita has a "probability" of 0.066, meaning there is a 6.6% chance that the true value could be zero. (This is equivalent to a 93.4% significance level.) The positive coefficient of 0.374 means that

**Exhibit 4-7. Logarithmic model of total ADA paratransit trips with revenue vehicle miles.**

**Regression 2**
**Dependent Variable: Log of Total ADA Paratransit Trips**

| | Unstandardized Coefficients | Standard Error | *t*-Statistic | Probability |
|---|---|---|---|---|
| (Constant) | 3.147 | 1.210 | 2.601 | 0.017 |
| Log of Service Area Population | 0.923 | 0.075 | 12.244 | 0.000 |
| Log of Base Fare | -0.618 | 0.185 | -3.343 | 0.003 |
| Percent found conditionally eligible/100 | -1.422 | 0.372 | -3.818 | 0.001 |
| Conditional Trip Screening | -0.537 | 0.185 | -2.897 | 0.009 |
| Percent below Poverty/100 | -6.800 | 1.795 | -3.788 | 0.001 |
| Log of Effective Window | -0.645 | 0.252 | -2.562 | 0.019 |
| Log of RVM per captia | 0.374 | 0.193 | 1.943 | 0.066 |

| | |
|---|---|
| R Squared | 0.930 |
| Standard Error of the Estimate | 0.423 |

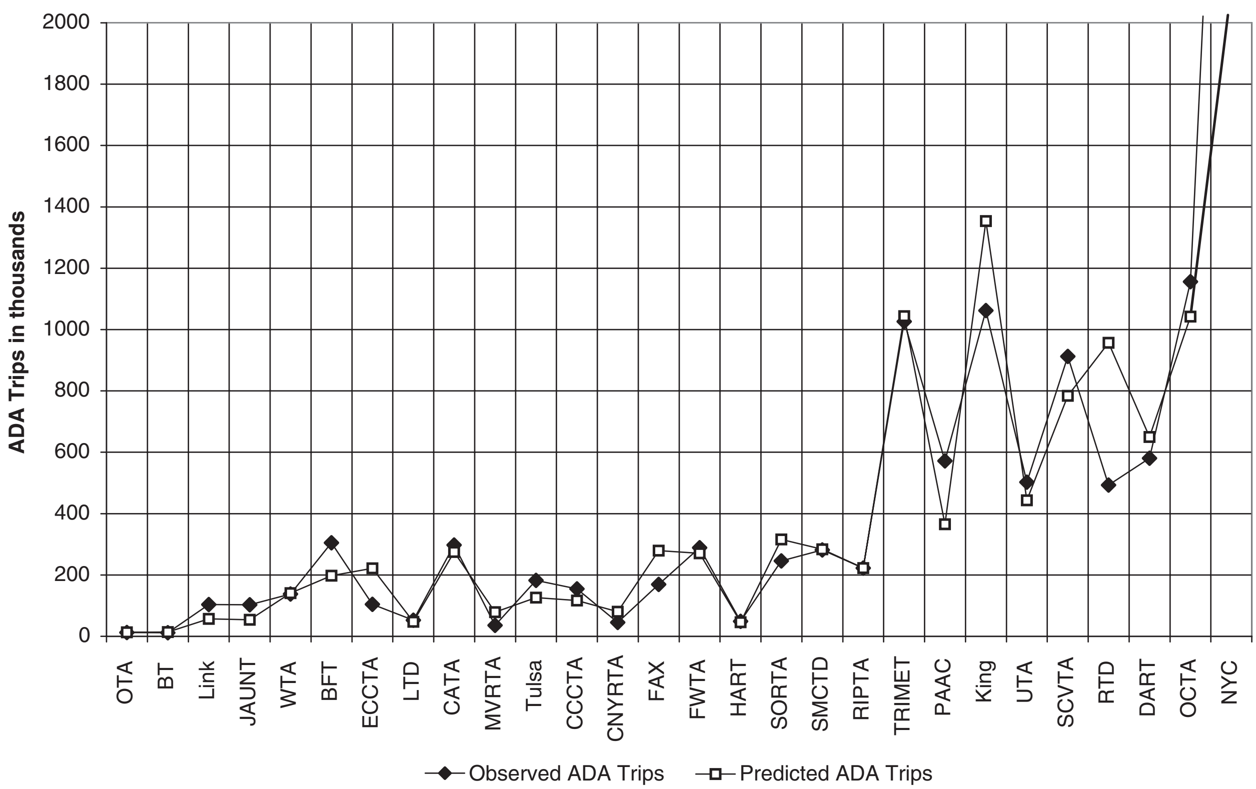
higher levels of fixed-route transit service correspond to higher levels of paratransit trip making. Further transformation of RVM—e.g., RVM per square mile per capita—did not produce significant results.

Clearly, adding transit service does not increase paratransit usage. Instead, it is assumed that this variable is acting as an indicator of an area's general transit-oriented character, reflected in less dependence on private automobiles for travel. If a significant fraction of people are used to travel by public transportation, then they may be likely to turn to paratransit when they can no longer use conventional service. However, if nearly everyone is accustomed to drive for all of their trips and drives until they can no longer do so, then they may be unlikely to consider transit or paratransit as a realistic alternative when they can no longer drive.

The predictions of Regression 1 track observed values for the representative systems reasonably well, as would be expected from the high R Squared values. Exhibit 4-8 shows observed and predicted ADA paratransit trips for each representative system for Regression 1. The systems are arranged in increasing order of population. (New York City is off the scale.) A key to the abbreviations is provided in Exhibit 4-9. Predicted trips increase with population generally tracking the trend of observed trips. More interesting are the deviations from the general trend that are due to other factors such as fares, service quality, and demographics. With a small number of exceptions, the predictions track these "turning points" generally deviating above and below the trend in the same way as the observations.

A more challenging comparison uses observed and predicted trips per capita, which shows equally for small systems and large systems how well predictions match observations. Exhibit 4-10 shows this comparison. Here it is clear that the most difficult cases are the small systems with much higher than average paratransit trip making. Overall, the predications

**Exhibit 4-8. Observed and predicted trips: Regression 1.**

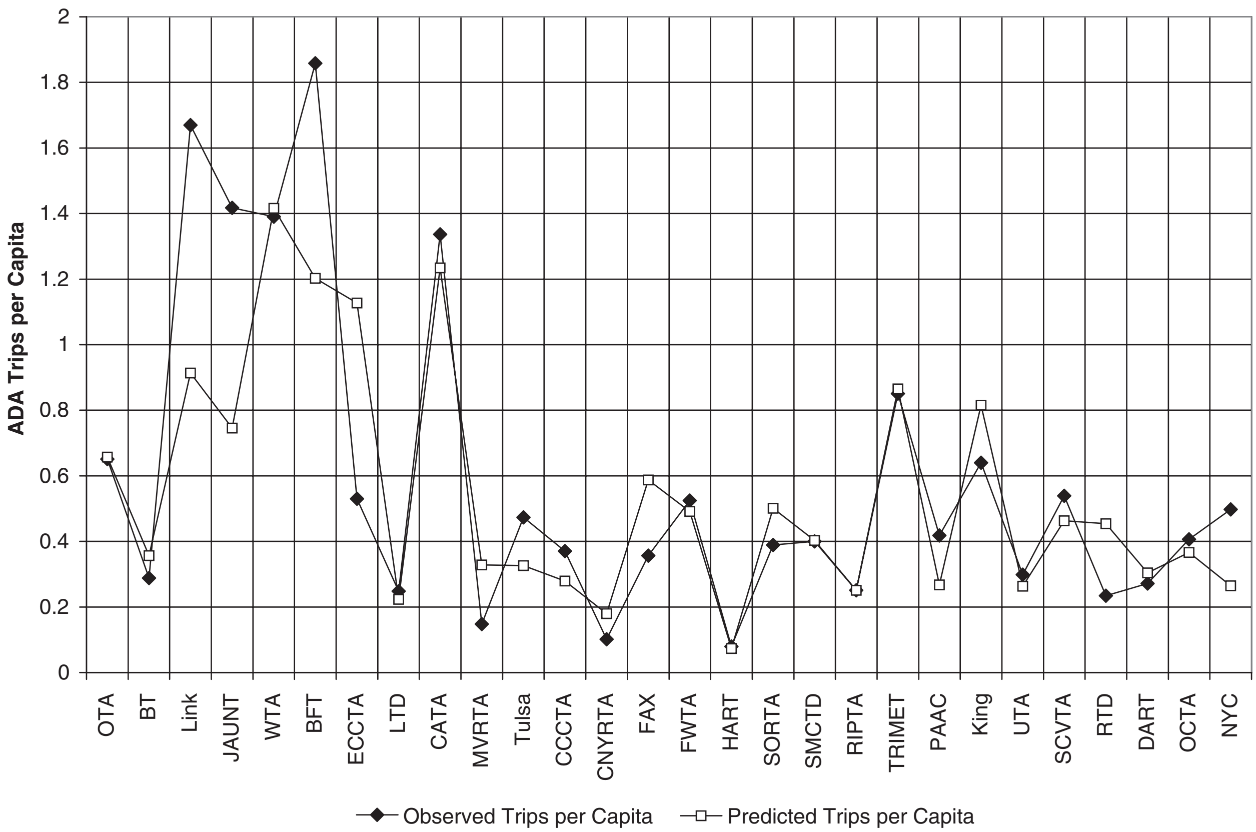



Note: Representative systems arranged in increasing order of population. (New York City is off the scale.)

**Exhibit 4-9. Representative system abbreviations.**

| | | | |
|---|---|---|---|
| OTA | Ottumwa Transit Authority | FWTA | Fort Worth Transportation Authority |
| BT | Blacksburg Transit | HART | Hillsborough Area Regional Transit |
| Link | Link Transit | SORTA | Southwest Ohio Regional Transit Authority |
| JAUNT | JAUNT, Inc. | SMCTD | San Mateo County Transit District |
| WTA | Whatcom Transportation Authority | RIPTA | Rhode Island Public Transit Authority |
| BFT | Ben Franklin Transit | TRIMET | Portland Tri-Met |
| ECCTA | Eastern Contra Costa Transit Authority (Tri-Delta Transit) | PAAC | Port Authority of Allegheny County |
| LTD | Lane Transit District | King | King County Metro Transit |
| CATA | Capital Area Transportation Authority (Lansing, Michigan) | UTA | Utah Transit Authority |
| MVRTA | Merrimack Valley Regional Transit Authority | SCVTA | Santa Clara Valley Transportation Authority |
| Tulsa | Metropolitan Tulsa Transit Authority | RTD | Regional Transportation District (Denver) |
| CCCTA | Central Contra Costa Transit Authority | DART | Dallas Area Rapid Transit |
| CNYRT A | Central New York Regional Transportation Authority | OCTA | Orange County Transportation Authority |
| FAX | Fresno Area Express | NYC | New York City Transit Authority |

**Exhibit 4-10. Observed and predicted trips per capita: Regression 1.**




Note: Representative systems arranged in increasing order of population.

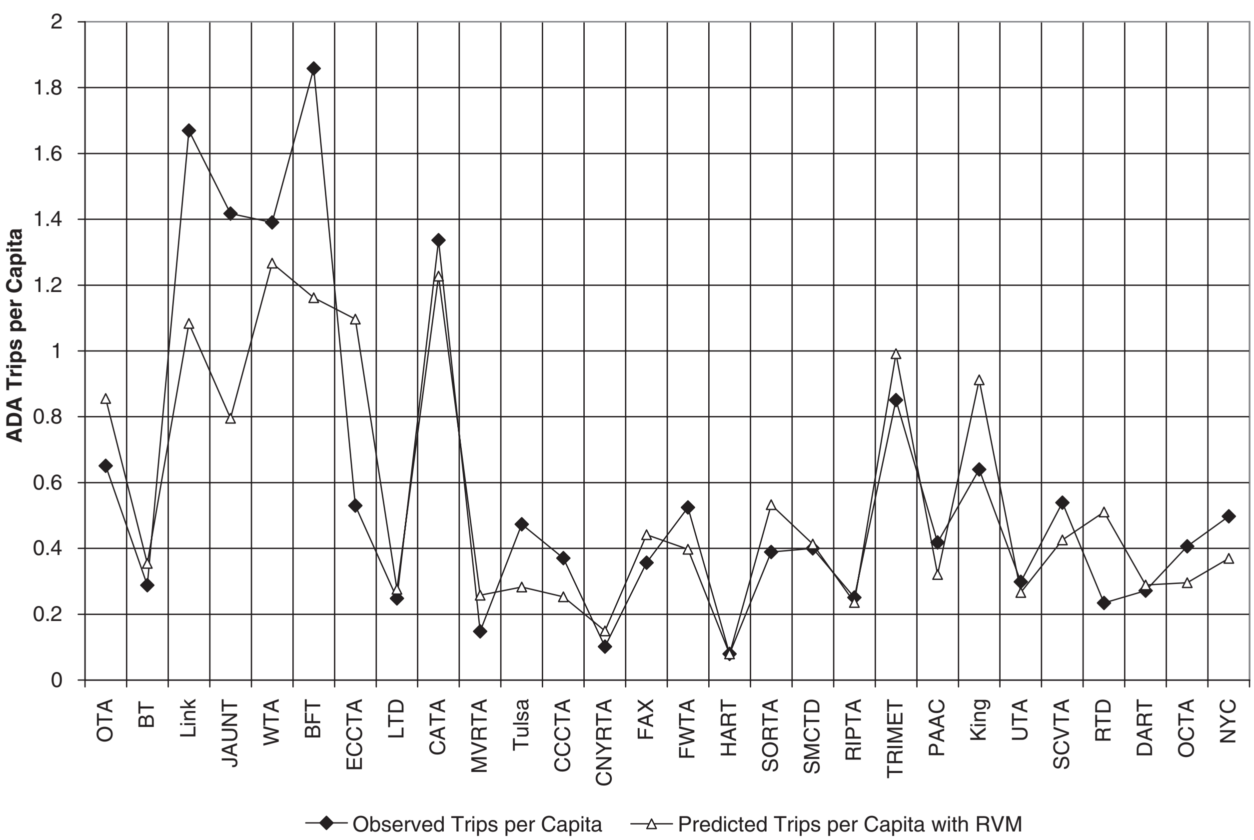
track observation reasonably well, giving good confidence in the equations as models of paratransit trip making on average. However, predictions for individual systems can vary considerably from actual experience. Exhibit 4-11 provides a similar comparison as Regression 2 using the RVM per capita variable. Regression 2 gives a closer match for systems including Link Transit and New York City, but worse for others such as Ottumwa, Whatcom, King County, and Orange County.

The coefficients for the raw percentage variables (poverty rate and conditional eligibility) turn out to have a simple interpretation, similar to elasticities when working with other variables. Each 1% increase in the poverty rate or the percentage conditionally eligible (e.g., from 5% to 6%) corresponds to a constant percentage drop in ADA paratransit ridership. The amount of the percentage drop is equal to $1 - e^b$, where "e" is the base of the natural logarithms and "b" is the coefficient. For example, in Regression 1 the coefficient for poverty rate is −6.686. Each 1 percentage point increase in poverty rate corresponds to a 6.5% drop in ADA paratransit ridership, which can be calculated as $1 - e^{-(0.01 \times 6.686)} = 0.065$. The coefficient of −1.373 for conditional eligibility implies that each additional 1 percentage point increase in the conditional eligibility rate corresponds to a 1.4% drop in ADA paratransit ridership. Users do not need to be able to do this calculation; instead these factors can be supplied with the model.

## Logarithmic Model of ADA Paratransit Trips per Capita

Since the total trip model showed that trip making is proportional to total population when other factors are held constant, it makes sense to test models of paratransit trips per capita. The entire set of candidate variables was tested as before. The procedure produced a model nearly

**Exhibit 4-11. Observed and predicted trips per capita: Regression 2.**




Note: Representative systems arranged in increasing order of population.

**Exhibit 4-12. Model of trips per capita.**

**Regression 3**
**Dependent Variable: Log of Trips per Capita**

| | Unstandardized Coefficients | Standard Error | *t*-Statistic | Probability* |
|---|---|---|---|---|
| (Constant) | 3.463 | 0.972 | 3.564 | 0.002 |
| Log of Base Fare | -0.772 | 0.167 | -4.612 | 0.000 |
| Percent found conditionally eligible/100[a] | -1.385 | 0.382 | -3.625 | 0.001 |
| | -0.662 | 0.181 | -3.668 | 0.001 |
| Percent below Poverty/100[b] | -6.633 | 1.851 | -3.583 | 0.002 |
| Log of Effective Window | -0.722 | 0.255 | -2.831 | 0.010 |

| | |
|---|---|
| R Squared | 0.744 |
| Standard Error of the Estimate | 0.440 |

* Probability that the estimated coefficient is due to chance.
[a] The coefficient implies an elasticity of –0.29 at the mean observed conditional eligibility percentage.
[b] The coefficient implies an elasticity of –0.90 at the mean observed poverty rate.

identical to the one shown before, with the exception that there is no population variable since the effect of total population is eliminated by expressing trips as trips per capita. The detailed results are shown as Regression 3 in Exhibit 4-12.

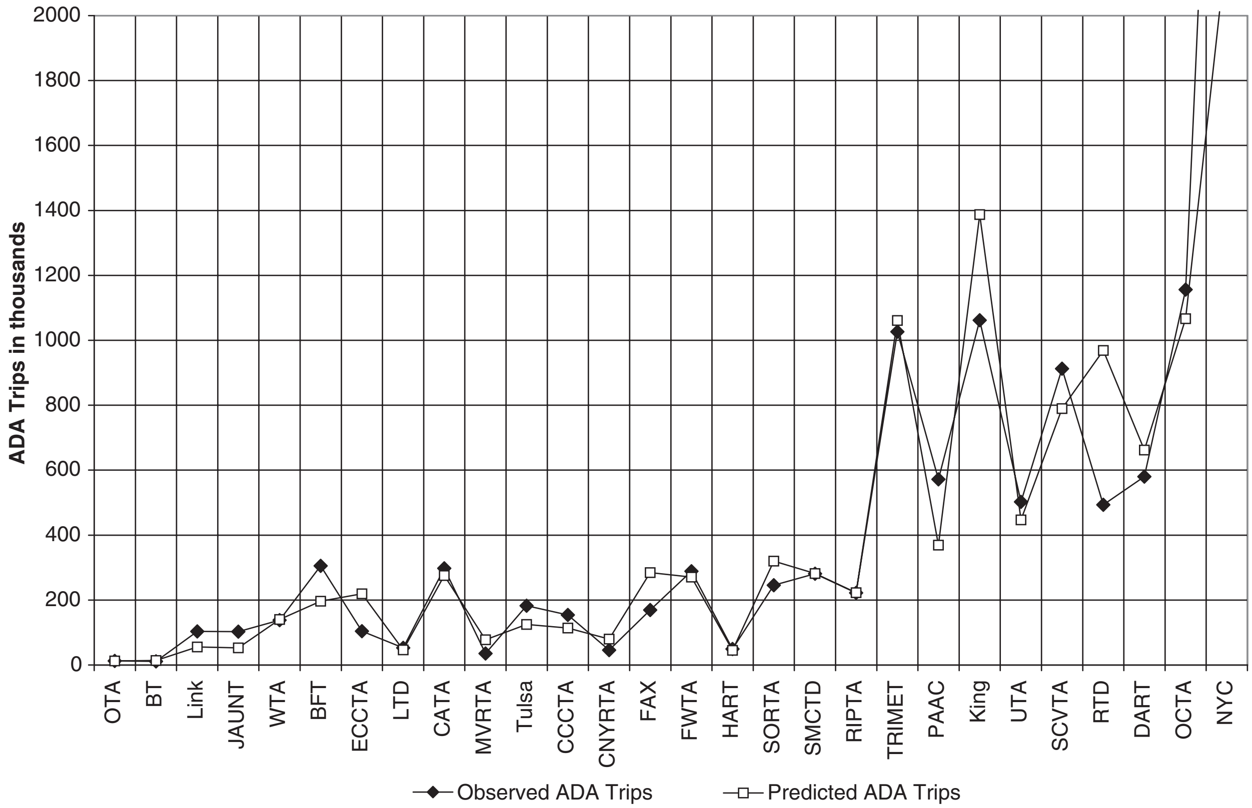
As before, none of the other candidate variables are significant if added to this model. The variables are listed in approximate descending order of statistical significance, with the most significant variables first. The coefficients are very similar to those of the total trip model, as they should be, and all of coefficients are highly significant. The coefficients are slightly more significant in the per-capita model than the total trip model (Regression 1). As before, the constant term, although statistically significant, has no practical meaning. Exhibits 4-13 and 4-14 show how predictions from Regressions 3 compare with observed values.

Because most of the variation in trips has been removed by using trips per capita, it is to be expected that R Squared is somewhat lower than in the total trip model. However, the Standard Error of Estimate is lower in the per-capita model than in the total trip model. This statistic provides an absolute measure of the unexplained variation. It indicates that the per-capita model (Regression 3) predicts trip making slightly better than the total trip model.[3] It is recommended for use as the basis for a demand estimation tool.

The unexplained variation in Regression 3 can also be stated in terms of percentage variation of trips per capita. Individual systems with observed trips per capita higher than the predicted value differ from the prediction by an average of 55%, while systems with observed trips per capita lower than the predicted value differ by 36% from the prediction.[4] The "accuracy" of the model is from −16% to +19%. In statistical terms, this is a 95% confidence interval for the

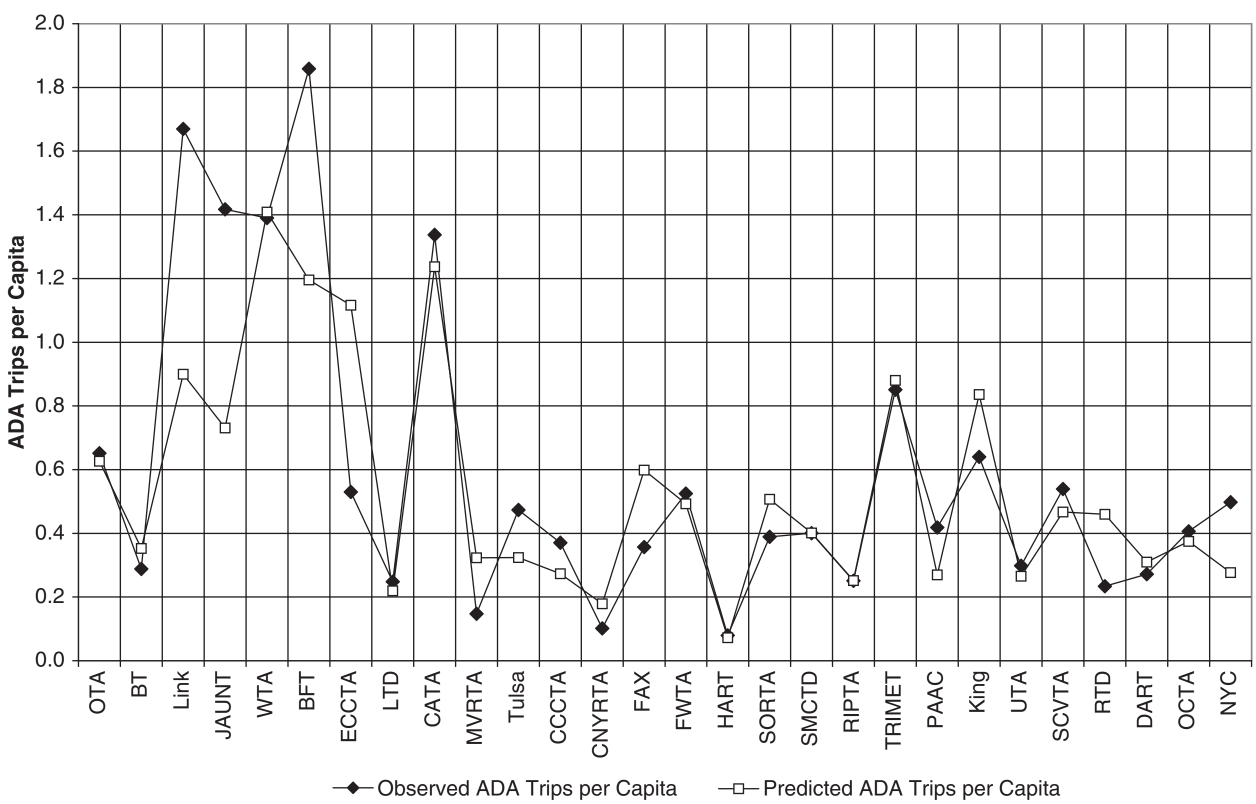
[3] The unexplained variation in log(total trips) and log(trips per capita) can be compared directly since both of them represent proportions.
[4] The Standard Error of the Estimate gives the mean unexplained variation in log(trips per capita), which is 0.440 in Regression 3. This is converted to a percentage variation using exp(0.440) = 1.55 or 55% for "high side" deviations. The "low side" deviation is 1/1.55 = 0.64 or 36% less than 1.0.

**Exhibit 4-13. Observed and predicted trips: Regression 3.**




Note: Representative systems arranged in increasing order of population.

**Exhibit 4-14. Observed and predicted trips per capita: Regression 3.**




Note: Representative systems arranged in increasing order of population.

position of the regression line at the point where the average values for all the explanatory terms are used.[5]

As for the total trip model, RVM per capita was nearly significant. Again, because of its implications for further research, the regression with this variable included is shown in Exhibit 4-15. The other variables have coefficients very similar to those in Regression 3. The coefficient for RVM per capita has a "probability" of 0.11, meaning there is an 11% chance that the true value could be zero. The positive coefficient of 0.292 means that higher levels of fixed-route transit service correspond to higher levels of paratransit trip making.

## Sensitivity Analysis

None of the variables in the model are highly correlated except with trips per capita. The strongest correlation is between base fare and percent below poverty, where there is a negative correlation. This correlation, at –0.42, is not so strong as to make the model unstable or unreliable, but it does mean that leaving either variable out would result in a biased estimate of the coefficient for the remaining variable. In other words, since the two effects have a weak tendency to cancel each other out (higher poverty, which depresses ridership, often goes with lower fare which encourages ridership), leaving out poverty rate would result in too-low an estimate for the effect of fares.

One of the surprising outcomes of the modeling process is that none of the age variables turns out to be significant. Since the percentage of older people and conditional trip screening have what appears to be a chance correlation (from 0.45 to 0.46 depending on the choice of age variable), the possibility was tested that the conditional trip screening variable is preventing the age variables from remaining in the stepwise regression procedure. However, age turns out statistically insignificant even if conditional trip screening is removed from the list of candidate variables.

**Exhibit 4-15. Model of trips per capita with revenue vehicle miles.**

**Regression 4**
**Dependent Variable: Log of Trips per Capita**

| | Unstandardized Coefficients | Standard Error | *t*-Statistic | Probability* |
|---|---|---|---|---|
| (Constant) | 2.579 | 1.075 | 2.400 | 0.026 |
| Log of Base Fare | -0.701 | 0.167 | -4.208 | 0.000 |
| Percent found conditionally eligible/100[a] | -1.462 | 0.370 | -3.947 | 0.001 |
| Conditional Trip Screening | -0.581 | 0.180 | -3.222 | 0.004 |
| Percent below Poverty/100[b] | -6.558 | 1.781 | -3.682 | 0.001 |
| Log of Effective Window | -0.701 | 0.246 | -2.853 | 0.010 |
| Log of RVM per capita | 0.292 | 0.175 | 1.668 | 0.110 |

| | |
|---|---|
| R Squared | 0.774 |
| Standard Error of the Estimate | 0.423 |

* Probability that the estimated coefficient is due to chance.
[a] The coefficient implies an elasticity of –0.31 at the mean observed conditional eligibility percentage.
[b] The coefficient implies an elasticity of –0.89 at the mean observed poverty rate.

[5] The 95% confidence interval for the prediction at the mean is $\pm t_{.025}$ (Standard Error) / sqrt($n$). Where $t_{.025}$ is Student's $t$ for a two-tailed test using 22 degrees of freedom, or 2.07. The 95% C.I. for predicted ln(trips per capita) is ± (2.07)(0.440)/sqrt(28) = 0.172, and exp(0.172) = 1.19.

The effect of eliminating certain systems from the regression was also tested. Since New York City is so different from all other systems, the regression was repeated with its data removed. This produces no significant change in the estimated coefficients. Removing the cases with the most extreme differences between predicted and observed trips per capita (JAUNT and Denver RTD) also results in no significant change in the estimated coefficients.

Removing as many as four cases that have the strongest overall influence on the coefficients (as indicated by Cook's Distance and leverage values) produces very little change in the estimated coefficients. All of the coefficients remain significant. In response to concerns about the strength of the poverty rate variable, the cases with the most extreme values for poverty rate were removed, again with no significant impact on estimated coefficients.

The overall conclusion of the sensitivity analysis is that the regression results are highly stable and should be reliable, within the limited accuracy of the model, for predicting ridership at other systems. Also, the coefficient values can be considered meaningful as a basis for policy discussion and guiding further research.

## Exploratory Analysis of Hold Time

Because nine of the representative systems could not provide quantitative measures of telephone hold time, it was not considered a candidate for inclusion in the model. However, there is strong reason to believe that long hold times do discourage ridership. To test this hypothesis, a model was developed including average hold time with imputed values for the missing data. The missing values were imputed using multiple imputation as implemented in the SOLAS software.[6] In the multiple imputation procedure, values for the missing variable are estimated by regression on the other variables. A random error term is added to the imputed values based on the regression. Then a regression model of the variable to be explained (trips per capita in this case) is estimated on all the variables, including the imputed values. The process is repeated multiple times with the random error terms chosen anew each time. The results of all of the regressions are combined, with variance of the estimated coefficients calculated using the estimated variance for each trial plus the variance among the individual trials.

The multiple imputation method is considered superior to simply discarding the cases with missing average hold times because it preserves the information for all the other variables in the cases that only lack a value for average hold time. This is particularly important when there is some difference between the cases that have missing data and those that do not. In the case of average hold time, systems that did not provide this measure have somewhat higher poverty rates than systems that did and are somewhat less likely to use conditional trip screening. As a result, simply discarding the systems without hold time data would produce biased results. The multiple imputation procedure is specifically designed to avoid this difficulty. Also, compared with some simpler methods, it avoids the appearance of unrealistically high estimates of significance for the variable with imputed values.

Exhibit 4-16 illustrates the concept, showing a dataset for which three values of an explanatory variable are missing. Four sets of imputed values are shown for the missing values. The imputed values retain the overall trend, but avoid creating the appearance of a clearer trend than can actually be inferred from the available observations.

Sample results are reported in Exhibit 4-17. (Repeating the procedure produces slightly different results each time, but the results shown are typical.) The results of all the variables previously included are similar to those obtained before. For average hold time, the estimated

[6] http://www.statsol.ie/html/solas/solas_home.html, accessed on November 29, 2006.

**Exhibit 4-16. Multiple imputation of missing values.**

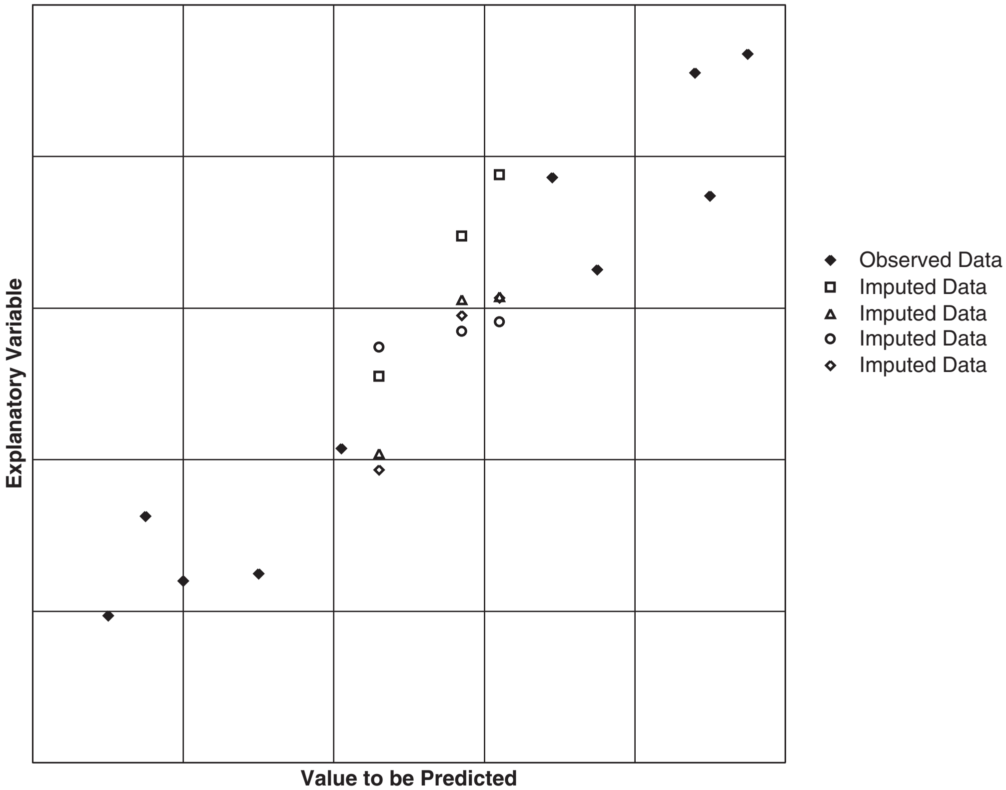



**Exhibit 4-17. Model with imputed values for missing hold times.**

| | Unstandardized Coefficients | Standard Error | *t*-Statistic |
|---|---|---|---|
| (Constant) | 3.649 | Not reported | |
| Log of Base Fare | -0.684 | 0.163 | -4.208 |
| Percent found conditionally eligible/100 | -1.393 | 0.381 | -3.657 |
| Conditional Trip Screening | -0.630 | 0.174 | -3.616 |
| Percent below Poverty/100 | -6.129 | 2.173 | -2.821 |
| Log of Effective Window | -0.826 | 0.241 | -3.424 |
| Log of Average Hold Time | -0.263 | 0.161 | -1.626 |

| | |
|---|---|
| R Squared | 0.804 |
| Standard Error of the Estimate | 0.397 |

coefficient of −0.264 is consistent with a negative effect of hold times on demand. However, the estimated value of Student's *t*, −1.626, corresponds to a probability of 0.119 that the estimated coefficient is due to chance (i.e., a "confidence level" of only 88%). In the survey of practitioners conducted for this research, "ability to get through on the phone to reserve a ride" was ranked very highly as a factor that influenced demand. Most likely, there is a strong effect due to hold times, and the lack of significance in the model is a result of the small data set that was available.

CHAPTER 5

# Long-Term Trends that May Affect ADA Paratransit Demand

Long-term trends in ADA paratransit demand cannot be predicted in the same way that the demand estimation tool predicts short-term demand. However, likely trends and influences can be discerned by consideration of the available literature. Where no clear evidence is available, some possible tends have been identified using the experience of the research team.

There are five fundamental components of demand for ADA paratransit services that need to be considered when thinking about potential ADA paratransit demands in the next 20, 30, or 40 years. These trends may differ from community to community, so practitioners should carefully form their own judgments about trends in their own service area. These fundamental components can be seen as the independent variables in an equation in which the demand for ADA paratransit services is the dependent variable.

The five major considerations regarding estimates of future specialized paratransit demands are as follows:

- The numbers of persons with disabilities.
- Geo-spatial settlement patterns.
- The overall community-wide supply of transportation resources.
- Significant societal trends.
- Overall policy considerations.

Projections of future trends can be made with relative confidence for the numbers of persons with disabilities, but confidence in the accuracy of future projections decreases as one proceeds down the list of these five factors.

There are obvious interrelationships among these factors, and each factor has obvious subcomponents, all of which increase the difficulty of projecting future ADA paratransit demands with any degree of certainty. It appears likely that demand for paratransit services will increase in the future. The proportion of that future demand served by ADA complementary paratransit services is liable to increase as well, but those projections are less certain.

## The Numbers of Persons with Disabilities

The number of persons with disabilities in the United States—now estimated at about 51 million persons with some level of disability[7]—is expected to increase in the future. Among certain groups, the proportion of the population with disabilities is declining, but overall

[7] "In 2002, 51.2 million people (18.1 percent of the population) had some level of disability and 32.5 million (11.5 percent of the population) had a severe disability." Erika Steinmetz, *Americans With Disabilities: 2002* U.S. Census Bureau, 2006. http://www.census.gov/hhes/www/disability/sipp/disab02/awd02.html

population growth is currently projected to create a larger number of persons with disabilities. This is likely to be one of the largest influences on the overall level of demand for specialized paratransit services and will have the effect of increasing the demand for services.

## Major Trends

The trends that are likely to have the greatest impact on the numbers of persons with disabilities are described below. Some of these trends could reduce the potential rate of growth in the number of persons with disability, but they do not keep the overall number from growing, which indicates that the overall level of demand for ADA paratransit services will continue to rise.

- There are rising rates of disability in the United States due to the aging of the population, poverty, and "medical advances." In addition, recently recognized "emerging conditions" have added to overall rates of disability, although much of the growth in disability due to emerging conditions may be attributable to increased awareness and access to treatment.[8]
- Current trends show a declining rate of disability (the percentage of the population that has disabilities) among older population groups.[9] The most recent Exhibits[10] show an accelerating rate of decline in chronic disability among older Americans, leading to more optimistic assessments of seniors' future health and functioning than were previously available. The Director of the National Institutes on Aging calls this finding "one of the most encouraging and important trends in the aging of the American population."[11]
- Our society is rapidly aging: the number of persons age 65 and over is projected to nearly double from 2000 to 2030, to a total of 71.5 million seniors in 2030. During that period, the proportion of the population 65 and over is projected to rise from 12.5 % to nearly 20 %.[12] This trend to increased aging will most likely increase the number of persons with disabilities, even if the rate of disabilities declines, because an increase in disability is a common component of advanced age.[13] In localities where the average age increases significantly in the future, the growth in the number of persons with disabilities may be dramatic. Furthermore, while the elderly of the future are likely to exhibit patterns of higher education, higher incomes, and better health status than

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[8] Glenn T. Fujiura, "Emerging Trends in Disability," *Population Today*, August/September 2001, accessed at http://www.prb.org/Content/NavigationMenu/PT_articles/Jul-Sep01/Emerging_Trends_in_Disability.htm.

[9] ". . . *disability levels for people* age 65 and older have been falling at an accelerating rate since 1982 . . ." National Institute on Aging, Strategic Plan: Research Goal A, Subgoal 2: Maintain Health and Function, http://www.nia.nih.gov/AboutNIA/StrategicPlan/ResearchGoalA/Subgoal2.htm

[10] Manton, K.G., Gu, X., & Lamb, V.L. (2006). Change in chronic disability from 1982 to 2004/2005 as measured by long-term changes in function and health in the U.S. elderly population. PNAS, National Academy of Sciences, 103(48); 18374-9.

[11] December 6, 2006 press release from the National Institutes on Aging describing the release of the Manton study.

[12] A Profile of Older Americans: 2005, Administration on Aging, U.S. Department of Health and Human Services, Washington, DC.

[13] National Institute on Aging, Strategic Plan: Research Goal A, Subgoal 2: Maintain Health and Function, http://www.nia.nih.gov/AboutNIA/StrategicPlan/ResearchGoalA/Subgoal2.htm. Using 2004 U.S. Census projections, the percentage of persons with disabilities in the population would have to fall from the 2000 level of 19 percent among persons 5 years of age and older to 15.8 percent in 2030 to register no increase in the number of persons with disabilities, based on a 2000 population of 262,907,000 persons 5 years of age and older and a projected 339,312,000 2030 5-and-older population. See "U.S. Interim Projections by Age, Race, and Hispanic Origin," www.census.gov/ipc/www/usinterimproj/. The percentage of the U.S. population in 2000 who could be considered as "transportation disadvantaged" was 5.3 percent, according to projections based on the Bureau of Transportation Statistics' 2002 National Transportation Availability and Use Survey. See Wallace, R., Hughes-Cromwick, P., and Mull, H. (2006). "Cost-Effectiveness of Access to Nonemergency Medical Transportation: Comparison of Transportation and Health Care Costs and Benefits." *Transportation Research Record 1956*, Transportation Research Board, National Academies, Washington, DC., 2006; pp. 86–93.

the elderly of today,[14] some analysts project that many elderly will outlive their ability to drive by 7 to 10 years,[15] thus increasing the demand for additional transportation services.
- General trends toward higher education, higher incomes, and better health status could reinforce the trend toward declining rates of disabilities among the older population, although population increases among seniors will still lead to higher numbers of seniors with disabilities despite the decline in disability rates among seniors.[16]

## Other Trends of Note

There are a number of other trends that must be taken into account. These could have the effect of increasing the number of persons with disabilities and thus the demand for ADA paratransit services.

- Current trends involving increasing rates of obesity could overwhelm the other factors that would otherwise lead to reduced disability rates and thus reverse the disability rate gains of recent cohorts.[17] Obesity increases the risk of diseases such as Type 2 diabetes, heart disease, osteoarthritis, and cancer, as well as increasing the probability of being disabled at a younger age. At lower levels of severity, increases in such conditions could increase ADA paratransit demands; at higher levels of severity, they would increase demands for nursing home placement, which would likely reduce ADA paratransit demands.
- War and global illnesses could increase the number of persons with disabilities.[18] To the extent that these factors affect people living in the United States, demands for ADA paratransit services could increase.
- Increases in medical technology may lead to greater survivability of injuries and illnesses but in conditions of partial disability, thus increasing the number of persons with disabilities and potentially increasing ADA paratransit demands.

## Other Considerations

An extremely important consideration that must be examined when making local projections of the numbers of persons with disabilities is that there are currently very large variations from community to community in the percentage of the population with disabilities.[19] In fact, some communities now report nearly triple the percentages of persons with disabilities reported in other communities. The model developed in this project was not able to determine how incidence of disability affects paratransit demand; however, that is most likely due to limitations of existing

[14] National Academy on Aging, *Old Age in the 21st Century: A Report to the Assistant Secretary on Aging Regarding His Responsibilities in Planning for the Aging of the Baby Boom*, Syracuse, NY: Maxwell School, Syracuse University, 1994.
[15] Daniel J. Foley, Harley K. Heimovitz, Jack M. Guralnik, and Dwight B. Brock. "Driving Life Expectancy of Persons Aged 70 Years and Older in the United States." *American Journal of Public Health,* August 2002, Vol 92, No. 8.
[16] NIA Strategic Plan, op cit.
[17] "Since the late 1980s, adult obesity has steadily increased in this country. About 64 percent of Americans are overweight and more than 30 percent are obese. . . . As Americans get heavier, their health suffers. Overweight and obesity increase the risk for coronary heart disease, type 2 diabetes, and certain cancers." Calories Count: Report of the Working Group on Disability, 2004, U.S. Food and Drug Administration, http://www.cfsan.fda.gov/~dms/owg-toc.html.
[18] Medact, 2004, Enduring Effects of War, cites increased mortality, morbidity, and disability among the effects of war: http://www.medact.org/content/wmd_and_conflict/Medact%20Iraq%202004.pdf.
[19] The differences between communities with the lowest percentage of persons with disabilities (such as Naperville, Illinois; Provo, Utah; Gilbert, Arizona; and Plano, Texas) and communities with the highest percentages of persons with disabilities (such as Patterson, New Jersey; Miami, Florida; Newark, New Jersey; and Detroit, Michigan) is approximately a factor of 3, according to Disability Status: 2000 - Census 2000 Brief. www.census.gov/hhes/www/disability/disabstat2k/table4.htm. See also table5.htm.

data and should not be taken to imply that there is no effect. Local baselines, causative factors, and mitigating factors need to be addressed in making detailed local estimates.

## Geo-Spatial Settlement Patterns

The residential patterns of persons with disabilities, coupled with overall community land-use patterns of employment, commerce, services, and other destinations, is likely to have a large impact on demands for specialized paratransit services and the cost of operating those services. Current trends suggest a noticeable increase in demand for these services, especially in locations that involve relatively expensive trips.

### Major Trends

The following geo-spatial settlement trends are expected to have the largest impacts on demands for specialized paratransit services, and they are expected to have the effect of increasing ADA paratransit demands.

- The overall decentralization of residential, employment, and economic activities is likely to create significantly increased overall vehicular miles traveled (VMT). This is expected to hold true for ADA paratransit services as well as for other modes of travel: the average number of miles per ADA paratransit trip is expected to increase (which is expected to increase the average ADA per trip cost).
- Assuming that persons with disabilities age in place, there will probably be increased numbers of persons with disabilities in the future living in the suburban and rural communities that are not now well served by public transportation. How public transit agencies will react to these developments is not obvious at this point; if fixed-route services are extended, ADA paratransit service areas would be extended too. Further research in this area is needed.
- While a majority of new developments will probably focus on undeveloped or underdeveloped land outside of central cities, existing central cities and inner-ring suburbs may experience population growth leading to greater population densities per square mile in these areas. If this is the case, then public transit options may become more attractive in these communities. The impact on ADA paratransit demand is unclear: more attractive public transit services could reduce the demand for ADA paratransit, but the results of the sketch modeling process suggest that a greater emphasis on public transit services could increase ADA paratransit demands.

## The Overall Supply of Transportation Resources

The supply of transportation resources needs to be considered on an overall community-wide basis. All modes of travel need to be considered. On a national basis, passenger travel on all modes is expected to increase by 68% as a result of population increases and per-person travel increases in the time period from 2000 to 2025.[20]

### Automotive Travel

Automobile ownership and use is expected to increase in the coming decades. This is expected to have the effect of reducing the probable growth in the overall demand for specialized paratransit services.

[20] John S. Miller, *Expected Changes in Transportation Demand in Virginia by 2025*. Virginia Research Council, Charlottesville, VA, 2003.

- Auto ownership is expected to become even more widespread in the next several decades. By about 2025, the United States will have 260 million vehicles, up from 221 million in 2000.[21] Autos owned per household will increase, and the percentage of households without an auto will decrease. However, the number of households without autos is likely to remain nearly constant or increase very slightly due to overall population growth.[22]
- Auto travel is expected to increase. Both trips per day and total mileage driven are expected to increase, as they have in recent years, but it is possible that they will not increase as fast as they have in recent years.
- The next cohort of senior citizens will include persons who have driven all their lives and will expect high-quality transportation services. Seniors (especially, older women) are likely to continue to be drivers later in life and to take more trips per day.[23] These once-highly-mobile seniors are predicted to outlive their abilities to drive by 7 to 10 years.[24] Assuming that, by the time they can no longer driver, these seniors have also outlived their ability to use conventional public transportation, this could create an increase in ADA paratransit demands. This is an area in which further research could provide a more definitive answer regarding future travel demands.
- The continuing spatial dispersion of origins and destinations is expected to increase the need for transportation modes—like the private automobile—that are highly flexible in terms of factors such as origins and destinations, timing, and special trip-by-trip needs like transporting children or packages. If general public paratransit services arise to serve such demands, that might reduce the demand for ADA paratransit services.

## Public Transit Services

The public transit industry appears to be at an historic crossroads with significant uncertainty of which path will be taken. Potential trends could have the effect of increasing or decreasing ADA paratransit demands.

- On the one hand, the industry could embrace new paradigms involving mobility management strategies that would increase modal options and ridership. The new paradigms approach has the potential for a significant growth in the proportion of community trips served by new kinds of services, some of which might be supervised (if not provided) by public transit agencies.[25] Such a trend would be particularly significant for future paratransit demand if new services are designed to better meet the needs of people with disabilities, for example, using flexible routing and higher levels of driver assistance in community service. The availability of new services could increase the demand for demand-responsive services in general, might decrease the per-trip cost of demand-responsive services if more shared-ride demand-responsive services became popular, and thus might decrease the demand for paratransit services limited to ADA-certified riders.

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[21] U.S. Department of Transportation, Bureau of Transportation Statistics. *The Changing Face of Transportation*, BTS00-007, Washington, D.C., 2000, See Table 1-1 and pp. 1-11 through 1-13.

[22] John S. Miller, *Expected Changes in Transportation Demand in Virginia by 2025*. Virginia Research Council, Charlottesville, VA, 2003.

[23] Burkhardt, J., Berger, A.M., Creedon, M.A., and McGavock, A.T. (1998). *Mobility and Independence: Changes and Challenges for Older Drivers* (Prepared under contract to the U.S. Department of Health and Human Services and the National Highway Traffic Safety Administration). Bethesda, MD: Ecosometrics, Incorporated.

[24] Foley, et al., *op cit.*

[25] Stanley, R.G., Coogan, M.A., Bolton, M.P., Campbell, S., and Sparrow, R. *TCRP Report 97: Emerging New Paradigms: A Guide to Fundamental Change in Local Public Transportation Organization*. Transportation Research Board, National Academies, Washington, DC., 2003.

- It may be equally likely that current services will not change and that the industry's focus will remain on mass transit services provided on fixed routes and schedules. Focusing on the traditional fixed-route paradigm could result in a relatively constant number of riders but a smaller and smaller share of total trips in the community. This scenario would probably not create a change in the number of ADA paratransit trips over time. The implications of the findings of the sketch modeling process about greater ADA paratransit demand in communities with more intensive fixed-route service remain to be elucidated.
- The decentralization of residential, employment, and economic activities will create significantly increased travel demands, at least in VMT and possibly in numbers of trips as well. (For example, VMT increased by 26% from 1993 to 2003, an annual rate of change of 2.3%.[26]) Meeting these demands at significantly lower densities is likely to create real challenges for public transportation operators. A key issue is to what degree public transit services will be extended into suburban and rural areas not now served by public transportation. An important consideration for some transit operators will be whether or not such service extensions will require extensions of ADA complementary paratransit services, which are currently among the most costly services operated by public transit agencies.

### Taxi and Paratransit Services

Technological improvements may make it easier for the taxi industry to schedule shared-ride trips and to equitably establish fares for shared rides even when the riders have discrete origins and destinations. This development could relieve some of the demands on ADA paratransit services. However, the implementation of such technologies may not be uniform within the industry, leading to real differences in capabilities from community to community.

### Other Trends

The overall effects of other trends on paratransit demands are unclear at this point in time. Continued price rises in gasoline costs might reduce the growth in the amount of travel by personal autos, shifting some of that travel to public transit[27], although the reduction in growth of auto travel is not expected to be sufficiently large to create an overall decline in the absolute numbers of trips by autos or miles driven. It is possible that a lower proportion of trips by auto could result in a modest increase in demand for general public paratransit services. Gasoline price increases would not be expected to change demands for ADA paratransit services, but an increase in general public paratransit services could decrease the demand for ADA paratransit services.

## Significant Societal Trends

Some societal trends are apparent that might significantly influence the demand for specialized paratransit services. But the emergence of "disruptive technologies," always extremely difficult to predict in advance, could also significantly affect paratransit travel demands. Recent examples of such hard-to-predict disruptions would include personal computers, cell phones with advanced capabilities, the World Wide Web, and the Internet.

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[26] Bureau of Transportation Statistics, *Transportation Statistics Annual Report: November, 2005*. U.S. Department of Transportation, Washington, DC., 2005.

[27] Several research projects demonstrate price elasticities in the -0.13 range. Currie, G. and Phung, J., "Transit Ridership, Automobile Gas Prices, and World Events: New Drivers of Change?"; Haire, A.R. and Machemehl, R.B., "Impact of Rising Fuel Prices on U.S. Transit Ridership" *Transportation Research Record 1992*, Transportation Research Board, National Academies, Washington, DC., 2007; pp. 3–10 and 11–19.

## Major Trends

Many of the current societal trends could lead to some modest increases in demand for demand-responsive services, although much of this demand could also be satisfied by private auto trips. As previously noted, if such demand is met by general public paratransit providers, ADA paratransit demands could decrease.

- Over the long term, the ADA may produce major increases in participation by people with disabilities in activities of all types as a result of steadily increasing accessibility of the built environment as well as greater educational and employment opportunities. Increased activity levels could increase the demand for ADA paratransit, while improved physical accessibility may create more alternatives to ADA paratransit, reducing demand.
- Per-capita personal income may rise substantially, by as much as 50%, by about 2025, leading to an increase of about 36% in VMT.[28] Past increases in personal incomes have led to growing travel demands.[29]
- Average household sizes have been dropping for decades.[30] The proportion of travel needs being met by family members can be expected to decrease because of decreases in numbers of children per family, decreases in the numbers of children in the same community as parents, and increases in the numbers of older persons living alone. Fewer travel needs met by family members could lead to a greater need for specialized ADA paratransit and other transportation services.
- Significant growth in Hispanic and other minority populations in the United States may somewhat mitigate the previously noted trend. Families of certain minority cultural groups are said to have closer family ties than do other families. If true, this means that members of these cultural groups are likely to receive more transportation assistance from family members and may thus need less public assistance with trip making.[31]
- The decreasing emphasis on industrial employment and the corresponding increase in service-sector employment suggest a greater dispersion of work hours and days, increasing the need for flexible transportation services.
- The movement to provide services in community settings instead of large institutions has created a great demand for travel by people who now travel to out-patient services, training, day programs, supported work, and other destinations. The movement to reduce institutionalization in nursing homes or similar facilities by providing community-based health care has triggered a need to bring the former in-patients to adult day health and other programs. Future transportation needs may be most highly influenced by public policy considerations, particularly financial considerations (see the Public Policies section below), but the overall impact of the de-institutionalization movement is likely to be a continued increase in demand for ADA paratransit services.

## Other Trends

Other trends could have positive and negative influences on future paratransit demand; actual effects are difficult to predict at this time.

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[28] U.S. Department of Transportation, Bureau of Transportation Statistics. *The Changing Face of Transportation*, BTS00-007, Washington, D.C., 2000, See Table 1-1 and pp. 1-11 through 1-13.
[29] John S. Miller, *Expected Changes in Transportation Demand in Virginia by 2025*. Virginia Research Council, Charlottesville, VA, 2003.
[30] U.S. Census Bureau. *Projections of the Total Population of States: 1995 to 2025*. Washington, D.C. See http://www.census.gov/population/www/projections/stproj.html
[31] Zmud, J.P. and Arce, C.H. "Influence of Consumer Culture and Race on Travel Behavior." *Personal Travel: The Long and Short of It*. Transportation Research Circular E-C026, Transportation Research Board, National Research Council, Washington, DC., 2001.

- Economic and service specialization will most likely increase travel demands because of the discrete locations demanded by such specialization. Many of these discrete locations will be outside of traditional city centers, so this trend is likely to increase the need for flexibly routed and scheduled services such as the private auto, carpools, and demand-responsive transit services. Average trip lengths could also be expected to increase.
- Poverty has long been linked to disability, both as a consequence and a cause.[32] While recent years have seen short-term increases in poverty, long-term trends are difficult to project, as they depend heavily on changing public policies and priorities. The implications of changing poverty rates on ADA paratransit demands are unclear, especially regarding persons with disabilities who live in poverty. Increases in disability are likely to lead to increased ADA paratransit demands, but increases in poverty may decrease overall travel demands, also reducing ADA paratransit demands as suggested by the outcome of the sketch modeling process.
- Many persons with disabilities are unemployed or underemployed, leading to poverty or near poverty incomes.[33] Only 43% of persons with severe disabilities now work. If policies were implemented to reduce this large proportion of persons with disabilities who want to work now but cannot, employment travel demands among persons with disabilities would be likely to increase. This might create a brief upsurge in transit and paratransit use, but many of these new workers might eventually buy cars.
- Persons in poverty are more likely to defer or skip medical examinations or treatments, sometimes leading to disabling conditions.[34] Again, increases in disability are likely to lead to increased paratransit demands, but increases in poverty may decrease overall travel demands.
- Technological advances in at-home medical screening and reporting might reduce the need for some doctor visits. This could be a boon for some persons needing the special kinds of trip assistance provided by many ADA paratransit services, thus potentially reducing the demand for such services from this segment of the population.
- Advances in information technology have created a consumer group said to value a "customized shopping experience."[35] Such consumers may be attracted to transportation services that could satisfy individualistic trip demands, possibly increasing the demand for ADA paratransit services.
- While telecommuting and other technological changes may make it easier for persons with disabilities to be employed at jobs that more frequently allow them to work from their homes and thus require fewer work trips, experts do not expect an overall reduction in trip making due to telecommuting.[36] Telecommuters now represent about 10% of U.S. adults, a figure that has not changed much in recent years.[37]

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[32] Glenn T. Fujiura, "Emerging Trends in Disability," *Population Today*, August/September 2001, accessed at http://www.prb.org/Content/NavigationMenu/PT_articles/Jul-Sep01/Emerging_Trends_in_Disability.htm.

[33] "People with disabilities were significantly more likely to live in poverty (18.3%) than those in the general population (9.9%)." Adler, M. (1995). "Conditions and Impairments Among the Working-Age Population with Disabilities." U.S. Department of Health and Human Services. http://aspe.hhs.gov/daltcp/reports/conimpwa.htm. Of persons who live in poverty, 24.1% are persons with disabilities. (Special tabulations from 2002 American Community Survey Exhibits found at http://factfinder.census.gov/servlet/DTTable?_bm=y&-geo_id=04000US03&-ds_name=ACS_2002_EST_G00_&-redoLog=false&-mt_name=ACS_2002_EST_G2000_P060.

[34] Hughes-Cromwick, P., Wallace, R., et al. *TCRP Web-Only Document 29: Cost-Benefit Analysis of Providing Non-Emergency Medical Transportation*, Transit Cooperative Research Program, Transportation Research Board, Washington, DC., 2005.

[35] Marketing to Young Adults, Yankelovich Monitor, pp. 3-14, March 2002, Norwalk, Connecticut, available at www.yankelovich.com.

[36] ". . . even if an increase in telecommuting does occur and it reduces traditional work-based peak hour trips, there may still be increases in non-peak hour or nonwork trips." John S. Miller, *Expected Changes in Transportation Demand in Virginia by 2025*. Virginia Research Council, Charlottesville, VA, 2003.

[37] *Ibid*.

- Travel technology improvements that tend to automate operational decisions requiring strength, cognition, or responsiveness (such as the skills commonly required to drive) could increase travel options for persons with disabilities and thus increase overall travel demands. Were such systems actually put in place, their effect on paratransit demand is unclear.
- Technological advances in the next 30 years in personal mobility devices are possible. The increased use of low-powered vehicles (similar to golf carts or the Segway) for local travel suggests that more innovations are possible in this arena. Such advances might reduce the overall demand for specialized paratransit services.

## Public Policy Considerations

Public policy changes could create significant changes in both the supply of and demand for specialized paratransit services. Some of these changes could increase both supply and demand while other changes are as likely to decrease supply and demand.

- Debt and budgetary pressures now in evidence could reduce future federal investments in public transportation, potentially leading to declines in the amount and quality of fixed-route transit and paratransit services. Reduced supply could have the effect of reducing ADA paratransit demands. Further research in this area could be most helpful.
- Many federally funded human service programs face static or declining budgets at this time, and potential debt and budgetary pressures could reduce future investments in human service transportation systems. Conflicting scenarios regarding ADA paratransit demands can be imagined if human service program budgets are reduced. First, these programs now provide trips that relieve at least some of the demands on ADA paratransit services, suggesting that demands for ADA paratransit services could increase. Conversely, a number of public transit respondents to this project's survey have indicated that a substantial proportion of their current ADA paratransit demand (often 25% or more) is attributable to persons traveling to human service programs. If there is less funding for the services provided by these programs, fewer individuals will travel to them, thus reducing ADA paratransit demands. Further research here could be of great value.
- An increased recognition by public transportation authorities of the wisdom in partnering with agencies relying on volunteers could reduce some of the demand on ADA paratransit services for trips that are the most challenging and expensive to provide.
- Changes to policies specifically related to the usage of ADA paratransit services could have real impacts on the demand for these services.
- Medicaid and Medicare are the largest social service programs now operating, and their transportation policies directly affect the overall demand for paratransit services. The details of Medicaid transportation policies are set by each of the states and territories, so forecasting local paratransit demands (both on ADA services and transportation services provided by other agencies) requires a thorough knowledge of current Medicaid regulations and practices for a specific state (and, in some instances, for specific counties). By law, Medicare does not currently reimburse riders or providers for paratransit trips (only trips by ambulance are eligible for reimbursement). Changing the Medicare legislation to allow paratransit trips for preventive care services could save the Medicare program billions of dollars,[38] but such changes are not currently in progress. Both programs are now under serious pressures to reduce spending wherever possible. One result of these pressures is that some states have cut back on Medicaid transportation spending,[39] putting more pressure on ADA and other specialized paratransit services.

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[38] Burkhardt, J., (2002). Benefits of transportation services to health programs. *Community Transportation*. 20:6.

[39] According to interviews with United We Ride Ambassadors, Colorado, Florida, Missouri, South Carolina, and West Virginia have recently decreased Medicaid spending for non-emergency transportation or else have threatened to decrease these expenditures. Iowa and Mississippi are considering similar action.

## Overall Impressions

An increased demand for specialized demand-responsive services is likely in the next several decades, but the proportion of that demand that is met by ADA complementary paratransit services depends on policy decisions that are extremely difficult to forecast. With no significant policy changes, ADA paratransit demands are likely to exhibit relatively stable rates of growth. Increases in ADA complementary paratransit demand are likely to be in proportion to continuing population growth. Significant policy changes could alter the ADA share of the overall demand for specialized demand-responsive services in dramatic fashion.

### Trends that Could Increase ADA Paratransit Demands

Among the most significant factors likely to influence potential increases in the demand for ADA paratransit services, the following stand out:

- The forecasted increase in the numbers of persons with disabilities is likely to create significant increases in the demand for specialized transportation services.
- Increased travel demands (trips per person per day) are expected, especially for senior citizens. While much of this increased demand will be satisfied by private auto trips, an increase in paratransit demands is also likely.
- Trends in employment, geo-spatial settlement patterns, and a number of other factors are likely to increase the demand for travel services with a high degree of flexibility, such as those offered by some paratransit operators.

### Trends that Could Decrease ADA Paratransit Demands

Among the most significant factors likely to influence potential decreases in the demand for ADA paratransit services, the following stand out:

- Increasing incomes and overall health are likely to increase the proportion of trip demands satisfied by driving (although the impact of that on ADA paratransit demand is uncertain).
- Future federal and state budgetary pressures could easily reduce the proportion of transit budgets available from federal and state sources. This could in turn reduce the supply of transit and ADA paratransit services, thus limiting the level of demand that could be satisfied.

### Effects of Potential but Hard-to-Predict Changes

It is possible that the changes that are currently the hardest to predict could have great influence on future demands for ADA paratransit services.

- Hard-to-predict policy changes regarding federal and state funding for transportation could have large influences on the demand for ADA paratransit and other specialized demand-responsive services. These changes could have positive or negative impacts on overall demands, but the current situation suggests that the changes could be negative.
- Technological advances to personal mobility devices could reduce the demand for ADA paratransit services as they are currently structured.
- Advances in medical technologies and treatment protocols may have unpredictable influences on ADA paratransit demands.
- The extent to which possible major revisions are made to existing practices within the public transit and taxi industries could have major effects on the demand for ADA paratransit services.

## Key Areas for Further Research

A number of subjects appear as important but hard-to-predict components of future ADA paratransit demands. These subjects would be good candidates for further research. They include the following:

- To what extent will future drivers convert to transit and paratransit riders if they eventually experience disabilities that compromise their abilities to drive?
- Will advances in automotive technologies significantly extend driving abilities beyond what is possible today?
- How will public transit agencies react to the increasing decentralization of homes and commercial activities? Will transit agencies follow these new developments or continue to focus on central city services?
- If human service program funding declines, will that decrease or increase ADA paratransit demands?
- To what extent will potential advances in medical technologies and treatment protocols influence ADA paratransit demands?

CHAPTER 6

# Options for Disaggregate Analysis

The aggregate demand analyses done as part of this project provide an easy-to-use method to forecast ADA paratransit demand for an urban region. In this section, we discuss options for further data collection and analysis to move toward less aggregate models.

## Disaggregation to Counties or Cities

It is useful to note that all of the area-related variables in the recommended regression model (population, low-income proportion, fixed-route transit revenue miles) are also typically available for smaller geographic entities such as counties within metropolitan regions or cities within counties. This means that it would also be possible to apply the regression model for those smaller areas to predict ADA demand separately for each one. At such a modest level of disaggregation, it is likely that the recommended aggregate model will still provide valid predictions. We cannot be completely confident of that fact, however, unless the regression analysis were to be repeated at that level of aggregation. The majority of the paratransit operators who provided data for this study also maintain databases with the origins and destinations of trips, as well as demographic data on the travelers. Those operators could provide separate data on the number of ADA-eligible trips made by residents of each city or county in their service area. With that data, the regression analysis carried out in this study could be repeated without a major expenditure of time or budget. Possible advantages of carrying out such an analysis include:

- It would test whether the predictive model is also valid for somewhat smaller geographic areas.
- If carried out after a year or two has passed, it would also provide an opportunity to simultaneously repeat the more aggregate analysis done here and thus test the temporal transferability of the original model.
- If several paratransit operators are included in the new sample that were not included in this original analysis, it would provide an opportunity to test the spatial transferability of the original model across different regions of the country.
- Use of smaller areas would provide a larger number of observations with somewhat greater variability, and thus the further analysis may be able to identify additional variables that are significantly correlated with demand.

There is a limit, however, to the level of spatial disaggregation that could be accommodated with this approach. For example, if the objective were to predict trips generated within specific neighborhoods and/or to predict the origin/destination patterns of trips, a much more disaggregate level of analysis would be required, as described below. At this more detailed level, the destination opportunities available and the competitiveness of specific modes of travel to those destinations become just as important, if not more important, than the demographic characteristics of the residents or the overall service characteristics of the paratransit system.

## A Fully Disaggregate Approach

The main concept behind disaggregate travel demand modeling is to model choices at the behavioral level that they actually occur. In this case, it would be the decision of individual travelers to make a particular trip by paratransit. Most typical models of household travel demand treat the choice of how many trips to make for different purposes (trip generation/frequency choice), where to travel to (trip distribution/destination choice), and the choice of which travel mode to use (mode choice) as separate but interrelated decisions. These same types of choices will generally apply to paratransit users, although they may be more constrained in their choice of available modes.

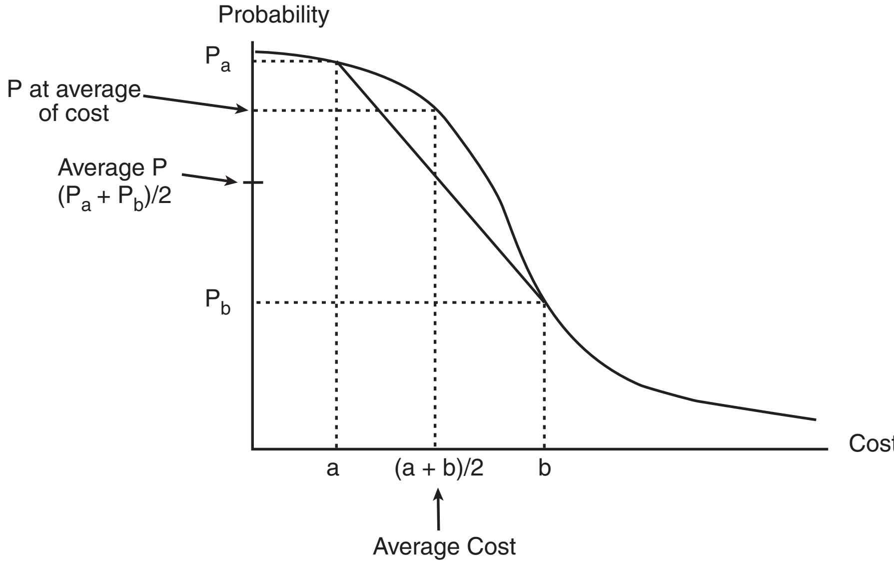
There are three primary advantages of the disaggregate approach, relative to a more aggregate approach. First, it may avoid the problem of *spurious results*. The more aggregate the data is, the more likely one is to find broad level correlations between variables, and the more difficult it is to attribute behavioral effects to any particular variable. An example in this study is the finding that higher fixed-route transit revenue miles in an urban area is related to higher ADA paratransit usage. This finding is probably related to variables that are correlated with high transit supply, such as the accessibility of destinations for transit and walking relative to driving, or the experience of ADA-eligible persons with transit use in the past. This element of the model cannot be used for short-term policy analysis, however, since it would imply that increasing the number of transit revenue miles per capita in an area would lead directly to an increase in the number of ADA paratransit trips. This is not likely to be the case. With disaggregate data, we could relate the paratransit trip rates of individual persons or households to the availability of fixed-route transit service near their home, the availability of an auto within the household, the accessibility to important destinations by auto versus other modes (parking convenience, parking costs, walking distance between stores, etc.), and land use mixes (the proximity of different types of destinations). With a large number of observed cases subject to different levels of these variables, we can overcome problems of correlation and sort out their relative effects on behavior.

A second important advantage of the disaggregate approach is that it can overcome *aggregation bias*. This type of bias arises from the fact that most models that represent discrete choices at the individual level, such as logit models and gravity models, are non-linear, and thus the probability share and model sensitivity at the aggregate average value is not necessarily equal to the average of the probabilities and sensitivity across all individual values. This is shown graphically in Exhibit 6-1, and it is true both for the predicted choice shares and the predicted elasticities. This means that if the data used to estimate and/or apply demand models is aggregated to too coarse a level, the predicted demand is subject to inaccuracies. As an example, suppose that households with 0 autos have few alternatives to using transit, and so their mode choice is not very sensitive to transit service levels. Also suppose that households with a car for every driver are very unlikely to use transit, and so their mode choice is also insensitive to transit service levels. The intermediate households that own cars but don't have a car for every driver are the ones where transit and auto are most competitive, and thus most sensitive to transit service changes. A model that uses aggregate average car ownership levels within a zone or a region would assign everyone an intermediate level of car ownership, and thus would overpredict the sensitivity of mode choice to transit service levels.

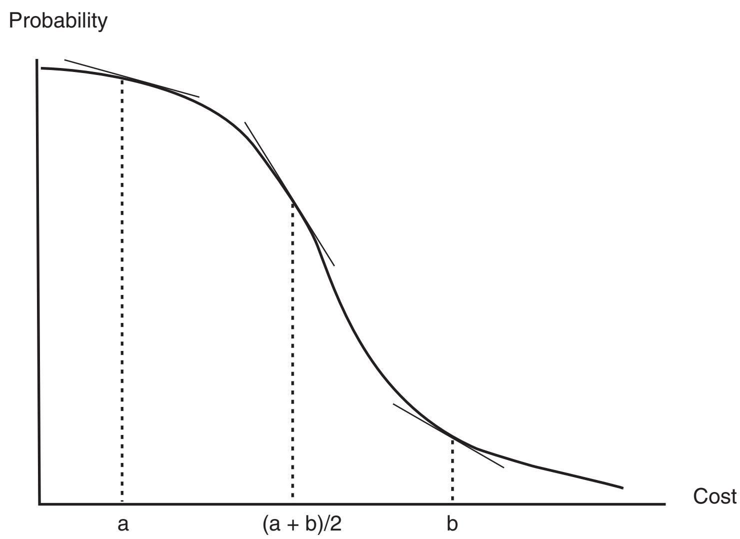
Although aggregate regression models such as used in this study do not include non-linear variables, they are subject to the same underlying behavioral inaccuracy—they are estimated using single average values for variables that are distributed across the population, and there is no guarantee that the predicted effects of changing those variables will be the same as what we would predict from more detailed models that segment the population into more homogenous categories.

**Exhibit 6-1. Aggregation bias with non-linear Logit models.**

1. Average probability is not equal to the probability at the average of explanatory variables.




2. The average impact of a change (average of slopes at a and b) is not equal to the impact calculated at the average of the explanatory variables.




## What Would Disaggregate Models Look Like?

The key decisions that lead to usage of paratransit include the following:

1. The decision to apply/register for ADA service eligibility
2. Trip generation: The decision to make a trip
3. Trip distribution: The decision to visit a specific destination
4. Mode choice: The decision to make that trip by paratransit or an alternative mode

Each of these decisions would be represented by a model.

Clearly, each decision is conditional on making the decision above it. We cannot treat the decisions as purely sequential, however, because each decision may also depend somewhat on the decisions below it. The decision to apply for ADA eligibility will depend on the number of trips a person makes and their propensity to make those trips by paratransit. This is analogous to the case for models of automobile usage—we typically do not include having a driving license as an explanatory variable because it is endogenous. For instance, people in NYC are less likely to have driving licenses, not because they are less able to drive, but because driving is less attractive there so they are less likely to make the effort. In addition, some people may have no feasible alternative to paratransit for some trips, so the decision to make a trip at all may depend on the availability of paratransit service. This inter-relationship is probably even stronger than it is for most other travelers who are able to use a wider variety of modes.

In disaggregate travel demand modeling, the most effective way of modeling inter-related decisions is to use the expected utility, or "logsum," across all available alternatives in the lower model (i.e., a model of one of the lower decisions in the list above) as an explanatory variable in the upper model (i.e., a model of the one of upper decisions in the list above). This essentially leads to a system of simultaneous nested models that are internally consistent. This type of linkage is illustrated further below, as part of a discussion of variables that should be considered in each of the four models above. Following this discussion, we discuss the types of data that can be used to estimate and apply the models.

### The Decision to Apply/Register for ADA Service Eligibility

The key variables are those which determine eligibility:

- Disability preventing use of fixed-route services? This may be a function of:
  - Age
  - Gender
  - Employment status (unemployment as an indicator of disability)
  - Income (provides access to healthier lifestyle, better health care)
  - Household size (people not living alone may tend to be healthier)

Other variables are related to the probability that eligible individuals will actually apply for registration and be accepted:

- Residence location within a fixed-route service area
- The increase in mobility and accessibility that ADA paratransit would provide for the individual. This is measured by the difference in the overall expected utility from the trip generation, distribution, and mode choice models (described below) with versus without paratransit as an alternative.
- The stringency of the provider in confirming eligibility
- The level of awareness of the service (the degree of activity/sophistication of social service agencies/advocacy groups in the region may be an indicator)

### Trip Generation: The Decision to Make a Trip

The key variables are those that influence the propensity of a person to carry out various types of out-of-home activities:

- Age (most activities generally decrease with age)
- Income (people with higher incomes typically travel more for all purposes)
- Employment status/student status (the need for commute or school trips)
- Gender (there is substantially higher paratransit usage among women, although this may be explained by other factors)
- Household size (people who live alone cannot delegate activities to others, but people who live with others may make more companion/helper trips)

- Regional effects (climate and lifestyles may vary somewhat across regions)
- Accessibility effects: The linkage to the trip distribution and mode choice models (described below) is provided by the expected utility of travel by all available modes to all relevant destinations (typically called a mode/destination choice logsum)

## Trip Distribution: The Decision to Visit a Specific Destination

The key variables are related to land use. Variables that may be particularly relevant for ADA eligible persons include the following:

- Shopping centers and restaurants—typically measured by retail jobs within a certain area
- Medical facilities—sometimes measured by medical/health care jobs within a certain area, or by signifying zones near hospitals
- Other services—this can sometimes be measured by service jobs in an area, although that may include many types of services, so further breakdown would be useful that would capture specialized services for people with disabilities such as adult day health care as well as training and supported work for people with developmental disabilities
- Parks and outdoor space—often measured by the acres of land within an area allocated to recreational uses
- Accessibility effects: The linkage to the mode choice model (described below) is provided by the expected utility of travel by all available modes to each destination (typically called a mode choice logsum)

## Mode Choice: The Decision to Make that Trip by Paratransit or an Alternative Mode

For a given type of trip to a specific destination, the key factors in mode choice fall into two categories:

1. Variables directly related to ADA paratransit service:
   - Fare
   - Service reliability (highest score on our survey)
   - Reservation requirements
   - Availability of most convenient requested time
   - Conditional screening
   - Denial rates (if a model is desired that includes non-ADA service as well as ADA service)
   - Availability of a program to coach use of the system
2. Variables related to alternatives to using paratransit:
   - Auto ownership and availability
   - The travel time, fuel cost, and parking cost of traveling by auto
   - Household size (may mean that a companion driver is available, but also may mean more competition for the available autos)
   - Specialized services provided by Medicaid, adult day health care, programs for developmentally disabled, and so on (2nd highest score on our survey)
   - Income (determines which options are affordable, and may also influence availability of specialized services)
   - Age (influences ability to drive and walk, and also may influence availability of specialized services)
   - Fixed transit route convenience, fare, frequencies, transfers required, wheelchair lifts, and so on

## Modeling Framework—Regional Travel Demand Modeling

Before discussing model estimation, it is useful to have a good idea of the framework in which the models will be applied, as that will to a large extent determine the availability of background spatial and demographic data.

First, note that three of the four models discussed above—trip generation/frequency, distribution/destination choice, and mode choice—are also three of the four typical steps included in regional travel demand models. Disaggregate models of paratransit demand should be designed to take advantage of the input data that typically already exist for those models, namely:

- The population of each transportation analysis zone (TAZ), ideally broken down into a joint distribution along a number of characteristics. Typical characteristics used are:
  - Household income (3 or 4 categories)
  - Household size (1, 2, 3, or 4+)
  - Number of workers in the household (0, 1, 2+)
  - Age of head of household (3 or 4 categories)
  - Auto ownership (0, 1, 2, 3+)
- Jobs in each TAZ, ideally broken down into a number of categories (retail, service, manufacturing, government, medical, other)
- School enrollment by TAZ, separately for grade schools and colleges
- Any other important land use characteristics such as amount of open/recreational land, mix of development types, and "walkability" factors such as intersection density
- Daily and hourly parking cost and availability
- TAZ-to-TAZ auto travel times and distances
- TAZ-to-TAZ fixed-route transit travel times, walk access and egress times, fares and headways

Note that TAZs are typically the size of a Census tract or block group and are often defined along Census boundaries in order to take advantage of Census data. In cases where we may want to use specific Census variables that are not used in the regional travel model (e.g., the fraction of residents of a zone with disabilities), it would be possible to supplement the zonal database used in the regional model.

Also note that all of these input data are typically developed for both a base year and a forecast year. In most regional models currently in use, the base year is 2000 or 2005, and the forecast year is 2030. Intermediate forecast years would be possible, but would require development of the input databases for those years.

The fourth step of typical regional travel demand models is trip assignment—the choice of specific paths or routes through the road network and transit network. This is the portion of the model system where travel demand and supply are reconciled, so it is important that demand from all significant travel markets (e.g., freight, commuters, school trips, shopping trips, etc.) be brought together at this stage. The demand for paratransit trips, however, is not likely to have a significant impact on traffic congestion levels and travel times in the region, so paratransit demand models can be run separately from the models for the rest of the markets, using as input the equilibrium congested travel times that result from other trips. This type of model operation, where demand forecasts for a specific travel market are coordinated with, but not fully integrated with, the forecasts for the larger markets, is quite common. The smaller markets are usually termed "special generators," and common examples are airport trips and visitors to convention centers or other tourist attractions. In this case, the "generator" would not be a specific destination, but rather a specific segment of the population.

In summary, the four-step regional travel demand framework would support the application of a series of disaggregate demand models as described above. The models as described would take advantage of detailed demographic segmentation of the population, as well as measures of accessibility[40] by all modes in all of the models, including destination choice and trip frequency. These two features are found in some of the more advanced regional demand models in the United States. Even in regions that use somewhat simpler model forms, however, the input data would still support more advanced models such as those proposed above.

The next step beyond these advances would be to move to an activity-based microsimulation model framework, as a few regions in the United States have already done. The tour-based aspect of those models (using home-based trip chains as the main unit of analysis rather than single trips) may be a useful concept for modeling paratransit demand, and tour-based models can use a structure that is virtually identical to the one described above for trips. The more complex features of activity-based models, however, such as models of scheduling activities across the day and models of interactions between household members, would probably not be worth the added time and cost of model development for paratransit demand.

## Data Needs

Last, but certainly not least, is a discussion of the data needed to estimate the proposed series of models. The typical data source for estimating urban travel demand models is a travel and activity diary survey of a random (or stratified random) sample of households in the region. The survey typically asks for details of all trips made by all household members during 1 or 2 specific days. A typical sample size is 3,000 to 6,000 households. As one would imagine, the number of paratransit trips reported in such a survey tends to be very small and is not adequate to estimate separate models for those trips.

Three of the four models described above apply only to people who are already registered as eligible to use ADA paratransit. This provides the very large advantage that data to estimate those three models can be collected from a very well-known universe whose contact information is already in the databases held by paratransit operators. Not only would contacting those people be efficient, but the survey method could be made cost-effective and accurate in a number of ways:

- It would only be necessary to collect data from the ADA-eligible person(s) in a household, rather than from every household member.
- Since ADA-eligible people tend to make fewer trips than the average person, the travel diary period could be extended beyond 1 or 2 days without adding significant respondent burden.
- The paratransit operator's database of actual trip transactions can be used to validate that part of the travel diaries, to ensure that at least the paratransit trips were reported fully and accurately.
- Additional questions about attitudes, constraints, and satisfaction related to paratransit and other modes could also be asked. Even if all of such data cannot be used directly in modeling, it would make the survey more useful from operators' and policy makers' standpoints, which could help in obtaining funding.

From the information gathered in this study, it does not appear that such a survey has yet been carried out by operators of any of the exemplary systems. The closest thing appears to be a survey described by Whatcom Transportation Authority: "A telephone survey by a consultant firm in 2003. Not exact numbers like a diary, but respondent's best guesses. I believe it touched on all the listed items except income." It may be worthwhile to obtain more information on this data.

[40] "Accessibility" here does not refer to adaptation for people with disabilities so much as "reachability" of destinations, which is the usual sense in travel demand modeling.

Another possibility is reported by the Santa Clara Valley Transportation Authority: "VTA is involved in the MTC Lifeline Community Based Transportation Planning effort which has started and includes large surveying efforts. This will go on for several years and Outreach, Inc. is participating in that process." That program is primarily designed to aid the economically disadvantaged, so it is not clear if there is scope for studies focused on the disabled population. The Bay Area region would be a good area for model development because the regional databases developed by MTC tend to be fairly comprehensive and up-to-date.

The remaining model to obtain data for would be the model of the decision to apply/register for ADA paratransit eligibility. Disaggregate modeling would require collecting data from the general population on whether or not they have applied for and obtained ADA eligibility, and relating that information to the characteristics of the person and household, as well as their accessibility of traveling with versus without paratransit near their residence. If any existing urban household travel surveys have asked that question, it would provide the needed data, but the number of persons in the sample who answer "yes" may be too small to estimate a useful model. Ideally, this question would be asked of all persons in a very large survey sample, and it would be in the same region where a survey focused on ADA paratransit users is also done. At least the sample would be from a region where exemplary paratransit exists so that paratransit demand models estimated elsewhere can be applied there to help estimate the service accessibility effect on registration rates.

A fall back option for this model would be to estimate a more aggregate model of ADA registration rates within specific TAZs in a region. From the operator databases, we can obtain data on the number of registered persons in each zone, perhaps broken down by a few key characteristics such as age group and gender of the travelers (few operators have data on car ownership or income). Such an aggregate model would explain the fraction of people who live in the zone with those same characteristics who are registered, as a function of the estimated accessibility of traveling with and without paratransit from that zone. As the number of characteristics becomes large enough, this approach approximates the disaggregate approach described in the preceding paragraph.

In summary, it does not appear that appropriate data currently exists to estimate disaggregate models of paratransit demand, but that such data could be obtained. Needed data include the following:

a) A diary-based survey of at least 500 individuals who are registered to use paratransit, based in one or more metro areas where exemplary paratransit service exists and where other data sources such as coded zonal land use data and road and transit networks are available.
b) A few supplementary questions in a large regional household survey, asking each person about disabilities that prevent use of specific modes, as well as ADA registration, if applicable. This does not need to be in the same region as survey (a) above.

## Model Development and Application Requirements

Once such data are available, it can be used to estimate the four types of models discussed above. Model estimation and subsequent coding of the model application to run in a regional model framework would likely require contracting a modeling consulting firm for a period of 9 to 18 months, for a typical budget in the range of $100,000 to $200,000.

The resulting models can be applied with the same inputs that are used in regional four-step travel demand models and thus provide forecasts of paratransit demand at an origin-destination level (OD) (and system-wide level) under:

- Various paratransit operating scenarios (fares, service levels, coverage areas).

- Various growth scenarios related to future changes in fuel prices, household size, income, auto ownership, age distribution, and residential distribution patterns.
- Scenarios related to changes in the service levels and/or coverage of the fixed-route transit system, as well as alternative transportation provided by health services.

Such a model system could be run either by the paratransit operator or by the local Metropolitan Planning Organization (MPO), whichever seems most efficient. Use of the model would likely require some proficiency with the network modeling software suite (typically TransCAD, TP+/MinUTP, or EMME/2) used to run the regional model, although only a fairly limited number of operations would need to be done in the software. These would include the following:

- Specifying paratransit-specific parameters for model input.
- Executing a run using pre-existing inputs (zonal data files, network skims).
- Querying the model output to obtain results in the form of OD tables, summary tables, and/or GIS maps.

CHAPTER 7

# Research Agenda

## Research Stemming from the Regression Analysis

The regression analysis results in some surprising findings about how community and service characteristics affect demand for ADA paratransit demand. Each of these findings suggests possible further research as discussed below. In addition, some refinements and extensions of the regression analysis are discussed.

### Age and Disability

The regression analysis found no significant effect from the percentage of people in older age groups or with various types of disability. In the case of disability, the lack of any observable effect most likely indicates that the Census measures do not correspond well to ADA paratransit eligibility. In the case of age, the result is somewhat surprising, since older people typically account for a high percentage of paratransit riders. However, younger people with disabilities are often very frequent riders and generate a disproportionate share of ridership. For example, in a planning project for the Whatcom Transportation Authority in Bellingham, Washington, Nelson\Nygaard determined that 60% of riders were age 65 and older, but people under age 65 made 58% of trips. If it is true, as found in the regression, that ridership is proportional to total population rather than population in older age groups, then paratransit ridership may grow far less dramatically than expected. A relationship based on total population is also much easier to use for predicting ridership than one based on older population, since projections of total population are more available than projections by age category.

The lack of relationship between age and ADA paratransit ridership could also be taken as an indication that many older people require demand responsive services other than ADA paratransit. In recent work for the National Cooperative Highway Research Program, Bailey and others analyzed National Transit Database and Census data and found a strong positive connection between growth in overall demand responsive transit ridership and growth in the 75 to 84 and 85 and older age groups. Their analysis did not distinguish ADA paratransit ridership from other demand responsive ridership such as general public dial-a-ride service.[41]

Additional regression analysis with a larger sample could help to test these findings. Disaggregate analysis could serve the same function.

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[41] ICF Consulting, *NCHRP Web-Only Document 86: Estimating the Impacts of the Aging Population on Transit Ridership*, National Cooperative Highway Research Program, TRB, January 2006.

## Poverty Rate and Incomes

The model shows a very strong connection between higher poverty rates and reduced demand for ADA paratransit. This suggests research to explore the following:

- How and why does the poverty rate in a community depress ADA paratransit demand?
- Is the effect really as strong as suggested by the regression results?
- Is demand reduced mainly due to limited incomes of individual travelers or due to community characteristics related to widespread poverty?

In general, demand for goods increases with income. In the case of public transportation, it might be thought that increasing income would go with more availability of other modes and therefore decreasing demand. Some research has in fact found a negative elasticity of transit ridership with respect to income.[42] Two hypotheses for the observed impact of poverty rate (corresponding to lower incomes) on paratransit demand area as follows:

- Individual people with disabilities might in fact use paratransit more as their incomes decrease, and the observed effect reflects mainly differences in communities.
- Lower incomes might correspond with higher paratransit ridership up to a point, but at the very low income levels associated with poverty status (which is disproportionately common among people with disabilities), total travel demand is so depressed that this overwhelms the effect of mode availability.

Both of these effects could be at work. Research that tests these findings and elaborates how they work would be valuable. This research would need to look at the choices of individual consumers. (An additional consideration is discussed in the later section about population growth.)

## Transit Service Availability

The regression results suggest that communities with more transit service have more paratransit demand. This contrasts with an expectation that more transit service would lead to lower paratransit demand, since transit would be a more viable alternative than in cities with less transit service. Clearly adding transit service does not increase paratransit usage. A possible explanation for the observed effect was suggested in the model development chapter, namely that the effect is a result of less dependence on private automobiles for travel in cities with more transit service. The observed effect might be explained if transit riders who can no longer ride transit are more likely to use paratransit than drivers who can no longer drive. In other words, if a significant fraction of people are used to travel by public transportation, then they would create a lot of demand for paratransit when they can no longer use conventional service. However, if nearly everyone is accustomed to drive for all of their trips, and if they drive until they can no longer do so, then they would create much less demand for paratransit, since they are unlikely to consider transit or paratransit as a realistic alternative when they can no longer drive. The effect would be intensified if, on average, people lose the ability to drive later than they lose the ability to ride transit.

These speculations suggest fundamental research on travel needs and preferences of people with disabilities and older people. Questions would include the following:

- How do people make choices between driving, getting rides, taking transit, and using paratransit in response to becoming disabled or in response to age-related limitations?

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[42] McLeod Jr., M. S.; Flannelly, K. J.; Flannelly, L.; Behnke, R. W., "Multivariate Time-Series Model of Transit Ridership Based on Historical, Aggregate Data: The Past, Present, and Future of Honolulu," *Transportation Research Record 1297*, Transportation Research Board, National Research Council, Washington, DC, 1991, pp. 76–84.

- How are these choices influenced by incomes, family situation, and availability of each mode, especially transit and paratransit service?

As in the case of research about poverty rate and incomes, this research would need to look at the choices of individual consumers.

## Cross-Sectional Effects and Changes Within One Paratransit System

The model was estimated by comparing ridership across various systems. The model is most useful as an aid for comparing paratransit systems. Effects within one paratransit system ("longitudinal effects") might be different or take a long time to occur. For example, the analysis produced a cross-sectional price elasticity of –0.77 for paratransit demand. This result suggests that paratransit trip making is much more sensitive to fares than is general transit ridership. In paratransit systems without capacity constraints, this might be expected given the general low income of people with disabilities and the relatively high fares that characterize many paratransit systems. In the first interim report for this project, evidence from the literature was presented that the estimated fare elasticity at individual paratransit systems is between –0.2 to –0.8. The literature review also found some evidence of elasticity over –1.0 when fare levels are high.

Another possibility is that the estimated cross-sectional price elasticity of –0.77 corresponds to long-term effects but not necessarily short-term effects. Research on response to transit fares has shown that long-term elasticities are much larger than short-term elasticities. The on-line TDM Encyclopedia of the Victoria Transport Policy Institute quotes the following results for transit fare elasticities from research by the British Transport Research Laboratory:[43]

| | |
|---|---|
| Buses: | |
| Short-run | –0.4 |
| Medium run | –0.56 |
| Long run | 1.0 |
| Metro rail: | |
| Short run | –0.3 |
| Long run | –0.6 |

The results of the regression analysis are reasonably consistent with these long-term elasticities.

Similar considerations would apply to other factors in the model, especially the on-time window. Further research about differences between cross-sectional and longitudinal effects and between long-term and short-term effects would help practitioners applying model results. Disaggregate analysis might provide some evidence on these questions. A relatively simple analysis would apply cross-sectional analysis to fixed-route transit ridership to see what difference there is in the impact of fares measured this way or as a short-term response to fare changes in one system.

## Additional Issues about Fares

It is possible that differences in cost of living or incomes between service areas would affect responses to fares. People with lower incomes would be expected to see a $2.00 fare as a stronger disincentive to travel than people with higher income. This might explain some of the impact of poverty rate seen in the regression analysis. It could also be true that the response to a given

[43] The Demand for Public Transit: A Practical Guide, Transport Research Laboratory, Report TRL 593, 2004, quoted at http://www.vtpi.org/tdm/tdm11.htm.

percentage change in fare would be different depending on incomes. A preliminary attempt to create a "poverty-adjusted fare" produced no significant change in the estimated fare elasticity. Conceivably using area-wide median income to adjust fares would work better. However, this would be a difficult analysis, and probably beyond the abilities of most paratransit system staff who might want to apply the resulting model.

Another issue is whether the response to fares changes is different at relatively low fares compared with relatively high fares. The regression model assumes that a given percentage fare change always produces the same percentage demand change. In other words, a change from \$1.00 to \$1.25 produces the same percentage ridership drop as a change from \$2.00 to \$2.50. Analysis of the model results indicates that the data fit this assumption reasonably well. (That is, residuals show no pattern when plotted against system base fare.) However, it may be that the sample is too small to detect differences, or that the assumption is true in the long run but not in the short run. Analysis with a larger sample of systems might help answer this question.

A related issue is the impact of fare discounts and zone charges. Discounts for passes or tickets and extra charges for zones were not included in the analysis because of concerns about reliability of the fare revenue data provided by some representative systems. If better fare data can be obtained, it should improve the analysis since some systems provide substantial discounts for passes and others have significant zone charges. It would also allow model users to estimate the impact of passes or zone charges. Some systems may have difficulty providing the necessary information, whether for researchers or even for their own use. Allocating pass sales revenue is often difficult. Also, the National Transit Database does not require that systems separate fare revenue for ADA paratransit from fare revenue for other demand-responsive service.

## Population Growth

An odd feature of the regression model is that it predicts paratransit demand as of about 2005 as a function of population and poverty status in 2000. Since the model indicates that demand increases in proportion to population (as long as other factors are constant), this mismatch should not affect the overall conclusion that any given percentage growth in population should translate to the same percentage growth in demand.

It is likely that population growth between 2000 and 2005 has been greater in some of the representative systems than others. If there is a correlation between differential population growth rates and the other factors, then the estimated impacts of other factors would be biased. For example, it is possible that areas with high poverty rates have grown less than areas with low poverty rates. If this is true, then the actual impact of the poverty rate alone may be somewhat less than estimated in the model. However, the impact of these differences over a period of only 5 years would probably account for a small part of the observed effect. If it were possible to determine these differential growth rates, then it is possible that the regression analysis could be slightly more accurate.

## Analysis with a Larger Sample

Experiments with omitting various representative systems from the regression give us confidence that the model results are valid and should apply to other systems. However, it would be even better if additional systems could be added to the analysis. Once the model results are published, it is possible that more systems would volunteer to be included in a similar effort in the future. If some candidate variables can be eliminated as a result of the research to date, then the effort to collect the data could be reduced.

## Long-Term Trends

The chapter about long-term trends noted that several subjects appear as important but hard-to-predict components of future ADA paratransit demands. They include the following:

- To what extent will future drivers convert to transit and paratransit riders if they eventually experience disabilities that compromise their abilities to drive? This is closely connected to the issues discussed regarding the regression analysis results concerning availability of transit service. Further exploration would require large surveys including people who use paratransit and people who do not, despite presence of significant disabilities.
- Will advances in automotive technologies significantly extend driving abilities beyond what is possible today? Exploration of this topic might be a reasonable topic for a research project.
- How will public transit agencies react to the increasing decentralization of homes and commercial activities? Will transit agencies follow these new developments or continue to focus on central city services?
- If human service program funding declines, will it decrease or increase ADA paratransit demands?
- To what extent will potential advances in medical technologies and treatment protocols influence ADA paratransit demands?

The trends discussed in the chapter about long-term trends also point to many issues that go beyond the limited topic of ADA complementary paratransit. As often noted, ADA paratransit is not intended as a comprehensive solution to the transportation needs of people with disabilities. Fundamental research into the travel needs and choices of people with disabilities could help to understand needs in a broader framework than is attempted in this project.

## Disaggregate Analysis

A disaggregate analysis of ADA paratransit demand could permit integrating ADA paratransit into the demand models used for regional transportation planning. The analysis could also help elucidate fundamental issues about travel behavior by people with disabilities. Chapter 6 concludes that appropriate data to estimate disaggregate models of paratransit demand do not yet exist but could be obtained. The chapter describes two needed types of data:

(a) A diary-based survey of at least 500 individuals who are registered to use paratransit, based in one or more metro areas where exemplary paratransit service exists and where other data sources such as coded zonal land use data and road and transit networks are available.
(b) A few supplementary questions in a large regional household survey, asking each person about disabilities that prevent use of specific modes, as well as ADA registration, if applicable. This does not need to be in the same region as survey (a) above.

The first of these data sets could probably be obtained for roughly $50,000 to $100,000 within the scope of a reasearch project. Alternatively it may be cost effective to piggy-back onto one or two regional household travel surveys that are going on anyway. This would be a less expensive way of collecting the data because the questionnaire will already be designed. Even if it is necessary to add questions specific to ADA paratransit, there would be minimal extra cost. The cost per completed survey would be less than for the rest of a regional household survey because the names and numbers of the eligible people are already known, and they will probably be a population that is easier to contact and more willing to participate than most households.

The second of these data sets, as indicated, can only be obtained at reasonable expense through a regional household travel survey. Note that ADA-eligible people probably compose only about 2% of the general population.[44]

One member of the study team is currently assisting in the design of the 2006–2007 Chicago area household travel survey, with a large sample size, and it may be possible to include a question or two about ADA eligibility and certification in that survey. Besides Chicago, two regional surveys that will happen next year are Washington, DC, and New York City/New Jersey. All of these present possibilities for obtaining travel diaries from paratransit riders.

Of these surveys, Chicago may present the best opportunity for paratransit research in the short run. Another team member is currently working on paratransit issues in Chicago and previously participated in an FTA compliance review. Paratransit service in Chicago has improved greatly in recent years, although many riders would still question whether it is good enough for use in this research. Also, service is undergoing major restructuring. New York is a second possibility, since it is one of our representative systems. An issue with New York would be whether it is too untypical to be considered transferable to other places. Paratransit service in the Washington, DC, area has been the subject of extensive controversy, which would make it unsuitable for this research.

As estimated in Chapter 6, once the necessary data are available, model estimation and subsequent coding of the model application to run in a regional model framework would likely require contracting a modeling consulting firm for a period of 9 to 18 months, for a typical budget in the range of $100,000 to $200,000.

A very different style of disaggregate research would use a multi-city or national travel survey such as the National Household Travel Survey (NHTS). With information about each person and average characteristics of paratransit and other modes in each city, it may be possible to estimate a model that explains how many trips each person makes by each mode of travel as a function of personal, household, and modal variables. This type of analysis was done in a recent NCHRP project about the future of transit ridership by older people.[45] Unfortunately, the 2001 NHTS did not include questions that would indicate ADA paratransit eligibility, although it did record use of transit agency paratransit by respondents. If a future NHTS were to include the appropriate questions, it would provide a basis for useful disaggregate analysis of how people with disabilities choose between ADA paratransit and other modes.

## Summary of Potential Research

The preceding discussion suggests three possible areas for further research: disaggregate modeling, additional regression analysis, and cross-section research on transit fares (see Exhibit 7-1). At least the last two could be done as an immediate follow-up for roughly $150,000 to $300,000, if there is interest.

For the first it needs to be determined how soon there will be an opportunity to cooperate with a regional household travel survey. An order-of-magnitude estimate for the disaggregate modeling project would be $200,000 to $400,000, including data collection, modeling, and project management.

These cost estimates would need to be refined following discussion with the panel.

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[44] Thatcher, R H; Gaffney J E; *ADA Paratransit Handbook*, U.S. DOT., September 1991.

[45] ICF Consulting, *NCHRP Web-Only Document 86: Estimating the Impacts of the Aging Population on Transit Ridership*, (Project 20-65[4]): Contractor's Final Report, National Cooperative Highway Research Program, Transportation Research Board.

**Exhibit 7-1. Opportunities for additional research.**

| Research | Topics Addressed | When to Do |
|---|---|---|
| Disaggregate analysis of travel choices by people with disabilities | ▪ Travel needs and choices of people with disabilities in general.<br>▪ Effect of incomes, mode availability, and prior travel experience.<br>▪ Likely impacts of future income, driving, and settlement trends on paratransit usage. | Depends on opportunities to cooperate with a regional household travel survey or inclusion of necessary questions in a future National Household Travel Survey. |
| Further regression with larger sample, population adjustments, additional measures of income, fare data | ▪ Cost-of-living and income effects on fares.<br>▪ Impact of discounts and zone charges.<br>▪ Discussion of whether fare elasticity is constant or not.<br>▪ Connections between population growth and other factors. | Possible immediate follow-up project or following the 2010 Census. |
| Cross-sectional analysis of transit ridership | ▪ Connections between cross-section, short-term, and long-run elasticities. | Possible immediate follow-up project. |

APPENDIX A

# Questionnaires

**TRANSIT COOPERATIVE RESEARCH PROGRAM**
***Project B-28***
***Improving ADA Complementary Paratransit Demand Estimation***

# Questionnaire for Representative Transit Systems

## A. General Information

1. **Transit agency official name:**
2. **Name and contact information of the person submitting this form:**
3. **General Public Service Name** *(The name used to market general public transit service to the public. If there is more than one name, used for distinct services, give the name of the service that principally triggers the requirement for ADA complementary paratransit.):*
4. **ADA Paratransit Service Name:**
5. **Definition of fiscal year** *(e.g., July to June)***:**
6. **What was the most recent month and year in which your system denied any significant number of ADA paratransit trip requests?**

   **For purposes of this question, how did you define "significant number"?**
7. **In what month and year did you last have any other significant capacity constraints?**

   **What were they?** *(e.g. late trips, problems with telephone access, etc.)*

**Comments about Section A:**

All of the information requested in Sections B – F should apply to your most recent complete fiscal year. Paratransit data should apply to trips within the ADA paratransit service area only. If you have been providing service without capacity constraints for more than one fiscal year, please repeat sections B – F for up to two previous fiscal years.

## B. Service Definition

**Fiscal Year:**

1. **What was the fare structure for ADA paratransit trips?:**
2. **What was the total fare revenue for ADA paratransit service?**
3. **How was the ADA paratransit service area defined?**
   - ☐ Exact boundaries of one or more cities or counties
   - ☐ Boundaries of a transit district
   - ☐ ¾-mile around transit routes
   - ☐ Other *(please describe):*
4. **In which of the following ways can you provide us the exact boundaries of your ADA paratransit service area?**
   - ☐ GIS layer *(this is by far the preferred method) Please e-mail to dkoffman@nelsonnygaard.com.*
   - ☐ List of cities, counties, etc. *Please mail the list or attach as an e-mail with your response.*
   - ☐ Boundaries drawn on a map. *Please mail the map or attach as an e-mail with your response.*

**Comments about Section B:**

## C. Trips Provided

**Fiscal Year:** ______

1. **Total ADA paratransit trips provided, including trips for attendants and companions:** ______
2. **Total ADA paratransit trips provided to ADA-certified riders:** ______
3. **Of the trips included in Item C1, how many were provided to enable riders to participate in programs sponsored by public and non-profit agencies?** *(Note: boxes will expand as you type.)*

   Name of Agency ______ Type of program: ______ Trips: ______

   Name of Agency ______ Type of program: ______ Trips: ______

   Name of Agency ______ Type of program: ______ Trips: ______

   Name of Agency ______ Type of program: ______ Trips: ______

4. **How many trips did you provide that were sponsored by human service agencies and that are <u>not considered part of your ADA paratransit service</u> (for example trips you provided as a transportation coordinator or broker)?**

   Name of Agency ______ Type of program: ______ Trips: ______

   Name of Agency ______ Type of program: ______ Trips: ______

   Name of Agency ______ Type of program: ______ Trips: ______

   Name of Agency ______ Type of program: ______ Trips: ______

5. **How many other non-ADA paratransit trips did you provide within the ADA paratransit service area?**

   Subsidized taxi trips not included in C1: ______

   Paratransit or dial-a-ride trips for seniors *(eligibility based on age, not ADA eligibility):* ______

   Other Non-ADA trips not listed before: ______

   ☞ *Please describe:* ______

**Comments about Section C:** ______

## D. Service Quality Indicators

**Fiscal Year:** ______

1. **What percentage of ADA paratransit trips were served on-time?** ______
2. **How did you define “on-time” for D1?** ______
3. **How much could a window or scheduled pick-up time be changed before the rider must be notified?** ______
4. **If the definition in D2 concerned only pick-up times, did you track on-time drop-offs?** ☐ Yes ☐ No

   ☞ ***If “yes,”*** *what percent of ADA paratransit trips had on-time drop-offs?* ______

   ☞ *How do you define “on-time” drop-offs?* ______

5. **What was the average time on hold to make an ADA paratransit reservation (in minutes and seconds)?** ______

**Comments about Section D:** ______

## E. Eligibility Process

**Fiscal Year:** ____

**1. What percentage of new applicants for ADA paratransit (excluding applicants for re-certification) were interviewed or tested in person (face to face)?** ____

**2. What percentage of new applicants for ADA paratransit were found:**

Fully eligible for ADA paratransit (eligible for all trips) ____

Conditionally eligible for ADA paratransit (eligible for some trips) ____

Not eligible for ADA paratransit (denied) ____

**3. Did you conduct trip-by-trip eligibility screening for people with conditional eligibility?** ____

**Comments about Section E:** ____

## F. Fixed-Route Transit Service

**Fiscal Year:** ____

**1. How many revenue vehicle miles of fixed-route transit service did you operate, as reported to the National Transit Database?** ____

**2. Using NTD definitions, please provide:**

Active fleet (bus and rail vehicles operated in annual maximum service): ____

Number of these vehicles that were ADA accessible with lifts or ramps: ____

**3. Did you track boardings by riders using wheelchairs?** ☐ Yes ☐ No

☞ *If you do, how many were there?* ____

**Comments about Section F:** ____

TCRP is interested in determining whether paratransit systems have data available that could be used in a future project for a more detailed analysis of travel behavior by people with disabilities. You can help determine the feasibility of such an analysis by answering the following questions

## G. Data for Disaggregate Analysis

**1. What scheduling software do you use?** ______

**2. Does it record the latitude and longitude of each pick up and drop off?** ☐ Yes ☐ No

**3. How far back do you retain data about trips scheduled with this system?** ______

**4. What information about individual paratransit riders do you keep on file?**

| | | |
|---|---|---|
| Age | ☐ Yes | ☐ No |
| Sex | ☐ Yes | ☐ No |
| Car ownership | ☐ Yes | ☐ No |
| Mobility aids used | ☐ Yes | ☐ No |
| Type(s) of disability | ☐ Yes | ☐ No |

**5. In the past few years, have you conducted a survey of paratransit riders (e.g., a travel diary survey) that included all or most of the following?**

- **Exact numbers of trips taken on various modes—on paratransit, as a passenger in a car, as a driver, and by transit—in some specified period**
- **The location of the origin and destination of each trip**
- **The purpose of each trip**
- **Household income**
- **Car ownership**

☐ No
☐ Yes, with all of these items
☐ Yes, but only with some of them. Which ones were included? ______

**6. Has your agency or another agency in your area conducted a similar survey that would include this same type of information for people with disabilities regardless of whether they are currently registered to use ADA paratransit?**

☐ No
☐ Yes. Which agency? ______
☐ Not sure. Can you suggest who to contact on this question? ______

**Comments about Section G:** ______

Thank you for providing this information. Please return the form by e-mail (preferred) or as hard copy. If you are able to provide data about previous fiscal years, please complete a separate form for each fiscal year.

**TCRP Project B-28, Improving ADA Paratransit Demand Estimation**
**Supplementary Questionnaire No. 1**

1. Human Service Transportation

Thinking of human service agencies in your ADA paratransit service area, to the best of your knowledge, what portion of the transportation needed by their clients to agency programs or services do the agencies provide or pay for? To clarify:

- A human service agency that provides none (0%) of the client transportation needed to the agency's programs or services would be one that depends entirely on other programs (including your ADA paratransit system) or the clients themselves to provide transportation.
- A human service agency that provides 100% of the client transportation needed to the agency's programs or services would be one that assumes full responsibility for client transportation by operating its own vehicles for this purpose, contracting for transportation, reimbursing clients for their transportation, providing vouchers to clients, participating in a brokerage, or paying you to provide trips for their clients to agency programs (or some combination of these). If the State provides for client transportation that would count as well.

To the best of your knowledge, please estimate the portion of client transportation provided by human service agencies in your area:

| Type of Human Service Agency | What portion of needed client transportation do they provide? | | | | | |
|---|---|---|---|---|---|---|
| | 0% | 25% | 50% | 75% | 100% | Don't Know |
| Developmental disabilities / mental retardation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Adult day care / adult day health care | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Senior nutrition (congregate meals) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Dialysis | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Medicaid (other than dialysis) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: ________________ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Comments: ________________

2. Non-ADA Paratransit

In the area served by your ADA paratransit program, is there any other significant publicly funded paratransit service or taxi subsidy program (not limited to client transportation) that serves...

| | | |
|---|---|---|
| Seniors (regardless of disability)? | Yes ☐ | No ☐ |
| People with disabilities? | Yes ☐ | No ☐ |
| Low income people? | Yes ☐ | No ☐ |
| General public (Dial-a-Ride)? | Yes ☐ | No ☐ |

Note: Do not include non-ADA services operated by your agency that you have already told us about.

Comments: ________________

**TCRP Project B-28, Improving ADA Paratransit Demand Estimation**
**Supplementary Questionnaire No. 1 – State/Regional Contacts**

Human Service Transportation
Thinking of human service agencies in the area described by the cover memo, to the best of your knowledge, what portion of the transportation needed by their clients to agency programs or services do the agencies provide or pay for? To clarify:

- A human service agency that provides none (0%) of the client transportation needed to the agency's programs or services would be one that depends entirely on other programs (including the ADA paratransit system) or the clients themselves to provide transportation.
- A human service agency that provides 100% of the client transportation needed to the agency's programs or services would be one that assumes full responsibility for client transportation by operating its own vehicles for this purpose, contracting for transportation, reimbursing clients for their transportation, providing vouchers to clients, participating in a brokerage, or paying the ADA system its full cost to provide trips for their clients to agency programs (or some combination of these). If the State provides for client transportation that would count as well.

To the best of your knowledge, please estimate the portion of client transportation provided by human service agencies in the area:

| Type of Human Service Agency | What portion of needed client transportation do they provide? | | | | | |
|---|---|---|---|---|---|---|
| | 0% | 25% | 50% | 75% | 100% | Don't Know |
| Developmental disabilities / mental retardation | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Adult day care / adult day health care | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Senior nutrition (congregate meals) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Dialysis | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Medicaid (other than dialysis) | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other: ____________________ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Comments: ____________________

Service Area: ____________________
Respondent: ____________________

APPENDIX B

# Representative System Data

## System Identification and ADA Paratransit Trips

| Representative System | System Abbreviation | Fiscal Year | Total ADA paratransit trips | Trips per capita |
|---|---|---|---|---|
| Ben Franklin Transit | BFT | 2004 | 305164 | 1.86 |
| Blacksburg Transit | BT | 2005 | 11327 | 0.29 |
| Capital Area Transportation Authority | CATA | 2005 | 297493 | 1.34 |
| Central Contra Costa Transit Authority | CCCTA | 2005 | 154315 | 0.37 |
| Central New York Regional Transportation Authority | CNYRTA | 2005 | 45,465 | 0.10 |
| Link Transit | Link | 2004 | 103,300 | 1.67 |
| Dallas Area Rapid Transit | DART | 2005 | 580,363 | 0.27 |
| Eastern Contra Costa Transit Authority(Tri-Delta Transit) | ECCTA | 2005 | 104,090 | 0.53 |
| Fort Worth Transportation Authority | FWTA | 2005 | 288,663 | 0.52 |
| Fresno Area Express | FAX | 2004 | 169,543 | 0.36 |
| Hillsborough Area Regional Transit | HART | 2005 | 49,211 | 0.08 |
| JAUNT, Inc. | JAUNT | 2005 | 102,866 | 1.42 |
| King County Metro Transit | King | 2004 | 1,062,092 | 0.64 |
| Lane Transit District | LTD | 2005 | 52,4995 | 0.25 |
| Merrimack Valley Regional Transit Authority | MVRTA | 2005 | 35,433 | 0.15 |
| Metropolitan Tulsa Transit Author | Tulsa | 2005 | 182,657 | 0.47 |
| New York City Transit Authority | NYC | 2004 | 3,982,892 | 0.50 |
| Orange County Transportation Authority | OCTA | 2005 | 1,156,387 | 0.41 |
| Ottumwa Transit Authority | OTA | 2005 | 12,700 | 0.65 |
| Port Authority of Allegheny County | PAAC | 2005 | 572,114 | 0.42 |
| Regional Transportation District | RTD | 2004 | 493,346 | 0.23 |
| Rhode Island Public Transit Authority | RIPTA | 2005 | 222,382 | 0.25 |
| San Mateo County Transit District | SMCTD | 2005 | 281,398 | 0.40 |
| Southwest Ohio Regional Transit Authority | SORTA | 2004 | 245,455 | 0.39 |
| Portland TriMet | TriMet | 2005 | 1,026,154 | 0.85 |
| Utah Transit Authority | UTA | 2004 | 502,341 | 0.30 |
| Santa Clara Valley Transportation Authority | SCVTA | 2005 | 912,668 | 0.54 |
| Whatcom Transportation Authority | WTA | 2004 | 138,090 | 1.39 |
| | **Average** | | **467,514** | **0.59** |

## Paratransit Trip Detail

| System Abbreviation | Total certified rider trips | ADA Agency Trips | Non-ADA Agency Trips | Non-ADA Taxi trips | Non-ADA Senior trips | Other non-ADA trips | Total Non-ADA Trips |
|---|---|---|---|---|---|---|---|
| BFT | | 71,778 | 0 | 0 | 0 | 0 | 0 |
| BT | 11,131 | | 0 | | | | 0 |
| CATA | 279,224 | 45,897 | 0 | 0 | 14,681 | 36,553 | 51,234 |
| CCCTA | 141,507 | 26,887 | 0 | | | | 0 |
| CNYRTA | 42,953 | | 18,876 | 14,832 | 1,089 | 23,065 | 38,986 |
| Link | 101,000 | | 0 | 0 | 0 | 0 | 0 |
| DART | | | 0 | 0 | 0 | 0 | 0 |
| ECCTA | 95,546 | 20,436 | 0 | 20,818 | | | 20,818 |
| FWTA | 271,343 | | 0 | | | | 0 |
| FAX | | | 0 | 0 | 0 | | 0 |
| HART | 42,075 | | 0 | | | | 0 |
| JAUNT | 99,005 | 32,062 | 92,223 | | | 82,395 | 82,395 |
| King | 957,666 | 1,562 | 0 | 50,314 | 0 | 117,004 | 167,318 |
| LTD | 48,077 | 9,147 | 37,191 | | 7,672 | | 7,672 |
| MVRTA | 34,733 | 7,750 | 0 | 0 | 14,993 | 8,991 | 23,984 |
| Tulsa | 182,042 | | 0 | | | | 0 |
| NYC | 2,877,476 | | 0 | | | | 0 |
| OCTA | | 764,000 | 41,255 | 0 | 0 | 0 | 0 |
| OTA | | 2,860 | 0 | 0 | 0 | 34,100 | 34,100 |
| PAAC | 528,716 | | 1,137,128 | 0 | 524,642 | | 524,642 |
| RTD | | | 0 | 49,000 | | | 49,000 |
| RIPTA | 198,556 | | 492,920 | 0 | | 0 | 0 |
| SMCTD | | 44,091 | 0 | 0 | 0 | 0 | 0 |
| SORTA | 225,395 | 77,302 | 28,649 | 0 | 0 | 13,227 | 13,227 |
| TriMet | 815,792 | 210,362 | 673,524 | 0 | 0 | 0 | 0 |
| UTA | 467,909 | | 0 | | | | 0 |
| SCVTA | 739,331 | | 0 | | | | 0 |
| WTA | 126,942 | | | 0 | 5,950 | 0 | 5,950 |
| **Average** | **394,591** | **101,087** | **93,399** | **7,498** | **35,564** | **21,022** | **36,405** |

## Fares

| System Abbreviation | Fare structure description | Total fare revenue | Fare per Trip | Base Fare |
|---|---|---|---|---|
| BFT | $.75 per trip. 10-Ride tickets $3.50 | $110,294 | $0.36 | $0.75 |
| BT | $.50 per one-way trip, $8 monthly pass. Both = fixed route | $2,700 | $0.24 | $0.50 |
| CATA | $2.00 per one-way trip | $416,000 | $1.40 | $2.00 |
| CCCTA | $3.00 | $398,112 | $2.58 | $3.00 |
| CNYRTA | Base Fare: $1.25 Highest Fare: $2.25 (base plus suburban zone extension fares) | $197,938 | $4.35 | $1.25 |
| Link | $0.50 one zone, $1.00 two zones | $40,644 | $0.39 | $0.50 |
| DART | $2.50 per trip | $1,614,844 | $2.78 | $2.50 |
| ECCTA | $2.00 per trip | $144,561 | $1.39 | $2.00 |
| FWTA | $2.50 | $735,145 | $2.55 | $2.50 |
| FAX | $.75 exact fare, monthly pass $25.00. Children under 6 (limit 4) Free | $110,294 | $0.65 | $0.75 |
| HART | Fare based on the number of buses the trip would take on fixed route - $2.60, $3.90 or max $5.20 | $115,000 | $2.34 | $2.60 |
| JAUNT | $1.50 | $154,241 | $1.50 | $1.50 |
| King | $.75 for any one way ride | $196,126 | $0.18 | $0.75 |
| LTD | 2.50 per one-way trip | $100,218 | $1.91 | $2.50 |
| MVRTA | $2.00 per trip. | $99,336 | $2.80 | $2.00 |
| Tulsa | $2.00 per trip. LIFT customers can ride Fixed Route for $.60 | $419,043 | $2.29 | $2.00 |
| NYC | $2.00 per person, per trip | $5,903.677 | $1.48 | $2.00 |
| OCTA | $2.25 per passenger per trip. (beginning January 1 2005) | $3,570,694 | $3.09 | $2.25 |
| OTA | $2.00 per ride. | $25,000 | $1.97 | $2.00 |
| PAAC | $1.75 minimum one way fare - other fares distance based. | $1,273,000 | $2.23 | $1.75 |
| RTD | Twice the cost of fixed-route services | $907,991 | $1.84 | $3.00 |
| RIPTA | $2.50 from July to February; $3.00 from March to June | $411,321 | $1.85 | $2.50 |
| SMCTD | $2.00 standard fare, $1.00 lifeline fare assistance. (Fares have since increased.) | $463,850 | $1.65 | $2.00 |
| SORTA | .75 cents - Weekends and Holidays, Zone 1 $1 Zone 2 $1.50 - Weekdays. As of Feb 1, companions not permitted on non-ADA trips. | $285,935 | $1.16 | $0.75 |
| TriMet | $1.45 cash, $14.50 10-ticket book, monthly pass = $38. Jan 2006, fare increase of $.15 will be implemented. | $747,073 | $0.73 | $1.45 |
| UTA | $2.00 for one way trip, with monthly Paratransit Pass, and Trip Coupon book, Disabled Pass for Free trip on Fixed Route | $1,527,829 | $3.04 | $2.00 |
| SCVTA | $3.50 for Standard Paratransit trip;$7.00 for open/will call return; $17.50 for Second Vehicle for missed return trip; $14.00 for same-day trip; $7.00 surcharge beyond ADA area. | $2,527,032 | $2.77 | $3.50 |
| WTA | $0.50/ride cash, $7 monthly pass, $20 quarterly pass, 85+ years of age ride free. | $57,448 | $0.42 | $0.50 |
| **Average** | | | **$1.78** | **$1.81** |

## Service Quality

| System Abbreviation | Effective Window for On-time Pick-ups | Percent On-time Pick-ups | Track dropoffs? | Avg Time on Hold |
|---|---|---|---|---|
| BFT | 40 | 98% | Yes | 0:01:00* |
| BT | 20 | 85% | No | |
| CATA | 10 | 90% | Yes | 0:03:00 |
| CCCTA | 40 | 97% | No | 0:00:30* |
| CNYRTA | 25 | 98% | No | 0:01:12 |
| Link | 20 | 94% | No | 0:00:30 |
| DART | 20 | 90% | No | 0:01:10 |
| ECCTA | 20 | 80% | No | 0:00:39 |
| FWTA | 30 | 88% | No | 0:01:16* |
| FAX | 35 | 88% | No | |
| HART | 60 | 96% | No | 0:01:30 |
| JAUNT | 25 | 82% | Yes | 0:01:00* |
| King | 30 | 91% | No | 0:00:28 |
| LTD | 20 | 90% | Yes | |
| MVRTA | 30 | 98% | No | 0:01:30 |
| Tulsa | 30 | 95% | No | 0:00:21 |
| NYC | 30 | 94% | No | 0:00:15 |
| OCTA | 20 | 94% | No | 0:01:07 |
| OTA | 30 | 95% | No | |
| PAAC | 30 | 95% | No | 0:00:20 |
| RTD | 45 | 97% | No | 0:01:30 |
| RIPTA | 30 | 92% | Yes | 0:01:30 |
| SMCTD | 40 | 88% | No | 0:01:00 |
| SORTA | 30 | 95% | Yes | 0:01:59 |
| TriMet | 30 | 92% | Yes | 0:01:15 |
| UTA | 40 | 88% | No | 0:02:00* |
| SCVTA | 40 | 99% | No | 0:01:29 |
| WTA | 30 | 92% | No | 0:00:39 |
| **Average** | **30** | **92%** | **25% Yes** | **0:01:08** |

*Rough estimate by transit agency staff.

## Eligibility

| System Abbreviation | Percent of Applicants Tested | Percent Fully Eligible | Percent Conditionally Eligible | Percent not Eligible | Conditional Trip Screening |
|---|---|---|---|---|---|
| BFT | 0% | 99% | 0% | 2% | No |
| BT | 0% | 45% | 50% | 5% | No |
| CATA | 0% | 94% | 0% | 6% | No |
| CCCTA | 7% | 30% | 68% | 2% | No |
| CNYRTA | 0% | 13% | 79% | 8% | Yes |
| Link | 90% | 71% | 26% | 3% | Yes |
| DART | 100% | 23% | 66% | 11% | No |
| ECCTA | 15% | 85% | 0% | 15% | No |
| FWTA | 33% | 100% | 0% | 0% | No |
| FAX | 0% | 98% | 0% | 2% | No |
| HART | 100% | 45% | 53% | 2% | Yes |
| JAUNT | 100% | 100% | 0% | 0% | No |
| King | 47% | 84% | 14% | 2% | Yes |
| LTD | 80% | 72% | 28% | 1% | Yes |
| MVRTA | 0% | 86% | 10% | 4% | Yes |
| Tulsa | 100% | 95% | 3% | 2% | Yes |
| NYC | 51% | 58% | 27% | 11% | No |
| OCTA | 55% | 43% | 23% | 7% | Yes |
| OTA | 0% | 100% | 0% | 1% | No |
| PAAC | 100% | 53% | 36% | 11% | Yes |
| RTD | 100% | 83% | 4% | 4% | No |
| RIPTA | 0% | 85% | 12% | 3% | Yes |
| SMCTD | 100% | 79% | 10% | 2% | Yes |
| SORTA | 100% | 63% | 22% | 15% | Yes |
| TriMet | 2% | 78% | 13% | 9% | No |
| UTA | 100% | 54% | 26% | 3% | Yes |
| SCVTA | 100% | 90% | 7% | 3% | No |
| WTA | 70% | 87% | 11% | 2% | No |
| **Average** | **52%** | **72%** | **21%** | **5%** | **43% Yes** |

## Conditional Eligibility Criteria

| | |
|---|---|
| CNYRTA | Environmental (cold, heat, darkness, bright sun, snow, rain, humidity)<br>Walking distances to/from fixed route<br>Physical barriers (11 categories) |
| Link | Seasonal (typically November 15 to March 15)<br>Night blindness and heat sensitivity (not a lot of these)<br>Locational (e.g., except specific trips--very few in 2004) |
| HART | Trips requiring one or more transfers via fixed route<br>Barriers in the path of pedestrian travel<br>Conditional trips from dusk to dawn have been provided to individuals with low vision |
| King | Seasonal (extreme cold, extreme heat, hours of darkness, periods of bright light, snow)<br>Terrain (path of travel) - only if completed eligibility after Nov. 2005 and trip is made at least once per week.<br>• Uneven terrain<br>• Lack of curb cuts<br>• Complex traffic crossings<br>• Incline over 8%<br>• Distance in blocks<br>Non-accessible bus zone<br>Trip requires a bus transfer |
| LTD | If power mobility device is not available<br>Rider's destination is more than X number of blocks from the fixed route<br>Icy or snowy conditions<br>After dark<br>Temperatures are below or above a certain level<br>Intermittent disability (a few people)<br>Specific frequent destinations for which the rider is eligible |
| MVRTA | No curb cuts available at an origin and/or destination<br>Ice, snow, heavy rain (i.e., winter months) |
| PAAC | Actual weather forecast for next day service (not seasonal) - can be temperature, snow and / or ice (use National Weather Service forecast)<br>Maximum distance the person can walk or push their mobility aid<br>Trip requires a transfer<br>Before dawn or after dusk (for people with certain visual impairments)<br>Bus stop not accessible or detectable<br>Seat required at bus stop<br>Not trained to the destination (primarily for people with mental retardation who have learned single routine trips)<br>Path of travel. Examples:<br>• Lack of curb cuts<br>• Uneven terrain<br>• Have to walk through a large open space with no detectable path of travel (for people who are blind)<br>• Travel along the side of the road with no sidewalk, less than 5 feet with quickly moving traffic<br>• Can't negotiate intersection ( depending on the skill of the person, will have one or more descriptions of intersection designs)<br>• Slopes / hills |
| SMCTD | Weather (Cold, heat, smog, rain)<br>Time of day (night blindness, light sensitivity)<br>Path of travel (lack of curb cuts, lack of sidewalks, hills, uneven surfaces)<br>Distance<br>Fixed-route transfer<br>Variable health (most common)<br>Not eligible for trips to certain destinations (also common) |
| SORTA | Winter months only<br>Dialysis only<br>Others |
| UTA | Temp is above 90°<br>Only to destinations that are infrequently traveled to by the client<br>Other conditions ranging up to "very strict" |
| Tulsa | Temperature is above 85° and below 40°<br>Listed locations only |

## Fixed-Route Service

| System Abbreviation | Revenue Vehicle Miles | Active Fleet | ADA Accessible Fleet | Track wheelchair boardings? |
|---|---|---|---|---|
| BFT | 2,308,549 | 52 | 28 | No |
| BT | 708,028 | 35 | 35 | No |
| CATA | 3,185,000 | 96 | 96 | Yes |
| CCCTA | 3,631,923 | 131 | 131 | Yes |
| CNYRTA | 3,553,702 | 151 | 149 | No |
| Link | 1,272,732 | 29 | 29 | Yes |
| DART | 34,379,793 | 917 | 917 | Yes |
| ECCTA | 2,251,495 | 126 | 69 | Yes |
| FWTA | 3,949,592 | 141 | 141 | No |
| FAX | 4,320,952 | 84 | 84 | No |
| HART | 6,655,772 | 220 | 210 | Yes |
| JAUNT | 990,598 | 26 | 26 | No |
| King | 38,601,801 | 1,405 | 1,402 | Yes |
| LTD | 3,255,973 | 100 | 100 | Yes |
| MVRTA | 1,098,236 | 47 | 47 | No |
| Tulsa | 2,467,865 | 59 | 59 | Yes |
| NYC | 443,483,860 | 9,040 | 9,040 | Yes |
| OCTA | 21,927,998 | 473 | 473 | No |
| OTA | 313,640 | 11 | 11 | No |
| PAAC | 28,049,934 | 826 | 826 | No |
| RTD | 39,028,647 | 930 | 930 | No |
| RIPTA | 7,496,141 | 222 | 222 | Yes |
| SMCTD | 7,303,006 | 268 | 268 | No |
| SORTA | 11,291,291 | 344 | 336 | No |
| TriMet | 30,766,284 | 623 | 601 | No |
| UTA | 29,914,926 | 714 | 714 | Yes |
| SCVTA | 16,960,851 | 386 | 386 | No |
| WTA | 1,315,684 | 50 | 40 | Yes |
| **Average** | **26,447,402** | **625** | **620** | **46%** |

## Population, Age, and Poverty

| System Abbreviation | Total population in the service area | Pct. Males age 65+ | Pct. Males age 75+ | Pct. Females age 65+ | Pct. Females age 75+ | Pct. Non-white or Hispanic | Pct. population with 1999 household income below poverty level |
|---|---|---|---|---|---|---|---|
| BFT | 164,207 | 4.4% | 1.8% | 5.7% | 2.8% | 26.8% | 12.704% |
| BT | 39,286 | 2.2% | 1.0% | 3.5% | 2.0% | 16.6% | 32.9% |
| CATA | 222,547 | 3.6% | 1.5% | 5.7% | 3.0% | 28.4% | 15.9% |
| CCCTA | 416,987 | 5.5% | 2.6% | 8.0% | 4.4% | 25.9% | 4.6% |
| CNYRTA | 447,713 | 5.7% | 2.6% | 9.1% | 5.0% | 17.0% | 14.0% |
| Link | 61,875 | 5.8% | 2.7% | 8.3% | 4.6% | 22.1% | 13.8% |
| DART | 2,137,945 | 3.1% | 1.2% | 4.7% | 2.3% | 53.2% | 12.8% |
| ECCTA | 196,492 | 3.2% | 1.3% | 4.6% | 2.1% | 51.0% | 9.9% |
| FWTA | 550,016 | 3.8% | 1.1% | 6.0% | 3.1% | 52.9% | 15.2% |
| FAX | 475,181 | 4.1% | 1.9% | 6.0% | 3.1% | 60.9% | 24.6% |
| HART | 619,757 | 5.1% | 2.2% | 7.4% | 3.9% | 45.0% | 15.0% |
| JAUNT | 72589 | 4.3% | 2.0% | 7.0% | 4.0% | 29.1% | 17.2% |
| King | 1,659,855 | 4.4% | 2.0% | 6.3% | 3.4% | 27.4% | 8.4% |
| LTD | 211,600 | 4.7% | 2.3% | 7.2% | 4.1% | 13.3% | 16.1% |
| MVRTA | 239,997 | 4.9% | 2.3% | 8.0% | 4.6% | 27.3% | 12.1% |
| Tulsa | 385,785 | 5.0% | 2.2% | 7.9% | 4.1% | 31.7% | 13.5% |
| NYC | 8,008,278 | 4.5% | 1.9% | 7.3% | 3.6% | 65.0% | 20.8% |
| OCTA | 2,846,289 | 4.1% | 1.7% | 5.8% | 2.9% | 48.7% | 10.2% |
| OTA | 19,503 | 7.1% | 3.4% | 11.3% | 6.3% | 6.1% | 14.2% |
| PAAC | 1,367,393 | 7.0% | 3.2% | 10.9% | 5.9% | 15.9% | 10.9% |
| RTD | 2,107,013 | 3.8% | 1.6% | 5.5% | 2.8% | 30.3% | 8.9% |
| RIPTA | 885,811 | 5.8% | 2.7% | 9.1% | 5.1% | 20.8% | 12.8% |
| SMCTD | 702,980 | 5.2% | 2.4% | 7.4% | 3.9% | 49.9% | 5.7% |
| SORTA | 630,903 | 5.1% | 2.3% | 8.7% | 4.7% | 33.7% | 14.2% |
| TriMet | 1,206,191 | 4.2% | 2.0% | 6.4% | 3.6% | 21.8% | 10.1% |
| UTA | 1,682,961 | 3.4% | 1.5% | 4.6% | 2.3% | 16.0% | 8.6% |
| SCVTA | 1,692,026 | 4.0% | 1.6% | 5.5% | 2.7% | 56.4% | 7.5% |
| WTA | 99,322 | 5.0% | 2.4% | 7.3% | 4.2% | 14.2% | 15.8% |
| Average | 1,041,089 | 4.5% | 2.0% | 6.8% | 3.7% | 31.7% | 13.0% |

## Density, Disability, and Snowfall

| System Abbreviation | Population per square mile | Percent of housing units with no vehicle available | Pct. with sensory disability | Pct. with physical disability | Pct. with mental disability | Land Area (square miles) | Days with > -.1" of snowfall |
|---|---|---|---|---|---|---|---|
| BFT | 280 | 6% | 4.1% | 7.1% | 4.7% | 587 | 5.7 |
| BT | 1,578 | 7% | 1.6% | 3.3% | 3.1% | 25 | 6.1 |
| CATA | 2,368 | 9% | 2.9% | 6.8% | 5.0% | 94 | 17.2 |
| CCCTA | 2,506 | 6% | 2.8% | 6.1% | 3.5% | 166 | 0 |
| CNYRTA | 1,114 | 15% | 3.4% | 8.3% | 4.8% | 402 | 31 |
| Link | 416 | 8% | 4.5% | 7.4% | 4.7% | 149 | 11.1 |
| DART | 3,261 | 8% | 2.4% | 5.3% | 3.2% | 656 | 1 |
| ECCTA | 2,684 | 6% | 2.5% | 6.9% | 4.4% | 73 | 0 |
| FWTA | 1,858 | 9% | 3.1% | 7.0% | 4.1% | 296 | 1 |
| FAX | 3,220 | 13% | 3.5% | 8.1% | 5.8% | 148 | 0 |
| HART | 2,654 | 11% | 3.7% | 9.2% | 5.4% | 234 | 0 |
| JAUNT | 1,029 | 7% | 2.4% | 4.9% | 3.7% | 27 | 4.7 |
| King | 2,522 | 10% | 3.0% | 6.1% | 4.2% | 658 | 2.6 |
| LTD | 2,653 | 10% | 3.5% | 8.4% | 5.7% | 80 | 1.5 |
| MVRTA | 2,348 | 14% | 3.4% | 7.0% | 5.0% | 102 | 14.5 |
| Tulsa | 2,192 | 9% | 3.8% | 8.4% | 4.9% | 176 | 3.1 |
| NYC | 26,402 | 56% | 2.9% | 7.6% | 4.7% | 303 | 6.1 |
| OCTA | 3,605 | 6% | 2.4% | 5.1% | 3.2% | 789 | 0 |
| OTA | 1,230 | 10% | 5.2% | 12.1% | 7.4% | 16 | 8.8 |
| PAAC | 1,729 | 16% | 3.4% | 4.3% | 8.0% | 791 | 12 |
| RTD | 2,748 | 8% | 2.8% | 5.8% | 3.8% | 767 | 18.4 |
| RIPTA | 2,117 | 12% | 3.4% | 7.6% | 4.9% | 418 | 9.3 |
| SMCTD | 3,187 | 6% | 2.4% | 5.5% | 3.0% | 221 | 0 |
| SORTA | 3,606 | 16% | 3.4% | 8.2% | 5.2% | 175 | 7.3 |
| TriMet | 3,117 | 14% | 3.1% | 6.7% | 4.7% | 387 | 1.7 |
| UTA | 933 | 5% | 2.6% | 5.1% | 3.8% | 1,803 | 18.2 |
| SCVTA | 4,593 | 6% | 2.3% | 4.9% | 3.2% | 368 | 0 |
| WTA | 1,154 | 9% | 3.4% | 6.9% | 5.0% | 86 | 4.1 |
| Average | 3,111 | 11% | 3.1% | 6.7% | 4.5% | 357 | 6.6 |

APPENDIX C

# Excerpts from the First Interim Report (May 2005)

1. Factors Influencing the Demand for ADA Paratransit
2. Development of Recommendations for Tool Development

## Factors Influencing the Demand for ADA Paratransit

As a prelude to proposing specific tools for estimating demand, the team has researched factors that influence the demand for ADA paratransit. This research has been conducted through an extensive literature review and by means of a survey of paratransit practitioners, advocates, and riders. This chapter presents the findings of the literature review followed by the findings of the survey.

### Literature Review

The literature review includes:

- Basic travel demand theory as it would apply to ADA paratransit.
- Impacts of paratransit service design and delivery based mainly on prior work by the research team.
- How personal characteristics affect travel by people with disabilities based on empirical and theoretical research.
- Limited evidence in the literature about demand by specific subgroups of people with disabilities.
- Limited evidence in the literature about mode choice by people with disabilities.
- Evidence from FTA Compliance Reviews.
- A summary of other literature concerning methodology, survey results, and trends.

### Travel Demand Theory

A review of basic travel demand theory as described in Domencich and McFadden (1975 and 1996) and Glaister (1981), as well as theoretical work by one of the research team (Lewis, 1983), provides some insights as summarized in Figure 1. Only one of these works dealt specifically with people with disabilities. It finds that, in the most fundamental terms, people with disabilities behave according to the same rational travel demand principles as other people.

### Impacts of Service Design and Delivery

There have been several studies that specifically addressed the impact of service design and delivery on the demand for ADA or other types of paratransit. These studies include several econometric analyses that used time-series data and one that used a cross-sectional data set.

| Factor | Short run /long run | Degree of influence | Comments specific to this factor |
|---|---|---|---|
| Utility | Both | Strong: Travel time and discomfort are a disutility that consumers seek to minimize. | An important factor in making hypotheses about role of paratransit relative to car and relative to fixed-route transit in creating greater mobility. |
| Socio-economic characteristics | Both | Strong | Travel demand has been shown to stem from demand for activities away from home, the consumption of which is strongly linked to disposable income. Gender is tied to trip frequency, with females engaging in more trip chaining. |
| Modal characteristics | Both | Strong | Car ownership, a function of income, is strongly linked to mode choice. Bus travel has been found to be an "inferior good" (demand declines with increasing income). |
| Tastes | Both | Strong | Lewis reports that disabled peoples' value of time spent in a segregated (i.e., paratransit) rather than an integrated (i.e., fixed-route) public transit vehicle does not outweigh the value of door-to-door convenience. Implies limited ability of accessible fixed-route to draw people with disabilities away from paratransit (assuming equal fares). |

Domencich and McFadden (1975 and 1996), Glaister (1981), Lewis (1983)

***Figure 1. Insights from travel demand theory.***

Results from these models, including several developed by members of the research team, have been summarized in Figure 2. For a number of factors, a range of elasticities is available from these models, while for others less precise statements are possible based on survey research.

## Personal and Trip Characteristics

Several studies have specifically examined how personal characteristics affect travel, including specifically the travel of people with disabilities. Figure 3 summarizes these results.

## Demand by Specific Subgroups

In the survey of paratransit practitioners, advocates, and riders, many respondents noted that it is important to distinguish among various types of disabilities. One group that is often noted as making large numbers of trips consists of people with developmental disabilities, including mental retardation. A paper from 1986 (Starks, 1986) describes how trends in services for mentally retarded people are affecting travel demand. Starks notes the following trends:

- A marked increase in the quantity and availability of a great variety of services;
- A strong programmatic emphasis on the delivery of these services in community rather than institutional settings;
- Increasing decentralization of delivery of these services;
- A propensity of mentally retarded persons to use these services extensively.

The paper finds that these trends result in a demand for transportation that is particularly concentrated and exceeds that of elderly or physically disabled persons. Starks provides some data about the demographic factors that underlie the travel demand of mentally retarded persons and data about their distinctive travel patterns.

| Factor | Short run/long run | Degree of relative influence | Comments specific to this factor |
|---|---|---|---|
| Paratransit Eligibility | Long term | Strongest among paratransit factors if choosing between ADA and broader (non-ADA) eligibility. | Analysis that includes eligibility is over 20 years old. Limited evidence indicates a strong impact of variations in ADA eligibility. |
| Paratransit Advance request time | Short-medium term | The impact of offering same-day or advance reservations has been show to be very strong (20% to 30%). | Has not been addressed in post-ADA studies. No evidence concerning one-day vs. longer advance reservations. |
| Paratransit Fare | Short-Medium | Estimated fare elasticity = -0.2 to -0.8. Some evidence of elasticity over –1.0 when fare levels are high (i.e., ridership impact is greater at higher fares). | Good evidence from recent time series studies. Impact of fares appears to be greater when systems have no denials. |
| Secular Trend (Annual growth in trip requests after controlling for influence of fare and level of service) | Short to Medium Term | Ranges from 0.5% to 1.0% per year in monthly and quarterly time series studies over five to ten years. | Measured secular trend similar to expectations based on population growth. Cross-sectional data would give more meaningful long-run impact of population (holding other factors constant). |
| Paratransit Reliability/Predictability | Short-Medium | Strong in surveys and complaints data but as yet unquantified in multivariate analysis. | Measures may include missed trips, late pick-ups, late arrivals. |
| Paratransit Comfort | Short-Medium | Moderate in surveys but as yet unquantified in multivariate analysis. | Difficult to measure. |
| Fixed-route accessibility / level of fixed-route service | Short-Medium | Weak but statistically significant in one multivariate study. | |

Sources: Hickling Corporation (1991), HLB Decision Economics (1998 – 2004), Lewis (1998, 1992), Crain & Associates and HLB (1995).

***Figure 2. Impacts of service design and delivery.***

Noland et al. (2004) examined differences in total trip making for various types of disabilities using multivariate analysis of travel diary data and found significant lower total trip making for people with difficulty walking, people with difficulty understanding directions, and especially for those who use a wheelchair. However, this analysis was not limited to people with disabilities that prevent use of public transportation.

## Mode Choice

There have been a few attempts to apply mode choice modeling techniques to travel by people with disabilities. For example Stern (1993) used a correlated multinomial logit model and a Poisson regression model to measure the factors affecting demand for different types of transportation by elderly and disabled people in rural Virginia. The major results were:

- A paratransit system providing door-to-door service is highly valued by transportation-disabled people.
- Taxis are probably a potential but inferior alternative even when subsidized. Buses are a poor alternative, especially in rural areas where distances to bus stops may be long.
- Making buses accessible would have a statistically significant but small effect on mode choice.

| Factor | Short run/long run | Degree of relative influence | Comments specific to this factor |
|---|---|---|---|
| Income | Evidence available pertains to long run. No short/medium term evidence of paratransit income elasticity available | Measured impact of income about 1.0. Low income almost certainly interacts with disability and low car ownership to drive ADA paratransit demand in the long run. | Unclear how disability interacts with income in influencing travel demand and paratransit demand. |
| Disability | Evidence available pertains to long run. No short/medium term evidence of paratransit income elasticity available | Measured impact of disability on demand is distinct and additive to impact of age. | Whether or not disability is distinct and additive to impact of low income of depressing travel demand is key outstanding question |
| Age | Evidence available pertains to long run. | Strong. Travel demand declines with age, especially after age 75. | |
| Car ownership | Long run | Very strong | Car ownership and availability found to be key factor in ADA paratransit demand, but poorly measured due to focus on short term time series data |
| Employment | Long run | Strong. | Those working or studying travel more than those who are retired, who travel more than those unable to work. |
| Activity type | Long run | Strong in surveys and complaints data but as yet unquantified in multivariate analysis. | ADA systems cannot prioritize trip purpose, but individual riders make travel and mode decisions based on purpose. |

Principal source: Noland et. al. (2004). Also, Lewis (1979, 1983), Hickling Corp. (1991), McFadden (1985).

***Figure 3. Impact of personal and trip characteristics.***

- Demand is price inelastic.
- The total number of trips taken is insensitive to mode availability and characteristics.

These results, while intriguing, cannot be conclusive since they deal with a door-to-door service that is not limited to ADA-eligible people and that most likely did not comply with ADA capacity constraint requirements.

Levine (1997) describes the impact of efforts to manage demand for ADA paratransit, principally by offering free fares on accessible fixed-route transit. The study concludes that elimination of fares on fixed-route transit for people qualifying for ADA paratransit had a moderating impact on the growth of demand for paratransit. Neither information dissemination nor appeals to good citizenship appeared to have any effect on ridership patterns. A more comprehensive review of the impact of free fares on transit on ADA paratransit ridership is presented in Multisystems and Crain (1997).

Work in Sacramento (Franklin and Niemeier, 1998) illustrates mode choice analysis using choice-based samples—an on-board survey of riders with disabilities on Sacramento fixed-route service and ridership records of the paratransit system. The results, however, appear mainly to reflect limitations of the data. The survey on the fixed-route system had no way to identify ADA paratransit eligible riders. The data about paratransit riders did not indicate degree of type of disability, in particular disabilities that entirely prevent use of transit.

## Evidence from FTA Compliance Reviews

The ADA paratransit compliance reviews conducted for the FTA Office of Civil Rights often address factors that contribute to changes in paratransit riders, or that transit systems have used in an attempt to estimate future changes. Figure 4 provides a brief summary of factors noted in 30 of these reviews as having had an influence on demand at the system under review.

## Other Evidence

Schmoecker et al. (2002) analyzed usage data for a paratransit pilot program in London to determine how user characteristics, fares, trip type, etc., influence the choice between short advance-notice trips and longer advance-notice trips at a lower fare. The analysis demonstrates how travel data by people with disabilities can be analyzed by disaggregate methods. However, the particular choices analyzed are ones typically not available in ADA paratransit. The specific results appear to be highly dependent on local circumstances. The biggest influence was found to be users' remaining monthly trip allowance. This result supports the idea that, in paratransit systems that still have significant numbers of trip denials, these trip denials will be the dominating influence on demand and will mask the influence of other factors.

In 2003 the Bureau of Transportation Statistics reported the results of a national survey of 5,000 people, of which 2,241 had disabilities, about use of transportation modes for local and long-distance travel and problems with transportation (BTS, 2003). In principle, the survey data could be used to analyze travel patterns and choices of people with disabilities. However, the

| Factor | Transit system |
|---|---|
| High fares compared with other systems | MARTA (Atlanta) |
| Long term growth in population with disabilities due to growth in elderly population | ASI (Los Angeles) |
| Free fare on fixed route | VIA (San Antonio) |
| Alternative countywide service, more reliable but higher fare. | Birmingham |
| Reduced service area to ADA required area | Hampton Roads |
| Increased awareness among people with disabilities<br>Other agencies discontinuing service ("shedding") | GHTD (Hartford) |
| Eligibility recertification | MATA (Memphis) |
| Availability of statewide Transportation Disadvantaged program (Mentioned by reviewers in assessment of R-GRTA.) | Florida |
| County discontinued rural program | Wichita |
| Shift from state TD program | Gainsville |
| More thorough eligibility process<br>Shift to state-funded Shared-Ride program for seniors | SEPTA (Philadelphia) |
| Straight line projection | San Francisco |
| Historical market growth | PVTA (Springfield) |
| Implementation of supplemental taxi program<br>Cutback in state support of transportation for developmentally disabled<br>Stricter ADA eligibility process | CTA (Chicago) |

***Figure 4. Factors influencing demand identified in FTA compliance reviews.***

survey was not limited to ADA paratransit eligible people; instead it used the Census definitions of disability, which are much broader. The sample includes only 137 people who used paratransit (not necessarily ADA paratransit) in the past month and 76 who used human service agency transportation. In the published report, the most striking result is the very strong influence of driving on paratransit use: 2% of drivers use paratransit compared with 13% of non-drivers. The raw survey data are available for download from BTS.

TCRP research conducted by SG Associates (1995) provides an example of a tool for practitioners to estimate demand, in this case for rural passenger transportation. Although the tool is applied to a different mode, there is at least one aspect of the method used that may be appropriate for ADA paratransit. In the published demand estimation tool, a distinction is made between "program demand" and "non-program demand." Non-program demand is estimated entirely on the basis of population in various age and income categories and vehicle miles of service available. Program demand is estimated based on enrollment in 13 different types of programs and demand factors (similar to trip generation factors) for each program type.

Previous work by the research team for King County Metro (Crain & Associates, Inc. and HLB, 1995; Koffman and Lewis, 1997) illustrates the combined use of econometric analysis and other methods. A time series, econometric model was successful in estimating the impact on paratransit demand of reducing denial rate, changing fares, and long term growth, but only for individual weekday trips within the service zones that existed at that time. Group trips, weekend trips, and trips between service zones were estimated by other means. King County Metro found that the results matched experience for several years.

Recent work for the Orange County Transportation Authority (Menninger-Mayeda, et al., 2005) illustrates both the power and limitations of time-series econometric analysis. The model is very successful at explaining fluctuations in demand due to day of the week, seasons, and holidays. This result could be quite useful to systems in planning capacity to accommodate what often appear to be random fluctuations. However, the model does not provide any means of predicting the impact of changes in system policies such as fares, service area, on-time performance, eligibility methods, and so forth.

The 1990 Bay Area Regional Paratransit Plan (Crain & Associates, 1990) provides an early example of how data from "exemplary systems" can be used to predict paratransit demand. By comparing trip rates per "transportation disabled" person from a sample of exemplary paratransit systems, the paper developed an estimated per-capital trip rate that would occur on a paratransit system without capacity restraints. The analysis used the counts of "transportation disabled" people that were included in the 1980 Census (but not in the 1990 or 2000 Censuses). In order to find a reasonable relationship between paratransit use and transportation disabled population, the research separated "program trips" (those generated by human service programs) and "general trips." Only the general trips proved clearly related to population.

Bearse et al. (2003) used National Transit Database ridership reports to examine trends in paratransit ridership between 1980 and 1995. They found about 10.5% annual growth and determined that the rate of growth was 3.6 times as fast as growth in the elderly population and 4.7 times as fast as growth in the general population. An analysis of detailed data from the paratransit system in Charlottesville, Virginia, found that most of the growth there was due to growth in the number of riders rather than increased trip rates per passenger. The analysis found higher than average trip rates for paratransit users with vision disabilities or mental retardation and lower than average trip rates for users who live in nursing homes or have kidney problems.

## Results from the Survey of Paratransit Practitioners, Advocates, and Riders

Paratransit professionals, researchers, advocates, and riders were surveyed to obtain their views about the importance of various factors that affect demand for ADA paratransit. A list of people to invite to complete the survey or to be interviewed was compiled from membership lists of the APTA Access Committee, the TRB Committee on Paratransit, and the TRB Committee on Accessible Transportation and Committee and from lists of people who had attended ADA paratransit training provided by team members. The complete list contained 447 names, of which 410 included e-mail addresses. A subset of 20 names was chosen for telephone interviews that allowed extended, open-ended discussions. Those chosen included panel members; transit agency staff; and advocates representing large urban areas, medium to small urban areas, rural areas, and all geographic regions of the United States.

The researchers received 144 usable responses from the web version of the survey and conducted 16 telephone interviews. (Some of those originally identified for phone interviews chose instead to use the web version or could not be contacted.) The largest category of participants was transit system staff, but there was significant representation from paratransit advocates and advisory committee members and some paratransit riders. Figure 5 shows participants' self-reported categories. Participants marked an average of 1.35 categories. Participation by riders was lower than desired. In fact many of those who described themselves as riders were paratransit staff people. Since participation by riders is considered important to the success of the project, a special effort was made to include riders in the investigation of exemplary systems described in Chapter 3.

The survey/interview asked participants to rate 30 different factors on a scale from 1 to 5 to indicate how strongly each one influenced the demand for ADA complementary paratransit. The average scores for all the factors are given in Figure 6. The rectangular bars show the average score for each factor and the thick lines at the end of each bar show two standard errors for the averages. (Since this is not a random sample, the bars do not represent a 95% confidence interval, but they do give some idea of the spread of responses.)

The top scoring factors were:

- On-time performance
- Whether programs that provide services for people with disabilities also provide transportation
- Ability to get through on the phone to reserve a ride
- Denial rate
- Some other factors with high scores that are notable include:
  - Accessible transit service combined with travel training

| Paratransit Role | Number of Participants | Percent of Participants |
|---|---|---|
| Transit system staff planning, managing, or operating paratransit service | 112 | 70% |
| Consultant or university researcher | 24 | 15% |
| Staff of a contractor managing or operating paratransit service | 13 | 8% |
| Staff of a planning agency with responsibility for paratransit issues | 21 | 13% |
| Paratransit advisory committee member | 22 | 14% |
| Staff of an advocacy or policy organization | 18 | 11% |
| Paratransit rider | 7 | 4% |

***Figure 5. Survey participants.***

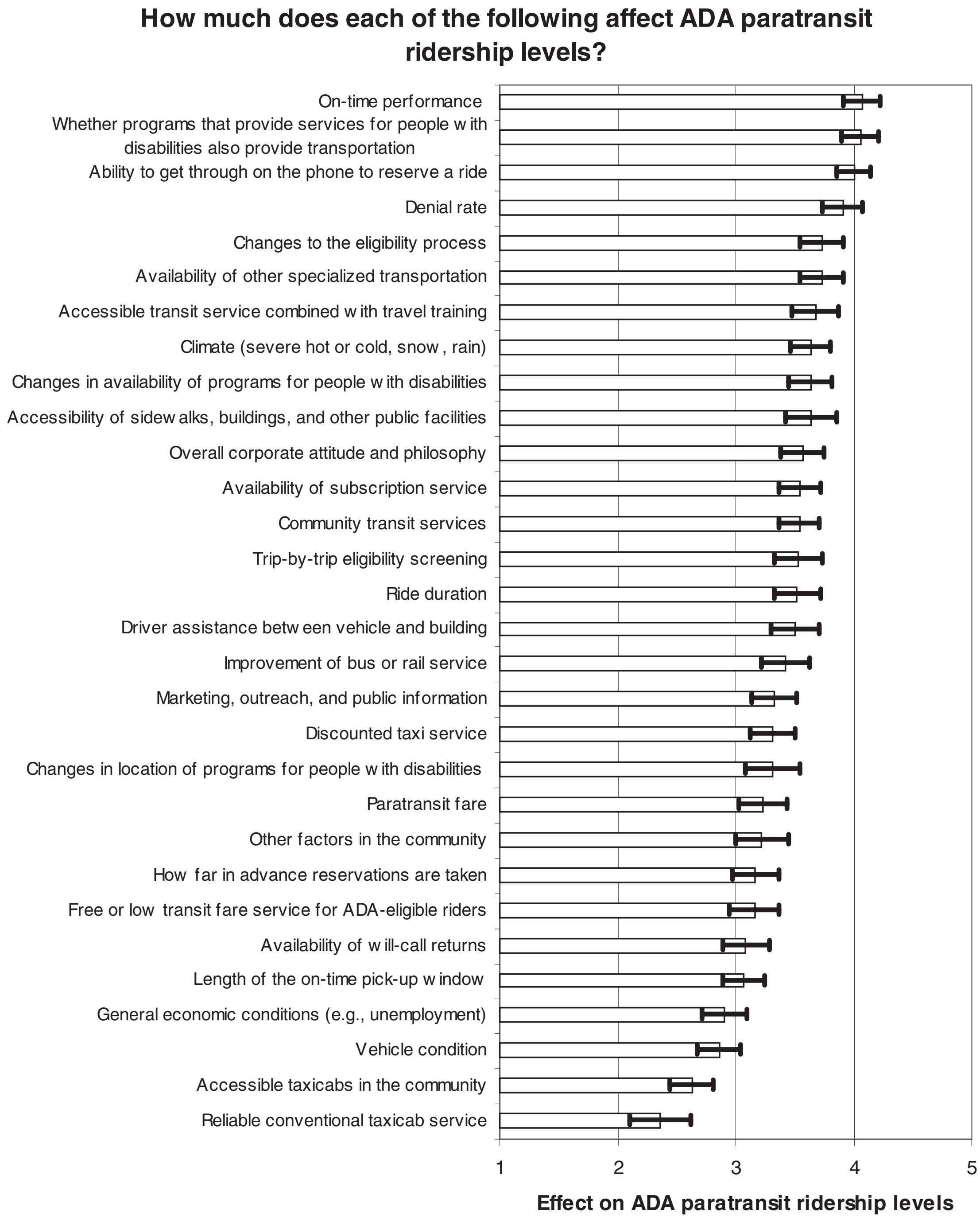


***Figure 6. Summary of survey ratings of factors influencing demand.***

- – Accessibility of sidewalks, buildings, and other public facilities
- Some factors notable for their relatively low scores include:
  - – Paratransit fare
  - – How far in advance reservations are taken
  - – Length of the on-time pick-up window
  - – Accessible taxicabs in the community

Note that denial rate was included as a factor for the sake of completeness, even though denial rate is not an issue in systems that are in full compliance. The survey was not limited to systems believed to be in full compliance, and open-ended comments make it clear that many of the participants still have significant denial rates.

In the open-ended portions of the survey, many participants provided very thoughtful comments:

- A frequent comment was that many factors have less impact on demand than they would if ADA paratransit riders had any other options. This view coincides with theoretical expectations and survey research that people with disabilities who do have other travel options, especially as a driver, choose not to use paratransit.
- A number of respondents indicated that, as long as a system has capacity constraints, other factors will have a weak impact on demand. This view underlines the importance of focusing on exemplary systems in this project. The comments also indicate that many of the respondents based their comments on experience with systems that do have capacity constraints. This fact suggests that the impact of some factors might be understated in the survey.
- A number of participants pointed out that different subgroups of people with disabilities will be impacted differently. One phrased this as follows: "There are different 'markets' within the group of people using ADA paratransit. The different markets are differentially affected by the factors." For example the choice between door-to-door and curb-to-curb service could strongly affect very frail people and some people with mental disabilities while having a weaker impact on others. Ride duration could similarly affect certain subgroups more than others.
- As with other modes, travel time and reliability are more important for some types of trips and some riders than others.

A comparison of ratings between 40 participants who are advocates or riders and the remaining participants showed no statistically significant difference in ratings.

Survey participants were also asked to rate long run impacts on demand in an open-ended format. The instruction was: "Thinking over the long run (the next 10 to 20 years), what are the things you expect to have the biggest impact on ADA paratransit ridership levels? (Choose three of the above or something else. Please list in order of impact.)" The results are shown in Figure 7, in which participants' responses have been grouped into categories.

The top-rated item, "Increasing number of elderly" is obviously important, although it was not a factor provided in the numerical rating section of the survey. The second most frequently mentioned factor was "Quality/predictability of service provided," which is consistent with the fact that participants gave "On-time performance" the highest quantitative rating and "Ability to get through on the phone to reserve a ride," which had the third-highest quantitative rating.

Two factors listed frequently concern funding and the cost of providing service. However, for our purposes, these factors can only be an issue indirectly. The purpose of this project is to estimate demand for ADA paratransit that fully complies with pertinent regulations. Cost and funding cannot be a reason to avoid complying, but they can influence policy choices within the framework of the regulations, such as the choice of door-to-door and curb-to-curb service, provision of feeder service, and whether to charge the maximum-permitted fare.

The factor with the second-highest rating in Figure 6, "Whether programs that provide services for people with disabilities also provide transportation," corresponds to "Human service transportation, including coordination," in the open-ended responses, which was the ninth most-frequently mentioned item. This difference may indicate that participants recognize this as having strongly influenced current demand but believe there is little prospect for change in the future. In contrast, "Denial rate" was rated as a strong influence in Figure 6, possibly indicating the major impact of having recently eliminated denials, but the same factor was mentioned by very few participants as an important future influence, which is consistent with the fact that denial rate is not a future policy choice.

| Factor | Number of responses (in order of impact) | | | |
|---|---|---|---|---|
| | Listed 1st | Listed 2nd | Listed 3rd | Total |
| Increasing number of elderly | 60 | 17 | 11 | 88 |
| Quality / predictability of service provided | 12 | 20 | 14 | 46 |
| Availability/level of paratransit operations funding | 13 | 16 | 13 | 42 |
| Eligibility criteria and process | 11 | 16 | 10 | 37 |
| Funding levels to support convenient fixed-route service | 5 | 7 | 12 | 24 |
| Accessibility of sidewalks, buildings and other public facilities | 6 | 10 | 5 | 21 |
| The cost of providing ADA service | 6 | 2 | 12 | 20 |
| Travel training | 5 | 4 | 5 | 14 |
| Human service transportation, including coordination | 5 | 3 | 6 | 14 |
| Urban growth | 3 | 7 | 4 | 14 |
| Quantity of service provided | 5 | 7 | 1 | 13 |
| Fares | 3 | 4 | 5 | 12 |
| Technology improvements | 2 | 5 | 2 | 9 |
| General health of population | | 9 | | 9 |
| Denials | 2 | 2 | 1 | 5 |
| Awareness of service | 2 | 1 | 2 | 5 |
| Increased service areas | 2 | 2 | | 4 |
| Availability of other specialized transportation | | 4 | | 4 |
| Revision of the Federal Regulations on eligibility | 1 | | 2 | 3 |
| Hybridization of service design | 1 | | 1 | 2 |
| Curb to curb vs. door to door | 1 | | 1 | 2 |
| Local agency involvement | | 1 | | 1 |

***Figure 7. Long run factors having the biggest impact on ADA paratransit ridership levels.***

## Development of Recommendations for Tool Development

The team has examined potential demand estimation tools based on guidance from the project Panel, priorities expressed by practitioners and advocates in the survey, and feasibility for development within the scope of this project. Feasibility will depend on the availability of data, the expense of obtaining data, and the level of effort needed to conduct data analysis.

### Panel Guidance

The project Panel has provided guidance in the project statement. Some of the same points cited earlier for selecting exemplary systems apply to the selection of appropriate demand estimation tools. In other words, the tools should estimate demand:

- Only by those persons who are truly eligible for service, as determined by eligibility process that use best practices in the transit industry.
- Only for those trips that these eligible individuals are unable to make by fixed-route service when the fixed-route system complies with the ADA.
- For service operated during the same hours as the fixed-route system and operated without capacity constraints.

These criteria can be met by basing tools on the demand observed at exemplary systems, while taking care to distinguish between demand at these systems for ADA paratransit and demand for any non-ADA services offered by these same systems.

The problem statement noted that, under the ADA paratransit regulations, transit operators are free to tailor their ADA complementary paratransit operations in response to the communities they serve. The problem statement gives the following examples:

- In some systems, complementary paratransit service is provided as a door-to-door service, and, in other systems, it is curb-to-curb;
- Systems have different rules regarding trip reservation policies and whether subscription service is to be provided; and
- Systems have different policies and standards regarding on-time performance, on-board travel times, and other performance characteristics.

These considerations suggest that the tools should be able to provide demand estimates that are sensitive to these choices. In other words, to the extent that it is possible to do so, the tools should provide a way to estimate the impact on demand of these policy choices.

The problem statement notes that effective coordination with other transportation programs in a community can have a significant impact on demand for ADA paratransit services. This suggests that demand estimation tools should take these other services into account.

Under the heading, "Improved Tools for ADA Complementary Paratransit Demand Estimation," the problem statement identifies as needed:

- A better understanding of riders who qualify for this service, their travel patterns, and the likely demand, given the level of service provided.
- Efforts for ADA paratransit similar to those devoted to fixed-route transit and other transportation services, including research to understand trip-making needs and patterns; choices to use various transportation options (i.e., mode choice); and the effects of various service parameters (i.e., fares, frequency of service, days and hours of operation, and service quality and reliability) on demand.

Under the heading, "Future Research on ADA Complementary Paratransit Demand Estimation," the problem statement says that:

> "developing an accurate understanding of demand for ADA complementary paratransit services will likely require ongoing research beyond what will be accomplished in this project. A better understanding of the number and percentage of people who are eligible for service will need to be developed. The travel needs of this segment of the population will then need to be studied in more detail (e.g., types of trips needed and trip making rates). Factors that influence potentially eligible individuals to apply for ADA paratransit eligibility and/or to use other transportation options will need to be better understood. The influence of service design parameters (e.g., fares, days and hours of service, on-time performance, and travel times) on demand and trip-making rates will also need to be researched."

The problem statement continues:

> "Tools also should be available to predict demand, when there are changes in system design or level of service variables change. For example, if the service area is expanded and the total population served increases, what will be the impact on demand? If systems provide curb-to-curb rather than door-to-door service, how will that affect the number of riders and trips that will be requested? If the hours of fixed-route operation are extended later into the evening, what effect will that have on demand? If systems have varying levels of reliability and service quality (e.g., on-time performance and on-board travel times), what effect will these have on demand?"

Subsequent guidance from panel included a request to examine the potential for demand estimation tools that can lead toward eventually incorporating ADA paratransit into regional travel demand models and the regional transportation planning process, based on state-of-the-practice and emerging transportation models. The panel also requested consideration of potential applicability to estimating demand for more generalized paratransit.

## Guidance from the Survey of Paratransit Practitioners, Advocates, and Riders

Survey participants were asked: "For your purposes (for planning, management or advocacy), what are the most important factors that should be included in the ridership estimation tools? (Please list up to four factors in order of importance.)" As shown in Figure 8, to a great degree responses mirrored those provided to the question regarding the factors that will have the greatest impact (shown in Figure 7 earlier). However some differences are notable:

- "Availability of funding" is much lower-ranked, possibly recognizing that this is a political issue and not a logical input to a demand estimation tool, since availability of funding is not a consideration in meeting the mandate for ADA paratransit.

| | Number of responses (in order of importance) | | | | |
|---|---|---|---|---|---|
| | Listed 1st | Listed 2nd | Listed 3rd | Listed 4th | Total |
| Population statistics/projections | 50 | 21 | 13 | 6 | 90 |
| Quality / reliability of service | 13 | 13 | 16 | 10 | 52 |
| ADA eligibility/certification | 3 | 9 | 11 | 7 | 30 |
| Accessibility of bus stops and fixed-route service | 5 | 10 | 10 | 5 | 30 |
| Availability of other transportation services | 6 | 8 | 8 | 4 | 26 |
| Service area designation | | 9 | 9 | 6 | 24 |
| Historical data (past patterns etc.) | 14 | 7 | | 1 | 22 |
| Fare elasticity | 2 | 7 | 4 | 3 | 16 |
| Cost of providing the service | 3 | 6 | 5 | 1 | 15 |
| Travel training | 1 | 1 | 10 | 2 | 14 |
| Funding levels | 2 | 1 | 6 | 4 | 13 |
| Number of current eligible riders | 8 | 2 | | | 10 |
| Community needs | 2 | 3 | 1 | | 6 |
| Day of week/time of day | 2 | 2 | | 1 | 5 |
| Trip length | | 1 | 3 | 1 | 5 |
| Location of riders and facilities | 1 | 3 | | | 4 |
| Population health | | 2 | 1 | 1 | 4 |
| Traffic conditions/trends | | | 4 | | 4 |
| Weather | | | 3 | 1 | 4 |
| Paratransit capacity constraints | 3 | 1 | | | 4 |
| Coordination with area programs | 2 | | | 1 | 3 |
| Average trips taken by each rider | | 2 | | 1 | 3 |
| Availability of housing | 1 | 1 | | | 2 |
| Population income | | 1 | 1 | | 2 |
| Economic growth of the region | | 1 | | 1 | 2 |

***Figure 8. Most important factors to include in ridership estimation tools.***

- "Historical data (past patterns)" was mentioned by many participants, indicating a concern that the tools should take into account local conditions as reflected in this established history.
- The mention of "service area designation" reflects a desire to be able see how adjustments in the area served can affect demand.
- "Cost of providing the service" in this context presumably indicates a desire for tools to help in determine not just the number of trips but the cost of serving those trips, for example as a result of peaking or trip length. This would overlap with "Day of week/time of day" and "Trip length" which were also mentioned separately.

Survey participants were asked, "For your purposes, how far into the future should a useful tool project ridership?" As shown in Figure 9, the majority of respondents (68%) would like tools to project ridership five to ten years into the future.

## Criteria for Selecting Demand Estimation Tools

The research team has combined the guidance from the Panel and the survey participants' with its own expertise and understanding of the issues to arrive at a proposed set of criteria for selecting the most appropriate methods to develop demand estimation tools in this project. These criteria are:

1. Feasibility within the scope of this project. The tools must be able to be developed using data that is available or can be collected within the schedule and budget of this project, and analytical methods than can be implemented within the schedule and budget of this project.
2. High confidence that the methods will produce an immediately usable tool (or tools) and not just interesting research results.
3. Transferability among regions, taking into account highly varied local conditions and histories. The tools should have widespread applicability in a variety of service areas: large and small cities and rural areas, severe and mild weather, high and low income. They should use local conditions as inputs.

| | No. of respondents | Percent of respondents |
|---|---|---|
| < 1 year | 3 | 2% |
| 1 year | 4 | 3% |
| 2 years | 4 | 3% |
| 3 years | 6 | 5% |
| 3-5 years | 12 | 10% |
| 5 years | 41 | 33% |
| 6 years | 4 | 3% |
| 7 years | 1 | 1% |
| 5-10 years | 18 | 14% |
| 10 years | 22 | 17% |
| 10-20 years | 2 | 2% |
| 15-20 years | 1 | 1% |
| 20 years | 6 | 5% |
| 25 years | 1 | 1% |
| 30 years | 1 | 1% |
| | 126 | 100% |

***Figure 9. How far into the future should a useful tool project ridership?***

4. Level of effort and data requirements to use. The tools should be usable by practitioners without extensive additional data collection with reasonable investment of staff time.
5. Technical sophistication required to use. The tools should be usable by transit planning staff and other interested parties without highly specialized expertise. Results should be easily explainable and transparent to policy makers, advocates, and the general public.
6. Limitation to ADA paratransit. The tools should produce estimates of demand for ADA complementary paratransit complying with all required service criteria (including the requirement that there be no capacity constraints), consisting of eligible trips by ADA eligible individuals only.
7. Ability to addresses policy issues of interest. The tools should address as many as possible of these issues:
   - Total ADA paratransit demand in cities that do not currently have ADA-compliant paratransit service.
   - Growth in ADA paratransit demand based on population increase, other demographic trends, and changes in service coverage.
   - Impacts of changes in paratransit policies and performance within the bounds of ADA service criteria: e.g., on-time reliability, fares, door-to-door vs. curb-to-curb operation, telephone hold times, availability of subscription service, strictness of eligibility process.
   - Impact of improvements in fixed-route transit accessibility.
   - Impact of changes in the availability of specialized transportation services for people with disabilities.
   - Detail related to determining the cost of providing service (time of day patterns, trip length, type of disability).
8. Relevance to planning in the medium term, i.e., five to ten years in the future. Tools that meet the criteria listed up to this point should in general be relevant in this time frame. Ability to use the tools for exploratory, "what-if" analysis of longer-term trends is also useful.
9. Contribution to increased understanding of travel behavior of people with disabilities. The tools and the development process should provide insights sufficient to guide future research.

## Analysis of Options for Developing Tools

The research team has considered a variety of possible methods for developing demand estimation tools in order to recommend one that is most suitable for this project. This section provides a description of these methods and reasons why they are appropriate or not. Some methods that are clearly not appropriate include:

- Consumer surveys,
- A compendium of experience,
- Time series statistical analysis, and
- Stated preference analysis.

Descriptions of these methods and their uses are provided for completeness.

Methods that are stronger candidates for this research include:

- System-level demand modeling, and
- Disaggregate travel demand modeling.

These methods are described at greater length, with a sketch of how they could be applied to this research.

### Consumer Surveys

Surveys of people with disabilities have been invaluable in understanding their needs and preferences. In the 1970s surveys of this type helped define the need for accessible public transportation, including paratransit. The most ambitious of these was the National Survey of Transportation Handicapped People, conducted by Grey Advertising under contract to the Urban Mass Transportation Administration (Grey Advertising, 1978). Many transit agencies conducted similar surveys after passage of the ADA to help them plan how to come into compliance with the complementary paratransit requirements of the law. These surveys commonly obtained information about respondents' disabilities, their travel, specific barriers to use of existing transportation options, and likely use of new options. Examples of such surveys include one conducted by members of the research team for King County Metro in Seattle in 1995 and one conducted by the Denver Regional Transit District in 1993. In combination with other types of analysis, these surveys produced useful information for planning a service that was very different from existing services.

Surveys of people with disabilities are expensive to conduct, since it is typically necessary to call multiple households before locating qualified respondents. Further it is difficult to locate and survey people with disabilities living in group settings, and a significant minority of people with disabilities are not able to speak for themselves (for example older people with dementia and some people with developmental disabilities). Accommodation needs to be made for people with disabilities who cannot use a voice telephone. A further difficulty is that a brief series of questions in a survey format cannot reliably determine whether respondents would be judged eligible for ADA paratransit. Beyond all these practical concerns, experience has shown that consumers' predictions about their travel (or other behavior) are not very accurate.

Even if all these difficulties could be overcome, consumer surveys would still have limited suitability for this research. Consumer statements about travel obtained in a survey conducted in one metropolitan area would not necessarily apply in a different area. A national survey would provide interesting data for policy development, but would not be useful for local planning.

These statements apply to surveys that directly ask consumers about their preferences and likely travel decisions. As will be discussed at more length in a later section, consumer surveys may in fact be appropriate as part of developing a travel demand model. However, the surveys used for travel demand modeling obtain data about actual travel behavior, not planned or intended travel behavior. In addition, more structured surveys can be useful in stated preference analysis as described more below.

## Compendium of Experience

Where rigorous modeling is not practical, practitioners commonly rely on the experience of other systems, applying their professional judgment to determining which other systems are most comparable and to determining how to compensate for different situations. TCRP is currently engaged in a long-term project that has collected this type of information for many different public transportation modes and issues. The results of this project, called "Traveler Response to Transportation System Changes," is being published as individual chapters of *TCRP Report 95.* (Two previous editions were published in 1977 and 1981.) Chapter 6, dealing with "Demand Responsive/ADA" service, was published in interim form in March 2000 and in final form in May 2004.

The usefulness of the results for ADA paratransit planning is limited by reliance on previously published material (most of it completed before many paratransit systems were in compliance with ADA requirements and much of it completed before the passage of the ADA) and by the fact that most of the analysis treats services other than ADA paratransit. However, it is entirely possible that an effort focused specifically on the exemplary systems identified for this research could produce more useful data. For example, the exemplary systems have probably experimented with most of the policy options of interest (fares, door-to-door and curb-to-curb service, advance reservation policies, etc.) and many no doubt have experience with changes in eligibility processes and planned or unplanned changes in service reliability. This information can be useful and instructive, as in the case studies often presented in research reports. However, a simple presentation of experiences can be very misleading, since it does not provide any way to account for differences among service areas or to separate out the influence of multiple factors. It also does not provide an organized way to predict future demand based on population growth. For this reason, the experiences of individual systems will not be the central focus of this research, although they can be presented as supplementary material that will enrich the structured tools that will be developed.

## Time Series Econometric Analysis

Time-series econometric analysis has been the most-commonly used type of analysis for paratransit demand in recent years. Several examples of time series models developed by the research team and others were cited in the literature review. These analyses have used data about actual demand on a daily, monthly, quarterly, or yearly basis along with data about fares, population, service reliability, etc. The statistical method applied to the data with varying degrees of sophistication is so-called "ordinary least squares regression." The result is an equation that matches past experience and allows predictions about the near future. For example a time series analysis of monthly data for Access Services Inc. in Los Angeles (HLB Decision Economics, 2004) produced the following model:

$$\begin{aligned} \log(\text{Trip Requests}) = &-70.3 \\ &-0.43 \log(\text{Average Real Fare}) \\ &+5.11 \log(\text{Population}) \\ &-0.04\ (\text{Winter}) \\ &+0.07\ (\text{October}) \\ &-0.03\ (\text{PDL of Complaint Rate}). \end{aligned}$$

Where:

Trip Requests are trips requested by customers in any month of the analysis period.

"log" represents the natural logarithm.

Average Real Fare is the paratransit fare in a month adjusted for inflation.

Winter is 1 in December, January, and February and 0 otherwise.

October is 1 in October and 0 otherwise.

PDL of Complaint Rate is a polynomial distributed lag of the natural log of complaint rate in the region.[1]

The equation was estimated using monthly data over a 42-month period. Applying the actual values of fare, population, and complaint rate during the analysis period, the equation produces estimated trip request that closely match actual trip requests. By applying projected future values, the equation provides projections of future trip requests. The model has an "R-squared" of

[1] Polynomial distributed lags (PDL) are used to reduce the effects of collinearity in distributed lag settings by imposing a particular shape on the lag coefficients. The specification of a polynomial distributed lag has three elements: the length of the lag (the number of time periods it covers), the degree of the polynomial (the highest power in the polynomial), and the constraints on the lag coefficients. A near end constraint says that the immediate effect of $x$ on $y$ is zero, whereas a far end constraint says that the effect of $x$ on $y$ dies off at the end. It is also possible to impose both constraints or no constraint at all.

0.97, meaning that, in a statistical sense, it explains 97% of the observed variation of trip requests over the 42-month analysis period. All of the coefficients are statistically significant with 99% or better confidence.

Other factors were also tested, including denial rate, on-time performance, and employment. These probably influence trip demand, but the strength of their effects was not statistically discernible using the data available.

Models like can be very useful for short-term planning. For example, in the Los Angeles model, future projected values of population, fare, and complaint rate were inserted in the model to produce estimates of future demand, as represented by trip requests. Models with a so-called log-log form like this one produce coefficients that can be interpreted as elasticities. In this example, computed real fare elasticity is -0.43: for every 1 percent increase in real fare, trip requests decline by 0.43 percent.

The great limitation of time series models is that they cannot make predictions about any change that the paratransit system has not actually experienced in the past. For example, a time series model cannot predict the impact of changing advance reservation rules if the paratransit system has not experimented with a similar change before. Also, predictions that go significantly beyond the range of recent experience are unreliable. For example, a prediction about the impact of doubling a fare will not be very accurate if the paratransit system has only made very small fare changes in the past. For similar reasons, early attempts to predict what would happen when capacity denials were eliminated were not very reliable.

A further limitation of time series analysis is that a model developed using data from one system may not be valid for a different system. For example, the estimated response to a fare change (expressed by the fare elasticity) may be quite different in two systems depending on differences in service reliability, differences in the availability of other services, and differences in economic conditions. By way of illustration, the estimated fare elasticity for Los Angeles is at the high-impact end of the spectrum defined by experience in other paratransit systems. This higher elasticity may reflect the easier access to alternate modes of transportation in Los Angeles County, since many local jurisdictions provide paratransit in addition to the ADA paratransit operated by Access Services. Also, the short-term elasticities determined from time series analysis may understate the impact of changes over the long term.

The most likely use of time series analysis for this research will be in combination with cross-sectional analysis. In compiling data from the exemplary systems, it may be possible to obtain data for multiple years from some systems. If there have been significant differences from year to year, this data could enrich a cross-sectional analysis as described later.

## Stated Preference Analysis

Stated preference analysis is a consumer survey-based method that has been developed to test consumer reactions to new choices in a more rigorous fashion than is possible with simple consumer surveys. At a time when there were no paratransit systems in compliance with ADA requirements, data about existing services mostly reflected the influence of service limitations. Stated preference would have offered a more sophisticated alternative to the consumer surveys described previously. The stated preference method relies on "contingent valuation" surveys. The contingent valuation survey is a measurement instrument in which statistically drawn respondents make trade-offs among experimentally designed choice situations designed to simulate real-world conditions that might not presently exist. In principle, stated preference can also illuminate individual travel behavior in ways that system-level data cannot. For example, a stated preference survey can show the value that disabled consumers place on various components of travel by paratransit and other modes and can show how these values differ depending on specific types of disabilities.

For purposes of this research, the stated preference method has significant drawbacks. Obtaining the necessary data can be quite expensive. The expertise needed to apply the stated preference method is not widespread, so it would be difficult for many transit and planning agencies to conduct their own analyses of new service alternatives as they become of interest. More fundamentally, even though the method is far more sophisticated than simple survey analysis, it still relies on consumers' statements about hypothetical responses to hypothetical situations.

## System-level Demand Modeling

A system-level demand model would allow individual paratransit systems to obtain predictions of total ADA paratransit demand (and ideally, total people certified as ADA paratransit eligible) depending on future values of key factors such as population, rates of disability, income, ADA paratransit service policies and service reliability, availability of accessible fixed-route transit, and availability of other specialized transportation services. To illustrate how this would work, Figure 10 provides a diagram of the influences that would ideally be included in such a model.

The right-hand side of the diagram shows the many factors that influence the demand for paratransit, and the left hand shows the impacts of these influences, separated into stages. The top layer shows the factors that influence the size of population (i.e., number of individuals) in a service area that is theoretically eligible for ADA paratransit, regardless of whether these individuals have actually applied and been certified as ADA paratransit eligible. The diagram then proceeds in stages showing the factors that influence: the percent of theoretically eligible people who actually apply for ADA paratransit and are certified as eligible; the percent of these people who actually use the service; the number of trips that these users reserve; and the number of reserved trips actually taken. The specific influencing factors listed in the diagram are provided as a starting point for discussion and analysis. There may be other factors that can be included, and some factors could be eliminated based on analysis results.

The right-to-left arrows connecting the influencing factors with the demand outcomes represent the strength and direction of each factor. In mathematical terms, these would be coefficients on equations that need to be estimated using statistical analysis of data from the exemplary systems where possible. Where the data from the exemplary systems do not allow coefficients to be estimated (for example how community awareness affects the percentage of theoretically eligible people who apply for certification), expert opinion could supply default values or users could insert values based on their local knowledge and judgment. Similarly, expert opinion or local knowledge would be needed to supply input values for many of influencing factors such as the age distribution of the population at a future date of interest.

**Estimation Method:** The principal statistical method to be used to estimate equations for the influences would be cross-sectional econometric analysis of data from exemplary systems. In a cross-sectional econometric analysis, data from numerous systems are gathered, usually for a single point in time (commonly the most recent fiscal year) and analyzed, usually with ordinary least-squares regression and/or analysis of variance.[2] For the sake of illustrating the concept, Figure 11 shows an example of a very crude analysis of this type, just using actual paratransit demand and service area population. Points of the graph show population and paratransit

[2] Analysis of variance is equivalent to regression with dummy variables and is relevant where variables are expressed in categories (yes/no) or discrete levels (low/medium/high) instead of continuous values.


***Figure 10. Structure and logic diagram of a system-level demand model.***

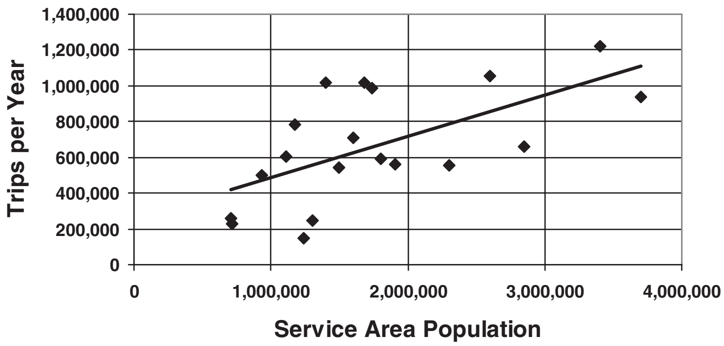


***Figure 11. ADA paratransit demand and population.***

demand as of fiscal year 2000-01 in most cases. The line is a best-fit line determined using least-squares regression. The equation of the line is:

Trips per year = 254,255 + 0.23 (Service Area Population)

This equation, in effect, collapses most of the diagram in Figure 10, going straight from the top to the bottom of the diagram in one step with only one influencing factor. The challenge for this research would be to fill in as much additional detail as possible using the available data. At a minimum, the researchers are confident that an equation or equations can be estimated connecting many of the most important influencing factors with total paratransit demand. This would be a more refined version of the equation given before. For example, total paratransit trips may be a function of the population with disabilities in a service area, some measure of the rigor of the eligibility process, a measure of service reliability, a measure of the availability of non-ADA specialized transportation, and a measure of the availability of accessible fixed-route transit service.

A single equation of this type, while more refined than the one given, would still collapse the diagram to a single layer, leaving out the intermediate stages concerning the percent of theoretically eligible people who become certified, the percent of those who use the service, etc. To fill in these intermediate stages would involve estimating multiple equations, one for each stage. Estimating these multiple equations is theoretically possible, but may prove impractical for three reasons:

1. **Unknown variables:** Estimating an equation to represent the first stage of the diagram would require knowing the size of the population theoretically eligible for ADA paratransit in the service areas of the exemplary systems. In practice this number is not known. Even the number of certified individuals (needed for the second stage of the diagram) may be unknown in some cases. This uncertainty arises from the fact that some systems have poorly maintained lists of certified individuals, including many people who are no longer living or who may have moved out the service area.
2. **Processes that are not independent:** The processes represented by stages two, three, and four of the diagram (certification, becoming an active user, and reservation rate) are not independent. As shown in the diagram, the same factors influence becoming an active user and reservation rate, and these factors also probably play a role in influencing the certification rate. For example, service reliability certainly influences the rate at which users reserve trips, and most likely influences whether people who have become certified use the service at all. But it probably also influences the rate of applications for ADA paratransit eligibility. If the perception in the community is that service is very unreliable, many potentially eligible people will probably not even bother applying for certification. This would be more true for those people who have other transportation available (for example, in the

form of rides from a family member) illustrating how this factor, too, influences multiple stages of the process.

3. **Small sample size:** At least the problem of lack of independence might be overcome with sufficiently large samples. However, it appears that on the order of 20 exemplary systems will be available for analysis. With a sample this size, it is unlikely that multiple equations can be estimated.

The form of the equations to be estimated will be determined according to what provides the best fit to the data. In principle, a multiplicative form has desirable properties. This type of model would have an equation or equations of the following type:

$$\text{Demand} = a \times (\text{Factor 1})^{b} \times (\text{Factor 2})^{c} \times (\text{Factor 3})^{d} \ldots$$

and so forth. The superscripts represent exponents and are measures of the strength of each factor that are equivalent to elasticities.

These exponents and the constant "a" will be estimated using the data from the exemplary systems. If the estimated exponent for a factor is close to zero, then, since $(\text{Factor})^0 = 1$ always, values of that factor have no impact on demand. Large positive exponents mean that increases in a factor strongly influence demand to *increase*. Large negative exponents mean that increases in a factor strongly influence demand to *decrease*. "Demand" may be expressed in the form of trips per capita or total trips. Trips per capita has the desirable property that it "automatically" adjusts for the impact of population, providing a measure that is more comparable across service areas than total trips.

This type of equation is typically transformed using logarithms to the equivalent form:

$$\log(\text{Demand}) = a + b \log(\text{Factor 1}) + c \log(\text{Factor 2}) + d \log(\text{Factor 3}) \ldots$$

Here the exponents are seen as coefficients that can be estimated using linear regression. Other model forms will also be tested including simple additive and mixed forms.

**Uses of the Model:** Regardless of the amount of detail that would prove practical to include in the model, the result could be used in two ways. First, by assuming future values of population, fares, transit accessibility, etc., a transit system could obtain an estimate of future paratransit demand. Second, systems that are not currently in full compliance with ADA could use the model to determine hypothetical demand under today's conditions assuming full compliance. For example a system that currently denies trips but is otherwise in compliance would simply input values for current population and service variables. Since the model would be estimated using only exemplary systems, the output of the model would be demand under conditions of zero or near-zero denials.

For use by practitioners, the model would be implemented as a spreadsheet or self-contained program that allows users to input values for local conditions and obtain estimates of demand. For inputs that users do not have available, values from the survey of exemplary systems would be provided that users can substitute based on their judgments about comparability. The model could also provide estimates of upper and lower probability bounds for estimated demand based on assumed probability bounds of the input variables as well as estimated statistical error in the values of the coefficients used in the model.

**Relationship to Selection Criteria:** The system-level demand model meets most of the criteria listed earlier. The researchers are confident that it can be accomplished within the available resources with available data. It explicitly includes variables describing local conditions, so it would be transferable among cities. For the most part, systems should be able to obtain the data needed to use the model, although predictions of future population and other conditions are always uncertain. The model can be provided in a form that does not require great technical sophistication. The model would be estimated using data from exemplary systems; as a result, it could be limited to ADA trips by ADA eligible individuals as long as the exemplary systems that also operate non-ADA service are able to provide data separating out those trips. The model would address many of the policy issues of interest to the extent that it proves possible to obtain good data. Compared with time-series models that project from current conditions, a model based on cross-sectional analysis should have good ability to produce estimates for periods five or more years in the future. This ability stems from the wide range of conditions represented by the exemplary systems used to estimate the model.

A system-level model would provide little detail related to determining the cost of service provision, for example, trip lengths, time-of-day peaking, or the portion of trips by people who use wheelchairs. A system-level model would also provide limited insight into fundamental issues of travel behavior by individuals with disabilities. However, the process of creating the model would at a minimum provide extensive input for an agenda to guide future research.

The model results would have potential for implementation within a conventional regional travel demand model. Most regional models have zone-specific base year and forecast year values for the non-paratransit variables in the model. By default, all zones served by a particular paratransit system would have the same values for variables describing the paratransit level of service. The model would be implemented as a demand equation (or set of equations) that can be scripted inside of the typical MPO software environment (TransCAD, TP+, Cube, etc.), providing access to all zonal and network input variables and writing out zone-specific forecasts that can be easily viewed in GIS/network format to see where the ADA trips will most likely originate from. The user would need to be given the caveat that this model is likely to be less geographically accurate than typical trip generation models, so any zone-specific output should be used only as an indication. The total regional demand forecast would be more accurate, as would the totals for major sub-regional areas such as counties or cities.

## Disaggregate Travel Demand Modeling

The kind of modeling described in the previous section is "aggregate" in the sense that it groups together data for all of the individuals in a particular service area. Conventional travel demand models used for regional planning use aggregate methods. That is, they treat all trips origins and destinations within a given zone as if they were located at one point in space. They represent all households in a zone using average values or at most a small number of averages for ranges of income, household size, and car ownership. And they represent all trips within two or three periods of the day as subject to the same conditions of traffic congestion (Vovsha et al., 2004). In contrast, a newer generation of travel demand models use disaggregate methods, meaning they use data about individual people and individual trips.

For purposes of this research, the differences can be described as follows:

**Aggregate:** Data are counts or averages across geographic areas, such as cities, counties, zones, zip codes, etc. This includes both the dependent variables (e.g., ADA paratransit certification rates and trip rates) and the explanatory variables (e.g., population by age and gender, income distribution or average income, system-level paratransit service descriptors).

**Disaggregate:** Data are collected from individual persons. The data items typically represent the same variables as in aggregate data, but are measured at the individual level. Again, this includes both the dependent variable (e.g., whether a person has certified as ADA paratransit eligible, or how many paratransit trips a person makes during a given day or has made in the most recent week), and the explanatory variables (the person's age, gender, income, household size, distance from shopping, etc.).

In considering the possibility of applying disaggregate methods, it becomes even clearer than before that, in a fundamental sense, travel choices by people with disabilities are driven by the same factors that drive travel choice by non-disabled people. For example, the literature review at the beginning of this report identified several key principles of travel demand theory, including:

- Travel time and discomfort are disutilities that consumers seek to minimize in choosing how, whether, and when to travel.
- Travel demand has been shown to stem from demand for activities away from home, the consumption of which is strongly linked to disposable income. Gender is tied to trip frequency, with females engaging in more trips.
- Car ownership, at least partly a function of income, is strongly linked to mode choice. Bus travel has been found to be an "inferior good" (demand declines with increasing income).

In addition it is known that travel decisions are influenced not just by individual characteristics, but by household characteristics, including trips by other household members and availability of rides with other household members.

In considering people with disabilities and paratransit, we can hypothesize the following:

- Disabling conditions make any trip more time consuming for people with disabilities than for people without disabilities; thus people with disabilities travel less than people without disabilities. This effect may be reduced but probably not eliminated by modifications to buildings, sidewalks, and transportation vehicles.
- The mode choices of people with disabilities are constrained by functional inability or greater difficulty in driving or using public transportation, even assuming availability of adapted vehicles and fully accessible public transportation.
- People with disabilities of working age have higher unemployment rates and lower incomes than people without disabilities; thus people with disabilities travel less than people without disabilities. Eliminating employment discrimination will reduce but probably not eliminate this effect.
- A high proportion of people with disabilities are older, thus they travel less than people without disabilities.
- Because many people with disabilities are older, and possibly for other reasons, they are more likely to live alone than people with disabilities. Thus they have less ability to rely on others for rides or to perform activities that substitute for travel.

The exact workings of these connections remain to be determined. However, given an understanding of each of them, the travel behavior of people with disabilities could, for the most part, be understood by treating the identical explanatory factors used in modeling travel behavior of non-disabled people. An important caveat in this respect concerning ADA paratransit is that the eligibility process determines the availability of this mode for each person. Also, in the case of people with disabilities, modes that impact travel choices include some that are not considered in the analysis of travel by the general public, including specialized services operated by agencies that serve people with developmental disabilities, adult day health centers, senior centers, and Medicaid.

Figure 12 provides a preliminary sketch of how demand for ADA paratransit might be viewed at the level of choices by individual people. The rectangular boxes at the left of the diagram represent stages similar to the stages represented at the aggregate level by Figure 10. Some of these stages are individual choices (whether to apply for eligibility, whether to travel by paratransit), while others are stages leading to individual choices (awareness, extent of functional limitation). The boxes with rounded corners to the right of these rectangular boxes represent the various factors that influence these stages.

As in the earlier figure, many factors influence multiple stages. As in the earlier figure, observations representing many of the intermediate stages are not available. For these reasons, a practical

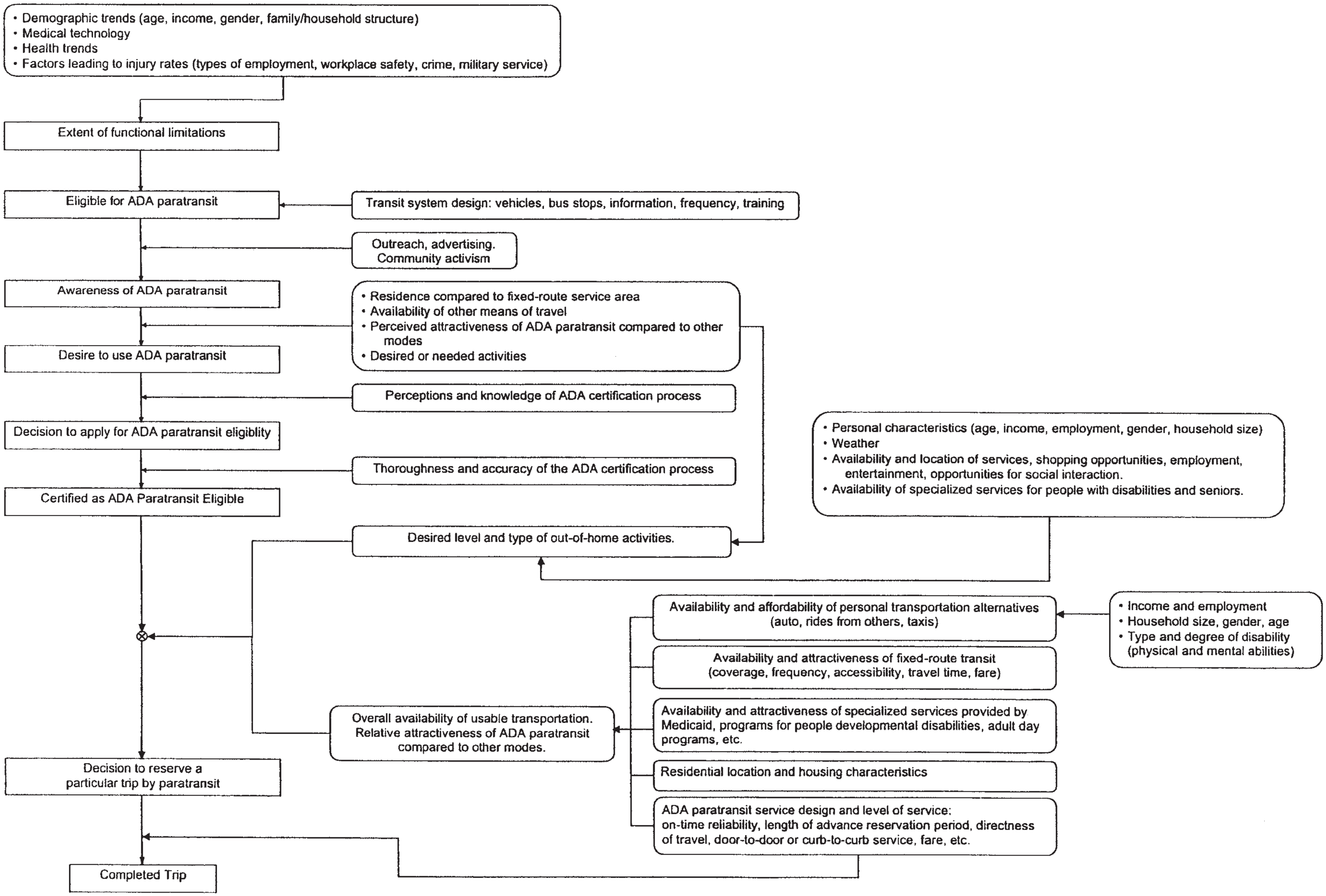


*Figure 12. Influence diagram for individual paratransit travel.*

disaggregate model would probably be much simpler than suggested by the diagram, representing the impact on paratransit demand of personal, household, and mode characteristics in one or two steps.

Where the aggregate model uses regression analysis, with disaggregate data, there are more choices, including discrete choice models such as multinomial logit that can accommodate yes/no type choices or choices involving more than two alternatives, e.g., the mode used for a given trip. The immediate outputs of the model equations are typically probabilities that are translated into trip totals by various means.

Considerations for this research in deciding whether to pursue a disaggregate approach include the following:

**Transferability:** Models based on disaggregate data from one or a few regions are typically assumed to be more transferable to other regions because they measure behavior at a more fundamental level, rather than simply picking up aggregate correlations in the data that may not hold for other aggregate samples or at other points in time. As a corollary to this point, we typically learn more about behavior when analyzing disaggregate data compared with aggregate data.

**Detailed Data:** Disaggregate data sets typically cover a much wider range of data items than can be collected from sources of aggregate data. Estimating a model requires a person-based survey asking about trips made by modes other than ADA paratransit, including private modes, whereas aggregate data collected from the paratransit operators and other transit operators would not provide such information.

**Expense of Data Collection:** Disaggregate data collection may be more expensive in general. This depends on the study context and how difficult it is to reach the target population. For this research, it may be possible, working with transit operators, to obtain data for people who have already been certified as ADA paratransit eligible. However, it would also be important to reach those who are disabled but do not use ADA services. A random telephone survey would be a very inefficient way to find such a limited population. If suitable disaggregate surveys have already been done in the past and the data already exists, then this option becomes more attractive. If future regional household travel surveys include the necessary questions, they could be used for this purpose.

**Appearance and Use of the Model:** In terms of what the final models "look like" and how difficult they are to apply, both types of data and both types of modeling methods end up producing models that look very similar in terms of the variables they include and the type of information needed to apply them. As mentioned above, disaggregate data can be used to include more variables in the models, but the "final" model need only include the variables for which information is available to apply it. If the model is applied to zonal or regional aggregate data, it will be applied in essentially the same manner regardless if it was estimated on aggregate or disaggregate data. However, aggregation bias will also occur to some extent if a model is estimated from disaggregate data but then applied to aggregate zonal or regional data. This is one of the main reasons for the growing popularity of micro-simulation methods in regional travel demand modeling to simulate individual decisions and then aggregate those simulated choices. There are ways to use aggregate population statistics to generate representative "synthetic" populations of individuals, though it may be more challenging to synthesize a representative population of disabled individuals.

**Level of Expertise:** Discrete choice modeling methods require more expertise than more common regression methods, although most packages such as SPSS and SAS now include routines for binary and multinomial logit model estimation. Also, the fact that there is usually a wider range of explanatory variables available in disaggregate data is a good feature, but it can require more time and judgment on the part of the analyst to decide on the best model specification.

Looking forward to eventually incorporating paratransit into regional travel demand models, the disaggregate approach offers important advantages. With aggregate data, if the segment of the population being studied is a small percent of the general population, then aggregate statistics for any given geographic area will not be very accurate for that particular segment. With disaggregate data collection focused on that specific segment of the population, this problem does not occur (although it does mean they may be more expensive to contact).

Referring again to the criteria for choosing tools to develop in this research, a disaggregate model would have good ability to address policy issues of interest. More than a system-level model, it would contribute to increased understanding of travel behavior and needs of people with disabilities and has greater potential for incorporation in the next generation of regional travel demand models. Like the system-level model, a disaggregate model could be limited to ADA paratransit eligible trips and individuals.

A major drawback of disaggregate modeling is that it requires data beyond what can be obtained in this project. A survey of people with disabilities that would obtain the necessary data would be a major undertaking even in one region. To produce a model with a reasonable degree of transferability, it would be necessary to conduct similar surveys in several regions with exemplary systems. Even then, the credibility of the results would be less than a model based on data from the larger sample of exemplary systems planned for the system-level model. Applying the model in another region would require similarly detailed data about people with disabilities in that region and a degree of expertise not generally available within a transit agency.

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*Abbreviations and acronyms used without definitions in TRB publications:*

| | |
|---|---|
| AAAE | American Association of Airport Executives |
| AASHO | American Association of State Highway Officials |
| AASHTO | American Association of State Highway and Transportation Officials |
| ACI–NA | Airports Council International–North America |
| ACRP | Airport Cooperative Research Program |
| ADA | Americans with Disabilities Act |
| APTA | American Public Transportation Association |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| ATA | Air Transport Association |
| ATA | American Trucking Associations |
| CTAA | Community Transportation Association of America |
| CTBSSP | Commercial Truck and Bus Safety Synthesis Program |
| DHS | Department of Homeland Security |
| DOE | Department of Energy |
| EPA | Environmental Protection Agency |
| FAA | Federal Aviation Administration |
| FHWA | Federal Highway Administration |
| FMCSA | Federal Motor Carrier Safety Administration |
| FRA | Federal Railroad Administration |
| FTA | Federal Transit Administration |
| IEEE | Institute of Electrical and Electronics Engineers |
| ISTEA | Intermodal Surface Transportation Efficiency Act of 1991 |
| ITE | Institute of Transportation Engineers |
| NASA | National Aeronautics and Space Administration |
| NASAO | National Association of State Aviation Officials |
| NCFRP | National Cooperative Freight Research Program |
| NCHRP | National Cooperative Highway Research Program |
| NHTSA | National Highway Traffic Safety Administration |
| NTSB | National Transportation Safety Board |
| SAE | Society of Automotive Engineers |
| SAFETEA-LU | Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005) |
| TCRP | Transit Cooperative Research Program |
| TEA-21 | Transportation Equity Act for the 21st Century (1998) |
| TRB | Transportation Research Board |
| TSA | Transportation Security Administration |
| U.S.DOT | United States Department of Transportation |