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16. Abstract

The purposes of this report are: (1) to identify the direct, as well as latent, demand for public and mass transportation services, and (2) to assess the factors which are critical to developing expanded transit usage.

Individual and behavioral characteristics explaining transit demand are assayed, as well as transit system and population characteristics influencing the demand for mass transportation. In addition, forecasts of transit demand by Texas transit leaders are included in the report.

It is often problematic to tie systemwide demand estimation models to micro-level characteristics, such as individual preferences, but increasing transit ridership is dependent on identifying and isolating both sets of "critical factors." Once these critical factors have been evaluated, transit personnel can proceed to plan service alterations and improvements to better serve the needs of the potential market, which is the key to a successful transit marketing effort.

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CRITICAL FACTORS INFLUENCING THE DEMAND FOR TRANSIT

by

Patricia Knight Guseman
Assistant Research Sociologist

Nancy J. Hatfield
Research Assistant

Judith Hall
Research Technician

Research Report 1052-2
Research Study Number 2-10-76-1052
Marketing Public and Mass Transportation in Texas

Sponsored by the
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in cooperation with the
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Texas Transportation Institute
Texas A&M University
College Station, Texas

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Many staff members of the Texas Transportation Institute have facilitated the completion of this report. Mr. G. Sadler Bridges, Head, Economics and Planning Division and Dr. Ronald W. Holder, Program Manager of Transport Operations have provided substantive advice and assistance in the study. Additionally, Dr. William F. McFarland, Program Manager of Transportation Economics and Sociology, provided administrative assistance for the research effort. The authors wish to thank Mrs. Melinda Morgan for her painstaking efforts in all stages of typing.

SUMMARY OF FINDINGS

The intent of this second report in the research project, "Marketing Public and Mass Transportation in Texas," was to explore a number of components which have been assessed as important in increasing mass transportation ridership. A bundle of critical factors is isolated based on two types of demand forecasting models. The findings enable transit planners and managers to determine the most significant service factors required by the general public, as well as for specific market segments.

PERSONAL CHARACTERISTICS AND INDIVIDUAL PREFERENCES THAT INFLUENCE TRANSIT DEMAND

Indicators for determining current and potential transit demand among individual residents were analyzed, based on two surveys undertaken in Waco, and Beaumont, Texas. The most significant personal and attitudinal characteristics which predict current bus ridership (regardless of trip purpose) were:

I. The lack of personal use of an automobile,

II. Close proximity to a bus route from one's residence, and

III. A positive evaluation of buses relative to automobiles.

A similar procedure isolated the factors which most accurately explained current ridership for eight specific trip purposes. Two indicators were found as most explanatory of patronage for conventional buses:

I. The lack of personal use of an automobile, and

II. The lack of limiting physical disabilities.

The propensity to use buses among current <u>non-riders</u> was examined to determine the most critical factors that influence a decision to switch to public transportation. The three factors that most clearly explained a high interest in transit use by current non-riders were:

I. Older individuals as modal switch patrons,

II. Proximity to a bus route from one's residence, and

III. A positive evaluation of buses relative to automobiles.

These three behavioral demand forecasting models outlined above should be of assistance in examining alterations or improvements in transit service. Not only can differences among cities be compared with the three models, but also current and latent transit demand in specific sectors of a city can be determined.

Service requirements sought by residents in Waco and Beaumont that should receive closer attention by transit management and city officials were:

- Bus service closer to key destinations (with these destinations closely keyed to recommendations provided by a representative resident sample)
- Bus reliability--arrivals and departures at scheduled times
- Bus shelters (provided at high usage bus stops), and
- Maintenance of low fares.

Blue collar females, older persons, and white collar females showed higher intensities of demand for improved bus services than did blue collar and white collar males and housewives. Each of these three target market segments emphasized the following three priorities:

- ROUTING: Routes should be closer to destinations pertinent to these individuals,
- RELIABILITY: Buses should arrive and depart at scheduled times, and
- AMENITIES: Bus shelters should be provided at high usage bus stops.

As can be noted, these three factors were also top requisites for the public-at-large.

FORECASTS OF MASS TRANSPORTATION DEMAND BY TEXAS TRANSIT LEADERS

Generally, the findings which emerged from the survey of Texas transit leaders and city representatives were optimistic in regard to increased ridership levels. Transit managers evidenced higher projections of patronage for 1980 and for a ten-year period (i.e., 1986) than did city officials. Overall, 73 percent expected at least a 10 percent increase in total ridership levels by 1980.

TRANSIT SYSTEM AND POPULATION CHARACTERISTICS THAT INFLUENCE TRANSIT DEMAND

While the findings from behavioral models that predicted the demand for transit have been discussed, macro-level indicators for demand forecasting also were assessed. The responses from 32 transit systems nationwide were utilized to determine transit system characteristics and population characteristics influencing demand. Measures of demand included:

(1) average daily passengers;

(2) percent of the total population using transit; and

(3) percent of total urban trips made by transit.

A consistently strong association between headway frequency and average daily ridership was observed. Additionally, daily passengers, the percent of the total population using transit, and the percent of urban trips by transit increased after 80 percent transit coverage (residence within one-fourth mile of transit routes) was reached. These two findings reinforce the continued expectation of a high correlation between level of service and transit demand.

Captive market segments, especially those with less than $5,000 median income and older persons, represented a higher proportion of the total ridership for systems with low service levels. White collar workers and housewives, on the other hand, were sensitive to the level of service provided in their respective cities.

Population density was shown as an important indicator of transit demand, while population size, per se, did not heavily influence demand. A density level of at least 4,000 persons per square mile appeared to provide a "tipping point" beyond which dependency on transit increased significantly.

Two systemwide demand models for estimating daily ridership were presented. The first model, developed by Chadda and Mulinazzi, is useful for cities of approximately 50,000 population. According to this forecasting procedure, the demand for transit service in a small city is based on:

- The percent of older persons;
- Fares charged; and
- Median family income.

The second model was developed from 26 medium-sized cities in the Texas Transportation Institute nationwide survey. According to this forecasting procedure, the demand for service (or daily ridership) in cities of 100,000 to 500,000 can be narrowed to three indicators:

- Average headways;
- Population size; and
- Number of buses in regular service.

UTILIZATION OF "CRITICAL FACTORS" AS TRANSIT SERVICE TOOLS

A key problem in assessing factors that indicate the demand for transit is the fact that systemwide demand forecasting models, based on system and population characteristics, cannot easily be tied to behavioral models based on individual characteristics and preferences. Each approach has certain advantages and limitations. Effectively improving transit systems and increasing ridership are dependent on isolating both sets of "critical factors."

Public investments in transit as an alternative transportation mode to the automobile must be substantiated on a knowledge of the most significant factors affecting modal choice. If such investments are to be effectively utilized, it is essential that transit planners accurately assess the public's perceptions of needed service requirements and the demand for transit facilities.

IMPLEMENTATION STATEMENT

The presentation of transit demand estimation procedures in this report will find applicability in transit planning and development efforts for cities, as well as for the State Department of Highways and Public Transportation. The most critical service requirements that are sought by current patrons, as well as by those not presently utilizing bus systems, should receive careful consideration for future public transportation investments. Additionally, the intensity of transit demand among six market segments will more clearly point out those individuals at whom concentrated service and marketing efforts must be directed. Presentation of the transit system and population characteristics that differentiate the demand for transit will enable transportation planners to determine expected ridership levels to be used in marketing efforts and in sketch planning processes.

Forecasts of future ridership by Texas transit leaders also are summarized in the report. The anticipation of at least a ten percent increase in urban trips via transit within four years is an indication of the need for improving mass transportation demand estimation procedures and putting these methods into fuller practice.

The reported findings and recommendations are designed for use by the State Department of Highways and Public Transportation and by localities, especially small and middle-sized cities, to facilitate their efforts to become more responsive to the transit needs of current and potential riders. Implementation of feasible service alterations and improvements geared to the public's assessment of critical factors necessary for effective transit systems will result in increased operating and service efficiency.

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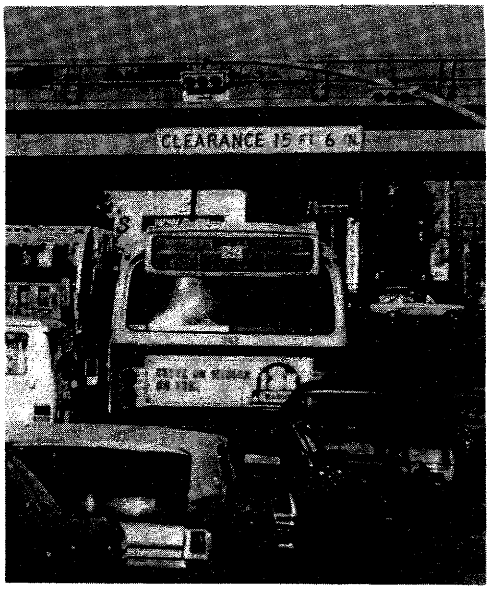


Expenditures for streets and highways were stressed as a more urgent concern by residents than was public investment in transit facilities. Nevertheless, public transportation improvements were viewed as important future investments.

The most significant personal or attitudinal characteristic explaining current transit ridership, both overall and by trip purpose, was the lack of personal use of an automobile. Households with two or more vehicles, as depicted above, do not utilize public transportation.

CHAPTER I

INTRODUCTION

The determination of predominant factors that explain the demand for transit is an integral component of the transit marketing and public transportation planning process. The intention of this report is to explore a number of components which have been assessed as important in increasing mass transportation ridership. A bundle of critical factors is isolated based on two types of demand models. The first set of models attempts to explain transit demand based on personal background characteristics, including travel behavior, and attitudinal characteristics. The second set of demand forecasting models utilizes city population characteristics (in the aggregate) and level of service characteristics for the respective transit systems.

THE CONCEPT OF TRANSIT DEMAND

Travel demand modeling has evolved over the last two decades as a mechanism for the estimation and forecasting of travel patterns, particularly by origins and destinations. With the use of such a process, subsequent evaluation of alternative investment strategies and policies have been undertaken (Stopher, 1977).

For transit marketing and planning, demand equations serve to point out the public's likely response to changes in the transit system. Many current demand models are not able to assess the actual transit needs of various population segments nor the impact of service alternations or improvements as noted by Louviere and Norman (1977:91-92):

> Current predictive models are fairly insensitive to policy alternatives. That is, it is difficult or impossible to answer questions such as "what is the response of the public if the fare is decreased by 10 cents while cutting back the frequency of service 30 minutes?"

"Transit demand" as a concept is based upon the number of trips required by residents and the supply or number of trips actually provided by the system. The single point at which the demand function and the supply function meet is commonly referred to as the "quantity of services demanded" or the balance between the two functions, as shown in Figure 1. Level of service indicators are incorporated in Figure 1 to explain the public's requirements for transit service. However, other intervening factors should also be included to explain the relationship between supply and demand functions. For example, population characteristics of the transit service area, such as population size and density, median income level, and percent of the population 65 years and older, are important predictive variables of transit demand. Personal characteristics of individuals and evaluation/attitudinal pronouncements regarding transit provide further intervening variables between the supply and demand functions.

MAJOR COMPONENTS IN THE ASSESSMENT OF TRANSIT DEMAND

In order for transportation planners to develop transit as a viable travel alternative, investments and policy-determination must be based on reliable estimates of transit demand. While some of the factors critical in assessing mass transportation use are well-known, other criteria may be less obtrusive. Interestingly, there is a wide divergence of opinion among planning officials regarding indicators that most adequately explain modal choice, when that option is transit usage (Wallin and Wright, 1974). Moreover, the public view is often different from that of the professional planner and policy-maker. For example, the average resident tends to place more importance on the "package" or appearances of transit than do planners. It is believed that this desire is more strongly felt among captive riders than choice riders (Wallin and Wright, 1974).

In interpreting these and other findings it is very important to separate out personal preferences and evaluation at an individual level from aggregate system and/or population characteristics that predict transit demand. In the first case, the demand model is based on a micro-analytic situation, whereas in the second situation, macro or aggregate characteristics are the crucial factors. Table 1 points to several different indicators of transit demand, some of which should prove to be more salient than others. A thorough knowledge of the most critical factors influencing demand in any one city provides the focal point for service alterations or improvements and for undertaking a successful transit marketing effort.

Figure 1. The Needed or Required Transit Trips and the Number of Trips Supplied by the Transit System as Measures of Demand*

Figure 1-A.

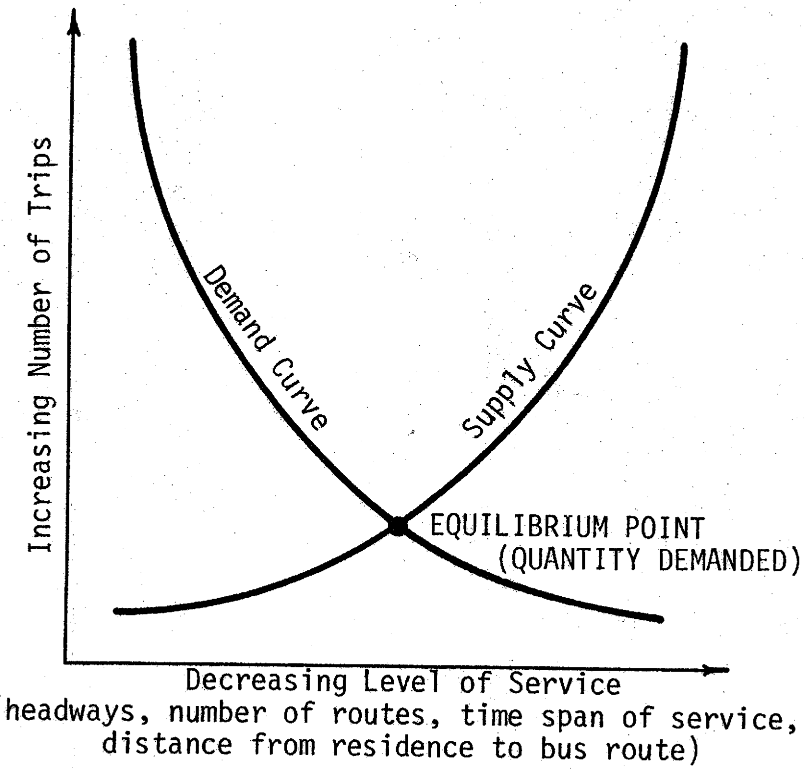
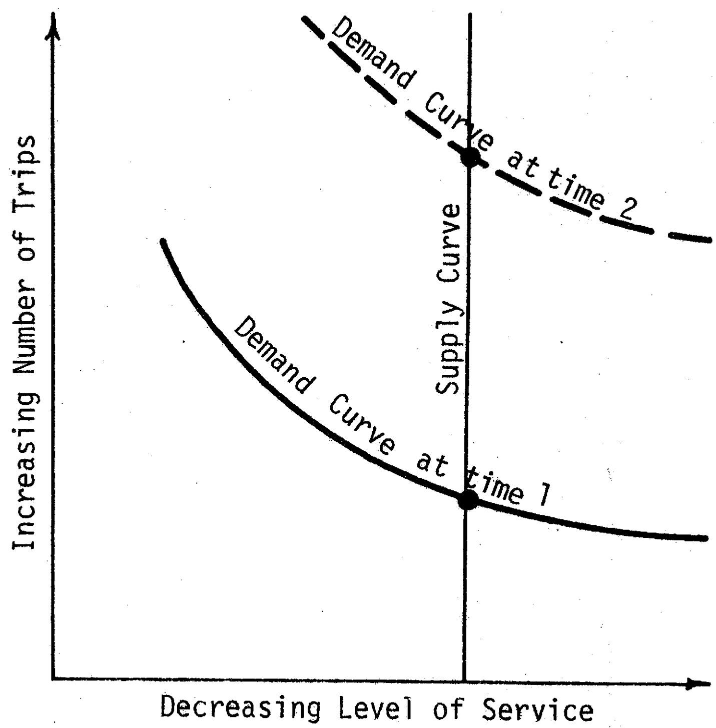


Figure 1-B.



*Source: D. Brand and M.L. Manheim "General Concepts" in Urban Travel Demand Forecasting, Special Report 143 of the Highway Research Record (1973): 8.

Table 1. Possible Bases for Transit Demand Estimation

Micro Factors

A. Personal Characteristics of Individual Travelers

1. Age
2. Sex
3. Socioeconomic status
4. Distance from residence and from work to nearest bus route
5. Auto availability
6. Trip purposes and frequency
7. Personal disabilities

B. Attitudinal/Evaluational Characteristics of Individual Travelers

1. Benefits sought from transit or service requirements
2. Evaluation of buses relative to automobiles
3. Attitudes toward current transit service
4. Attitudes regarding personal current use or potential use
5. Awareness of transit system

Macro Factors

A. Population Characteristics of City or Transit Service Area

1. Population size
2. Population density
3. Median family income
4. Percent of population 65+

B. Level of Service Characteristics of the Transit System

1. Headways, peak and off-peak
2. Percent of population within one-fourth mile of transit route
3. Time span of service per day
4. Vehicle miles per day
5. Number of buses in regular service
6. Number of bus routes
7. Revenues per passenger or base fare

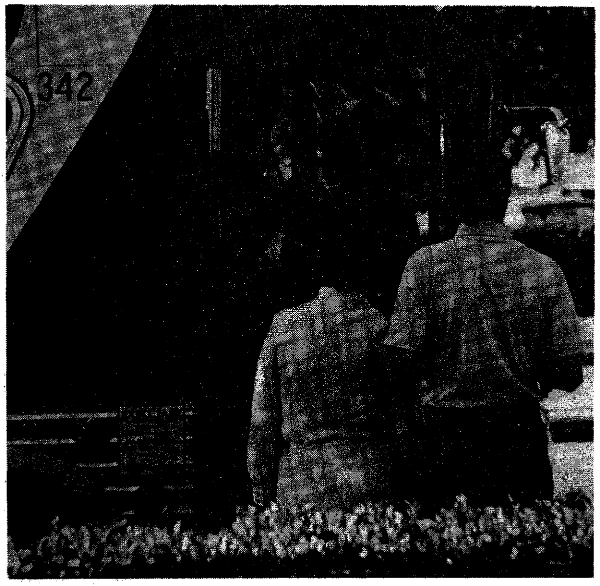
Chapter II of the report is devoted to the development of micro indicators and concomitant models for assessing current and potential transit demand. The emphasis is on personal characteristics and individual preferences and attitudes of residents, based on two surveys undertaken in Waco, and Beaumont, Texas.

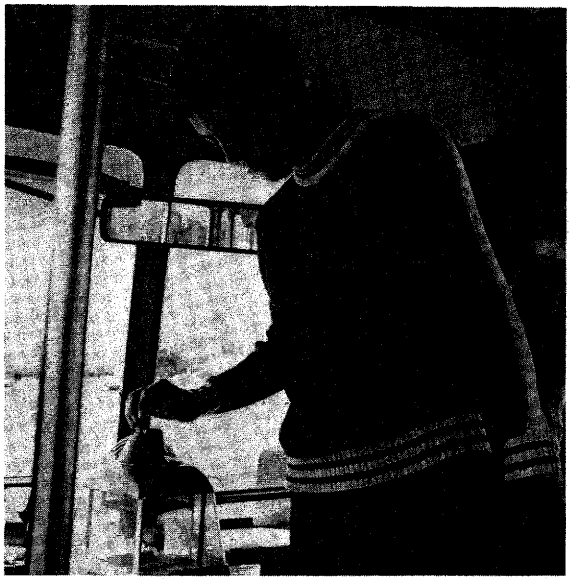
Chapter III deals with forecasts of Texas intracity transit demand, based on the projections of transit managers and city officials throughout the state. Forecasts are provided for the expected proportion of urban trips to be served by transit and the changes in daily passenger ridership levels.

Chapter IV is comparable in many respects to Chapter II with one major exception: the intention in Chapter IV is to uncover the critical macro-level factors that determine current and potential transit demand. Thus, population characteristics (in the aggregate) and level of service characteristics for 32 transit systems nationwide are utilized to isolate the key components of demand for transit facilities.

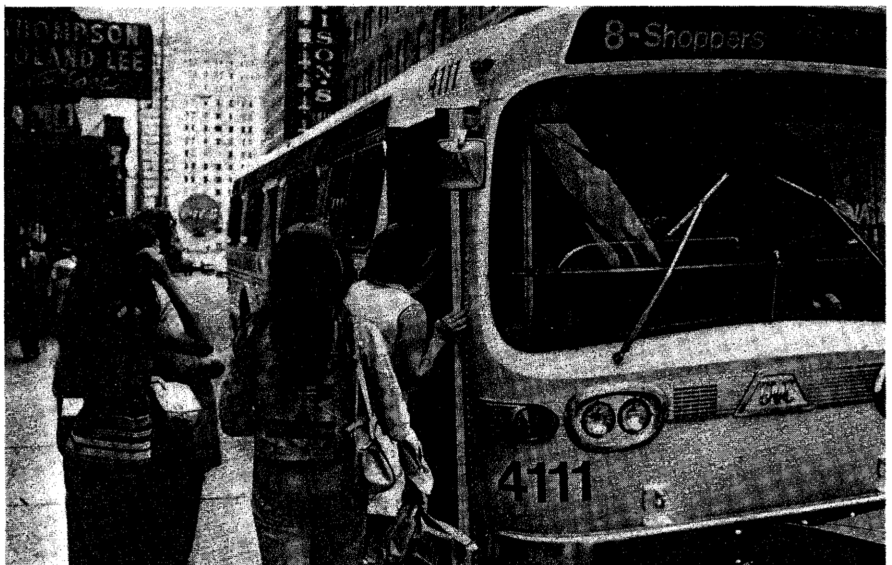
In the vast majority of cases, the transportation researcher or planner utilizes either a micro- or a macro-level model for estimating demand characteristics. Nonetheless, each approach has different strengths, as well as weaknesses, which are discussed in Chapters II and IV. Hopefully, the inclusion of both approaches in one report will:

- Increase the understanding of factors influencing transit ridership
- Improve existing transit forecasting capabilities
- Improve methods for approaching demand estimation and put these procedures into fuller practice, and
- Provide a basis for implementing successful service improvements and transit marketing strategies.





The correct identification of critical service requirements and other factors which predict patronage is necessary to provide an effective transit system. Particularly for initiating service changes or improvements, residents' transportation needs must be carefully considered.



CHAPTER II

CHARACTERISTICS OF INDIVIDUAL RESIDENTS THAT INFLUENCE TRANSIT DEMAND: AN EXAMINATION OF TWO SMALLER TEXAS CITIES

Waco, and Beaumont, Texas were selected as study sites representative of transit service levels and population characteristics for an in-depth assessment of transit marketing potential. The assessment included as a primary component the evaluation of factors critical in influencing transit demand. It was determined that, on the whole, no concensus existed among several population segments in their attitudes toward buses and service requirements sought (refer to Volume I, Identification of Market Segments: An Analysis of Transit Needs and Service Requirements). A multiple discriminant analysis procedure determined the existence of six independent adult population segments, as shown in Table 2.[1] These groupings have significantly different perceptions of the need, and performance requirements, for transit.

Four primary objectives in analyzing representative citizen survey data from the two study sites were:

- the assessment of potential transit demand and factors influencing demand
- the determination of current transit use by market segments and factors critical in explaining these usage levels
- the identification of demand forecasting variables based on service requirements sought, and
- the measurement of citizens' views toward the relative importance of transit.

In this chapter, these topics will be assayed, beginning with a discussion of the perceived importance of transit.

RELATIVE IMPORTANCE OF TRANSIT: THE CITIZENS' VIEWPOINT

Justification of transit service provision in cities can only be viewed in comparison to other needed community services. Public expenditures are rarely allocated for specific projects or programs based on a funding surplus.

[1]Omitted from these segments were four special populations: adult students, the disabled, and the unemployed, as well as younger persons under the age of eighteen.

Table 2. Market Segments and Proportionate Sizes of Each Segment in the Total Adult Population, Waco and Beaumont, Texas*

	Beaumont	Waco
Older Persons (65+)	13.4	18.0
Housewives	31.5	31.9
White Collar Females	12.8	14.1
Blue Collar Females	7.5	9.0
Blue Collar Males	20.4	16.9
White Collar Males	14.8	14.7

*These percentages were obtained from the U.S. Bureau of the Census, 1970 Census of Population and Housing. Washington, D.C.: U.S. Government Printing Office, PHC, 1972.

Demand estimation proceeds on the basis of relative need and potential for customer usage.

Ranking of Transit Relative to Other City Concerns

If public expenditures are based solely on citizen assessment of the most urgent and pressing community problems that should be attacked, a current ranking of community concerns is very salient. Table 3 depicts an ordering of community problems perceived as critical in Beaumont and Waco, including an aggregated ranking. In Waco, better provision of transit/public transportation services is ranked fifth, with combating crime, road and street repair, attracting new industries/jobs, and air/water pollution viewed as more urgent problems. Beaumont residents rated more adequate transit service as eighth, most likely based on the city's recent acquisition of a new bus fleet, which lowered the saliency of transit as a community concern. Viewed as an average ranking between the two cities, mass transit/public transportation received the low priority of seventh out of nine problems rated.

Recommended Sources of Funding for Transit

City councils, transit managers, and other concerned transit representatives have repeatedly questioned whether bus service provision can, and should, be a money-making concern. The almost universal concensus among transit authorities currently is that no transit system can be sustained by the fare box alone. Nevertheless, the public view is at variance with this conclusion, as shown by the responses of Beaumont and Waco residents (see Table 4). Property and gasoline taxes were consistently viewed as the least appropriate means of funding transit. Increased transit fares were recommended as the most satisfactory funding source, followed by an increase in the local sales tax rather than state taxation, which encompasses the state general revenue funds.

Support for Transit Relative to Street and Highway Expenditures

Roadway and street repairs were shown in Table 3 to receive the top ranking among Beaumont residents as the most urgent and pressing city problem, and a rating of third in priority for Waco. Similar support for roadway improvements is depicted in Table 5, with an assessment of roadway

Table 3. Ranking of Public Transportation/Mass Transit in Relation to Other City Concerns (in percentages, n = 618)

Most Important Problem in City	Aggregated (for both cities)	*Waco*	*Beaumont*
I. Crime	32.8	*38.9*	*26.4*
II. Road and Street Repair	25.9	*21.3*	*30.8*
III. New Industry and Jobs	17.8	*23.2*	*12.0*
IV. Property Taxes	7.0	*3.1*	*11.0*
V. Air and Water Pollution	5.5	*4.7*	*6.3*
VI. Cost of City Government	4.2	*2.8*	*5.7*
VII. Public Transportation/Mass Transit	3.1	*3.8*	*2.3*
VIII. Race Relations	2.9	*1.9*	*4.0*
IX. Other	0.8	*0.3*	*1.3*

Table 4. Sources of Transit Funding Viewed As Acceptable (n = 686)*

Funding Source	Aggregated (for both cities)	*Waco*	*Beaumont*
Increase transit fare	43.6	*38.08*	*49.6*
Increase local sales tax	20.7	*18.6*	*22.8*
Increase state sales tax	15.2	*13.0*	*17.5*
Increase taxes on gasoline	12.3	*13.0*	*11.6*
Increase property tax	8.6	*8.4*	*8.8*

*Transit funding sources residents defined as "Very Satisfactory" or "Satisfactory."

Table 5. Support for Transit Relative to Street and Highway Improvements
(n = 748)

Opinion Item	Item Favorable to Supporting Transit	Percent Strongly in Favor of Item[a]	Percent in Favor of Item[b]
"There should be greater emphasis on improving bus service and less on building freeways."	Yes	22.35	41.95
"If more people used buses, the freeways and roads would be less crowded for those who use automobiles."	No	40.52	69.60
"The space available for parking should be reduced to discourage the use of cars in the downtown area."	Yes	8.41	14.72
"I really can't see much of a future for public transportation."	No	9.33	21.41
"Special freeway lanes should be set aside for the use of high-speed, non-stop buses into and out of downtown Beaumont (Waco) during rush hours."	Yes	32.89	53.47

[a]Percent of residents sampled that "Strongly Agreed" with the opinion item.

[b]Percent of residents sampled that "Strongly Agreed" or "Agreed" with the opinion item.

improvements for automobile driving rather than for bus usage predominating. Nevertheless, only 21 percent of the residents sampled in the two cities reported that they could not "see much of a future for public transportation."

DEMAND FORECASTING VARIABLES BASED ON SERVICE REQUIREMENTS SOUGHT

Determination of performance requirements has been viewed as an important component of demand forecasting for all transportation modes. Particularly with transit demand modeling, it also is important to assess the current and potential capabilities of the transit system in attaining the performance standards prescribed by the public (Fox, 1975; Buttke, 1976). One critical rationale behind market segmentation lies in the knowledge that most transit systems, especially those in smaller cities, cannot meet the performance criteria required by the majority of the population. These systems actually provide a very limited level of service, based on daily time span of service, headways, routing distances from homes, places of work, and other critical destinations, and various other measures of service intensity. Thus, some market segments evidence no interest in bus service, while others find that transit service fills an important transportation need.

A Ranking of Service Requirements by the Total Resident Samples

In both Beaumont and Waco, many of the system attributes ranked as most important by residents are not feasible service improvements (refer to Table 6). Ranked second in importance, for example, was, "The bus trip needs to take less time than an automobile trip"; such a service requirement cannot be met by smaller systems. Of the top ranking five most salient requirements sought, however, four should receive closer attention by transit management:

- Bus services closer to key destinations (with these destinations chosen by residents)
- Bus reliability--arrivals and departures at scheduled times
- Bus shelters provided at high usage bus stops, and
- Maintenance of low bus fares.

System Attributes Predicting Transit Demand for Six Market Segments

Blue collar females, older persons, and white collar females showed higher intensities of demand for improved services (see Table 7). The top

Table 6. System Attributes Predicting Transit Demand for the Total Sample Population in Beaumont and Waco (n = 694 to 684)

Importance Rank	System Attributes	Average Rank ($\bar{X}$)*	Standard Deviation
1	Buses should run closer to places I want to go	2.48	1.33
2	The bus trip needs to take less time than an auto trip	2.50	1.36
3	Buses should always arrive and depart at the scheduled time	2.54	1.35
4	Shelters are needed at bus stops	2.60	1.36
5	Low bus fares should be maintained	2.63	1.32
6	More information should be provided about bus routes and schedules	2.67	1.29
7	There should be better bus service between shopping centers	2.68	1.33
8	The bus should pick you up and drop you off at your front door	2.69	1.39
9.5	The trip should not require transfers	2.72	1.30
9.5	There should be benches at bus stops	2.72	1.29
11	There should be better night and weekend service	2.77	1.35
12.5	There should always be a seat available	2.80	1.23
12.5	Community leaders stress the need to use buses for environmental reasons	2.80	1.24
14	You should be able to drive to a nearby free and secure parking area and ride an express bus to downtown (i.e., park-and-ride)	2.81	1.38
15.5	The buses need to run more frequently on routes	2.31	1.34
15.5	It should not be necessary to have correct change	2.31	1.26

Importance Rank	System Attributes	Average Rank ($\bar{X}$)*	Standard Deviation
17	The trip should take the same amount of time as an automobile trip	2.32	1.29
18.5	Routes should be closer to home, work, and shopping	2.88	1.34
18.5	The trip should be as safe as an automobile trip	2.88	1.19
20	Buses need to be safer to wait for and to ride on	2.91	1.28
21	Your friends and associates also are using the transit service	2.93	1.13
22	Better telephone information service should be available	2.97	1.21
23	Drivers should be more courteous and considerate	2.99	1.13
24.5	The trip should not go through downtown Beaumont (Waco)	3.20	1.11
24.5	The people on the bus should be more sociable	3.20	1.04
26	The bus trip should not require sitting next to strangers	3.40	1.00

*The highest possible rank a desirable system attribute could receive was 1.00 and the lowest a 5.00. The highest rating (or average rank) found was 2.48, "Buses should run closer to places I want to go."

Table 7. System Attributes Predicting Transit Demand for Six Market Segments in Beaumont and Waco

Importance Rank	*System Attribute*	*Average Rank*	*Standard Deviation*	*Sample Size*
	<u>OLDER PERSONS</u>			
1	Buses should run closer to the places you want to go	2.43	1.32	67
2	There should be benches at bus stops	2.45	1.29	68
3	The buses should always arrive and depart at the scheduled time	2.50	1.31	63
4.5	There should be shelters at bus stops	2.51	1.28	66
4.5	Community leaders should stress the need to use buses for environmental reasons	2.51	1.26	68
	<u>BLUE COLLAR MALES</u>			
1.5	Buses should run closer to the places you want to go	2.71	1.40	96
1.5	The trip should take less time than an automobile	2.71	1.48	96
3	The buses should always arrive and depart at the scheduled time	2.76	1.40	95
4	The bus should pick you up and drop you off at your front door	2.79	1.43	96
5	The trip should not require transfers	2.80	1.41	96
	<u>BLUE COLLAR FEMALES</u>			
1	There should be shelters at the bus stops	2.21	1.31	61
2	The buses should always arrive and depart at the scheduled time	2.22	1.23	63
3	The buses should run closer to the places you want to go	2.25	1.24	63
4	Low bus fares should be maintained (not to exceed 25¢)	2.26	1.24	65
5	Buses need to be safer to wait for or to ride on	2.32	1.25	67

Importance Rank	*System Attribute*	*Average Rank*	*Standard Deviation*	*Sample Size*
	WHITE COLLAR MALES			
1	The trip should take less time than an automobile trip	2.59	1.31	100
2	The buses should run closer to the places you want to go	2.68	1.35	101
3	The bus should pick you up and drop you off at your front door	2.82	1.34	101
4	The buses should always arrive and depart at the scheduled time	2.85	1.34	100
5	You should be able to drive to a nearby free and secure parking area and ride an express bus downtown (i.e., park-and-ride)	2.93	1.24	101
	WHITE COLLAR FEMALES			
1	The trip should take less time than an automobile trip	2.13	1.28	77
2	The trip should not go through downtown Beaumont (Waco)	3.15	1.19	77
3	The buses should always arrive and depart at the scheduled time	2.19	1.23	77
4	The buses should run closer to the places you want to go	2.23	1.25	77
5	There should be shelters at bus stops	2.36	1.29	77
	HOUSEWIVES			
1	The trip should take less time than an automobile trip	2.40	1.30	111
2	The buses should run closer to the places you want to go	2.45	1.36	112
3	There should be shelters at the bus stops	2.51	1.35	110
4	More information should be provided about bus routes and schedules	2.53	1.29	111
5	The buses should always arrive and depart at the scheduled time	2.60	1.36	112

five priorities stressed by these three segments should be carefully considered by transit officials, as it is these segments who have the greatest likelihood of riding buses in smaller cities. Each of the three segments stressed the following priorities among their top five requirements:

- ROUTING: Routes should be closer to destinations pertinent to these individuals
- RELIABILITY: Buses should arrive and depart at the scheduled times
- AMENITIES: Bus shelters should be provided at high usage bus stops

Relationships Among Performance Requirements Sought

A factor analysis was undertaken to determine the number of service requirements that clustered together and the types of factors that evolved to explain service requirements sought (refer to Table 8). Surprisingly, only two factors were formed in the factor analytic procedure. The first factor was established as a great deal more important (in terms of percent variance explained) than the second factor. This first dimension was labelled "performance criteria" required of the bus system by residents in the two cities sampled. The critical performance criteria were similar to those described in the two previous tables (Tables 6 and 7) and are depicted in Table 8 by the largest darkened circles (factor loadings of .80+) as:

- Buses need to run more frequently on routes
- Buses should run closer to the places residents want to go
- There should be better night and weekend service
- There needs to be better bus service between shopping centers
- There should be shelters at bus stops
- The bus should always arrive and depart at the scheduled time
- There needs to be benches at bus stops

The second factor was termed "social criteria", or requirments sought from bus transportation that had no relationship to vehicle performance per se. The most explanatory social criterion (factor loading of .84) was:

- The bus trip should not require sitting next to strangers

The social criteria, while important as a variable clustering to point out the most explanatory social features of bus ridership, nevertheless were of considerably less importance than the performance criteria.

Table 8. Clustering of Service Requirements Sought by Resident Samples (Factor Analysis of 26 Requirements)*

Service Requirements	Factor I Performance Criteria	Factor II Social Criteria
Routes should be closer to home, work, shopping	● (.77)	
Buses need to run more frequently on routes	● (.80)	
Buses need to be safer to wait for and to ride on	● (.66)	
The bus trip should not require sitting next to strangers		● (.84)
The drivers should be more courteous and considerate		● (.75)
The people on the bus should be more sociable		● (.79)
The bus should pick you up and drop you off at your front door	● (.55)	
More information should be provided about bus routes and schedules	● (.77)	
The trip should take less time than an automobile trip	● (.65)	
The trip should take the same amount of time as an auto trip	● (.68)	
The trip should be as safe as an auto trip	● (.65)	
The trip should not go through downtown Beaumont (Waco)		● (.65)
There should always be a seat available	● (.69)	
The buses should run closer to the places you want to go	● (.84)	
There should be better night and weekend service	● (.80)	

Service Requirements	Factor I Performance Criteria	Factor II Social Criteria
There should be better bus service between shopping centers	● *(.82)*	
There should be shelters at bus stops	● *(.84)*	
You should be able to drive to a nearby free and secure parking area and ride an express bus to downtown (i.e., park-and-ride)	● *(.67)*	
Your friends and associates also are using the transit service		● *(.58)*
The bus should always arrive and depart at the scheduled time	● *(.80)*	
There should be benches at bus stops	● *(.81)*	
Community leaders stress the need to use buses for environmental reasons	● *(.55)*	
Low fares should be maintained (should not exceed 25¢)	● *(.75)*	
Should not be necessary to have correct change	● *(.69)*	
Better telephone information service should be available	● *(.70)*	
The trip should not require transfers	● *(.71)*	

*The eigen value for Factor 1 was 16.35, explaining 11.80 percent of the variance. Factor II had an eigen value of 1.21 and explained 5.76 percent of the variance. Factor I, an operations or performance factor, was clearly the most important dimension.

The factor loadings are shown in italics. Requirements with a factor loading of .80 or greater explain most critical service features desired and are depicted by the large darkened circle: ●. Those requirements with a .65 - .79 factor loading are less critical service features and receive a smaller darkened circle: ●. Finally, the requirements of .50 - .64 loadings are represented by a small, darkened circle: ●.

CHOICE/CAPTIVE RIDER CONTINUUM AND TRANSIT PATRONAGE

As should be anticipated in cities with lower levels of transit service, a large proportion of current patrons consider themselves "captive riders." In Beaumont and Waco, 50.9 percent suggested that they used transit because they had no other transportation alternatives (see Table 9). Further, only 2.54 percent of the six population segments rode buses regularly. Over 12 percent used buses either on an occasional or part-time basis, according to the residents sampled.

Table 9. Level of Bus Patronage and Choice/Captive Rider Continuum for Beaumont and Waco, Aggregated Across the Six Market Segments (n = 550)*

Rider Category	Choice or Captive Rider	Percent Using the Bus
"I am a regular user of public transportation by choice"	Choice	1.09
"I am a regular user of public transportation because I have no alternatives"	Captive	1.45
"I sometimes use public transportation by choice"	Choice	4.00
"I sometimes use public transportation, but only when I have to"	Captive	8.55
"I don't use public transportation at the present time, but have in the past"	—	54.73
"I don't use public transportation and I never have in the past"	—	30.18

*This table omits adult students, the disabled, and the unemployed members of the total adult resident samples.

A breakdown by market segments more clearly depicts the choice/captive differentiation and the relative intensity of usage among the six basic population groupings. Table 10 refers to older persons as being the heaviest riders, with 20.5 percent either regular or occasional patrons, followed by

Table 10. Transit Patronage and Choice/Captive Rider Status of Market Segments
(n = 550)*

(percentages)

Six Market Segments	Regular Users		Occasional Users		Non-Users	
	Choice	Captive	Choice	Captive	Used in Past	Never Used
Older Persons	2.6	5.1	5.1	7.7	53.9	25.6
Blue Collar Males	1.0	0.0	4.1	12.2	46.9	35.7
Blue Collar Females	3.1	3.1	1.5	10.8	56.9	24.6
White Collar Males	0.0	0.0	4.1	5.2	49.5	41.2
White Collar Females	1.3	0.0	1.3	6.3	65.8	25.3
Housewives	0.8	1.6	4.8	7.1	56.3	29.5

*Adult students, the disabled, and the unemployed, as well as those under 18 years of age were omitted from the tabulation. Largest column percentages are denoted with dashed lines.

blue collar females, with 18.5 percent using the bus regularly or occasionally. Blue collar females showed the largest proportion of regular ridership by choice (3.1 percent) and one out of twenty older persons were choice riders occasionally. The largest proportion of non-users were white collar females and white collar males, with 91.1 and 90.7 percent, respectively, making no trips currently by bus.

Based on the present user segments, the potential demand for transit in cities with small systems should lie in increasing patronage among older persons and blue collar females. These two segments form the primary market and, without further service improvements, will continue to be the predominant users. Seventy-five percent of the regular patrons in Beaumont and Waco are either 65 and older or blue collar females; further, these two groups form 36 percent of the occasional ridership.

FACTORS INFLUENCING CURRENT RIDERSHIP

To understand the reasons for current ridership, nine possible variables were examined:

- age of users
- sex of riders
- educational level of users
- distance from residence to nearest bus route (in blocks)
- auto availability
- persons per household relative to number of vehicles (autos/motorcycles) per household
- an evaluation scale of buses compared to autos on 12 different dimensions[2]
- awareness of bus system's title
- existence of personal disability

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[2] Evaluation of buses and automobiles for the 12 broad dimensions could range from 1 = quite positive; 2 = positive; 3 = slightly positive; 4 = neutral; 5 = slightly negative; 6 = negative; 7 = quite negative. The "bus/auto evaluation scale" could range from a +72 to a -72. This scale compared buses to autos on the 12 different dimensions, each of which could range from a +6 to a -6. Thus, the "Bus/Auto Evaluation Scale" = (Bus Punctuality - Auto Punctuality) + (Bus Simplicity - Auto Simplicity) + (Bus Safety - Auto Safety) + (Bus Modernity - Auto Modernity) + (Bus Comfort - Auto Comfort) + (Bus Speed - Auto Speed) + (Bus Status - Auto Status) + (Bus Convenience - Auto Convenience) + (Bus Enjoyability - Auto Enjoyability) + (Bus Cost - Auto Cost) + (Bus Reliability - Auto Reliability) + (Bus Flexibility - Auto Flexibility). The residents sampled actually provided a rating of +70 to -57. Because "7" = quite negative and "1" = quite positive, +70 refers to a high auto evaluation and -57 to a high bus evaluation.

As might be anticipated, the regular users (described in the preceding section) were *older*, had *less education*, tended to be *female*, were *closer to bus stops*, had *personal use of a car only occasionally*, evidenced *fewer vehicles per household members*, had *higher evaluations of buses*, were *more aware of the bus system's title*, and had *fewer limiting disabilities*.

Additionally, a scale was formed to measure level of current bus usage by trip purpose, which included eight possible destinations:

1. work
2. school
3. grocery shopping
4. nonfood shopping
5. visit friends
6. medical/dental facilities
7. church
8. personal business or recreation

This measure of level of use by purpose was termed the LOUP scale, and could range from 0, inferring no bus usage for any destination, to 8, suggesting at least some dependency on buses for all eight trip purposes outlined above. Again, as with the factors found to influence "regular ridership", the same characteristics were noted to predict high levels of use by trip purpose (the LOUP scale).

To isolate which of these nine explanatory indicators were the most critical factors influencing ridership, a set of multiple regression analyses was undertaken. As pointed out in Table 11, three primary indicators were isolated that explain current transit use:

- AUTO AVAILABILITY: The availability (or lack of availability) of personal use of a car
- ROUTE COVERAGE: The distance in blocks from place of residence to the nearest bus route, and
- TRANSIT EVALUATION: An evaluation of buses relative to automobiles.

Further, the example of City A points out that the level of ridership can be predicted by using the regression equation shown in Table 11. This model has at least three different possibilities for use. First, the equation would be of utility in comparing cities that differ in regard to the three indicators. Second, if routing is improved, for example, so that average distances to bus routes within City A are 2.5 blocks rather than 3.5, changes in level of use can be ascertained. A final use of the equation or model is in determining different levels of ridership for specific portions of the city, such as census tracts. Because the "Evaluation" variable was included in the final three-indicator model, a survey would be

Table 11. Characteristics of Individual Residents in Beaumont and Waco That Are the Most Significant Indicators of Bus Ridership*

USER LEVEL MODEL

(RIDERSHIP LEVEL) = 1.07 + (0.11884 X AUTO AVAILABILITY) + (0.00109 X DISTANCE FROM BUS STOP) + (-0.00298 X EVALUATION OF BUSES RELATIVE TO AUTOS)

EXAMPLE OF USER LEVEL MODEL FOR CITY A

1.07	(0.11884	X	1.5)	+	(-0.00109	X	3.5)
[Intercept]*	[Coefficient for Auto Availability]		(Average Personal Use of a Car in City A, where 1 = Always 2 = Most of the time 3 = Part of the time 4 = Occasionally 5 = Never)		[Coefficient for Distance from Residence to Bus Stop]		(Average Distance in blocks from Bus Stop in City A)

+	(-0.00298	X	16.5)	=	1.2
	[Coefficient for Evaluation of Buses Relative to Autos]		(Average Evaluation in City A, where buses were compared to autos on 12 different dimensions each of which could range from a +6 to a -6 [see footnote 2)		(User Level in City A, where 1 = No use 2 = Occasional use 3 = Regular use)

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*Brackets [ ] in the example refer to constants in the equation and the values in parentheses ( ) will change from city to city. Six of the original nine variables were depleted as explanatory, since the purpose of the maximum-R^2 regression is to obtain the fewest number of explanatory variables. The three variables that were retained all had a significance level less than .01. The R^2 is low at 10.3, indicating that there are many other possible factors intervening to explain level of bus use for individual residents.

required to determine residents' opinions toward buses which would be identical to the questions used to derive the "bus/auto evaluation scale" in this study.

Factors Predicting Level of Transit Use by Trip Purpose

A similar procedure to that used above to discern level of overall use was applied to level of use for specific trip purposes.[3] This level of use for trip purposes scale (the LOUP scale) was included in a maximum-R^2 regression. The same nine variables were included as potentially predictive indicators of the LOUP scale. The most predictive model contained only two indicators--auto availability and lack of limiting disabilities, as shown in Table 12.

The use of this two-variable model, does not require the inclusion of the "evaluation of buses/autos" indicator which the model for overall bus ridership level was found to include (as was depicted in Table 11). Therefore, a survey need not be required for a city to apply this second level of use model, if average auto availability for households in the city is known, as well as the mean disability level (preventing conventional bus usage) for the city. The LOUP ridership model in Table 12 is similar to the overall level of ridership equation presented in Table 11, in that it has several applications. First, the model can be used to compare differences among cities in level of bus usage for the eight destinations. Second, the impact of an alteration in one of the two predictive variables for any city--such as reduction of personal auto availability in an energy crisis--could be predicted with the use of this equation. Third, different levels of bus usage for the eight destinations among specific sectors of the city, such as census tracts, could be ascertained by comparing these areas with the model.

An example of a two-city comparison is provided in Table 12. The LOUP scale (or level of bus use by trip purpose) raises from .06 for City A, which

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[3]Regression models also were established to depict the most highly explanatory variables for each of the eight trip purposes, such as the best model to explain the choice of bus ridership rather than autos for work trips. However, the number of regression models was so lengthy that they are not included in this report. The authors can be contacted for more information regarding these models.

Table 12. Characteristics of Individual Residents in Beaumont and Waco That Are the Most Significant Predictors of Current Bus Ridership by Trip Purpose (LOUP Scale)*

LEVEL OF CURRENT TRANSIT USE BY TRIP PURPOSE MODEL

LOUP = -0.10803 + (0.10603 X Auto Availability) + (0.29815 X Proportion Disabled)

EXAMPLES FOR CITIES A AND B OF LEVEL OF TRANSIT USE BY TRIP PURPOSE

CITY A

-0.10803 + (0.10603 X 1.5) + (0.29815 X 0.04) = 0.06

- -0.10803: [Intercept]
- 0.10603: [Coefficient for Auto Availability]
- 1.5: (Average personal use of autos, where
  - 1 = Always
  - 2 = Most of the time
  - 3 = Part of the time
  - 4 = Occasionally
  - 5 = Never)
- 0.29815: [Coefficient for Porportion of City's Population with Disabilities Preventing Use of Conventional Buses]
- 0.04: (Average Disability Level, where
  - 0 = No Disability
  - 1 = A Limiting Disability,

  totaled over the City A population or survey sample)
- 0.06: (Level of Bus Use for City A by 8 Trip Purposes or LOUP Scale)

Holding proportion of disabilities the same in Cities A and B, but lowering auto availability levels in City B to 2.5, a higher LOUP scale is found.

CITY B

-0.10803 + (0.10603 X 2.5) + (0.29815 X 0.04) = 0.17

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*Brackets [ ] in examples of Cities A and B refer to constants in the equation and the values in parentheses ( ) will change from city to city. The level of use by trip purpose model (LOUP scale) could range from 0 to 8 for individual residents in Waco and Beaumont, or for the total city's average as in the case of Cities A and B. With auto availability levels used in City A that are representative of most cities (i.e. 1.5), the LOUP scale was .06. With a lowered level of auto availability used for City B, the LOUP scale was .17. Seven of the nine original variables were deleted as explanatory, since the purpose of the maximum-R^2 regression is to obtain the fewest number of explanatory variables. The two variables retained had significance levels less than .01 and R^2 was 0.14.

has an average level of personal auto availability, to a .17 in City B, which has a low availability of autos.

In both cities A and B, the proportion of the two populations that have limiting disabilities preventing use of conventional buses is the same. It might be possible for this variable to become altered in a city, if specialized vans were provided, so that the reduction of demand for conventional transit by this population segment could be predicted.[4]

POTENTIAL TRANSIT DEMAND BY MARKET SEGMENTS

For those not currently riding buses, the propensity to use transit for the eight specific destinations was determined. The non-users responding that they would be "Extremely Likely" or "Likely" to ride buses for these eight trip purposes were examined.[5] These potential patrons are shown in Table 13. Overall, 9.9 percent of the non-users stated they would be "Very Likely" to attempt use of buses for work trips in the near future. As will be discussed in a later portion of this chapter, correction factors have to be provided for determining more accurately the propensity to actually attempt bus usage for any trip purpose.

Adult residents in Waco and Beaumont are more interested in potential off-peak bus trips than in peak hour trips. Medical/dental trips, school trips (university and technical school destinations), and church activities received the greatest number of mentions as destinations in which residents would be highly likely to consider a modal switch. The frequency or intensity of bus usage for these trips at an individual level is difficult to determine.

Potential bus patronage was further broken down by the six market segments, as portrayed in Table 14. For four of the eight destinations, blue

[4]In Waco and Beaumont, 40 percent of the handicapped who could not use conventional buses were also 65 years of age or older. An increase in the number of specialized vehicles provided for either older persons or the disabled would have an impact on the demand for conventional buses, as 4.1 of those in Waco and Beaumont professing a disability are regular riders of buses.

[5]Other responses were "Neutral", "Not Very Likely", and "Extremely Unlikely", as well as "I Use a Bus Now."

Table 13. Potential Users of Public Transit by Trip Purpose in Beaumont and Waco (in percentages)

	Extremely Likely	Likely
Work	9.9	13.8
School	10.1	13.8
Grocery Shopping	7.5	4.7
Nonfood Shopping	8.3	10.9
Visiting Friends	8.8	9.6
Medical/Dental Trips	11.1	13.3
Church Activities	10.0	10.9
Personal Business/Recreation	9.1	12.3

Table 14. Potential Transit Use by Market Segments of Those Not Currently Using Buses for Specific Trip Purposes (in percentages)[a]

	Work	School	Grocery Shopping	Non-food Shopping	Visiting Friends	Medical/ Dental Trips	Church Activities	Personal Business/ Recreation
Older Persons	5.00	5.88	6.25	9.38	15.63	19.44	9.68	12.90
Blue Collar Males	8.08	6.94	3.16	2.15	4.12	3.16	7.29	6.25
Blue Collar Females	14.29	10.87	6.90	10.71	8.06	9.52	13.56	8.62
White Collar Males	9.36	8.22	7.78	8.51	9.38	7.45	6.67	8.42
White Collar Females	12.99	8.47	2.78	7.89	4.11	5.33	5.41	6.58
Housewives	6.74	5.81	5.83	5.98	5.93	10.57	2.54	5.83

[a]Responses of "Extremely Likely" to use transit for the trip purpose indicated was interpreted as potential patronage.

[b]Cells with slashed lines indicate highest potential ridership for each column (i.e. trip purpose).

collar females evidenced the greatest propensity to attempt transit usage in the near future. These four destinations included work, church activities, school, and non-food shopping. Older persons showed the highest potential for bus patronage in the case of three destinations: medical/dental trips, visiting friends, and personal business/recreation. White collar males suggested more interest than other segments in bus patronage for grocery shopping; it is likely that they were considering the possibility of transit for spouses in regard to this destination.

For individuals in all six segments not currently using transit, off-peak ridership potential was evidenced. However, blue collar females and white collar females showed the greatest propensity to ride buses for work purposes.

FACTORS INFLUENCING POTENTIAL TRANSIT DEMAND: A BEHAVIORAL APPROACH

In contrast to the traditional estimation procedures for urban travel demand, the behavioral approach includes characteristics of individuals which aid in explaining the decision-making process behind a modal switch. In describing the propensity of current non-users to switch to buses for specific trip purposes it is important to determine why some individuals are more interested in attempting bus ridership than are others. The differences in this potential demand do not lie solely in segmenting the market by one or two critical factors, such as age or socioeconomic status.

As was undertaken in the case of current bus use, an attempt was made to isolate those factors most important in predicting a future switch to bus usage. The possible predictive factors remained identical to those used earlier for explaining (a) overall current ridership and (b) current level of use by trip purpose (the LOUP scale). These factors were:

- age of users
- sex of riders
- educational level of users
- distance from residence to nearest bus route (in blocks)
- auto availability
- persons per household relative to number of vehicles (autos/motorcycles) per household
- an evaluation scale of buses compared to autos on 12 different dimensions
- awareness of bus system's title
- existence of personal disability

To determine which of these nine indicators are most useful in predicting transit demand among current non-users, all nine factors were included in a maximum-R^2 regression. The attribute being predicted was potential or propensity of use for eight trip purposes, termed the POUP scale.[6]

The best model at the .01 significance level contained three variables that were the highest predictors of potential transit demand by trip purpose (refer to Table 15):

- The age of individuals
- The distance (in blocks) from place of residence to the nearest bus route, and
- An evaluation of buses relative to automobiles.

The two examples in Table 15 point to a different level of potential transit demand based on the average age of the non-user. Whereas older persons are heavy current users, younger adults on the average evidence more interest in future use across trip destinations.

Altering any of the three predictors of potential transit demand within a city changes the potential level of use that can be expected by city transportation planners. For instance, if the public is made more aware of bus services, in terms of modernity, convenience, simplicity, low cost, safety, and other features which increase overall evaluation of the bus system, the demand estimation will change.

Not only is the model useful for comparing cities, but also the equation aids in predicting transit demand in specific sectors of the city. Because of the pressures that exist to increase routes or to expand route coverage in particular areas, such estimation models can be of considerable help in accurately choosing these sites within a city from a demand model.

METHODS FOR ESTIMATING TRANSIT DEMAND BASED ON SURVEY DATA

A review of behavioral demand estimation models reveals the difficulty of depending on an individual's subjective assessment concerning how he or

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[6]This scale was formed by adding likelihood of future use for each trip purpose, with likelihood varying from "Extremely Likely" = 5; "Likely" = 4; "Neutral" = 3; "Not Very Likely" = 2; and "Extremely Unlikely" = 1. A range of 5 × 8 or 40, as the highest value, to 8, the lowest value, was possible.

Table 15. Characteristics of Individual Residents in Beaumont and Waco That Are the Most Significant Predictors of Potential Bus Ridership by Trip Purpose (POUP Scale)*

LEVEL OF POTENTIAL TRANSIT USE BY TRIP PURPOSE MODEL

POUP = 20.24375 + (-0.10694 X Evaluation of Buses/Autos) + (-0.83221 X Age of Individual)
+ (-0.02229 X Distance from Residence to Nearest Bus Route)

EXAMPLES FOR CITIES A AND B OF LEVEL OF POTENTIAL TRANSIT USE BY TRIP PURPOSE

CITY A

20.24375	+	(0.10694	X	15)	+	(-0.83221	X 2)
[Intercept]		[Coefficient for Evaluation of Buses/Autos]		(Average Evaluation for City A)		[Coefficient for Age of Individual]	(Average Age of Current Non-User in City A, where 1 = 18-24, 2 = 25-34, 3 = 35-44, 4 = 45-54, 5 = 55-64, 6 = 65+

+	(-0.02229	X	4)	=	17.0
	[Coefficient for Distance (in blocks) from Residence to Nearest Bus Route]		(Average Distance from Residence to Nearest Bus Route)		(POUP Scale or Potential of Use for Trip Purposes)

CITY B

20.24375 + (-0.10694 X 15) + (-0.83221 X 4) + (-0.02229 X 4) = 12.0

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*Brackets [ ] in examples of Cities A and B refer to constants in the equation and the values in parentheses ( ) will change from city to city. The potential for increasing bus ridership is higher in City A than City B, because of the difference in average age of the current non-user in the two cities. Six of the nine original variables were deleted as explanatory, since the purpose of the maximum-R^2 regression is to obtain the fewest number of explanatory variables. The three variables retained all had significance levels less than .01 The R^2 is low in this model at .09, so that a greater number of respondents in many cities is needed to further test the utility of the demand estimation variables.

she might behave in the near future. In marketing research efforts, the central issue seems to revolve around the question of "How likely are you to buy ________?" (Schwarz, 1972). Although the results of such studies may provide estimates that are inaccurate predictions of subsequent behavior, obtaining public opinion from representative population samples has become indispensible in determining future travel behavior and travel demand, including choice of transportation mode, choice of destinations, and even the decision to make a trip.

Given the inadequacies of dealing with subjective assessments of future transit demand, transportation planners nevertheless need to include survey data into estimation and forecasting procedures. Two methods for meeting this need are outlined in this section of the report:

I. Procedures for demand estimation from survey data based on the use of correction factors; and

II. Procedures for demand estimation from survey data based on statistical models (such as the maximum-R^2 regression procedure).

Methods for Estimating Transit Demand from Correction Factors Used on Survey Data

In using probabilities to estimate the potential demand for bus service, a correction factor may be applied to the responses of "definitely plan to use" or "absolutely will ride the bus for work trips." A second correction factor can be used for less definite, but still positive, responses such as "likely will consider riding the bus for non-food shopping if buses ran between shopping centers." These probabilities attached to a particular response can be obtained from follow-ups of actual behavior based on statements gleaned previously from a survey. Additionally, an experienced panel can provide various weights to responses obtained from a survey, with "Absolutely will ride the bus" given a weight of .90 and "Probably will ride the bus" weighted at .30. Further, inconsistencies provided from a respondent based on comparisons of two or more questions in the survey can provide a basis for the correction factors.

Once the weight for each stated response is determined, a possible next step is to ascertain the proportion of the population that the response represents. For instance, if 15 percent of one population segment, such as housewives, state that they would be extremely likely to at least attempt bus usage for non-food shopping, then the stated demand multiplied by the correction factor and that sum multiplied by the proportion of the total population represented by housewives (such as 17 percent) provides one estimate of transit demand.[7]

To provide a concrete example of this procedure, the stated potential bus use for the six population segments was examined (refer to Table 14 presented earlier). For the eight destinations provided, blue collar females in Waco and Beaumont evidenced the greatest potential transit demand for four out of the eight trip purposes.

In the case of blue collar females not currently riding the bus for work trips, the estimate of demand could be derived for the City of Waco as:

14.29 percent that are "extremely likely" to use buses × 0.7 weight (or correction factor) = 10.00 percent.

22.22 percent that are "likely" to attempt bus ridership × 0.3 weight (or correction factor) = 6.67 percent.

$\Sigma(10.00 + 6.67) = 16.67 \times 6.3$ percent of 6,300 blue collar females in Waco = 41.99 percent × 6,300 blue collar females in Waco = 2,645.37.

Based on the use of correction factors, the City of Waco has a high potential for attracting blue collar females for work trips, either on a regular or an occasional basis. As the buses in this city do not run at capacity loads in peak hours, attempting to increase bus patronage by blue collar females would be a lucrative marketing strategy.

The use of correction factors to derive estimates of demand is in early stages of application. The weights used for the City of Waco are hypothetical in that no known panel of experts has attempted to derive correction factors for predicting transit ridership from survey data. More important, transportation planners and transit managers are reluctant to fund follow-up studies from which accurate weights of subjective statements made in previous surveys can be ascertained, based on actual behavior following the survey. A final problem lies in the fact that those surveyed often become more interested in transit and actually give buses a "trial" ride, whereas the majority of the population not in the survey sample have not been subjected to this "consciousness raising" experience.

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[7]The population segments can also be summed, providing an overall estimate of latent demand.

Methods for Estimating Transit Demand from Statistical Models Based on Survey Data

Census information, and other sources of aggregated data on individuals, can provide a base for transit demand estimation and forecasts. However, these data sources evidence major weaknesses in having no transit evaluation items and often lack currency in terms of travel behavior and mode choice information. The maximum-R^2 regression procedures (a) for explaining overall bus patronage, (b) for explaining current bus use by trip purposes, and (c) for predicting potential transit demand by trip purposes (refer to Tables 11, 12, and 15) include personal characteristics, such as auto availability and age, as well as opinions regarding bus features.

Survey data can also be utilized for determining very specific information (similar to origin-destination surveys), such as

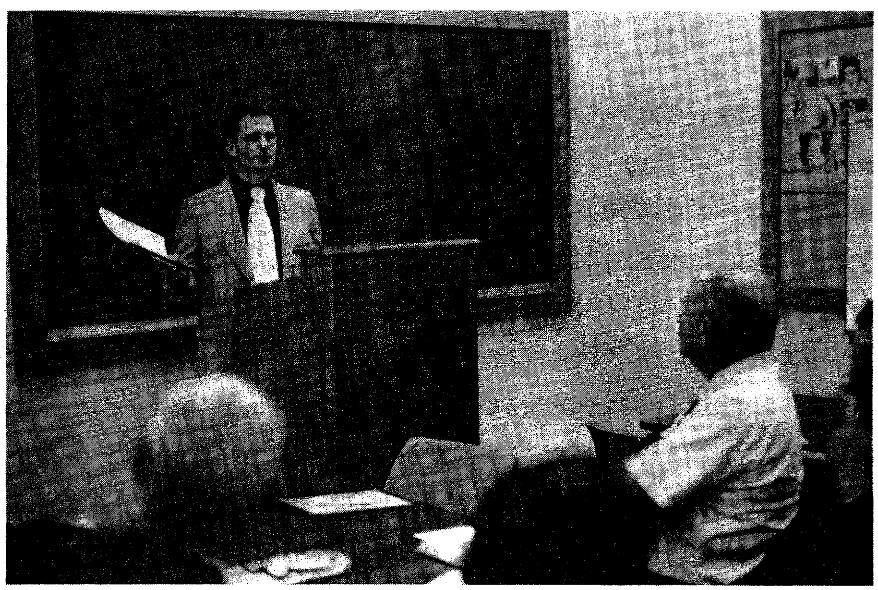
- frequencies of current bus use (daily, weekly and monthly)
- frequencies of current use by trip purpose
- times of bus usage on a daily coverage
- potential frequencies of ridership
- expected time periods of future use, and
- time span within which non-users expect first trial use.

Daily ridership levels on an individual basis can be obtained for population segments as the key to predicting future demand by specific markets.

Implications of Transit Demand Modeling Derived from Surveys

The weaknesses and strengths of behavioral demand models have been described. [For further assessment of behavioral demand models, refer to Stopher and Meyburg (1976), Dunbar (1976), or Hartgen (1976)]. Those who presently utilize buses as a transportation mode, as well as residents willing to switch modal choices for some trip purposes are expecting a set of service requirements from the bus system. If this bundle of critical requirements sought from current non-users is not met, the bus will be given at best only one trial. Adoption of buses as a transportation mode is based on an ability to successfully compete with privately operated vehicles. Thus, the overall effect of inclusion of behavioral factors in demand modeling rests on the implementation of feasible service improvements sought by key market segments.

The projections of Texas transit leadership regarding anticipated ridership levels were optimistic. Transit managers, however, forecast significantly greater 1980 and ten-year patronage increases than did city officials.



CHAPTER III

FORECASTS OF TEXAS TRANSIT DEMAND: THE VIEWPOINT OF TEXAS TRANSIT LEADERS

In June, 1976, the transit managers and one city official in the eighteen Texas cities having transit systems were mailed a questionnaire. The primary purpose of the survey was to determine two cities that were representative of the state in terms of transit service levels. Additionally, the willingness of the city representatives to have a transit marketing survey undertaken in their respective localities and to utilize the results of the survey was ascertained. In addition to these objectives, forecasts were obtained from the city representatives regarding expected changes in transit ridership and operations.[8]

PROJECTED RIDERSHIP INCREASES OVER THE NEXT DECADE

Of the 26 Texas transit leaders that responded to the survey, the majority agreed that urban trips by transit would continue to increase. As shown in Table 16, 61.5 percent of the city representatives projected a 5 to 15 percent increase in urban trips served by transit over a ten year period.[9]

It is interesting to note in Table 17 that transit managers--those most closely involved in assessing current bus ridership--are significantly more optimistic in their projections than are city officials. Forty percent of the transit managers forecast a 16 to 50 percent increase in patronage within the decade, while none of the city officials projected more than a 15 percent ridership increase.

Overall, the projections are highly feasible, in that Texas bus ridership in 1975 increased 3.3 percent over 1974 ridership levels. Clearly, a portion of this growth can be attributed to such factors as rising automobile costs,

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[8]For a full analysis of the findings of this survey, contact the authors or the Texas State Department of Highways and Public Transportation.

[9]Public and mass transit currently serves approximately three percent of all urban trips in Texas.

Table 16. Portion of Urban Trips to be Served by Transit in Ten Years, Projected by Texas Transit Leaders in June, 1976

Expected Percent of Urban Trips	Number	Percent
Less than 5 percent	4	15.5
5 - 15 percent	16	61.5
16 - 25 percent	3	11.5
26 - 50 percent	3	11.5
	26	100.0

Table 17. Projected Portion of Urban Trips to be Served by Transit in Ten Years, by Texas Transit Managers and City Officials in June, 1976

Percent of Urban Trips	Leaders	
	Transit Managers (n = 18)	City Officials (n = 11)
Less than 5 percent	13.3	18.2
5 - 15 percent	46.7	81.8
16 - 25 percent	20.0	--
26 - 50 percent	20.0	--

fuel shortages, and a growing concern for environmental quality. However, the increase in ridership levels also is due to the service improvements and marketing efforts of transit management and city officials who are becoming more aware of the importance of effective marketing techniques in the delivery of public and mass transportation services in Texas. As was determined from the mail-out survey, older fleets are receiving new vehicles, and three transit systems in Texas now offer instruction to their employees on more pleasing customer relations. Park-n-Ride express bus service is available in major Texas cities to serve the needs of middle- and upper-income customers. Additionally, several cities have completed or are currently undertaking marketing surveys to identify demand potential and benefits sought by various segments of the transit market.

PROJECTED RIDERSHIP CHANGES IN 1980

Table 18 points to the expected changes in transit patronage suggested by the 26 Texas transit representatives. By 1980, 73.1 percent forecast an increase of 10 percent in the total number of passengers riding buses. Additionally, 60 percent expected that patronage among upper income individuals would remain within 10 percent of current levels, with 69 percent of the transit leaders suggesting that the middle income segment would increase ridership by at least 10 percent by 1980.

Table 18. Expected Changes in Transit Ridership for 1980 by Texas Transit Leaders (n = 26) in June, 1976 (in percentages)

Passenger Characteristics	Increase by 10%	Remain Within 10% of Current Levels	Decrease by 10%
Passengers (total)	<u>73.1</u>	26.9	--
Lower income segment	46.2	<u>53.8</u>	--
Middle income segment	<u>69.2</u>	30.8	--
Upper income segment	32.0	<u>60.0</u>	8.0

In comparing the responses of transit managers to those of city officials, it was determined that those involved in the daily transit operations were more optimistic about ridership increases than were the city officials. As portrayed in Table 19, a higher proportion of transit managers projected an increase of at least 10 percent in overall passengers <u>by 1980</u>. Additionally, more transit managers than city officials expected at least a 10 percent increase in ridership for the middle-income segment, upper-income residents, and the lower-income segment.

Table 19. Percent of Texas Transit Managers and City Officials Projecting Changes in Transit Ridership in June, 1976 for the Year 1980

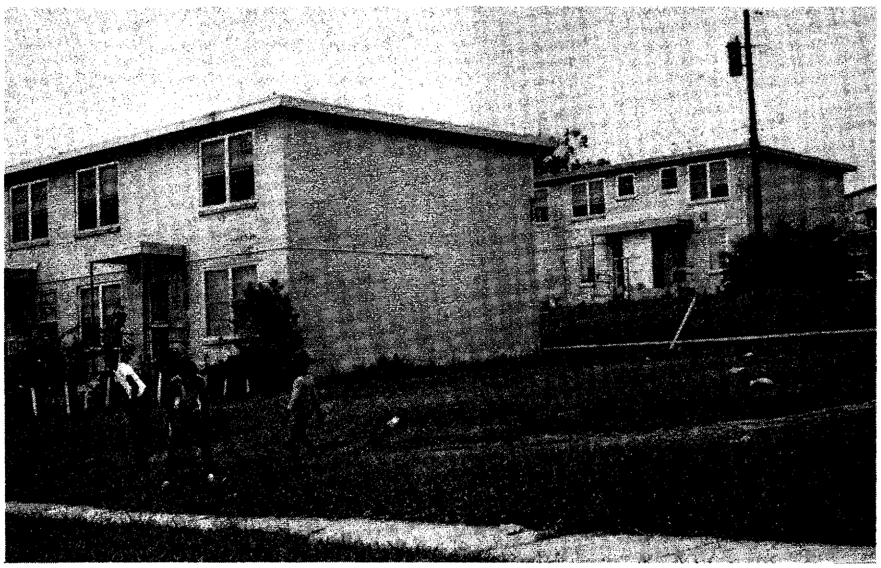
	Leaders			
	Transit Managers (n = 15)		City Officials (n = 11)	
Passenger Characteristics	Increase 10%	Remain within 10% of Current Levels	Increase 10%	Remain within 10% of Current Levels
Passengers (total)	80.0	20.0	63.6	36.4
Lower income segment	46.7	53.3	45.5	54.5
Middle income segment	72.3	26.7	63.6	36.4
Upper income segment	33.3	46.7	27.3	72.7

SYNOPSIS OF TEXAS TRANSIT LEADERS' FORECASTS

On the whole, the findings which emerged from the survey of Texas transit representatives were optimistic in regard to increased ridership levels. Clearly, most city representatives were encouraged about the potential for transit expansion in the near future. Transit managers forecast significantly greater 1980 and ten-year (1986) ridership levels than did city officials, however.

Of particular interest is the finding that the majority of transit leaders projected increases in the number of middle-income riders, while they were, generally, less certain about the other two socioeconomic segments. Thus, most transit leaders feel that middle-income individuals, as a rider segment, have the greatest potential for a modal switch.

Transit system characterisitcs, such as peak and off-peak headways, show a strong linkage with the demand for mass transportation in cities throughout the country.



Population density was shown to be an important predictor of transit demand. A density level of at least 4,000 persons per square mile appeared to provide a "tipping point" beyond which dependency on transit increased significantly.

Levels of ridership (that is, average daily passengers, percent of the city's population using transit) increase after more than 80 percent of the population is served by at least one route within a quarter of a mile from their residences.

CHAPTER IV

TRANSIT SYSTEM AND POPULATION CHARACTERISTICS THAT INFLUENCE THE DEMAND FOR TRANSIT: A NATIONWIDE PERSPECTIVE

In the mid-1970s, cities throughout the United States, both large and small, have been improving transit service. The huge investments in individual cities call for a means (1) of determining transit demand based on varying service improvements and (2) for providing a transit system that benefits the public generally and increases ridership for targeted population segments.

This chapter is devoted to an analysis of differential transit demand in 32 cities. The data were obtained from a mail-out questionnaire to 41 cities concerning service development, market segmentation, promotional strategies, customer relations, transit system characteristics, and operating efficiency. Responses were obtained from 32 marketing directors or other individuals in transit management positions between November, 1976 and March, 1977. Table 20 portrays the 32 cities and transit systems from which detailed information was obtained.

PREDICTING DEMAND FROM TRANSIT SERVICE AND POPULATION CHARACTERISTICS

The need for and use of transit is viewed in this chapter as varying according to (a) level of service and (b) city population characteristics. "Demand" is seen in this perspective as measurable by:

- Average daily passengers per weekday
- Percent of the total population in the service area using transit, and
- Percent of total urban trips made by transit

LEVEL OF SERVICE CHARACTERISTICS

Level of service characteristics for different transit systems are difficult to obtain for comparative purposes. The American Public Transit Association, as well as many other concerned organizations and individuals, have been encouraging the development of standardized measures to depict system characteristics such as operating efficiency and service measures. For

Table 20. Cities and Transit Systems Sampled in the Nationwide Survey*
(n = 32)

Code	City	System
A	Minneapolis/St. Paul, MN	Metropolitan Transit Commission
B	Cleveland, OH	Greater Cleveland Regional Transit Authority
C	St. Petersburg, FL	St. Petersburg Municipal Transit
D	Montgomery, AL	Montgomery Area Transit System
E	Wichita, KS	Wichita Metropolitan Transit Authority
F	Atlanta, GA	Metropolitan Atlanta Rapid Transit Authority
G	Jacksonville, FL	Jacksonville Transportation Authority
H	Eugene, OR	Lane Transit District
I	Sacramento, CA	Sacramento Regional Transit District
J	Ft. Wayne, IN	Ft. Wayne Public Transportation Corporation
K	Omaha, NB	Omaha Metro Area Transit
L	Los Angeles, CA	Southern California Rapid Transit Authority
M	Ft. Worth, TX	Citran
N	Birmingham, AL	Birmingham-Jefferson County Transit Authority
O	Kansas City, MO	Kansas City Area Transportation Authority
P	Harrisburg, PA	Capitol Area Transit
Q	San Antonio, TX	San Antonio Transit
R	Houston, TX	HouTran
S	Waco, TX	Waco Transit System
T	Beaumont, TX	Beaumont Municipal Transit
U	Youngstown, OH	Western Reserve Transit Authority
V	Akron, OH	Metro Regional Transit Authority
W	Milwaukee, WI	Milwaukee County Transit System
X	Nashville, TN	Metropolitan Transit Authority
Y	Portland, OR	Portland Tri-Met
Z	Charlotte, NC	Duke Power Company
AA	Tulsa, OK	Metropolitan Tulsa Transit Authority
BB	Washington, DC	Washington Metropolitan Area Transit Authority
CC	Louisville, KY	Transit Authority of River City
DD	Duluth, MN	Duluth Transit Authority
EE	Madison, WI	Madison Metro
FF	Austin, TX	Austin Transit

*These cities may not be equivalent to the total service area for the transit system.

example, "average length or time span of daily service" may or may not include "dead head" time, weekend service, and the wide variance among transit routes. "Vehicle miles" may or may not be equivalent to revenue miles of vehicles; further, this concept often includes charter bus miles rather than simply regular service mileage. With these definitional problems under consideration, three primary indicators will be discussed from the nationwide transit survey:

- Headways, peak and off-peak
- Percent of population within one-fourth mile of transit route, and
- Time span of service on weekdays.

POPULATION CHARACTERISTICS

Two city characteristics were considered as primary indicators of demand for transit service:

- Population size of primary city served, and
- Population density of primary city served.

The level of service characteristics and population characteristics were examined for predictiveness of overall demand.

MARKET SEGMENTATION AND DEMAND

Additionally, service levels were utilized to explain differential demand by market segments. In the case of the nationwide transit system survey, these segments were:

1. Persons 60+ years of age
2. Persons with less than $5,000 annual income
3. White collar workers
4. Blue collar workers
5. The young (ages 6 to 16), and
6. Housewives.

As may be observed, these six segments are not mutually exclusive. Thus, persons 60+ could also have less than $5,000 annual income and be housewives or in the work force. The goal in using these categories was to obtain information about these six predominant segments, with some overlapping anticipated. Overall, the average percentage of ridership for each segment was determined (see Table 21). As shown in this table, the percentages do not sum to 100.0, inferring that there is overlap among the segments at an individual level.

Table 21. Percent of Each Population Segment
As a Proportion of the Total Ridership
for Transit Systems Nationwide
(n = 32 systems)

Population Segment	Mean Percentage	Standard Deviation
Persons 60+	13.79	6.11
Persons with < $5,000 income	42.61	20.17
White collar workers	23.22	9.94
Blue collar workers	27.87	19.80
The young (6 to 16)	15.59	15.41
Housewives	15.40	12.53

THE DEMAND FOR TRANSIT BY LEVEL OF SERVICE PROVIDED

On the pages that follow are several graphs dealing with the current bus ridership as related to level of service. These graphs present comparisons of only two indicators at a time, and are provided as measures of associations of the demand for transit based on the level of service provided.

Demand and Headway Frequency

Figures 2 and 3 portray peak and off-peak headways (in minutes) and demonstrate the close association between daily ridership and service frequency. Headways are a function of transit travel demand; likewise, potential demand is dependent on service frequency. The average peak headway for the 32 systems was 21.39 minutes and for off-peak periods was 40.64 minutes. Peak headways ranged from 6 to 60 minutes, while off-peak headway frequency varied from 15 to 60 minutes based on the nationwide sample.

Note: In Figures 2-19, the lines on each graph are plotted by arbitrarily aggregating transit systems into two or three categories, and obtaining an average for each category. For example, in Figure 2, peak headways are grouped into 10, 20, and 30 minute categories.

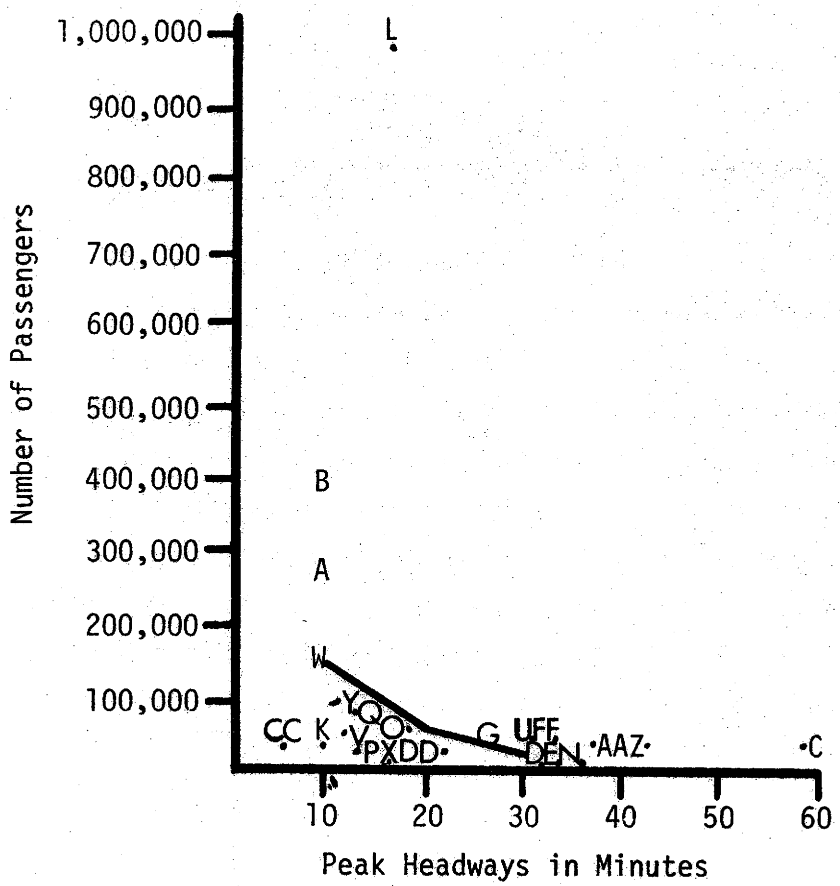


Figure 2. Daily Passengers and Headways (Peak)

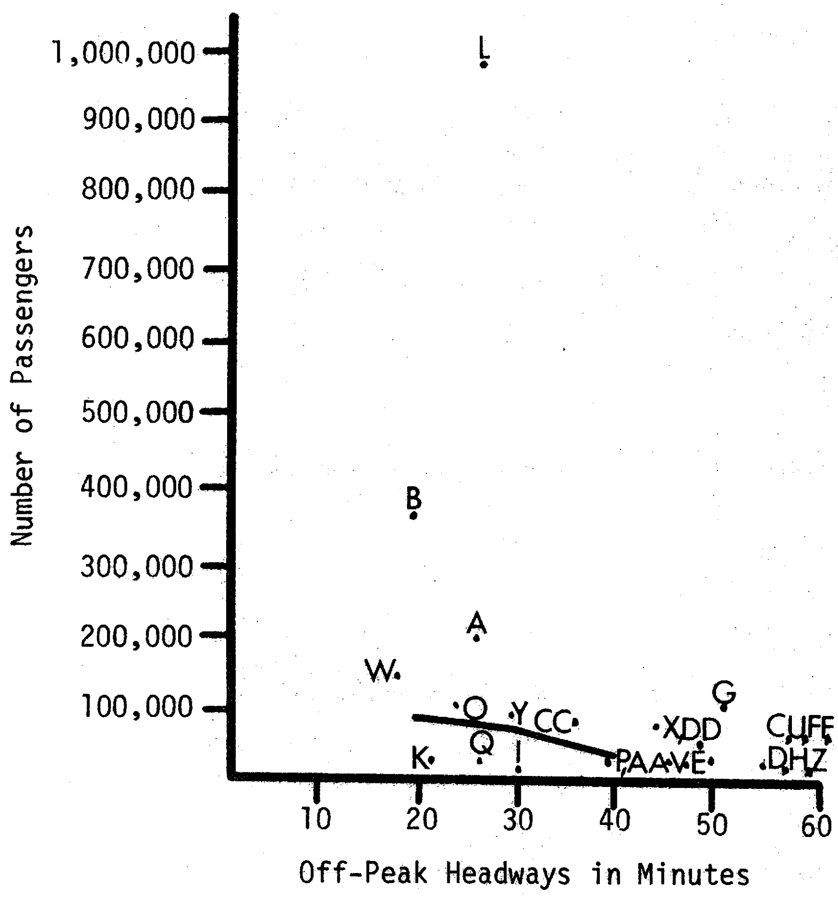


Figure 3. Daily Passengers and Headways (Off-Peak)

Demand Based on Proportion of Population Within One-Fourth Mile of a Route

While the data are incomplete for the 32 transit systems, Figures 4, 5, and 6 depict the percentage of the service area population within one-fourth mile of a transit route and the relationship of this level of service measure to demand indicators. As can be observed in all three figures, levels of ridership (measured by daily passengers, percent of the population using transit, and percent of urban trips by transit) increase after more than 80 percent of the population is served by at least one route within a quarter of a mile. Below 80 percent route coverage, the rates of ridership also are higher than might be anticipated, evidently based on the captive patrons who must use whatever facilities are available. The average coverage level was 77.48 percent of the total population served, but varied from 40.0 to 95.0.

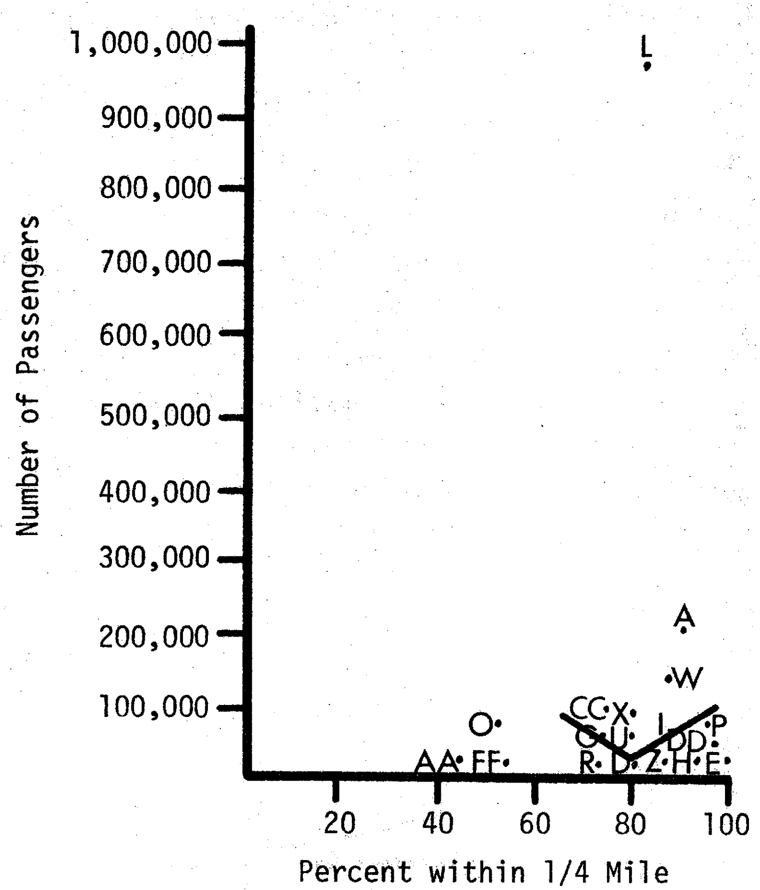


Figure 4. Daily Passengers and Percentage of the Population within One-Fourth Mile of a Transit Route

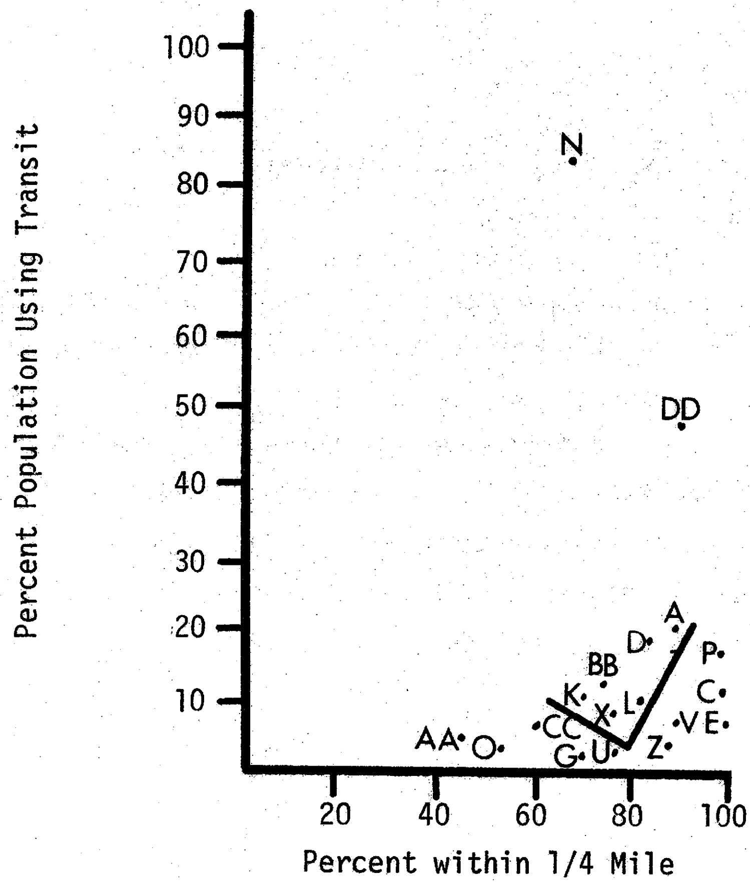


Figure 5. Percent of the Total Population Using Transit and Percentage of the Population within One-Fourth Mile of a Transit Route

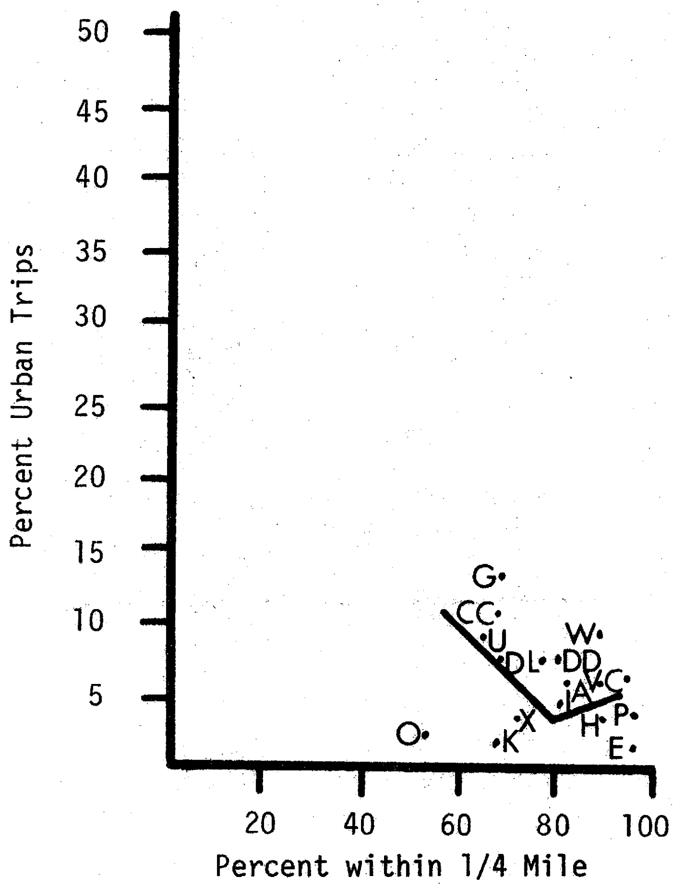


Figure 6. Percent of Urban Trips by Transit and Percentage of the Population Within One-Fourth Mile of a Transit Route

Demand and Daily Time Span of Service

As with the route coverage indicator of service level, weekday service span shows a marked patronage increase past 15 hours of daily service, but dips around 15 hours and is higher for the 12-hour time span (as shown in Figure 7). Again, the 10- to 14-hour coverage exemplifies a minimum level of service, so that captive riders are utilizing the system during daylight hours. The percent of the population using mass transportation for varied trip purposes, other than necessary destinations such as work, is likely to be very dependent on time span of service.

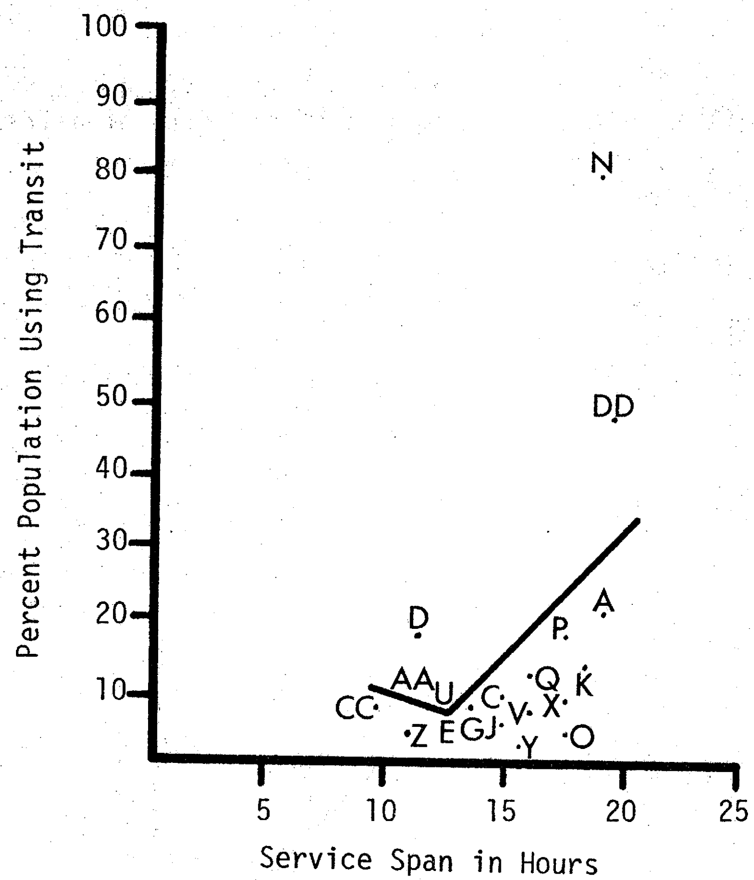


Figure 7. Percent of the Total Population Using Transit and Weekday Time Span of Service

RIDERSHIP AMONG MARKET SEGMENTS BASED ON LEVEL OF SERVICE INDICATORS

The proportion of total ridership that each population segment comprises varies by such transit service characteristics as headway frequency, time span of coverage and distance to nearest transit route. For example, the percent of white collar workers comprising the total daily ridership can be expected to be lower in cities with minimum service levels than in cities with very convenient, accessible systems. On the other hand, the percent of passengers that are blue collar workers should be a higher proportion of the ridership in cities with minimum service levels.

Older Persons As Percent of Total Ridership

To point out the relationship between proportions of each segment as a percent of the total ridership, only headway frequencies (peak and off-peak) will be utilized as the level of service indicators. Figures 8-A and 8-B depict older persons as consistent users of transit, independent of headways.

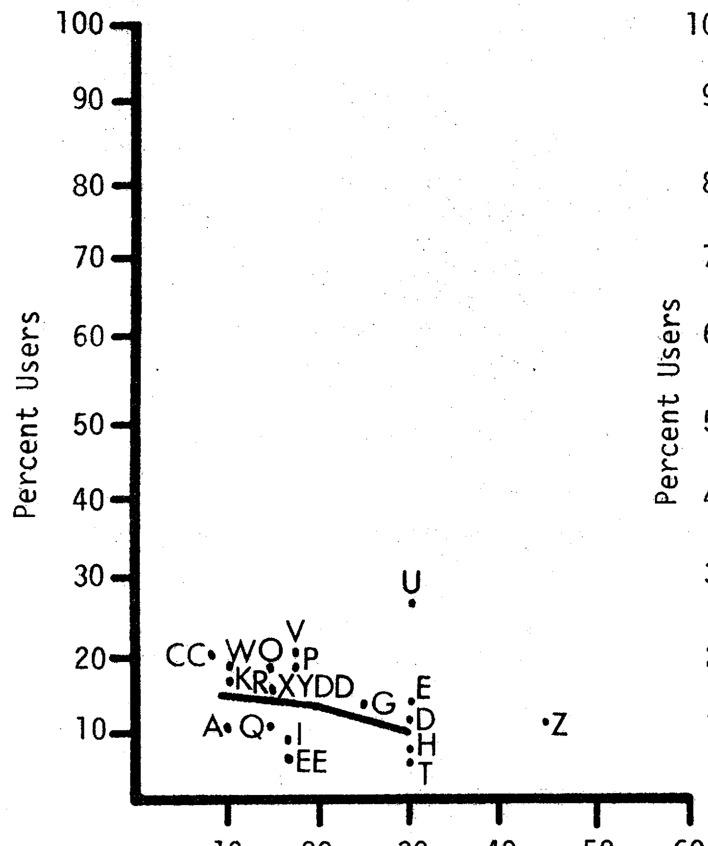


Figure 8-A. 60+ Users vs. Peak Headways (MIN)

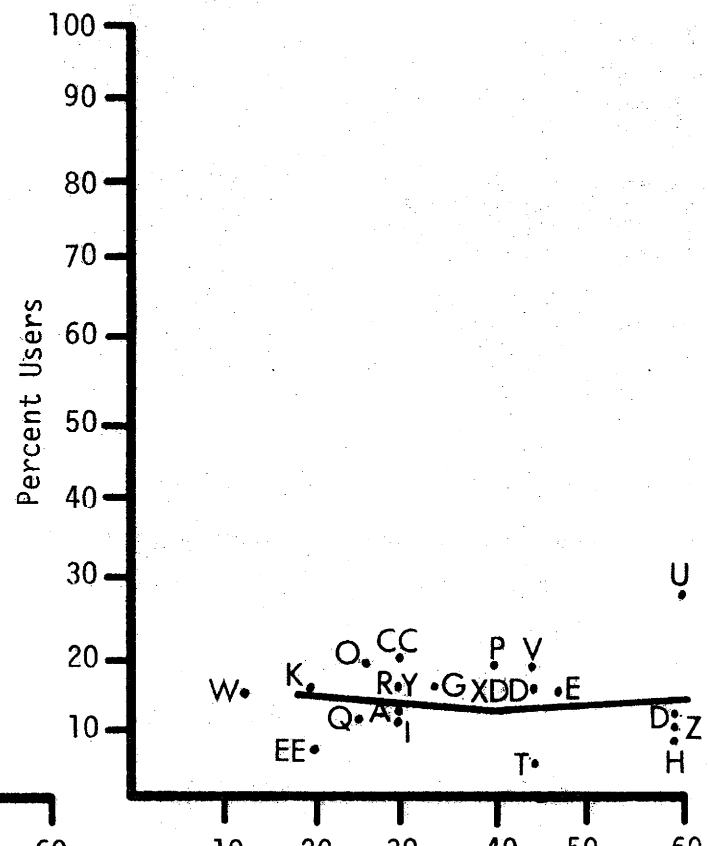


Figure 8-B. 60+ Users vs. Off-Peak Headways (MIN)

Convenience factors, such as service frequency, are of importance to the elderly. However, the proportion dependent on transit appears to remain stable regardless of such critical service features as minimum headways.

Persons with Incomes Under $5,000 As Percent of Total Ridership

As is depicted in Figures 9-A and 9-B, the poor increase as a proportion of the total ridership when service levels decline. This population segment has traditionally been considered the "captive" ridership, so that amenities and convenience factors play only a small part in their decision to ride transit. This transportation mode is utilized because no other viable alternatives are available.

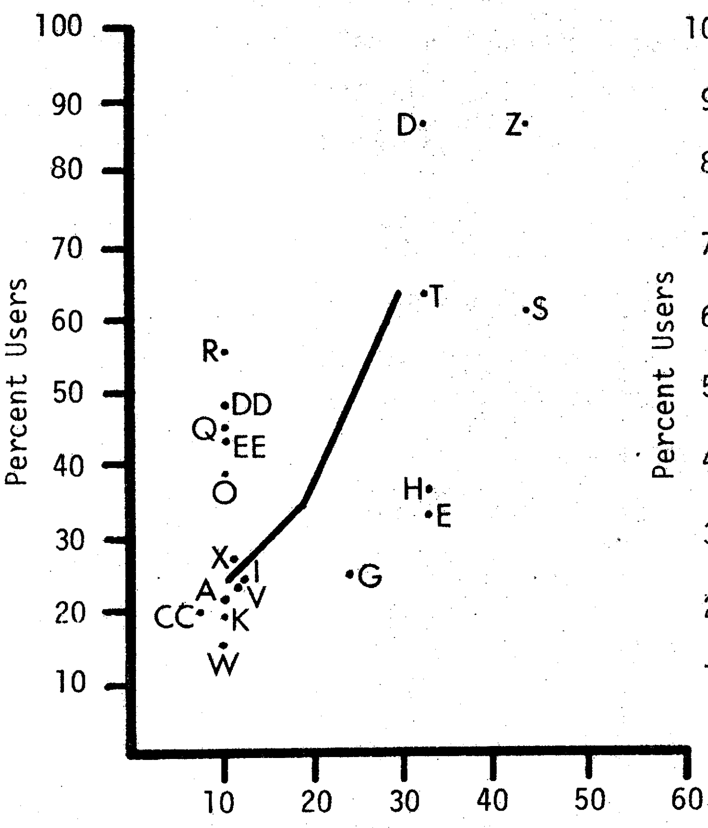


Figure 9-A. < $5000 Income Users vs. Peak Headways (MIN)

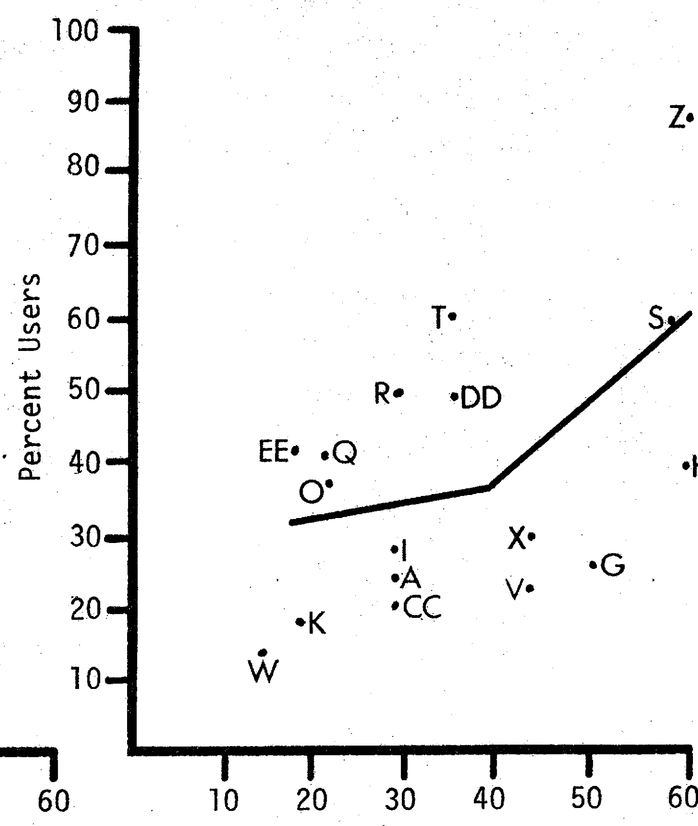


Figure 9-B. < $5000 Income Users vs. Off-Peak Headways (MIN)

Blue Collar Workers As Percent of Total Ridership

Blue collar males and females--those individuals who are service workers, craftsmen, operatives, and laborers--evidence a pattern of transit use similar to those with less than $5,000 income. As might be expected, these two segments overlap to some extent. However, many blue collar occupations provide median incomes equivalent to white collar positions. As noted in Figures 10-A and 10-B, blue collar users increase as a proportion of the total ridership when peak headways increase to greater than 20 minutes and when off-peak headways are more prolonged than 40 minutes. Again, blue collar workers can be viewed as a captive rider segment in many cases, so that, like the poor, these individuals become transit dependents with no alternative transportation modes.

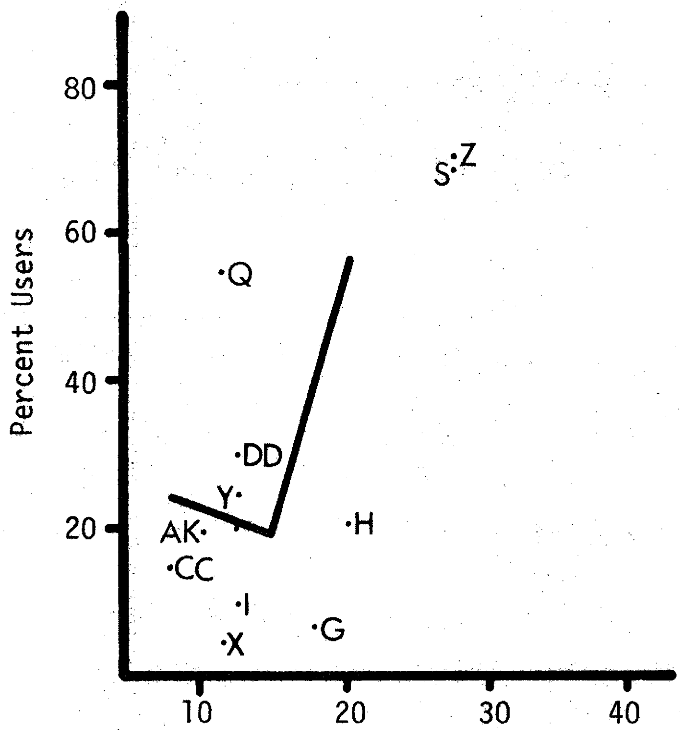


Figure 10-A. Blue Collar Users vs. Peak Headways (MIN)

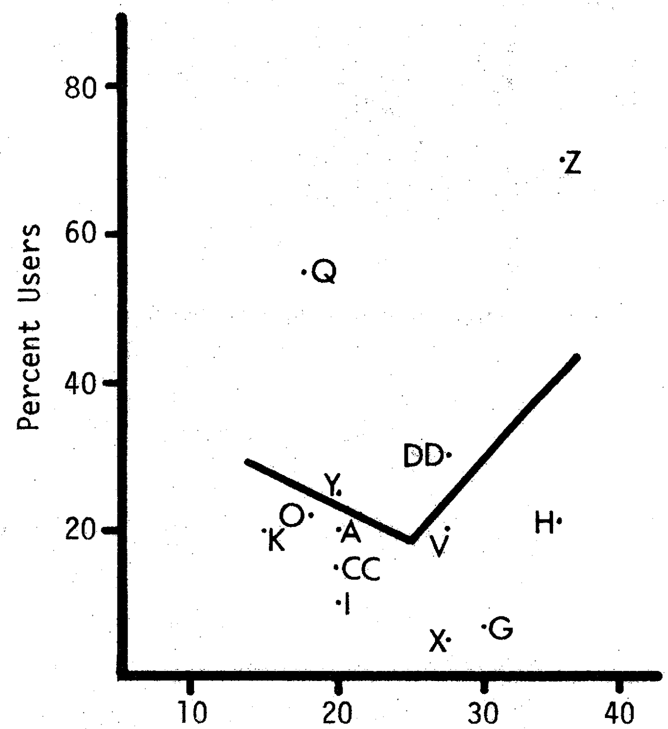


Figure 10-B. Blue Collar Users vs. Off-Peak Headways (MIN)

White Collar Workers As Percent of Total Ridership

Individuals in white collar positions--professional, managerial, clerical and sales occupations--appear more responsive to shorter headways, as shown in Figures 11-A and 11-B. Highest use is evidenced at 20 minute peak headways and at 40 minute off-peak headways; thus, the relationship between demand and high service levels is not linear. Nevertheless, ridership among white collar workers declines as service frequency diminishes. This segment normally has a modal choice, so that convenience and speed of public transportation largely determine degree of usage.

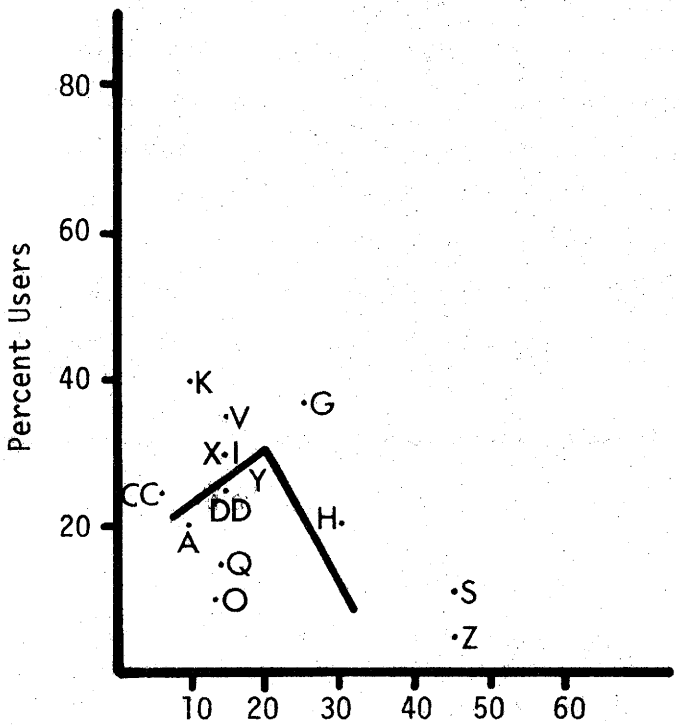


Figure 11-A. White Collar Users vs. Peak Headways (MIN)

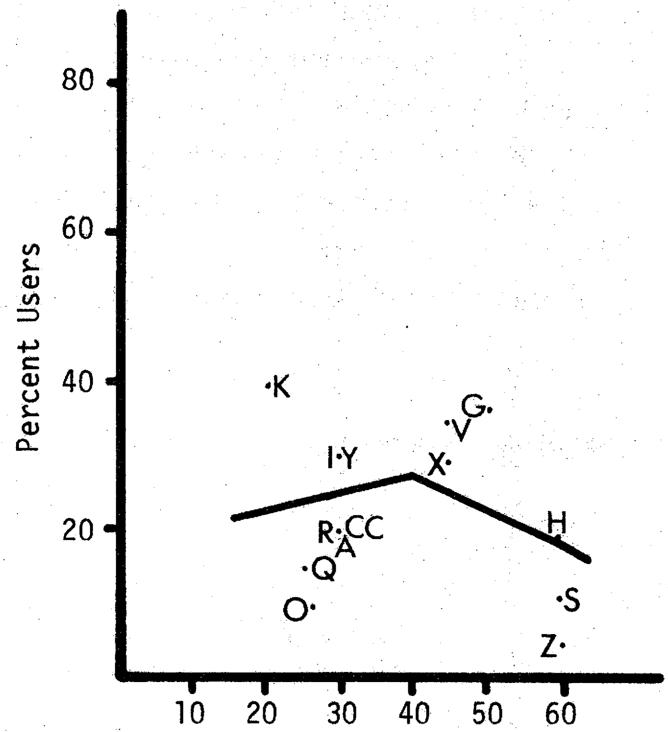


Figure 11-B. White Collar Users vs. Off-Peak Headways (MIN)

Young Persons (6-16) As Percent of Total Ridership

It has been found (Schaffer and Sclar, 1975) that younger people are often highly dependent on transit for non-school trips. Further, a great potential exists for attracting this segment to public transportation in lieu of carpooling and "toting" by parents. As shown by the sample of transit systems surveyed, young users decline as a percent of total passengers when off-peak headways increase, but rise with decreased service in terms of peak-period users (Figures 12-A and 12-B). It may be speculated that peak trips are school-related trips where time factors are an important requirement of usage. For non-school related activities, during off-peak periods, headways do not appear to be a critical consideration.

Housewives As Percent of Total Ridership

Of the six segments discussed, housewives appear more sensitive to decreased headways than any other population grouping. Many housewives have modal alternatives, other than transit, and can postpone most trips until a family vehicle is available. In this sense, transit service convenience becomes a crucial requisite for utilization. Figures 13-A and 13-B graphically portray the significant increase in housewives as a proportion of total daily ridership when headways are shortened.

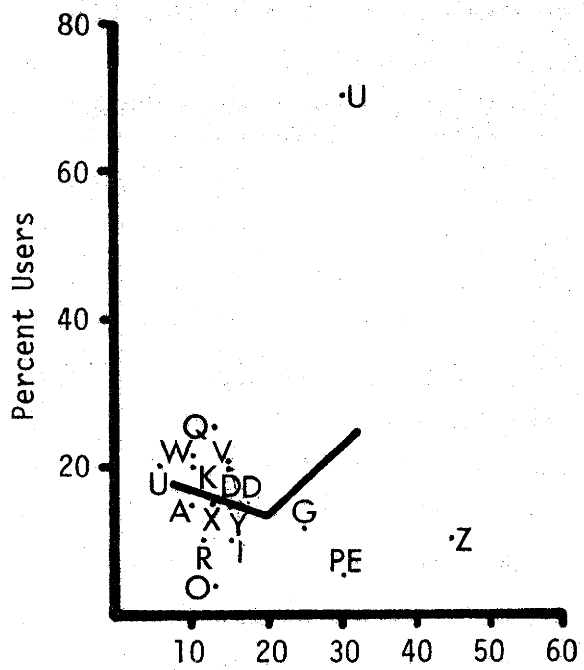


Figure 12-A. Young Users vs. Peak Headways (MIN)

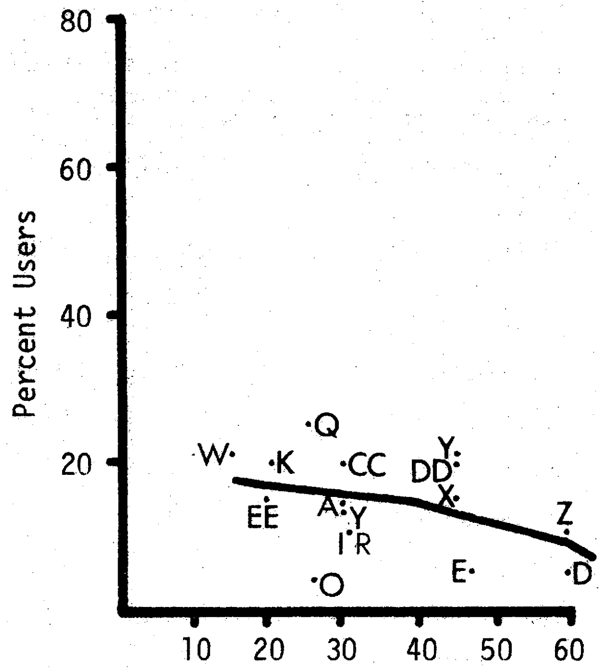


Figure 12-B. Young Users vs. Off-Peak Headways (MIN)

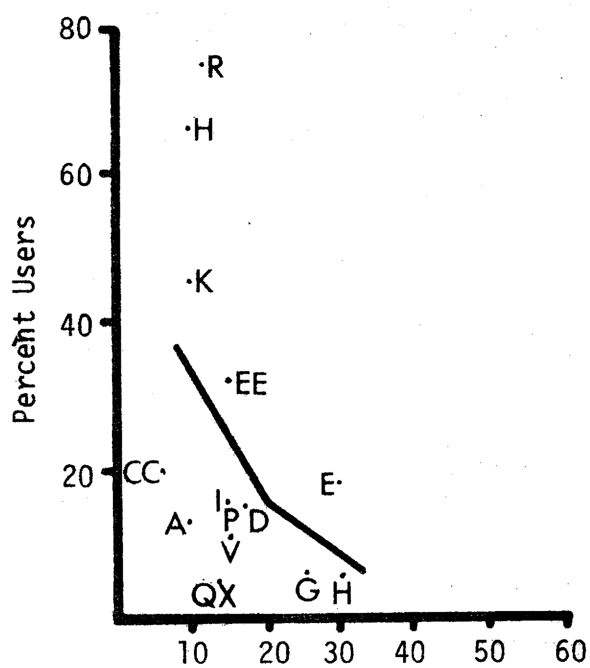


Figure 13-A. Housewife Users vs. Peak Headways (MIN)

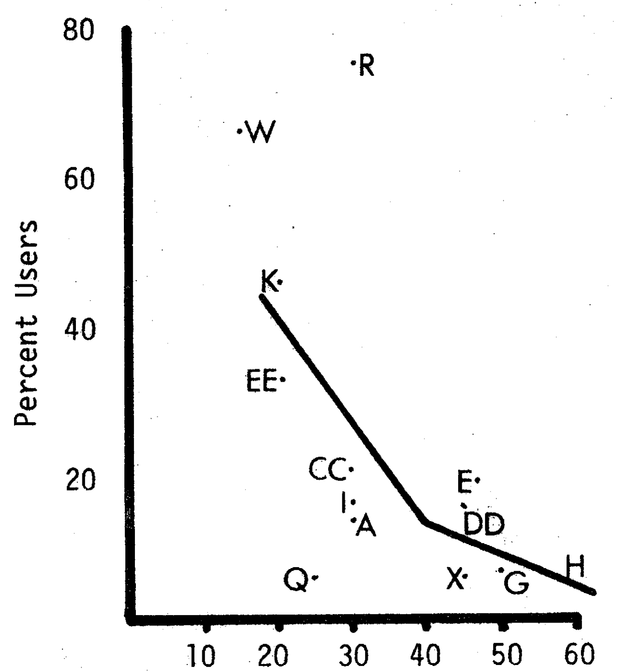


Figure 13-B. Housewife Users vs. Off-Peak Headways (MIN)

THE DEMAND FOR TRANSIT BASED ON POPULATION CHARACTERISTICS

Population size and density of the predominant city representing each transit system were utilized to explain the varying demand for transit. These two characteristics explain ridership levels in a manner that often is unrelated to level of service measures.

Current Demand Based on Population Size

City population size has been evidenced to have a positive effect on passengers per vehicle mile, as shown in the Texas Transit Development Plan, 1975-1990 (1974). When population size increases, so do the problems of automobile dependency, such as coping with peak-hour congestion and with accessing necessary shopping facilities and services conveniently by car. It is interesting to note in Figures 14, 15, and 16 that population size alone does not aid in explaining daily transit ridership. Based on the small sample of systems used to obtain ridership data, daily passengers and percent of urban trips made by transit do not vary significantly by population size. Further, the percentage of total population using transit has a slightly negative relationship to population size.

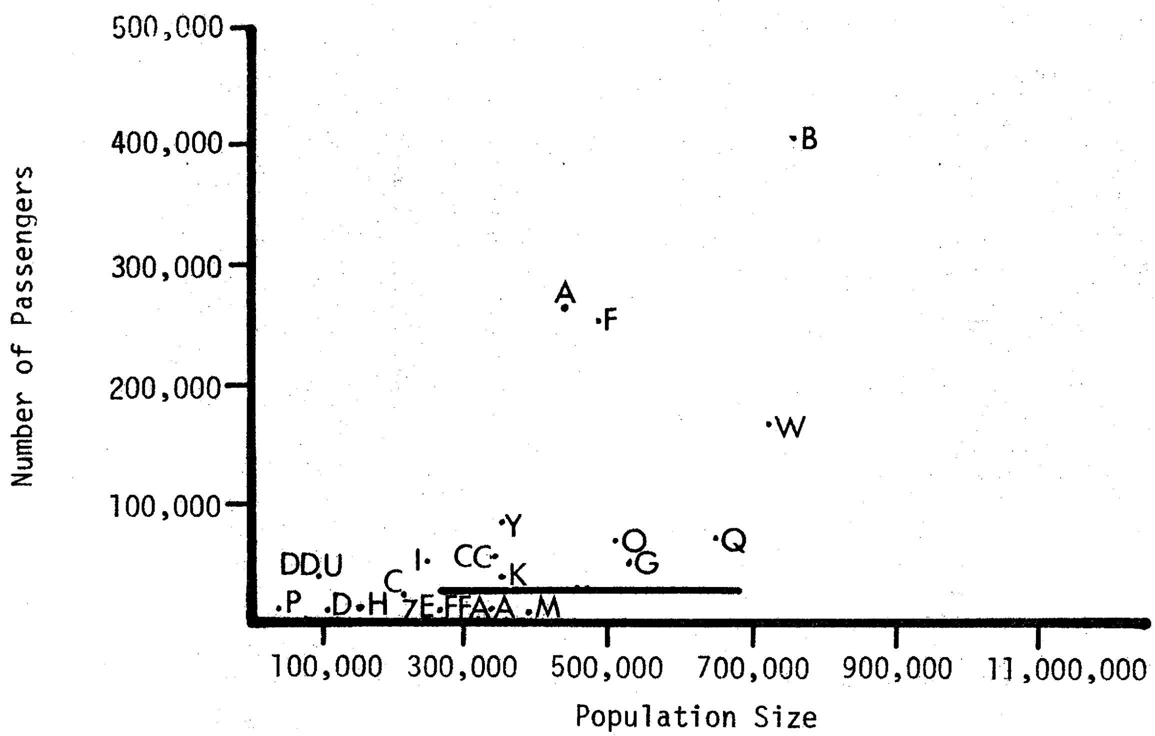


Figure 14. Daily Passengers and Population Size

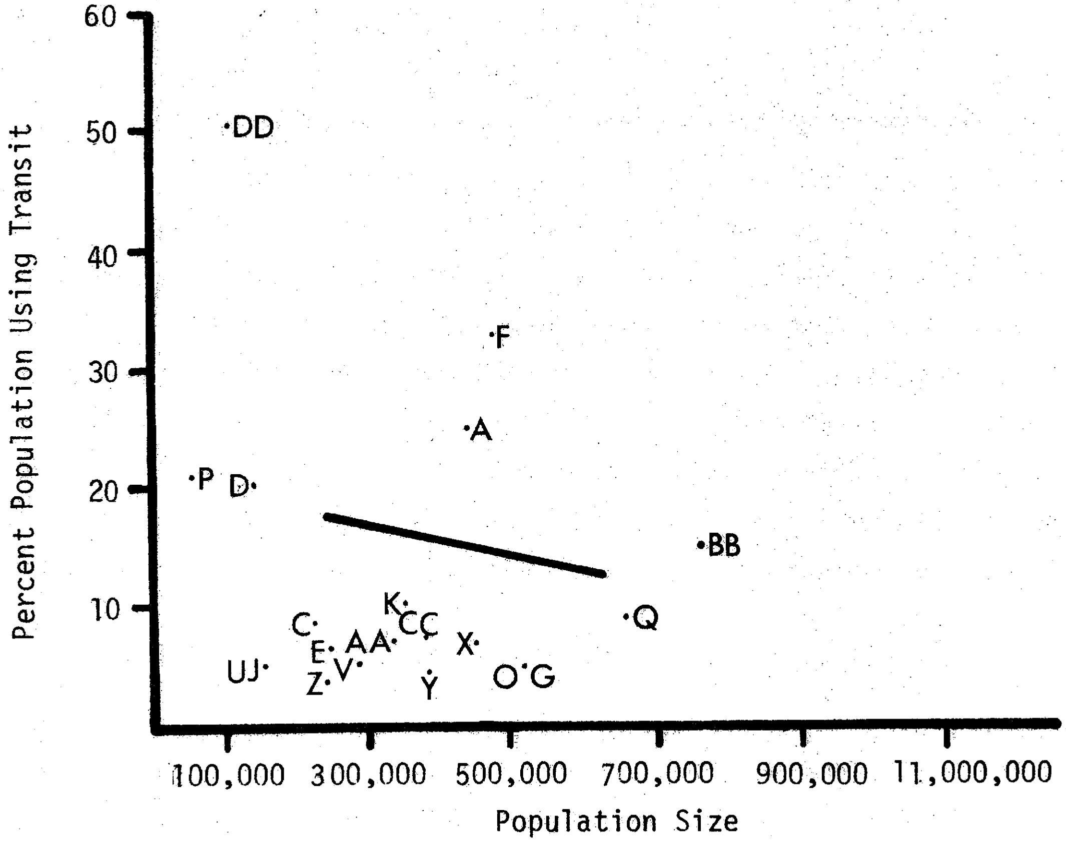


Figure 15. Percent of Total Population Using Transit and Population Size

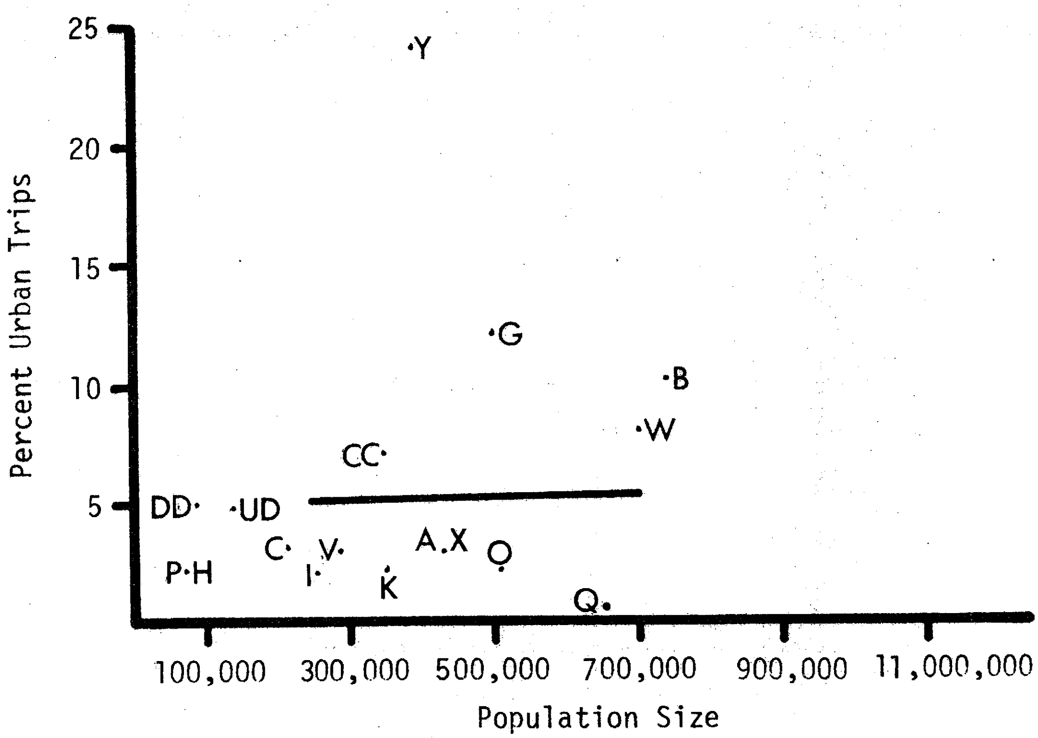


Figure 16. Percent of Urban Trips by Transit and Population Size

Current Demand Based on Population Density

While having some relationship to population size, density levels have been purported as the single most important city characteristic explaining the demand for transit (see Regional Plan Association, 1976). However, density levels within urban areas have been continually declining for almost 100 years (Gist and Fava, 1974). More dense urban development, nevertheless, both stimulates the use of transit and discourages the use of the automobile. Average relationships between residential density and transit use have been sumarized by the Regional Plan Association (1976:6) as follows:

- At densities between 1 and 7 dwellings per acre, transit use is minimal.
- Seven dwellings per acre is a threshold above which transit use increases sharply.
- At densities above 60 household units per acre, more than half the trips are made by public transportation.

As can be noted in Figure 17, daily passengers increase rapidly as density levels pass 4,000 persons per square mile. The percent of urban trips served by transit also is shown to be at least five percent when people per square mile is greater than 4,000 (Figure 18). However, in examining percent of the total city population using transit, the proportion served by public

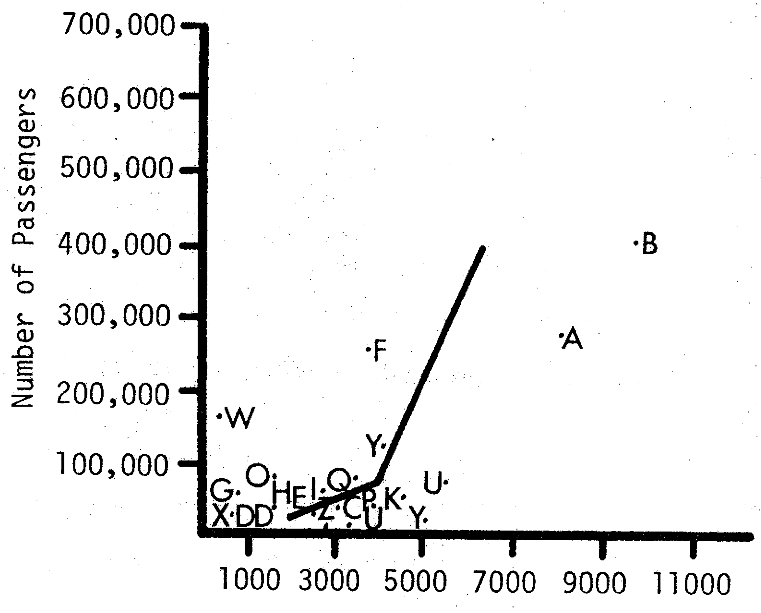


Figure 17. Daily Passengers and Population Density per Square Mile

transportation decreases somewhat after density levels approach 4,000 persons within a square mile (Figure 19). Though the small sample size produces inconclusive evidence, higher density levels do appear to support a heavier dependency on transit service.

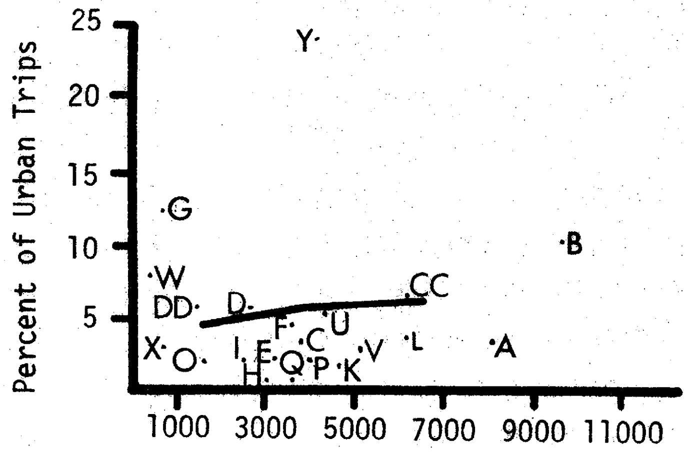


Figure 18. Percent of Urban Trips by Transit and Population Density per Square Mile

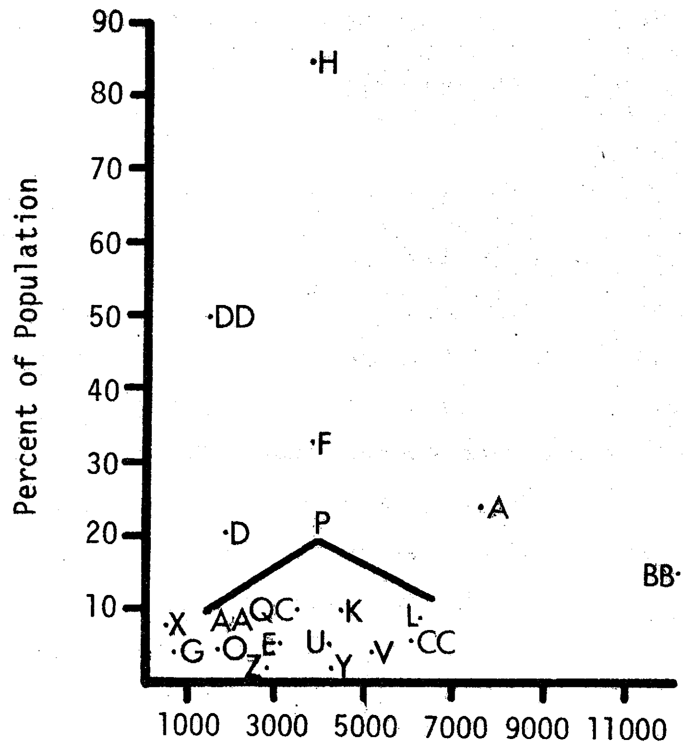


Figure 19. Percent of Total Population Using Transit and Population Density per Square Mile

METHODS FOR FORECASTING TRANSIT DEMAND BY SERVICE LEVELS AND POPULATION CHARACTERISTICS

Transit demand modeling based on existing service and population characteristics is responsive to accurate prediction of ridership. Unlike behavioral demand models, which assay individual ridership and potential use, models based on service and population criteria can predict demand within smaller error ranges. A primary reason for this accuracy lies in the fact that demand (as portrayed by daily passengers, for instance) is highly dependent on level of service characteristics. Conversely, supply, or level of transit provision, is keyed to the quantity of services demanded. Nevertheless, with a service/population demand model in use, systems not having the expected number of daily passengers, or exceeding the ridership level produced in the demand equation, can be isolated. Many transportation demand models presently incorporated in decision-making and planning have pronounced weaknesses:

1. Such models are often too dependent on specific input indicators or variables, and omit a critical explanatory variable for one particular city.
2. Many models derived from regression equations have too many requisites for input data that are unavailable. For example, forty input variables may be required where current data is available on only six items for any one city.
3. Often, mode-split models are not useful for incorporation in short-range planning, but provide a forecast for one or two decades in the future.

Two transit demand models based on level of service and population characteristics will be presented in this section. The first model is applicable to small cities in the 50,000 population range that has been developed by Chadda and Mulinazzi (1977). The second model for forecasting transit demand is based on the nationwide survey data discussed previously in this chapter. However, this demand equation has been derived from cities of 80,000 to 500,000 population (based on 1970 census data) in the sample, encompassing 26 cities. As only one city is under 100,000, the second demand model should more properly be representative of cities in the 100,000-500,000 population range.

Estimating Transit Demand for Small Cities

The following regression model developed by Chadda and Mulinazzi (1977:24) estimates ridership on a system-wide basis. The model has emerged from analysis of data exclusively from small cities, and is depicted in Table 22. Further, an example is provided in Table 22 of Victoria, Texas--a city currently without any form of mass transportation.

Victoria has an estimated population of approximately 50,000 (in 1977). Based on the estimate of transit demand for this city, a ridership level of 1095 passengers daily could be expected if a minimum service was provided. Total daily person trips in 1970 were 188,001 or the highest number of person-trips per capita of all urbanized areas in Texas (Texas Mass Transportation Commission, 1974). A daily ridership of 1095 thus would be approximating one-half of one-percent of the total daily trips. Using the demand model provided, a further breakdown by fleet size needed, expected vehicle capacity, and needed operational subsidy can be ascertained.

Estimating Transit Demand for Medium-Sized Cities

As with the behavioral transit demand models discussed in Chapter II, "Characteristics of Individual Residents that Influence Transit Demand: An Examination of Two Smaller Texas Cities," a maximum-R^2 regression procedure was utilized to isolate those transit system and population variables most explanatory of transit demand. These input indicators, from 26 cities are:

Transit System Characteristics

1. Percent of population in service area within one-fourth mile of a transit route
2. Average peak headway frequency
3. Average off-peak headway frequency
4. Average peak and off-peak headway frequency
5. Vehicle miles per day
6. Number of buses in regular service
7. Number of bus routes
8. Average weekday timespan of service
9. Revenues per passenger

Population Characteristics

1. Population size of primary city served by system
2. Population density of primary city served by system
3. Median family income
4. Percent of population 65+

Table 22. Ridership Estimation for Small Cities

TRANSIT DEMAND MODEL FOR CITIES OF 50,000 POPULATION

(DAILY RIDERSHIP) = 238 + (0.24 X POPULATION 65+) + (4,480 X FARE AMOUNT IN DOLLARS) + (-0.09 X MEDIAN FAMILY INCOME)

ESTIMATE OF TRANSIT DEMAND FOR VICTORIA, TEXAS

DAILY RIDERSHIP = 238 + 0.24 (6.4) + 4,480 (.35) - 0.09 (7,918) = 1,094.92

Source: (revised presentation from) H.S. Chadda and T.E. Mulinazzi, "A Transit Planning Methodology for Small Cities," Transit Journal 3 (Spring, 1977): 24.

Demand was measured by <u>number of daily passengers</u>. With the maximum-R^2 procedure, the best model for predicting the number of passengers or daily ridership was found to include only three of the thirteen possible input variables:[10]

- Average headways (peak and off-peak)
- Population size
- Number of buses in regular service

Table 23 portrays the demand estimation model for cities of 100,000 - 500,000. Additionally, an example is provided of the expected daily ridership for Corpus Christi, Texas--a city not utilized to provide data for the development of the model. Corpus Christi has a population of approximately 232,000. In 1961, Corpus Christi evidenced 2.36 person-trips per capita or 463,106 total daily person-trips. One projected estimate of person-trips per capita for 1990 is 4.05 (Texas Mass Transportation Commission, 1974). If roughly 600,000 total daily trips are undertaken during 1977 in the city, then transit currently serves approximately one percent of these trips.

The discrepancy between expected bus ridership at 10,057 (as shown in Table 23) and estimated current daily ridership at 6,390 is pronounced in Corpus Christi. One possible explanation is that, nationwide, cities are serving a higher proportion of urban trips than is true for Southern cities such as Corpus Christi. In this case, the demand model, developed from a nationwide example, is not appropriate for Corpus Christi. However, seven Southern cities outside Texas were included in the model--Montgomery, Atlanta, Jacksonville, Nashville, Birmingham, Tulsa, and Louisville. Five cities within Texas were incorporated into the demand estimation--Austin, Fort Worth, San Antonio, Beaumont, and Waco.

A further possibility for the discrepancy lies in the lack of public awareness among residents of Corpus Christi. Concentration on key rider segments and on service provision to meet transit needs of targeted population segments provide possible paths for the improvement of ridership levels in the city.

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[10] R^2 was .99 and the probability of a greater F was 0.0001. The R^2 points to the fact that the input variables, especially fleet size in regular service, are highly correlated with daily ridership figures. However, multicollinearity among input variables was not high, and ranged from -.47 to +60.

Table 23. Ridership Estimation for Medium-Sized Cities*

TRANSIT DEMAND MODEL FOR CITIES OF 100,000 - 500,000 POPULATION

$$\text{Daily Ridership} = -76{,}864 + (970.35 \times \text{Average Headways}) + (0.1456 \times \text{Population Size}) + (265.88 \times \text{Number of Buses in Regular Service})$$

ESTIMATE OF TRANSIT DEMAND FOR CORPUS CHRISTI, TEXAS

$$\text{Daily Ridership} = -76{,}864 + (970.35 \times 48) + (0.1456 \times 215{,}000) + (265.88 \times 34) = 10{,}057$$

(Estimate of Demand)

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*The estimate of daily ridership or the demand estimation per city shows a positive sign for average headways. The simple correlation of average headways and daily ridership was -.50 (significant at the .03). Peak headways and daily passengers were correlated at -.42; off-peak headways and daily ridership had a -.51 correlation. When placed in the maximum-R^2 regression, however, and holding constant population size and bus fleet size, the partial correlation of daily ridership with average headways showed a positive relationship. For this reason, the model must be used as predictive only of daily ridership; components of the model, such as the "average headways" indicator cannot be varied for any one city in order to predict changes in ridership levels.

Preliminary Transit Patronage Estimation

As noted in the two models, for small and for middle-sized cities, an estimation of expected bus ridership can be determined for individual cities. Descrepancies between expected and actual ridership provide a basis for implementing service improvements and accompanying marketing strategies.

In terms of overall ridership estimation, the two patronage estimation models provide a prelimiary basis for assessing expected transit usage. Because of the limited number of cities included in the models, further estimation models need to be examined.[11] Patronage in both small and middle-sized cities is, and will continue to be, guided by the primary users--that is, those population segments lacking the ability to satisfy their local travel needs via private automobiles. Further, transit service factors and population characteristics associated with low-to-moderate levels of service do not vary substantially (Neuzil, 1975). Thus, the cities examined in both models should prove to be similar along many critical service and population characteristics, including population segments utilizing the transit systems. The primary predictors of patronage did differ for the two models, however, in that "captive" ridership characteristics predominated in the small cities model; the percent of older persons and those with low incomes, as well as the bus fare, indicated the demand for bus patronage in small cities. In general, the middle-sized cities showed a greater sensitivity to operating characteristics per se, as well as fleet size, indicating somewhat greater diversity of the cities included in this second estimation model.

Determining the "bundle of critical factors" that influence transit patronage has been of special interest in the current decade. Models based on these factors provide an effective base for preliminary estimation of transit ridership. For dealing with systemwide ridership estimates, rather than the patronage of specific individuals, Neuzil (1975:32) notes:

> The choice and frequency of use of transit service in any size urban area is determined largely by basic socioeconomic and geographic characteristics together with the various facets of service

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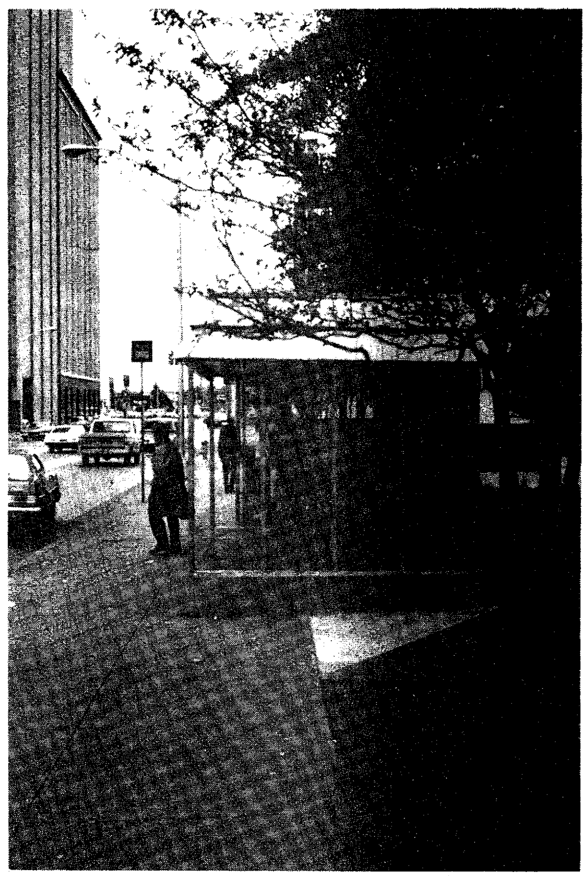
[11] All variables need to be examined on a per capita basis with more extensive data available.

offered by transit . . . [These factors provide a highly useful and convenient basis for initial estimation of transit patronage, particularly in connection with sketch planning studies associated with preliminary evaluation of a wide range of alternative bus systems and levels of service.]

Blue collar females, older persons, and white collar females evidenced the greatest likelihood of increased transit patronage. Systems, therefore, should attempt to meet the service requirements of these segments, particularly: (1) ROUTING: Routes need to be close to requested destinations; (2) RELIABILITY: Buses should arrive and depart at scheduled times; and (3) AMENITIES: Bus shelters should be provided at high usage bus stops.



CHAPTER V

SUMMARY AND RECOMMENDATIONS

The research project on which this report is based, "Marketing Public and Mass Transportation in Texas," explores strategies for stimulating transit ridership. Recommendations regarding marketing techniques for attracting specific population segments to transit are provided in Volume I, The Identification of Market Segments: An Analysis of Transit Needs and Service Requirements.

The intention of this second report is to identify the direct, as well as latent, demand for public and mass transportation services and to assess the factors critical to developing expanded transit usage. The correct identification of this "bundle of factors" is necessary in order to predict patronage. The findings in this second report will enable transit managers and planners to determine the most important service factors required by the general public, as well as for particular market segments. Systems involved in considering service alterations or improvements should find the information readily applicable, particularly for initiating service changes based on residents' transportation needs.

PERSONAL CHARACTERISTICS AND INDIVIDUAL PREFERENCES THAT INFLUENCE TRANSIT DEMAND

Based on two marketing surveys undertaken in Waco and Beaumont, it was determined that transit ranked low in priority relative to other city problems. Residents, contrary to the views of transit and city representatives, generally feel that funding for transit facilities should not be a public concern. In regard to overall transportation expenditures, road and street repairs were seen as a more urgent concern than improving transit service. However, only 21 percent of the residents interviewed stated that they could not "see much of a future for public transportation."

Service requirements sought by residents in Waco and Beaumont that should receive closer attention by transit management and city officials are:

- Bus service closer to key destinations (with these destinations more closely keyed to recommendations by residents),
- Bus reliability--arrivals and departures at scheduled times,
- Bus shelters (provided at high usage bus stops), and
- Maintenance of low fares.

Blue collar females, older persons, and white collar females showed higher intensities of demand for improved bus services. The top five service requirements stressed by these three segments (see Chapter II) should be carefully assessed by transit planners, as these three groups evidence the greatest likelihood of increased patronage. Each of the three segments emphasized the following three priorities among their top five requirements:

- ROUTING: Routes should be closer to destinations pertinent to these individuals,
- RELIABILITY: Buses should arrive and depart at scheduled times, and
- AMENITIES: Bus shelters should be provided at high usage bus stops.

As can be noted, these three factors were also top requisites of the public-at-large.

Smaller cities in Texas contain a heavy proportion of riders who consider themselves "captive" patrons, with 51 percent of those in Beaumont and Waco who use transit having no other transportation alternatives. The most significant personal and attitudinal characteristics which determine current ridership (regardless of trip purpose) were isolated from nine possible factors, and included:

I. The lack of personal use of an automobile,
II. Close proximity to a bus route from one's residence, and
III. A positive evaluation of buses relative to automobiles.

A similar procedure was used to isolate the factors which most significantly predicted current ridership for eight trip purposes. From the same nine indicators, a model, the LOUP scale (i.e., Level of Use by Trip Purpose), isolated two highly significant factors:

I. The lack of personal use of an automobile, and
II. The lack of limiting physical disabilities.

As might be anticipated, <u>current ridership</u> is dependent on a limited means of private transportation, accessibility to buses, a positive evaluation of buses, and no disabilities limiting use of conventional transit facilities. The propensity to use buses among current non-riders was examined to determine critical factors that influence a decision to switch to transit. Again, nine indicators were examined and three predictive factors were isolated, based on the POUP scale (i.e., Propensity of Use by Trip Purpose). The three factors that explained a high interest in transit use among current non-riders were:

I. Older individuals as modal switch patrons,

II. Proximity to a bus route from one's residence, and

III. A positive evaluation of buses relative to automobiles.

These three behavioral demand forecasting models outlined above should be of assistance to transit planners in examining alterations in service based on making changes in any one of the predictive indicators. Not only can cities be compared with these three models, but also transit demand in specific sectors of a city can be determined.

FORECASTS OF TRANSIT DEMAND BY TEXAS TRANSIT LEADERSHIP

Generally, the findings which emerged from the survey of Texas transit and city representatives were optimistic in regard to increased ridership levels. Transit managers evidenced higher forecasts of patronage for 1980 and for a ten-year period (i.e., 1986) than did city officials. Overall, 73 percent expected at least a 10 percent increase in total ridership levels by 1980.

Significantly, transit leaders projected the greatest ridership increases would occur in the number of middle income riders. However, the findings from the Beaumont and Waco surveys suggest that lower income residents are still the predominate transit target markets.

TRANSIT SYSTEM AND POPULATION CHARACTERISTICS THAT INFLUENCE TRANSIT DEMAND

While Chapter II was devoted to those individual or behavioral characteristics that explain the demand for mass transportation, Chapter IV utilized transit system and population characteristics as factors influencing demand. The responses from 32 transit systems nationwide were utilized to explain the overall demand for transit. Demand was measured by:

(1) average daily passengers;

(2) percent of the total population using transit; and

(3) percent of total urban trips made by transit.

A consistently strong linkage between headway frequency and average daily ridership was observed. Additionally, daily passengers, the percent of the total population using transit, and the percent of urban trips by transit, increased after 80 percent transit coverage (residence within one-fourth mile of transit route) was reached. These two findings reinforce the continued expectation of a high correlation between level of service and transit demand.

Captive population segments, especially those with less than $5,000 median income and older persons, represented a higher proportion of the total ridership at low service levels. White collar workers and housewives, on the other hand, were sensitive to the level of service provided in their respective cities.

Population density was shown as an important predictor of transit demand, while population size per se did not influence demand. A density level of at least 4,000 persons per square mile appeared to provide a "tipping point" beyond which dependency on transit increased significantly.

Two demand models for estimating daily ridership were presented. The first model, developed by Chadda and Mulinazzi, is useful for cities of approximately 50,000. According to this estimating procedure, the demand for transit service in a small city is based on:

- The percent of older persons;
- Fares charged; and
- Median family income.

The second model was developed from 26 medium-sized cities in the TTI nationwide survey. According to this procedure, the demand for service (or daily ridership) in cities of 100,000 to 500,000 is based on:

- Average headways;
- Population size; and
- Number of buses in regular service.

Two examples are provided based on the demand models. Victoria, Texas was used as the small city example for estimation of transit demand in a locality currently without any form of mass transportation. Corpus Christi, Texas provided an instance of the second model for medium-sized cities. In this case, the expected demand for bus service was considerably greater than that of the current daily ridership. Possibly this discrepancy can be explained in the lack of public awareness of the bus system in Corpus Christi, pointing to the need for a strong marketing effort.

Both the small city and middle-sized city models are helpful in sketch planning. While the data base on which the models are dependent is small, an overall estimation of daily ridership can be ascertained.

Based on the findings in Chapter IV, service factors and population characteristics are predictive of daily ridership, as well as other indicators of transit demand. As anticipated, captive population segments were found to be a greater proportion of the ridership for systems with low service levels. A key problem in assessing factors that influence demand is the fact that systemwide demand estimation models cannot easily be tied to individual characteristics and preferences. Each approach has certain advantages and limitations. Improving transit systems and increasing ridership are dependent on isolating both sets of "critical factors."

Public investments in transit as an alternative transportation mode to the automobile must be based on a knowledge of the most significant factors in the selection of transit as a viable mode. If such investments are to be effectively utilized, it is essential that transit planners accurately assess the public's perceptions of needed service requirements and the demand for transit facilities.

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