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RURAL PUBLIC TRANSPORTATION DEMAND: CHARACTERISTICS AND ESTIMATION METHODOLOGY

by

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Technical Study Report Number 1080-1F

Demand Estimation for Rural Public Transportation in Texas

Technical Study Project 3-10-85-1080

conducted for

Texas
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by the

CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

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ABSTRACT

The demand for rural public transportation service in Texas is documented and characterized in this report. The determinants for this demand are analyzed using a data base on existing Section 18 systems in Texas, developed from three sources of primary as well as secondary information: Census data, Section 18 contractors' quarterly reporting forms (submitted to the SDHPT), and a mail-phone survey of these contractors/operators.

Procedures for demand estimation are presented, capturing the dependence of this demand on system supply and service availability, in addition to the usual sociodemographic variables. Alternate procedures are also developed to estimate potential demand in the absence of supply information, and applied to calculate estimates for all counties in Texas.

Other useful parameters of rural public transit demand are also presented, particularly with regard to specialized market segments and elasticity of demand to service characteristics.

EXECUTIVE SUMMARY

This study was conducted to 1) assess and characterize the demand for rural public transportation (RPT) service in Texas; 2) develop practical procedures for demand analysis at the service area level; and 3) identify useful demand parameters of existing Texas systems. These objectives have been successfully accomplished.

A data base has been developed, documenting the characteristics and ridership patterns of the existing Section 18 RPT systems in Texas, using three principal sources of primary as well as secondary information: Census data, Section 18 contractors' quarterly reporting forms (submitted to the SDHPT), and a mail-phone survey of these contractors/operators, conducted by the Center for Transportation Research. This data base contains time-series profiles of the existing systems in Texas, revealing the sustained evolution and growth in the demand for these services over time. In addition, the composition of this ridership was analyzed across the existing systems, indicating that elderly passengers account for the largest fraction of trips (about 50%) served by these systems, underscoring the vital nature of the service provided by these systems.

The analysis leading to the development of systemwide and countywide demand forecasting methodologies determined that the two principal determinants of the observed ridership demand served by current RPT systems are: 1) sociodemographic characteristics, captured by the size of the rural dweller population in the service area, and 2) supply characteristics, particularly service availability, captured by the offered vehicle hours of operation. Analytical regression equations were developed to predict both the initial quarter demand (upon service introduction) as well as an average quarterly figure over the longer run.

In addition, equations that do not include service availability variables, as well as average trip rates (for small and large systems separately), were developed as acceptable alternates in the absence of supply information, such as in unserved or unreliably served areas. These rates were utilized to develop estimates of the expected current potential demand for RPT for all counties in Texas, revealing the extent of unmet demand in these areas relative to those with existing service.

The available ridership information also allowed some insights into specialized market segments for RPT, particularly the elderly, low-income and physically impaired ridership. Parameters useful for planning purposes were compiled on these segments. In addition, the elasticity of demand to service supply (expressed in vehicle hours of operation was calculated for those existing systems which experienced expansion of service availability during the observation period, thereby providing information that is useful for planning purposes.

In summary, this study has contributed to the characterization of the demand for RPT in Texas, and to the documentation of its extent and magnitude. It has also developed easy-to-use procedures for forecasting the demand for such services, as well as a set of useful planning parameters regarding various aspects of this demand.

IMPLEMENTATION STATEMENT

This report presents a procedure for estimating the demand for rural public transportation service in any given area, consisting of one or more contiguous counties, given readily available information about the study area. This approach recognizes the dependence of demand on the available transportation supply; however, alternative approaches are also developed to deal with situations where no particular service level is available or contemplated. The procedure is based on data obtained in the existing Section 18 Rural Public Transportation systems operating in Texas at the time of the study. Estimates for the potential demand for such service are developed for each county in Texas.

This report also presents parameters and characteristics of the usage of the public tranportation systems currently in operation in Texas, including ridership profiles, specialized market segments and elasticities with respect to service levels.

The information and procedures presented in this report will be of use to SDHPT planners and decision-makers involved in the assessment, evaluation and administration of existing or requested Section 18 programs in the State. In addition, these results will be of interest to planners and service providers at the local level who are either operating or considering the provision of a rural public transit system.

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CHAPTER 1. INTRODUCTION

Section 1.1 Origins of Rural Public Transportation Funding

The passage of the Urban Mass Transportation Act of 1964 marked the genesis of federal interest and support for public transportation in the United States. This represented a notable break from the traditional governmental policy of building superhighways for use by the private automobile. It was not until the wake of the Watts riots in the area of Los Angeles in 1965, however, that transportation was to be recognized as an effective and at least partial remedy for some of the evils of poverty, as was suggested in the McCone commission report on such instance of civil unrest. At this point a number of urban public transportation projects were undertaken for this purpose.

Nearly a decade passed before the enactment of Section 147 of the Federal-Aid Highway Act of 1973. Here, for first time, a federally sponsored interest was taken in the issue of the needs of the transportation disadvantaged in *rural* areas. Known also as the Rural Highway Public Transportation Demonstration Program, Section 147 resulted in approximately 134 projects by 1979; and, as early as 1976, transportation operations from a Section 147 project came on line.

Another major milestone in the life of rural public transportation occurred with the passage of the National Transportation Act of 1974 when Congress specifically allocated "up to $500 million for grants between 1974, and 1980 exclusively for assistance [with capital expenses] in areas other than urbanized."[1]

Despite such generous intentions, there were many limitations to this law: nonurbanized areas were required to follow the same application procedures as urban areas, funding was available to public entities only, and funds were not provided to defray operating deficits as they were in urban areas. In the end, the Urban Mass Transit Administration subsequently only spent less than $30 million of the original $500 million earmarked for distribution, and most of this went to small urban areas with populations of less than fifty thousand inhabitants instead of rural areas.

In 1978, Congress enacted Section 18, a formula-grant transportation program which was intended to be, from 1980 on, the sole source of capital and operating assistance of public transportation systems in non-urbanized areas. Social service organizations which provided specialized transportation to groups such as the elderly or handicapped could also receive Section 18 funds once their eligibility was established by making their service available to the general public. Funds today are administered by the individual states which distribute them to local rural transit system contractors. In accordance with the expressed goals of the program, funding is provided in order to "enhance access of people in nonurbanized areas for purposes such as health care, shopping, education, recreation, public services and employment by encouraging the maintenance, development, improvement, and use of passenger transportation systems."[2]

As of May 1985, twenty-nine such Section 18 contractors were operating in the State of Texas, serving roughly one hundred and twenty-five counties. During FY '83-'84 approximately $8.9 million in federal aid was distributed to contractors and administrative personnel of the Section 18 program projects in the State. Funds under this program can be used to defray up to 50% of total operating expenses, and 80% of capital and administrative expenses. Up to 15% of a state's apportionment may be used for state administrative and technical assistance.

The pie chart in ***figure 1.1.1*** gives the breakdown of cumulative average total expenditures incurred by Section 18 rural transit systems in Texas for FY '83-'84. As can be noted from the graph, operating costs alone comprise more than half of the total expenses involved in maintaining a Rural Public

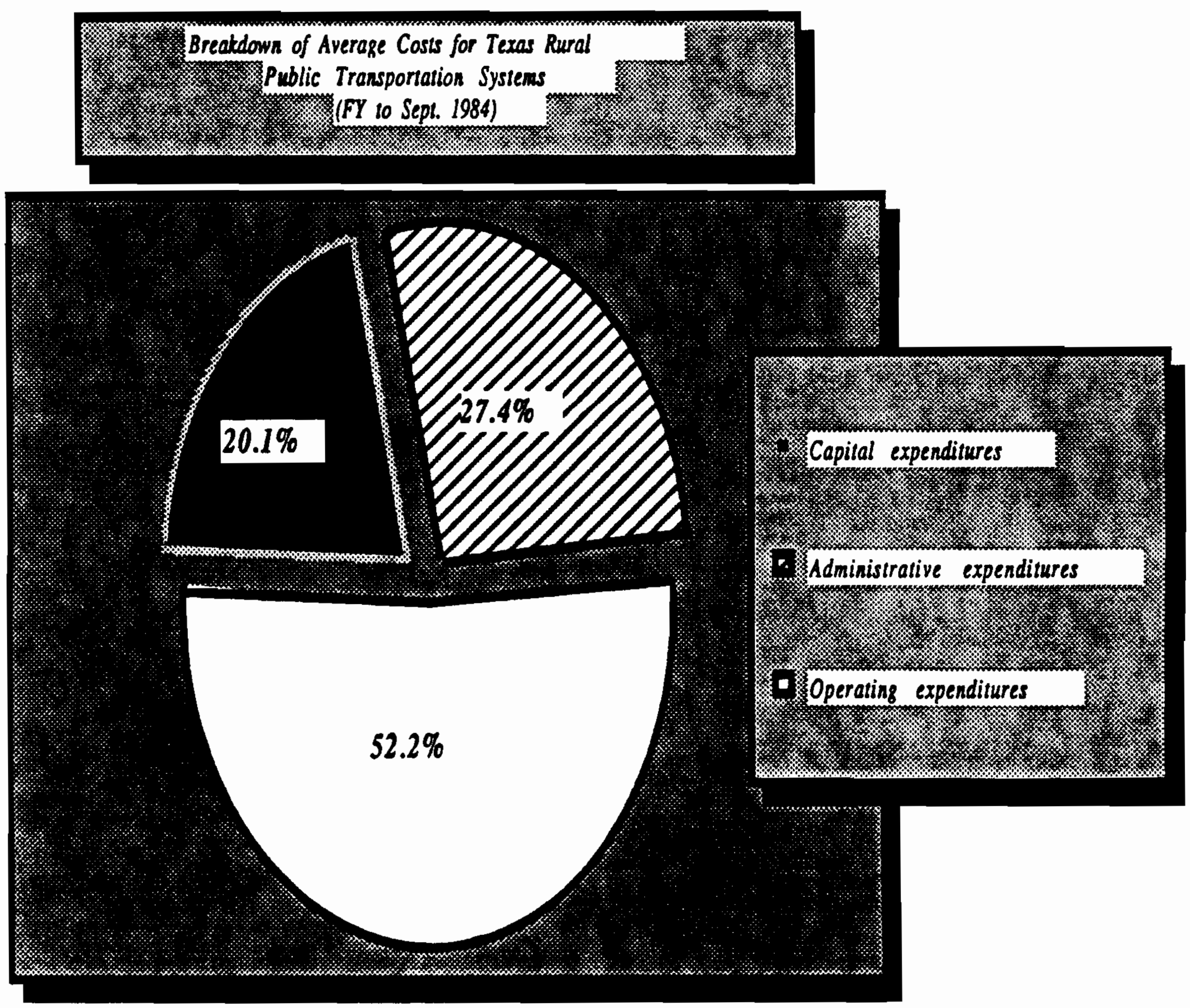


Figure 1.1.1

Transportation (RPT) system. Yet the funding scheme is such that this category is allocated the least amount of federal subsidy. At an overall cost of $12.4 million in FY '83-'84 for administration, capitalization, and operation, rural transit contractors in Texas had to provide approximately $3.3 million in local matching funds in order to cover just the operating deficits.

This point illustrates the fact that there is a relatively low level of funding support for the Section 18 program. Predominant trends in the Section 18 program which have been emphasized by the Urban Mass Transportation Authority are: (1) the necessity to coordinate Section 18 funds with other sources of federal or local matching funds, (2) increased efforts made to enlist participation from the private sector, (3) a certain flexibility in administering the system, (4) an incentives program rewarding increases in productivity and effectiveness, and (5) the fostering of innovations in rural transit service. Finally, it is worth noting that at no time has the full amount of funds encumbered for the Section 18 projects ever been apportioned to them by Congress.

Section 1.2 Innovative Options in Rural Public Paratransit

Many factors contribute to the need for new ideas and innovative approaches to providing transit service to transportation disadvantaged individuals that reside in rural areas. These innovations have generally been motivated by such factors as the government's consistent curtailment of funding subsidies for the Section 18 program, and other budgetary constraints, combined with the size and land use characteristics in rural communities. Rural areas typically have weak tax bases due to sparse population and the fact that agriculture is often the principal economic activity.

In addition to the fiscal environment, other demographic and geographic characteristics contribute to the special operating constraints of transit systems in rural areas: (1) sparse populations and expansive terrain necessitate substantial trip lengths (***figure 1.2.1*** depicts the average trip length observed for Section 18 systems in Texas, based on data data taken from a sampling of quarterly reports over the course of the three-year period of 1981 to 1984); (2) the ridership figures, per vehicle-hour of operation, tend to be relatively low (cf. ***figure 1.2.2***); (3) many rural environments often include adverse terrain which hinders transit operations particularly under inclement weather conditions; and, (4) the certain proportion of low income, elderly, handicapped and carless rural dwellers creates a certain dependence on public transit as a means of enhancing the quality of life.

The appropriate design and implementation of a particular rural transit system must therefore be approached with special attention to the contextual surroundings within which it is to operate.

It is important to note that many of the innovative solutions to the problem of systems design in the area of rural transportaion have come about through the underlying efforts of local individuals. In general, such people are likely to have a good appreciation the nature of the transportation needs of area residents as well as with the topographic features and settlement patterns in the area. In addition, it is generally the case that no single transit authority exists which might regulate the operational networks of rural transit providers. The lack of any such agency fosters diversity among the organizational responses and solutions for the task of serving the special mobility needs of those living in the country.

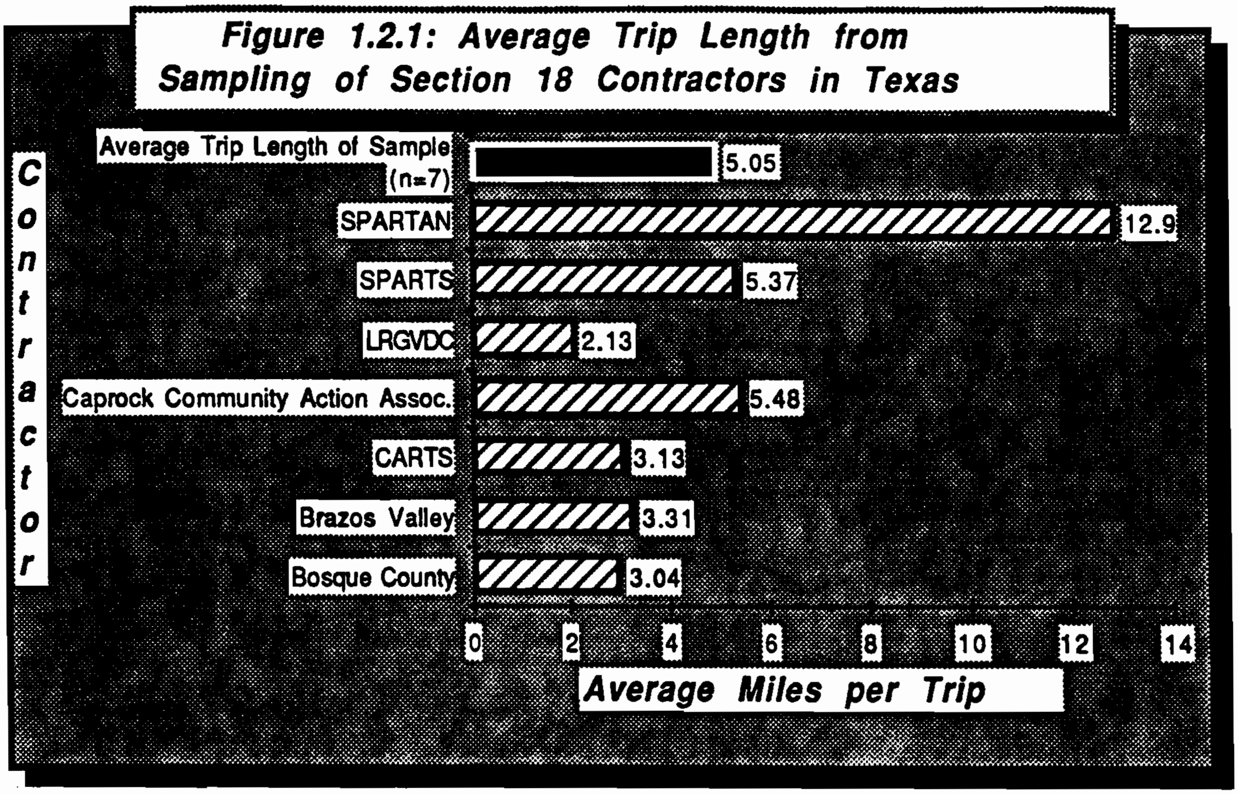


Figure 1.2.1: Average Trip Length from Sampling of Section 18 Contractors in Texas
Contractor
Average Trip Length of Sample (n=7)
5.05
SPARTAN
12.9
SPARTS
5.37
LRGVDC
2.13
Caprock Community Action Assoc.
5.48
CARTS
3.13
Brazos Valley
3.31
Bosque County
3.04
0
2
4
6
8
10
12
14
Average Miles per Trip

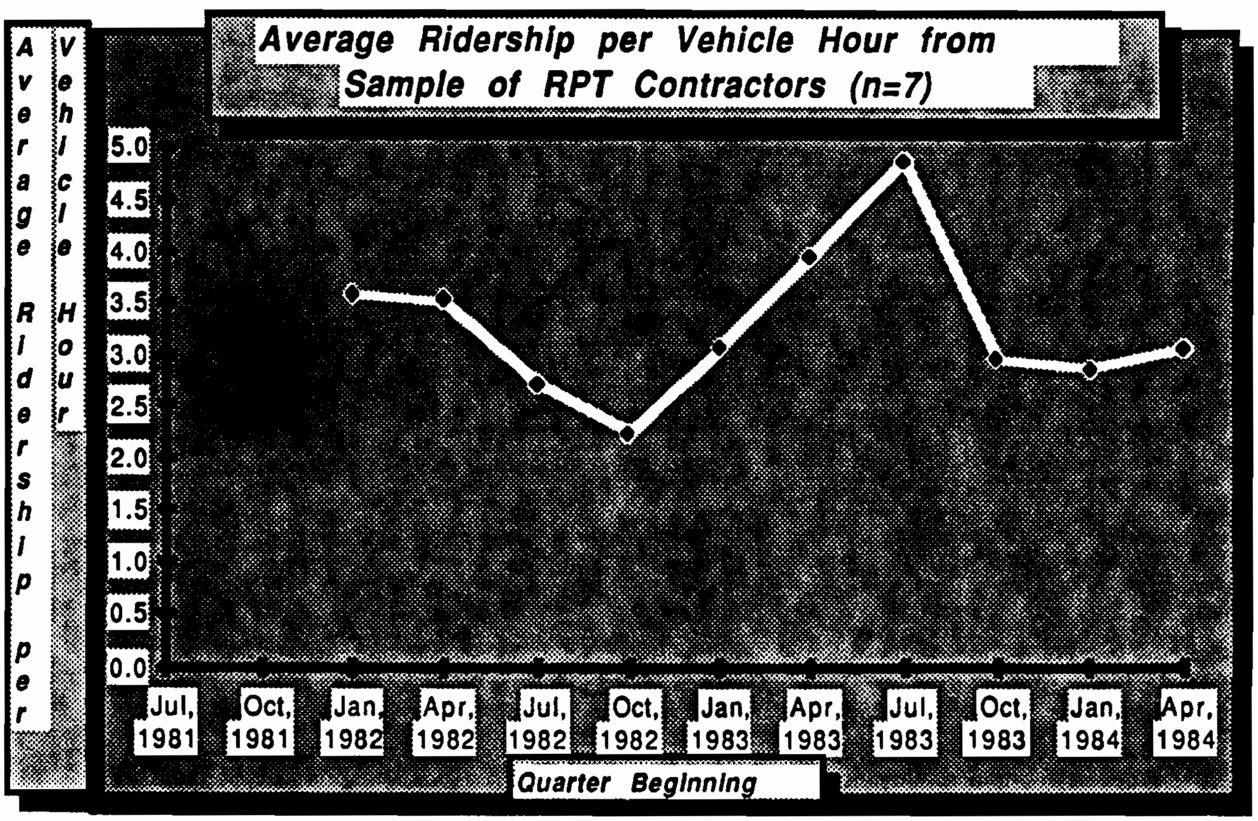

Average Ridership per Vehicle Hour from Sample of RPT Contractors (n=7)
Average Ridership per Vehicle Hour
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jul, 1981
Oct, 1981
Jan, 1982
Apr, 1982
Jul, 1982
Oct, 1982
Jan, 1983
Apr, 1983
Jul, 1983
Oct, 1983
Jan, 1984
Apr, 1984
Quarter Beginning

Figure 1.2.2

The thread of continuity that does exist, however, among the design and development of rural transit systems resides in the fact that they almost always are a by-product of the interactions between social service agencies, non-profit organizations, private contractors, as well as with input from local, county, and state agencies. Thus, it can be seen that the creation of a viable RPT network requires the coordination of the efforts from several different sources, a task which usually requires a capable transit manager. One contemporary trend developing in this arena is the progressive emergence of the manager's functional role as being basically that of a transportation broker. That is to say, one whose main purpose is to match the various mobility needs and demand in the market in which she operates--usually through identification of its segments--with the already available forms of public transportation and related service providers. The brokerage function also serves as a bridge between the aforementioned institutional funding sources, the ultimate recipients of such funds and the beneficiaries of the service they provide. Acting basically as a conduit for the limited fiscal means upon which the survival of a rural transit system is dependent, the transportation broker seeks to develop a broad portfolio of services that will facilitate mobility in the area at a cost to the user that is commensurate with his financial resources. Innovation, creativity and flexibility are generally the key for attainment of these goals.

When referring to rural public transportation options it must be kept in perspective that one is essentially dealing with the group or set of transportation modes that are categorized somewhere between the self-driven automobile and the fixed-route bus transit. This set of transportation service options is more commonly known as "paratransit". Paratransit modes are intended to achieve that which conventional mass transit operations cannot, namely to provide a cost-effective means of mobility in low population density areas or in situations where special equipment is required by riders with physical disabilities. It generally includes all demand-responsive types of transportation (e.g., Dial-a-ride) and often might serve as a feeder for conventional fixed-route lines.[3]

This latter situation is exemplified by the Austin area RPT system, with the awarding of a $63,000 contract to the Capital Area Rural Transit System (CARTS) by the Capital Metropolitan Transit System (Capital Metro). CARTS is using three newly modified vans in order to pick up residents from outside the greater Austin metropolitan area in San Leanna and Lago Vista and bring them to park-and-ride lots within the city limits. From these parking lots the Capital Metro buses take the passengers to their destinations along the usual inner-city fixed routes. CARTS also provides a dial-a-ride service to the residents of Lago Vista for a reserved ride into Austin which must be requested at least twenty-four hours in advance. It also serves the mobility needs of the handicapped and elderly while the fare for any of the CARTS services is $.60.

As part of the present study, a survey of Section 18 contractors was conducted to obtain information on characteristics of the rural transit systems which they operate. One of the more interesting findings has to do with the modes of paratransit which form the backbone of RPT in Texas. Coming under the scrutiny of this poll were approximately two hundred thirty-seven vehicles in sixteen different transit systems. Although exact percentagewise distributions were inascertainable, it was yet possible to obtain their varying descriptions as being: buses, minibuses, vans, trolleys, maxivans, taxis, handicapped-equipped vehicles, varying passenger sized vans and buses, Caprice Classic station wagons, 4-door sedans, and paravans with wheelchair capacity.

It should be apparent to the observant reader that innovation and diversity of modes of operation are but two of the indigenous characteristics of RPT not only in Texas, but in the majority of other contexts as well. The following sections will examine some of the cases where these features are found.

Section 1.3 Scope and Objectives of Present Study

The magnitude and characteristics of the demand for public transportation service in rural areas in Texas are not sufficiently documented. Such information forms essential input to planning decisions at both the state and local levels, particularly with regard to the feasibility of v :ous system options in a given area, the allocation of financial resources to such systems as well as the planning an. :sign of service options in a particular area. The objectives of the present study are thus as follows:

1. To assess and characterize the demand for rural public transportation service in Texas;

2. To develop practical procedures for demand analysis at the service area level for system planning purposes;

3. To identify useful demand parameters of existing Texas systems for future studies.

In addition, the following concerns must be incorporated in the procedures developed for demand estimation: 1) The data used in calibrating the methodology should be from existing Section 18 RPT systems in Texas, in order to achieve some degree of comparability with the areas for which this methodology is intended; 2) The approach should be aggregate in nature, and rely on easily available data (particularly Census information), given its intended scope of application; and 3) Demand estimation must be sensitive to system supply and service characteristics.

The resulting procedures are therefore primarily applicable in the Texas context, since they reflect the systems that are currently in operation in the State. However, they may also be of use in areas exhibiting the same general characteristics in other states. In addition, they may be applied to generate information useful for comparison purposes.

Further detail on the systems included in the data base are given in the next chapter. This data base was developed from three principal sources: 1) Contractors' quarterly reports to the SDHPT; 2) A mail-phone survey of existing RPT system contractors; and 3) U.S. Census Bureau data for the counties comprising these systems. The principal contents of this data base, particularly the time-series patterns of ridership and its composition, as well as system performance data are discussed in Chapter 2. The demand estimation procedures are developed and described in Chapter 3. Estimates of the potential demand for RPT are subsequently developed in Chapter 4 for all counties in Texas. Chapter 5 reports on the observed elasticities of ridership demand to service supply (availability) in the existing systems where service change shave been implemented over the reporting period. A summary of findings is given in Chapter 6, along with concluding comments and suggestions for further research.

Section 1.4 Notes to Chapter One

[1]Burkhardt, Jon E. "Rise and Fall of Rural Public Transportation," in *Rural Public Transportation: Fifth National Conference Proceedings*, Transportation Research Record No. 831, Washington D.C., 1981; p. 3.

[2]*Ibid.*, p. 3.

[3]Sustaita, Rudy, "Feeder buses to aid surrounding areas," in *The Daily Texan*, 11 June 1985; p. 8.

CHAPTER 2. CURRENT PERSPECTIVES OF RURAL PUBLIC TRANSPORTATION AND A COMPOSITE PROFILE OF THE TEXAS SYSTEMS

Section 2.1 Background

2.1.1 Role and Examples of For-Profit Carriers

Over the past decade, a substantial body of literature concerning the variety of modal options and institutional frameworks within the realm of rural public transportation networks has emerged. A selective review of some of the more recent publications (i.e. post-1980) attests to the diversity in a spate of case studies. As is frequently the case with respect to the delivery of transportation services, it can be shown that there are basically two types of rural passenger carriers: either non-profit or for-profit agencies. In contrast to urban areas, however, whose inhabitants generally enjoy a number of transportation service options which might operate in a competitive environment, the special mobility needs of rural dwellers are often served by only one public or private operator/provider, with sometimes insufficient or unreliable availability.

Any taxonomy of rural transit options must not fail to recognize the significant role which the "for-profit" transportation operators have performed in this domain. The vast majority of towns with populations under ten thousand inhabitants are served by taxicab companies, which can and do also provide service to several different and distant locations. Increasingly, taxicab service companies have been granted public subsidies in order to provide public transportation in small urban and rural areas.[1]

One of the major reasons for this development has to do with recent court decisions which have required cities wishing to supply demand-responsive transportation service to determine beforehand if the establishment of such service would have any substantial anticompetitive effects on existing taxicab operators. In Santa Clara County and Orange County, California, legal rulings handed down by the court in favor of local taxicab companies (those which were not included in then recently established dial-a-ride systems) compelled the respective transit districts to buy out and thus indemnify the transportation carriers which were adversely affected.[2]

Therefore, prior to the establishment of any transit service, it is generally recommended that the planners and authorities involved in such decisions to consider (1) whether or not the proposed service area is already being served by a taxicab carrier, (2) if the carrier is providing adequate service, (3) would the proposed service divert substantial revenues from the existing carriers, and (4) is the current private carrier interested in and capable of modifying and expanding his service to provide for special mobility needs such as those of the handicapped, the elderly, or rural inhabitants? If the response were affirmative to any of these preceding inquiries, the transportation planner should investigate and ascertain the feasibility of subsidizing an existing taxi operator.

Such an option has thus been implemented in a variety of rural transit contexts in which user-side subsidy programs operate by issuing coupons, fare tickets, or script to eligible recipients at substantially reduced rates. For example, in a user-side subsidized taxi transportation system in the rural community of Selma, California, each ticket cost the elderly passenger $0.25 and could be used for a one-way trip. The taxi operator would then collect such tickets throughout the month, and at the end of the month would submit all the fare tickets to the city, whereupon he would be reimbursed $1.00 for each ticket, yielding a $0.75 cost per trip to the community transit authority.[3]

Analogous programs are found in Los Gatos, California, and Richland, Washington; an impressive statewide demonstration project, the Transportation Remuneration Incentive Program, more commonly known as TRIP, was undertaken and administered by the West Virginia Department of Welfare. The novel feature of this particular user-side subsidy program is that it included the transportation modal options of taxicab companies, Amtrak trains, and intercity bus lines (Greyhound and Trailways) for use by eligible participants.[4] Another interesting example of user-side subsidy is the Kinston Independent Transportation for the Elderly (KITE), in Lenoir County, North Carolina. Here, in a very small area (8.9 mi^2), eligible participants from the Kinston rural community's 25,000-member population may choose from among six different taxicab companies and then pay the fare for the relatively short trips in script.[5]

In contrasts to the purely local service within rural areas, intercity bus service provides another important for-profit mobility resource to rural and small urban communities. Intercity bus service provides transportation service between rural and small urban areas, and between these latter areas and urbanized areas. In general, however, intercity bus operators have little interest in providing purely local service entirely within rural or small urban areas.[6]

Indeed a rather unique set of for-profit modal options for rural transportation operations are the "multiple-use" carriers, in which vehicles primarily used for other functions, like mail distribution or school transportation, are simultaneously utilized for regular passenger transit operations. An interesting case study on the integration of public school and rural public transportation was reported in 1980 by transportation officials from Minnesota based on visit Hohenlohekreis in the Federal Republic of Germany (40 miles northeast of Stutgart). The purpose of the study was to describe ongoing rural public transportation project in that essentially rural area (of about 300 $miles^2$).

The demonstration project in Hohenlohekreis appears to have been a model endeavor insofar as there was an integration of public school traffic into public transportation, in order to achieve the twin objectives of reducing overall cost and making rural transit more useful and attractive to potential users. The principal achievement of that project was the coordination of all rural public transit (regular-route transit, school bus, intercity bus and rail, and elderly and handicapped services) in a given geographic area under one organizational entity. Its major contribution as a demonstration project was that it: 1) demonstrated that integration of rural public transportation and school transportation is feasible in the logistical sense; 2) that the cooperation of school officials in this process is essential; 3) that planning for this type of service requires considerable time and effort at the tactical level; 4) that the successful coordination of rural public transportation is contingent upon the existence of some entity at the institutional level to perform the coordinating tasks and 5) that there may be significant room for innovation at the planning level in paratransit services in whatever geographic context they might be encountered.[7]

Although a non-profit transportation brokerage agency, the Central Vermont Transportation Association (CVTA), which defines its domain as broadly as possible, works with several modes of public transportation in its attempts to create and integrate new forms of service delivery systems. While emphasizing innovative, economical, low-capital investment services that utilize existing resources as much as possible, CVTA has also coordinated the school bus system in the area in such a way that it will provide transportation to the rural inhabitants of the area: the latter are transported by school bus, during slack time, to and from activity centers.

Another for-profit "multiple use" modal option that should be included in the current taxonomy of rural public transportation systems are the "postal bus" transit operations. Although there are very few examples of these systems in the U.S., the Mt. Lassen Motor Transit Company of Red Bluff, California is an operational postal bus line that has been functioning since 1938. This mail, freight and passenger carrier follows a 110-mile route. However, the proceeds over the years from the steadily growing ridership constitute only a small fraction of total system revenues.

In the European context, the Swiss postal passenger service is the result of a long-term evolution that attempts to offer a satisfactory response to mail and passenger transportation needs in its rural cantons. Such response emphasizes efficiency for both users and the collectivities. Long-term experience has resulted in the following initiatives: (1) adaptation to a diffused demand with the highest possible flexibility and spirit of creativity, (2) integration of the transportation operations of all private and public companies in order to take advantage of their common resources, and (3) sharing the responsibility between regional and local authorities in order to ensure a budgetary balance between the operating companies.[8]

2.1.2 Dimensions and Structure of Taxonomy

The conceptualization of one dimension of a taxonomy matrix of rural public transportation systems can be introduced at this point. This dimension can be represented by a horizontal axis or continuum along which the basic financial operating structure of such systems could be oriented. If one were to classify the polar extremes of this horizontal continuum as being conversely either "for-profit" vs. "non-profit" entities, the previously outlined systems could be arrayed, in varying degrees, toward the +"for-profit" direction (please refer to ***figure 2.1.1***). At the opposite end of this spectrum, however, lie the vast majority of rural public transit modal options and operating systems.

It is a fact, substantiated during the course of of the present research, that all of the Section 18 RPT systems in Texas are arrayed somewhere on the "non-profit" side of the financial operating structure axis. One may even go so far as to assert that RPT is for the main a non-profit industry. The handful of examples cited above on the "+profit" side of the continuum basically exhaust all of the existing systems at that end of the spectrum whereas the list of non-profit rural transit entities is indeed a rather formidable one.

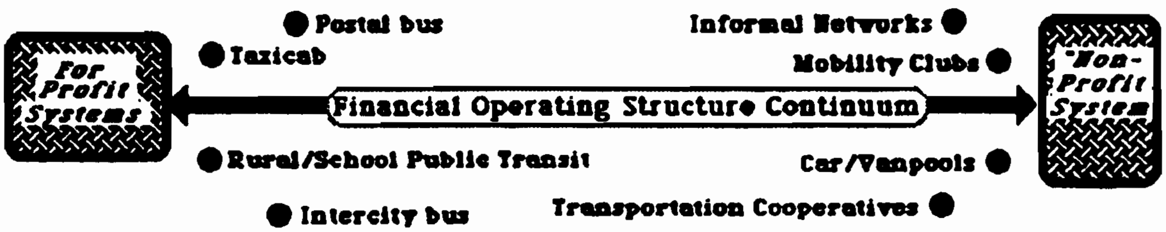


Figure 2.1.1

Financial Operating Structure of RPT Systems vis-a-vis Profit

Naturally, it would not be particularly useful in an operational taxonomy to simply lump all non-profit rural transit operations in a single class defined by the corresponding extreme of the financial operating structure dimension. Such a unidimensional taxonomy would be lacking in explanatory power, as it would include a non-profit brokerage in the same group as informal networks of friends and neighbors or carpooling.

The adequate development and formulation of the present taxonomy, therefore, motivates another axis in the vertical plane which would capture the degree of complexity of the organizational framework of individual rural transit system. Orientation along this dimension would be governed by the degree of formality or informality of structure of the administrative institutions of the respective individual transit system, as well as by the extent of its distance from or direct involvement with day-to-day system operations. In this scheme it can be expected that a rural transportation agency primarily performing a brokerage function would be positioned at one extreme of this dimension, that which is typified by a certain formality of organizational characteristics, yet removed from the daily functional tasks of transportation operations. The other polar extreme on this plane would include the independent operator, or informal networks with a minimum of organizational structure such as carpooling, friends-and-neighbors networks, mobility clubs, etc.

The resulting two-dimensional taxonomy is depicted graphically in ***figure 2.1.2,*** which is intended to convey keener perception of the nature of rural public transit systems.

A logical point of departure for a more concise review of the literature on the non-profit sector of the RPT industry systems could be the bottom end of the scale depicted in ***figure 2.1.2*** . Here, the less structured arrangements such as carpooling, informal friends-and-neighbors networks, mobility clubs, vanpools, etc. may be oriented. The initiators and providers of these services can be either individuals, loose-knit cooperatives, or sometimes employers. Undoubtedly the most noteworthy characteristic of the RPT systems at the lower end of the spectrum is <u>not</u> that they are demand-responsive type systems: on the contrary, all RPT systems include, for the main part, some form of demand-responsive transportation service: that which sets the latter apart is the lack of fixed-route service. On the other hand, by their very nature, the RPT systems which do offer some fixed-route service concomittantly imply and require the existence of a definite level of organizational structure and formalized operation. Consequently, they are at the upper end of the vertical scale in ***Figure 2.1.2;*** conversely those RPT operating systems at the lower end are generally characterized by the absence of "fixed-routedness" service.

Such an example of an informal, less structured RPT arrangement was the object of a 1975 case study in North Dakota.[9] The federally funded demonstration project, conducted by the North Dakota State Highway Department, was designed to test the validity of a transportation-cooperative concept in a sparsely populated rural area. The purpose of the project was to improve the mobility of people who were lacking adequate transportation and also to develop a model to be used and improved in similar areas across the state and nation.

The communities within the area of that study were not well served by public transportation; however, an informal public service already existed within those communities. Friends and neighbors of those in need of transportation assistance were providing it. Therefore, the goal of the demonstration project was to develop and expand on this already existing basic friends-and-neighbors approach to rural public transportation. The underlying hypothesis here is that the institutionalization of the friends-and-neighbors network of transportation assistance will

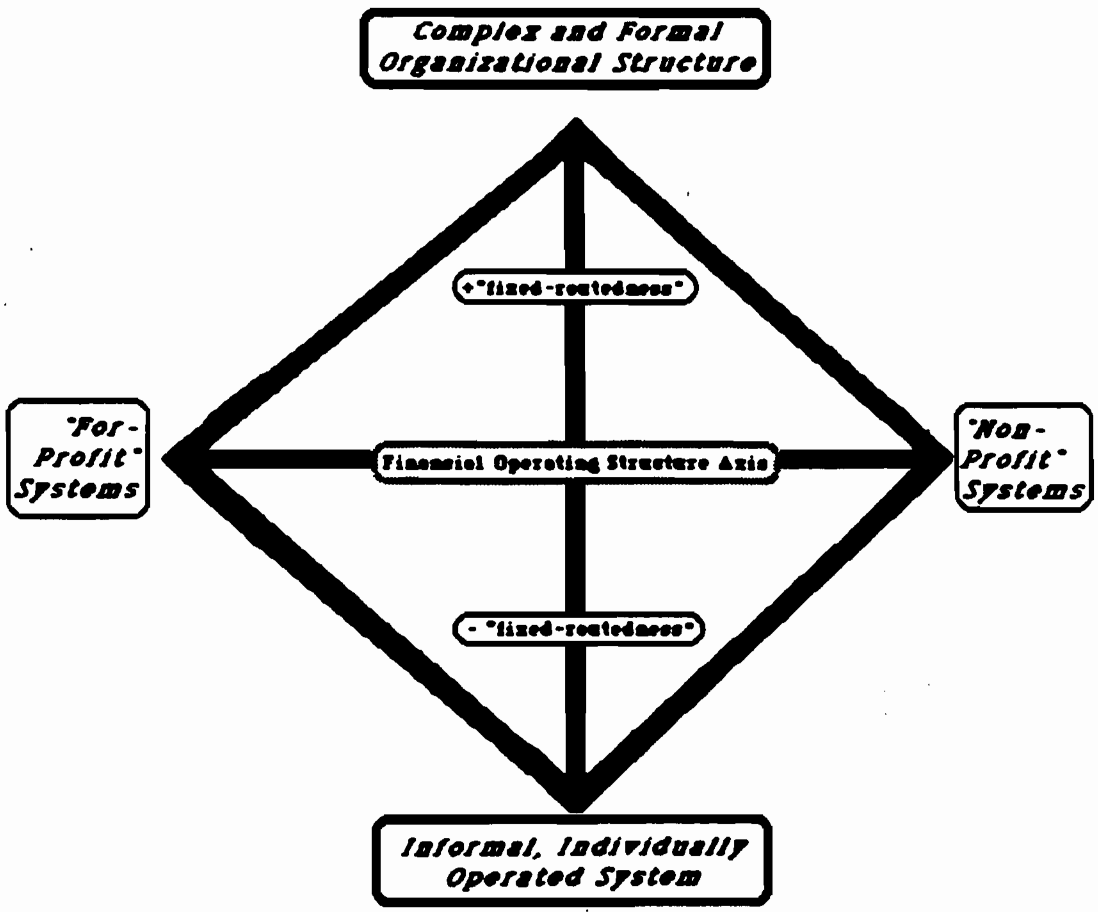


Figure 2.1.2

RPT Taxonomy Matrix

encourage more requests for mobility assistance (thus increasing the propensity and ability to travel) and, at the same time, possibly through the use of nominal remunerative incentives to drivers, increase the propensity to provide service.

It was found that a key success factor of this program was the formation in each community of a local transportation association. These informal agencies would coordinate the travel demands of those in need of transportation and the automobile drivers in the community who are willing to provide transportation. At the same time, they would actively try to increase the pool of volunteer drivers willing to give rides to those in need.

The diverse findings from this study were that (1) as it is a local service, operated by local individuals who are sensitive to local needs, the communities take a certain pride in the transportation association and thus promote its welfare; (2) since the organization structure is basically quite simple to administer, many individuals can help in the local managerial activities; and (3) the relatively small magnitude of this type of program is such that it can be continued by the local community associations with very little outside financial support.

The significance of the above study is that it typifies the development and trajectory that the majority of the non-profit public transit systems take from the point of inception. Many such systems have begun as loose-knit and informal networks, only to have gone on to become small agency-based service providers. It is also not uncommon, as is the case with systems like the Stagecoach project of Bethel, Vermont, for the small agency-based providers to grow further and develop into the next stage, namely that of the regional transportation brokerage.

In continuation, an overview is made of the Texas RPT systems, many of which are found in varying stages of this growth, i.e. from being small agency-based transportation providers to regionwide transportation brokerages which provide for a wide array of special mobility needs.

Section 2.2 A Profile of Rural Public Transportation Systems in Texas

The research design for the present study was principally motivated by the express purpose of assessing and characterizing the demand of rural public transportation in the state of Texas. In reviewing background material for rural public transportation, it was found that that there is considerable information regarding the context and type of operations of such systems from a general standpoint. It has already even been demonstrated that a systematic taxonomy for RPT is a feasible working concept, and that any system can be more or less appropriately classified in it with reference to its financial and institutional operating characteristics.

On the other hand, it was also evident that no widely accepted procedures were available for rural public transportation demand estimation. The considerable variation that is inherent from system to system, effectively precludes such universal estimation techniques which might be applicable on a nationwide basis, or even on a country-to-country basis.

Thus, the foremost methodological premise, around which the research design portion of the present demand estimation project revolved, suggested a definite need for, and therefore motivated the use of county-level data from the Texas systems for the demand estimation per se and for the related procedures that were developed. This was the primary consideration that served as the point of departure for the first phase of the development of a data base which ultimately integrates three components or sources of readily accessible information which are indispensable for the assessment, characterization and projection of the demand for rural public transportation in Texas. In effect, the three components which serve as the basis for the analysis and projections made in this study were 1) Quarterly Reporting Forms filed by Section 18 system contractors, 2) the information obtained from the "Mail-phone Survey written and conducted in conjunction with background research for this project, and 3) 1980 Census data which provided essential information concerning the population parameters in which Section 18 rural transit systems operate.

2.2.1 Data Base Development from Quarterly Reports

The initial data gathering endeav lead r ncipally to the acquisitition of the Section 18 system contractors' Quarterly Reporting Forms suomitted to the Texas State Department of Highways and Public Transportation. An analysis of the longitudinal data collected from these financial and statistical reports, that each contractor must file every quarter with the SDHPT, yielded a number of observations regarding the nature and the characteristics of the particular demand being served by each system. In essence, time series profiles of existing Section 18 systems in Texas were established processing about two to three years of quarterly reports (some with fewer quarters due to their more recent start-up date) of approximately sixteen systems (please refer to ***table 2.2.1*** for specific details on systems).

Graphic representations of chronological data on ridership revealed the size and composition of the demand in terms of one-way passenger trips [recorded every time a passenger boards a vehicle]. The ridership demand has been decomposed into time-series profiles of the total demand and that by categories of riders: non-subsidized, elderly, handicapper outh and ow income (cf. ***appendices 2.A*** and ***2.B*** found at the end of this chapter).

In some instances it is evident that the variability observed in a particular system demand is caused by mediating factors such as seasonality, fluctuations in the amount of use being make by specific categories of passenger groups, changes in the level of service being offered which are primarily due either to breakdowns or acquisition of new vehicles, etc.

The time-series ridership data for each system lends itself somewhat favorably to the projection of trends in growth of demand through the simple fitting of an exponentially smoothed curve; as such, random fluctuations are removed and done is left with the basic trend, as depicted in ***figure 2.2.1***. Clearly, these system demands have been taking off with unmistakableestimation momentum--minor decline in growth is manifest in only one instance and this is due ostensibly to vehicle breakdowns, which constitutes a supply-side constraint or limitation.

TABLE 2.2.1. A BREAKDOWN OF TEXAS SECTION 18 RPT SYSTEMS IN THE DATA BASE

Case Number	Name of System	Counties Included	'80 Population	Service Area (sq. miles)	Market Share (% of Av. Quarterly Demand)
1	Bosque County	Bosque	13,401	985.4	2.30%
2	Brazos Transit	Brazos, Burleson, Grimes, Leon, Liberty, Madison, Montgomery, Walker, Washington	379,086	7,224.8	13.70%
3	Caprock Comm. Action	Crosby, Dickens, Floyd, Hale, Motley	61,774	4,777.6	4.70%
4	Capital Area Rural Trans.	Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Travis, Williamson	637,529	7,558.1	18.60%
5	Lower Rio Grande Valley Develop. Council	Cameron, Hidalgo, Willacy	510,451	3,063.9	13.80%
6	San Patricio (SPARTS)	Aransas, San Patricio	72,273	973.8	7.30%

(continued)

TABLE 2.2.1. (Continued)

Case Number	Name of System	Counties Included	'80 Population	Service Area (sq. miles)	Market Share (% of Av. Quarterly Demand)
7	South Plains (SPARTAN)	Bailey, Cochran, Garza, Hockley, Lamb, Lynn, Terry, Yoakam	91,713	6,990.3	2.80%
8	Aspermont	Haskell, Jones, Stonewall, Kent, Knox, Throckmorton	35,926	5,370.1	0.10%
9	Bee Community Action Agency	Bee, Live Oak, MacMullen, Refugio	45,714	3,830	4.60%
10	Cents Project	Palo Pinto, Parker, Somervell	72,825	2,038	11.00%
11	City of Cleburne	Johnson	67,649	730.6	2.10%
12	Comm. Council of Southwest Texas	Dimmit, Edwards, Kinney, La Salle, Real, Uvalde Zavala	57,569	9,774	4.60%
13	Freestone County Senior Services	Freestone	14,830	888	1.30%

(continued)

TABLE 2.2.1. (Continued)

Case Number	Name of System	Counties Included	'80 Population	Service Area (sq. miles)	Market Share (% of Av. Quarterly Demand)
14	Hill Country Community Action	Bell, Coryell, Hamilton, Lampasas, Llano, Mason, Mills, San Saba	259,461	7,421.7	11.20%
15	Kleberg County Trans. Services	Kleberg, Kennedy	33,901	2,211.4	1.90%
16	Rolling Plains Campus of the Texas State Tech. Institute	Nolan, Taylor	128,291	1,830.4	1.20%

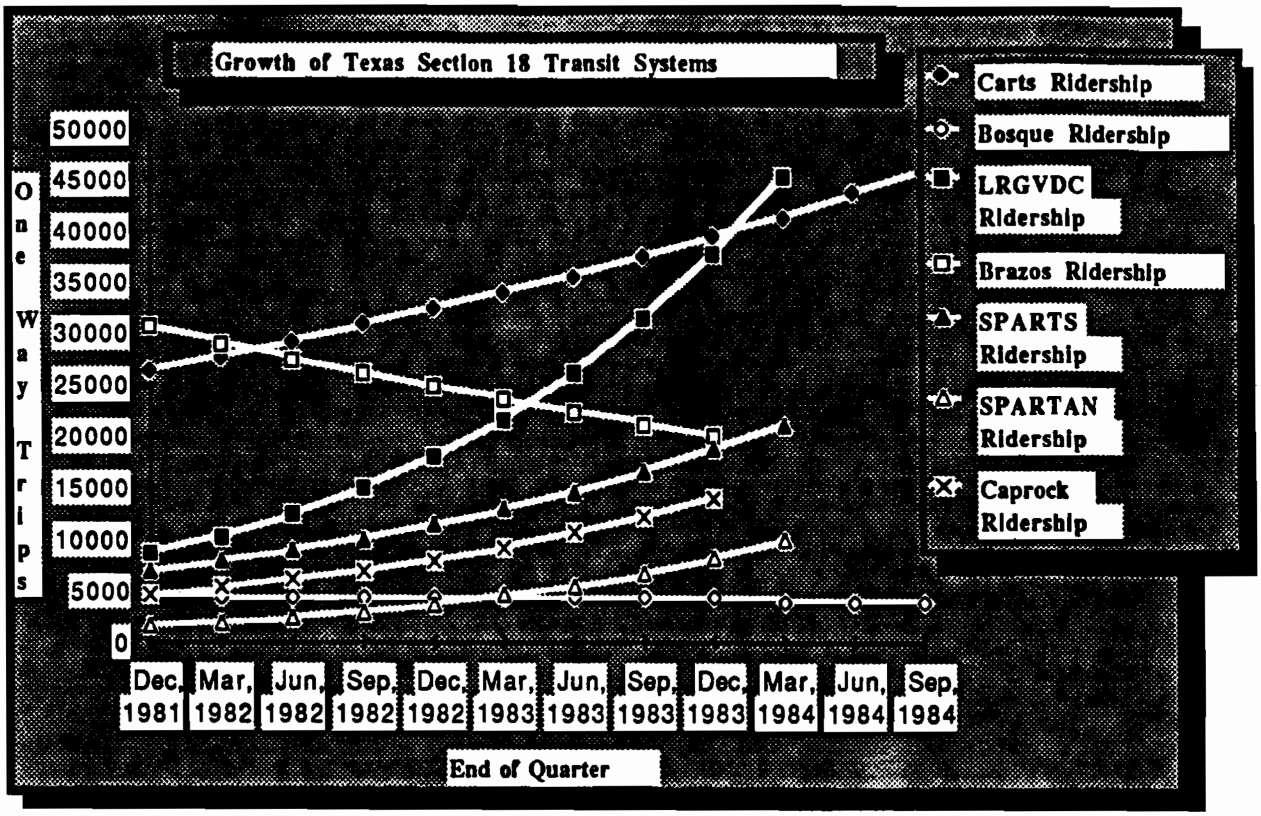


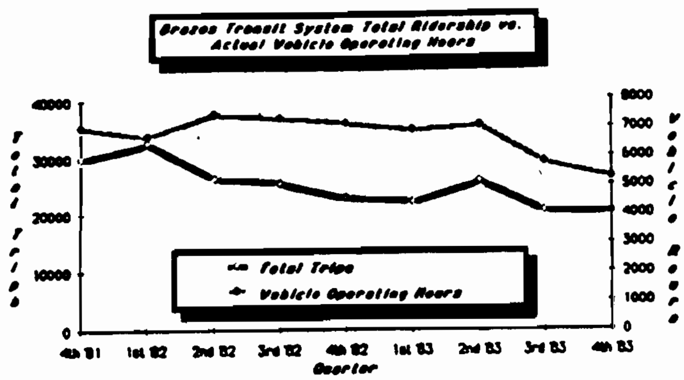
Figure 2.2.1

The data from the quarterly reports was also arranged in spreadsheet format which facilitated the calculation of certain performance variables that are useful in determining system operating efficiency and effectiveness; included among these variables are (1) cost per vehicle mile, (2) cost per passenger trip, (3) percent vehicle operating capacity, (4) ridership per route mile, (5) ridership per vehicle hour, (6) average trip length, etc.

In general, the interrelation of ridership and system characteristics--namely the level of service supplied--is one that needs careful examination in order to uncover the determinants of the observed demand. Therefore, the demand estimation models must be sensitive to system supply characteristics: one cannot assume a supply-independent demand. Moreover, it is not meaningful to assume unlimited service availability given the severe budgetary constraints under which these systems typically operate. Service supply information, subsequently used in the calibration of demand estimation equations, was available from the system reports in the form of maximum hours of service operation provided by the transit system vs. actual hours of service operation. A subsequent comparison of the total ridership on a system-by-system basis clearly established the fact that it changes over time in stepwise synchronization with the maximum hours of operation offered by the system (cf. ***figure 2.2.2*** for one example).

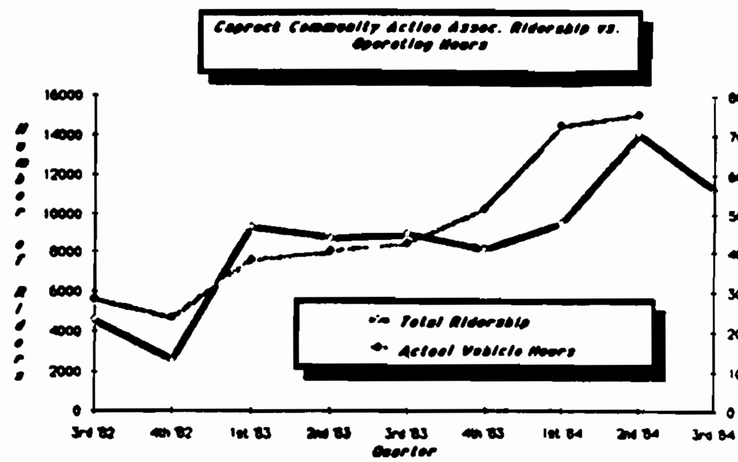
Finally, financial data concerning system revenues--whether from funding sources, donations or limited fare income--and the various expense categories related to operating, capital and administrative outlays were found to be

BRAZOS RIDERSHIP VS VEHICLE OPERATING HOURS



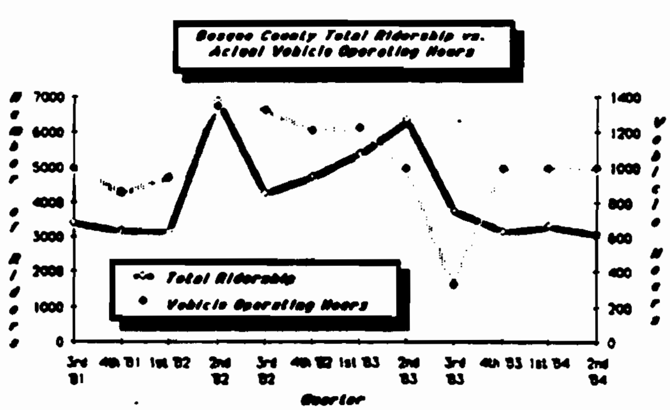
BRAZOS VALLEY COMMUNITY ACTION AGENCY/BRAZOS TRANSIT SYSTEM

CAPROCK RIDERSHIP VS ACTUAL VEHICLE OPERATING HOURS



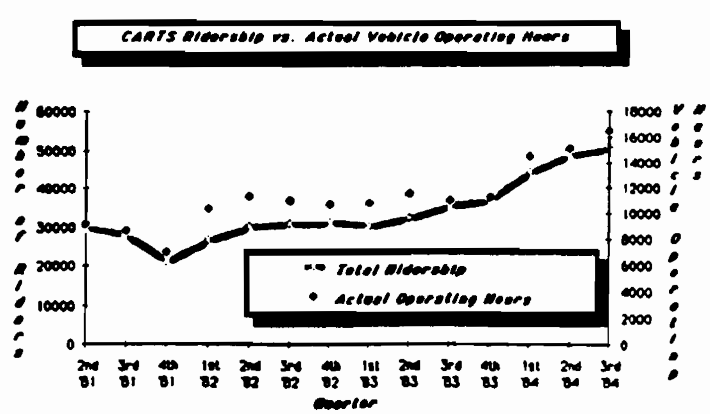
CAPROCK COMMUNITY ACTION ASSOC, INC

BOSQUE TOTAL RIDERSHIP vs. ACTUAL VEHICLE OPERATING HOURS



BOSQUE COUNTY SENIOR SERVICES RIDERSHIP PROFILE

CARTS RIDERSHIP VS. ACTUAL VEHICLE OPERATING HOURS



CAPITAL AREA RURAL TRANSPORTATION SYSTEM

Figure 2.2.2

contained by the reports. This information can provide the input for developing cost models of the transit system operations.

2.2.2: Survey of Section 18 System Operators in Texas

The second component in the compilation of a data base for the Texas RPT systems for use in the demand estimation was motivated by the realization that no adequate information on the type of service offered by the individual transit systems was available in one source. It became apparent that each system had its own particular dynamics with respect to the stage and rate of growth or development which it was encountering. The systems seem to be in a somewhat continual state of change: many are relatively new; some are smaller in scale; and among the latter, there seems to be a tendency of premature folding presumedly because of difficulty in keeping up their stipulated share of local matching funds.

These circumstances motivated the decision to conduct a survey in order to obtain the individual systems' service features. The survey was conducted either by a telephone interview of key personnel, or in the cases where this was not feasible, through the mail. The survey questionaire which was developed included inquiries into the following items: (1) the service area covered; (2) routes and types of service; (3) purposes and fluctuations in number of trips; (4) vehicles used; and (5) the composition of the users. Furthermore, an additional section was provided which allowed for open-ended remarks by the respondent. This produced some needed concrete information as some very useful insights into the nature of each system and into that of RPT on a more general level (a facsimile of the survey instrument can be found in ***Appendix 2.C***)

Out of of twenty eight contractors operating in Texas, seven were excluded from the target list for being only then in the first quarter of operation. Of the remaining twenty one contractors, sixteen participated in the survey, thus constituting a response rate of approximately seventy-six percent. It was determined that non-response was due to such factors as inability to make contact with the individual system personnel [e.g. change of address, telephone number, etc.] or, as in one instance, the manager's unwillingness to participate in the survey because of time constraints.

The findings from the *"Mail-phone Survey of Section 18 Contractors"* are reported hereafter as illustrative case examples of of the types of contexts, concerns, goals, and objectives facing RPT system managers and service providers.

The Capital Area Rural Transportation System (CARTS) is a Section 18 rural transportation system coordinating agency which also acts as a brokerage office and as a conduit for federal funds to recipients that come under its organizational umbrella in a nine-county area. CARTS links seven otherwise isolated rural pockets into a transit network, and strives to increase the mobility of residents in the rural areas around Austin with the help of federal, state and local subsidies. CARTS operates through local contractors who provide transportation with vans and special lift-equipped vehicles. The contractors establish schedules best designed to meet the local population's need for transportation to health care, shopping, recreation, public services and work. One of the main objectives of the service provided by CARTS is to be trip assurance for rural residents. Essentially anyone can ride CARTS, yet service is targeted specifically to increase the mobility of the elderly and mobility- impaired, particularly to provide access to medical services and shopping facilities, and thus be able to lead independent lives. CARTS presently has one commuter route from Elgin to Austin with fares set to cover costs only. Other commuter routes have been developed recently, as mentioned in the previous chapter, and other contractors may help commuters arrange carpools. CARTS has basically existed to support, coordinate and improve the services of nine local (county level) community organizations over the years.

One of the local community organizations coming under the umbrella of the CARTS network is Combined Community Action of Smithville, Texas. In the first quarter of 1985, CCA provided 20,727 rides to passengers in Bastrop, Fayette and Lee counties. The philosophy behind the operation of CCA is to provide the best possible service to the most possible passengers. It is felt that CCA must be made better known to potential users and its service more available to the public. Plans for accomplishing this include greater use of fixed-route options and a fare structure for those who have the ability to pay. It is thus hoped that CCA can become more efficien by taking few vehicular trips and carrying more passengers, yet without compromising the basic service and close attention that the elderly and handicapped clientele deservedly are due.

In an interview with the manager of CARTS, the upcoming year's business plan was discussed, particularly the proposed transition from a "social service"-type organization to a transit system with a fare structure in place. It is anticipated that such a transition would generate much needed revenues to help defray the costs of providing a viable service. This is not to say that the mainstay eligible ridership [i.e. the elderly, handicapped, low income, rural-dwelling sectors] would be abandoned. On the contrary, introduction of a fare system would help to better serve existing passengers. The underlying logic is to better utilize existing resources; for instance, on an inner city portion of a primarily rural transit loop, the operator could take on those passengers otherwise unserved yet able to pay a fare? In his own words, the CARTS manager characterized the alluded transition to the installation of a fare structure as a "quantum leap" in the development of a rural public transportation system.

This transition corresponds to a stage that several rural systems are currently experiencing. These systems are considered by some to be on the "leading edge" of the Section 18 contractors. Transit managers at this stage are preoccupied with, among other things, marketing and advertising strategies for their service. There is a particular need for publicity and promotion of RPT within the community in order that potential passengers may become aware of the availability of the service, particularly outside the core ridership of transportation-disdvantaged individuals. If, for example, a mother is too ill to drive her child to school, it would be useful for her to know that there is an alternative means of transportation for her child's needs. If a commuter's car breaks down, he should know that a ride may be available to him.

The desirable message of such advertising would also concomittantly reposition RPT in the mind of the consumer [i.e. passengers]. Additional findings from the telephone survey of Section 18 contractors revealed a latent desire to enhance the image and the status of RPT in the public's mind. In general, the association is unhappily made that the users of RPT services either come from, or are close to, the ranks of poverty. There quite possibly may even exist a self- or socially imputed inferiorization involved with the personal use of such service.

Therefore, RPT's realignment among the community as a viable transportation option rather than a symbol of poverty is a goal desired by most operators.

Another important role of advertising was typified in the comments which were made in response to the telephone survey by the RPT system manager of the Aspermont Small Business Development Center, Inc. enterprise in Aspermont, Texas. The Aspermont system is basically a one-vehicle, demand-responsive system in a six-county area of which thé largest town has a population of 7,000. It provides service mainly for medical visits and shopping- related travel purposes. Relative to RPT contractors, it was observed that their advertising creates an awareness of the desirability of consumer utilization of the service, and correspondingly induces first-time riders and influences their decision to become loyal users. Therefore, insofar as the non-captive demand for RPT might be relatively sensitive to levels and types of advertising, it would be desirable to incorpc this as one of the intervening variables in a demand estimation procedure. Of particularyly significant interest, of course, would be to determine the elasticity of demand to advertising. However, this is not a readily quantifiable research construct within the scope of the present study insofar as data on levels of advertising expenditures and types of media utilized are simply unavailable.

The type of advertising strategy that can be followed to promote the concerns of RPT operators is exemplified by the plan devised by the Aspermont RPT system for publicizing that organization's service within the community. The manager of that system outlined a four-pronged advertising campaign in which a) public service commercials would be broadcast either by radio or television media, b) advertisements would be placed in local newspapers, c) informational public addresses would be presented at the meetings of OUTREACH workers, and d) information would be disseminated at senior citizens' centers thereby targeting elderly passengers. However, it should be noted that, for the time being no advertising was actually being undertaken regarding the availability of the Aspermont RPT service. The reason is quite simple: generating a demand that cannot be met with existing levels of service would necessitate the refusal of potential passengers, an outcome that is considered higly undesirable.

A system which provides a variety of dynamic social services operating in a tri-county area, the sociodemographic characteristics of the population of which were respectively decsribed as being low income, high poverty, high rate of unemployment, and a proportionately high migrant population, is the Lower Rio Grande Valley Development Council (LRGVDC). The Section 18 Program there consists of three subsystems: the Rural Public Transit System (RPTS), the Tropical Texas Center for Mental Health and Mental Retardation System (TTC for MHMR) and the Amigos del Valle, Inc. Rural Transportation System.

The LRGVDC sub-contracts with the TTC for MHMR for provision of transportion services to mentally handicapped persons and with the Texas Department on Aging for provision of transportation services to Amigos del Valle, Inc.'s elderly.

The Rural Public Transit System is administered and operated through the LRGVDC and serves four rural fixed routes in the three-county area. The persons desiring transportation either wait for the bus at its designated bus stops or can board at any point along those roads and streets where the bus runs. These routes transport rural residents into the closest major city(ies. There are no eligibility criteria for service and the program serves the general public.

The Tropical Texas Center for Mental Health and Mental Retardation System comes under the administration of the LRGVDC but is operated by Department of Mental Health and Mental Retardation. This program transports MHMR's mentally ill clients to service centers and back home and can be classified as a hybrid of fixed route and demand-responsive, door-to-door system. Each center has its clients that are brought into the center daily unless the client notifies them in advance that they will not be coming on a particular day. Transportation to medical, shopping and recreational facilities is also provided. This system provides transportation services to twelve different mental health sites within the three counties. The main criterion for utilizing this system consists of being an MHMR client; however, when seat capacity is available, the program is open to the general public.

The Amigos del Valle, Inc. transportation program is administered by the LRGVDC but is operated through Amigos del Valle. This program provides transportation service to the rural elderly from their homes to nutrition sites and service centers. This program can also be defined as a hybrid of fixed route and door-to-door service, and is virtually identical to the TTC for MHMR.

As can be seen from the above discussion, there exists a wide variety of modal options and service types in rural areas in Texas and elsewhere. A key element in the design, evaluation and selection of service options consists of the determination of the characteristics of the existing and potential demand. Once this is accomplished, then the type of service and modal options, in terms of the kinds of vehicles used, service configuration, etc., can then be integrated and matched with the specific needs of the community to be served. In other words, the mobility needs of rural area residents should be the point of departure in the design and planning of the transit system. The next chapter focuses on the nature of the demand in the Texas area systems in order to facilitate future needs-based approaches to rural transit planning.

Section 2.3 Notes to Chapter Two

[1]Hart, Kathy, "Using Taxis to Provide Rural and Small Urban Area Transportation" in *Proceedings of the First National Conference on Rural Public Transportation*, October 1976, Douglas J. Mckelvey, editor. (DOT-TST-77-11) pp. 128-132.

[2]*Ibid.*, p. 128.

[3]*Ibid.*, p. 130.

[4]Wolf, Jr.; Audley, "T.R.I.P.: A Transportation Demonstrtation Project in West Virginia" in *Proceedings*, pp. 212-218.

[5]Hayden, Linda, "Rural Public Transportation," unpublished monograph. Transportation Education Project, West Virginia University, 12 June 1985. p. 27.

[6]Webb, Charles A. "The Role of Inter-City Transist," in *Proceedings*, pp. 153-157.

[7]Fausch, Peter A., "Integration of Public School Transportation: Hohenlohe, Germany, Case Study," in *Rural Public Transportation: Fifth National Conference Proceedings*, Transportation Research Record No. 831, Washington D. C., 1981. Pp 56-59.

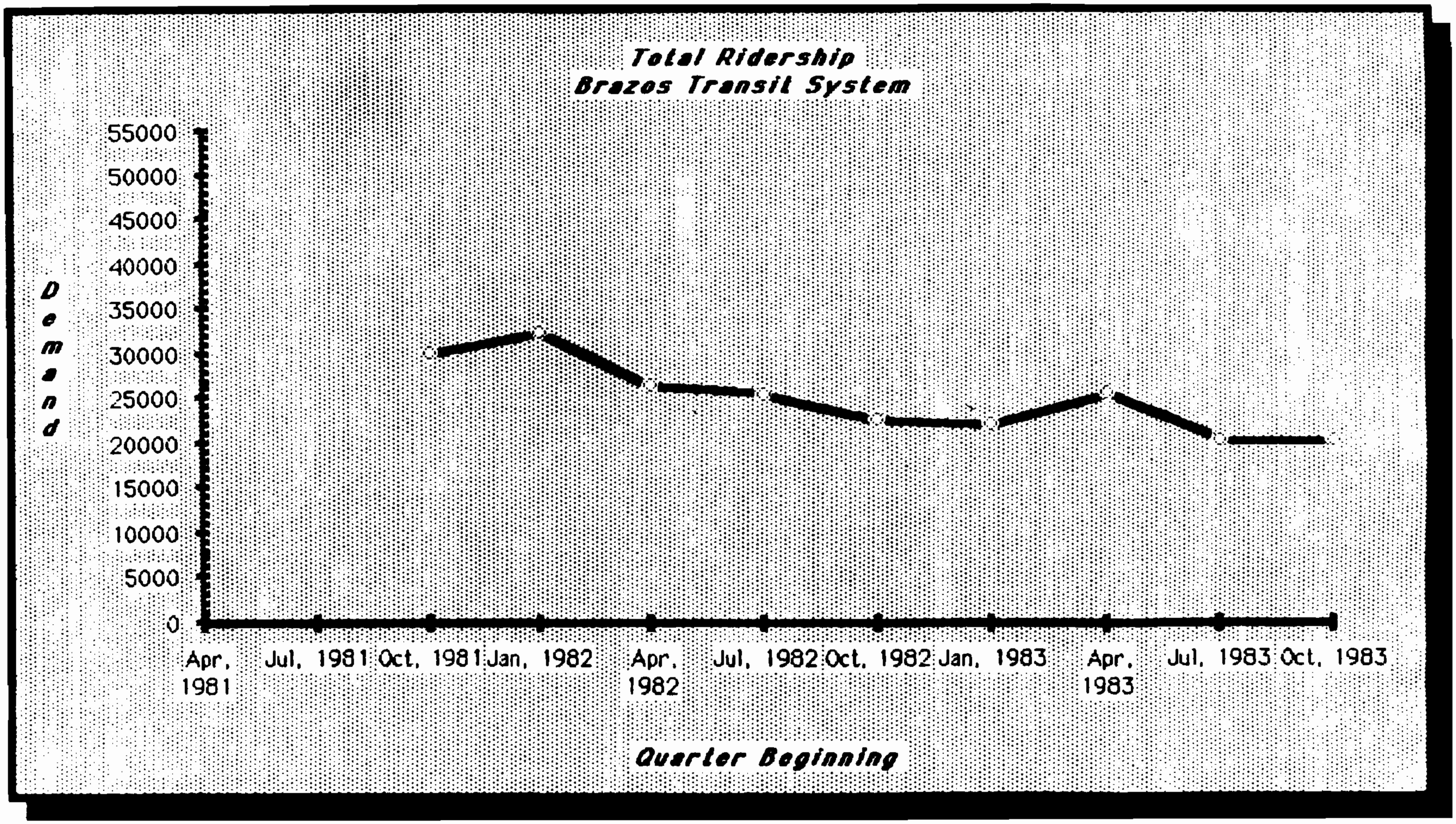
[8]Genton, David L. and G. Rathey, "Swiss Postal Passenger Service" *Ibid.*, pp. 59-62.

[9]Weaver, Clayton V. and Barry D. Lundberg, "Rural Public Transportation: North Dakota Case Study" in *Transportation Planning Techniques for Small Communities*, Transportation Research Record No. 638, Washington, D.C., 1977. Pp. 44-46.

APPENDIX 2.A

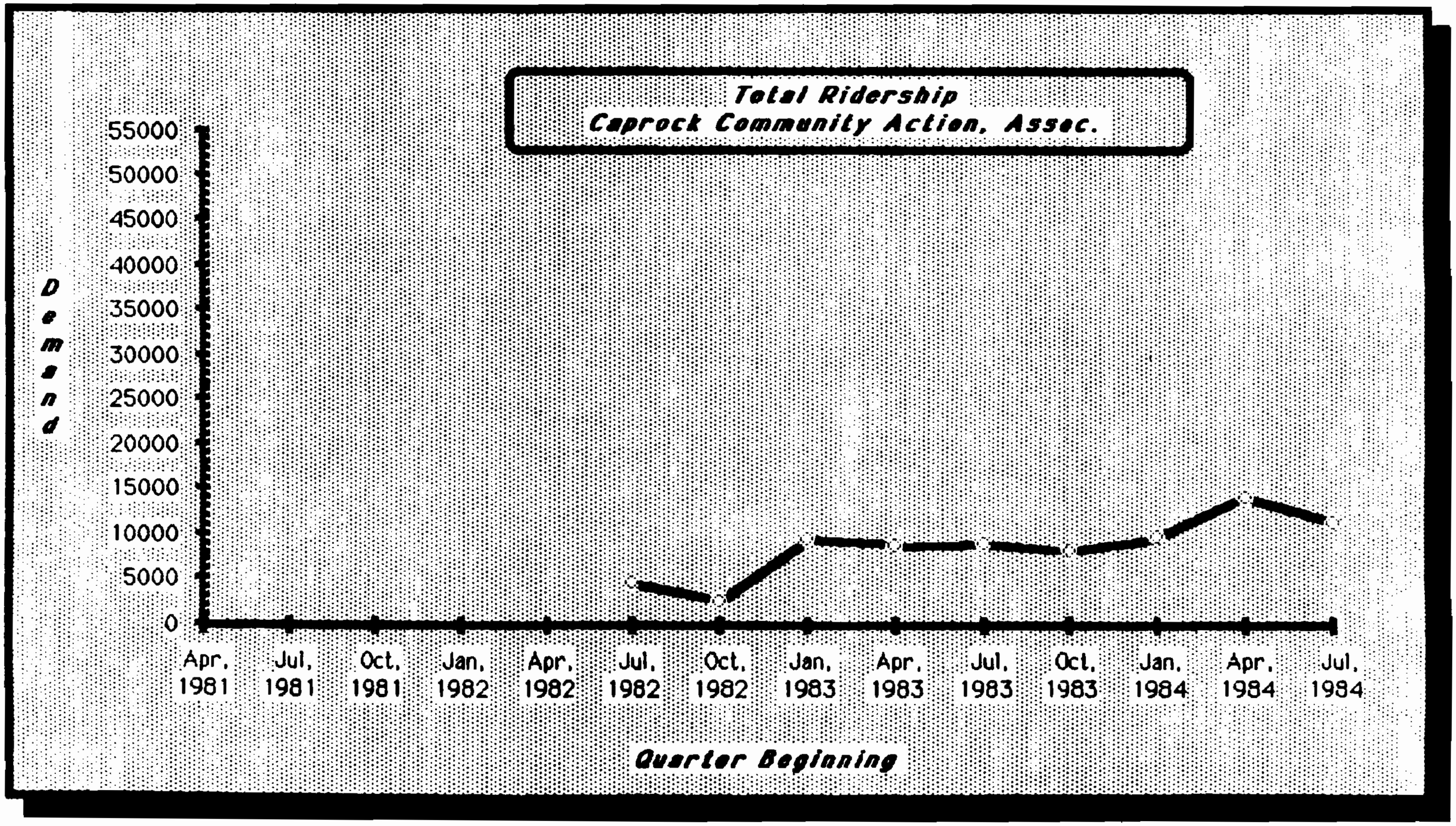
TIME-SERIES PROFILES OF TOTAL SYSTEM RIDERSHIP DEMAND

TOTAL DEMAND OF ONE-WAY PASSENGER TRIPS



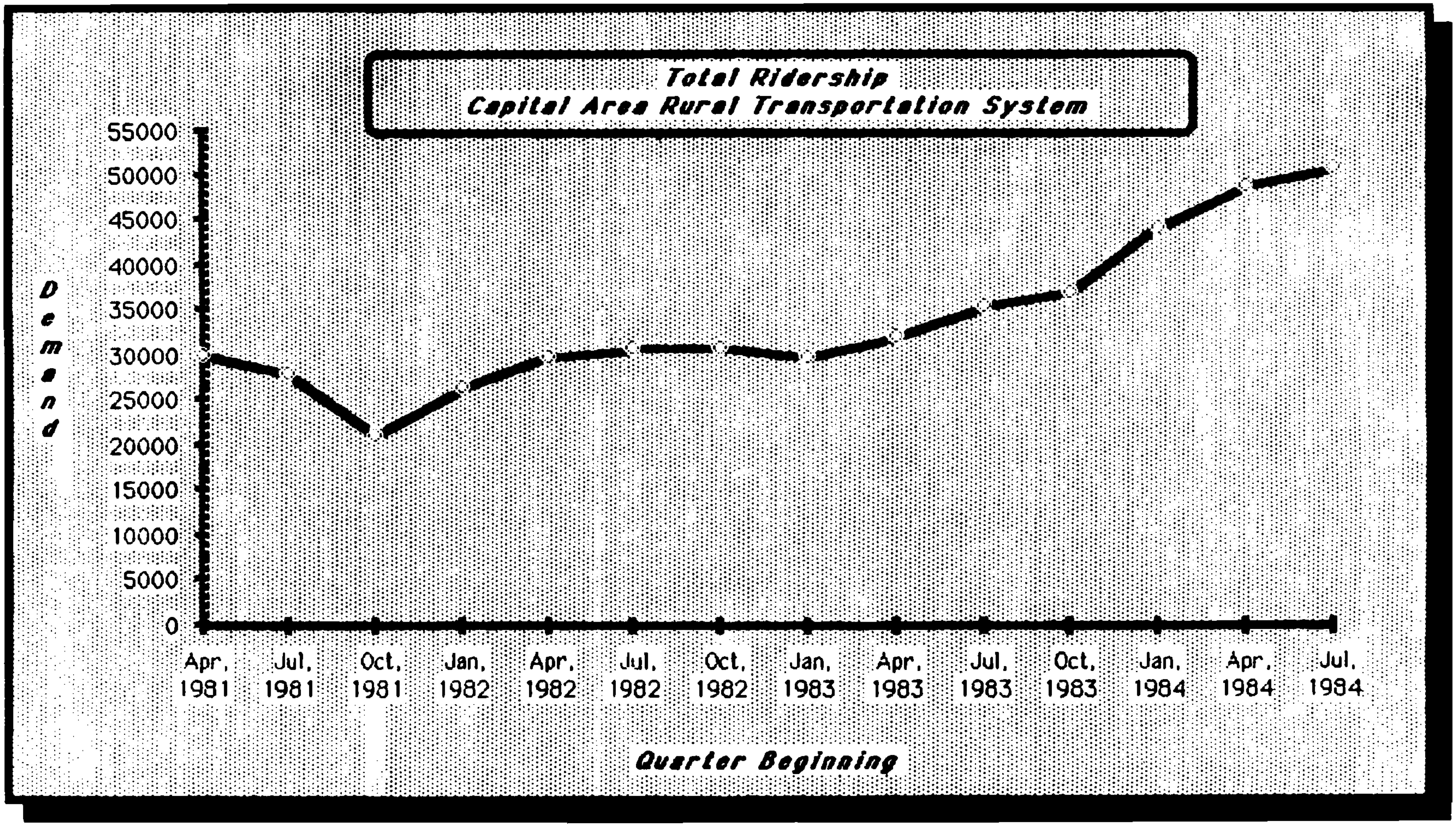
BRAZOS TRANSIT SYSTEM

TOTAL DEMAND OF ONE-WAY PASSENGER TRIPS



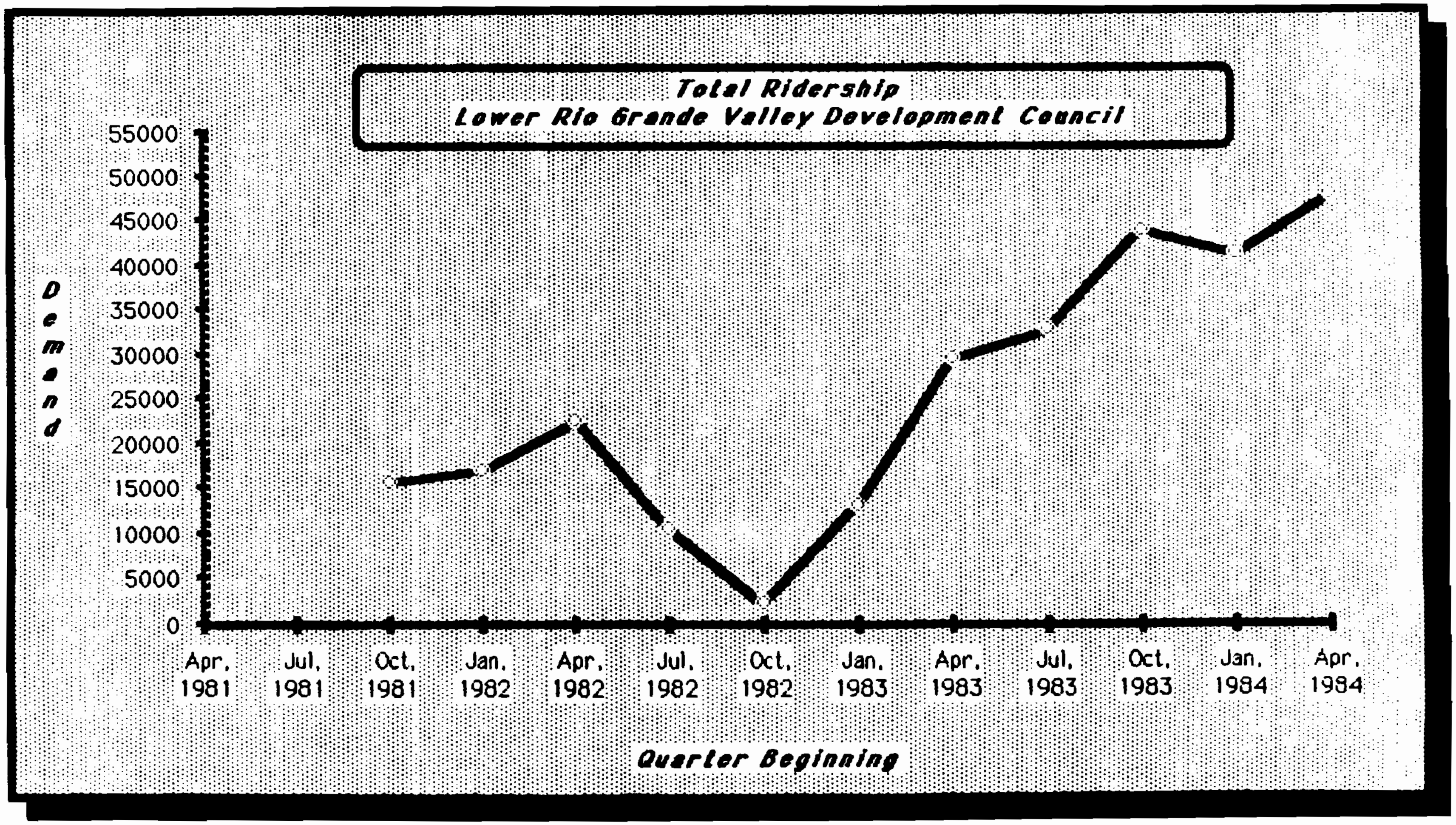
CAPROCK COMMUNITY ACTION, ASSOC.

TOTAL DEMAND OF ONE-WAY PASSENGER TRIPS



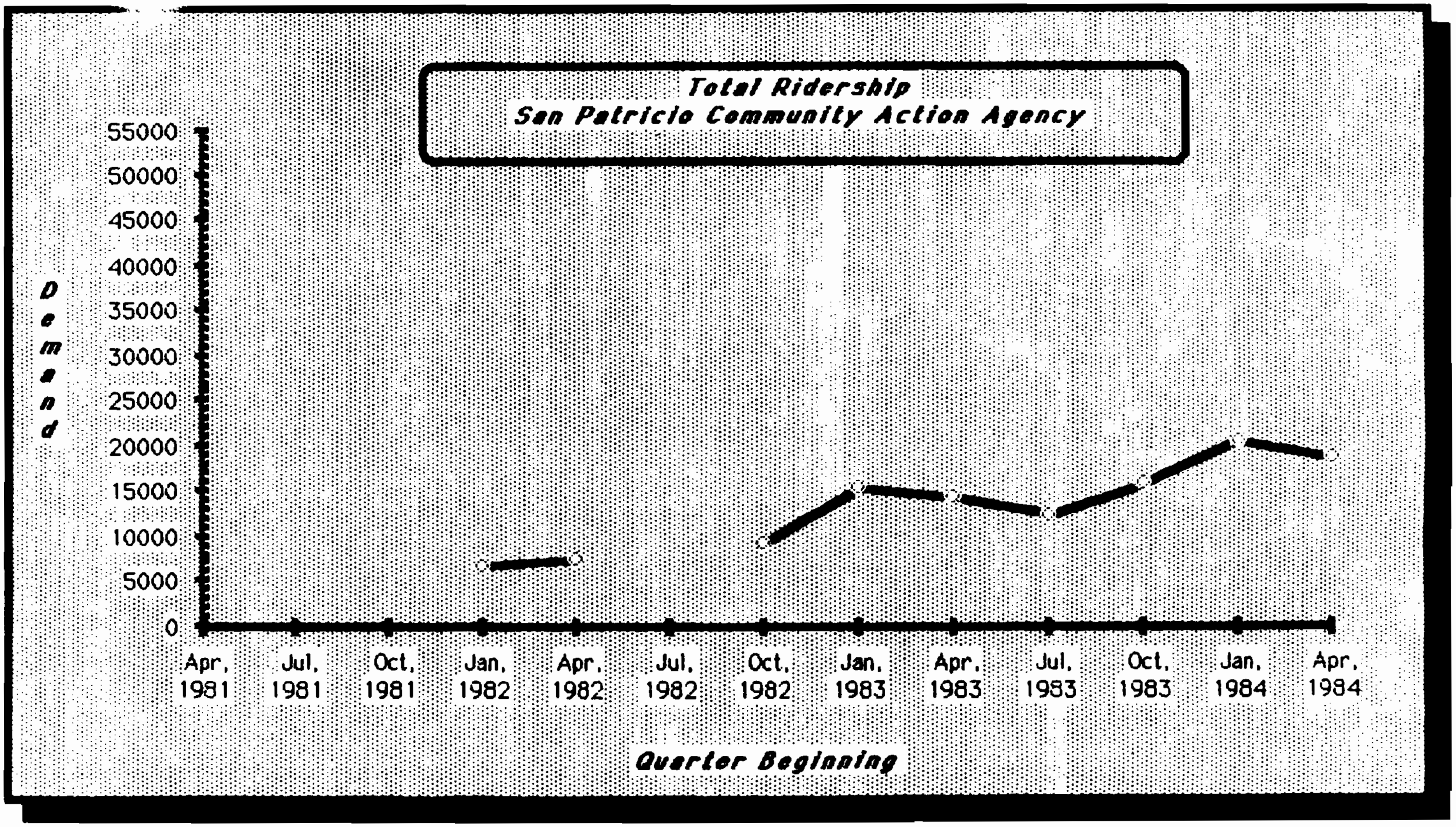
CAPITAL AREA RURAL TRANSPORTATION SYSTEM

TOTAL DEMAND OF ONE-WAY PASSENGER TRIPS



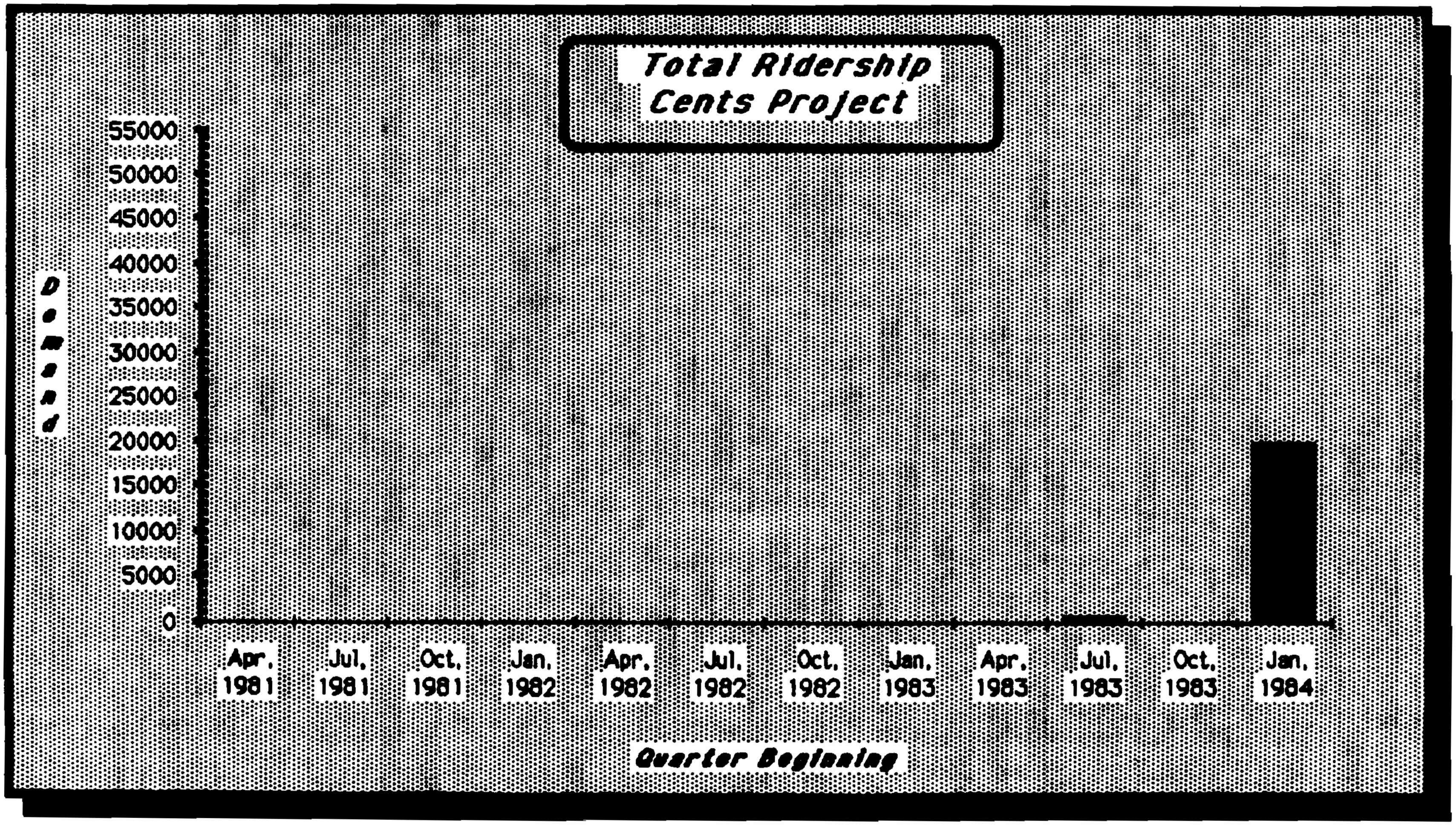
LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL

TOTAL DEMAND OF ONE-WAY PASSENGER TRIPS



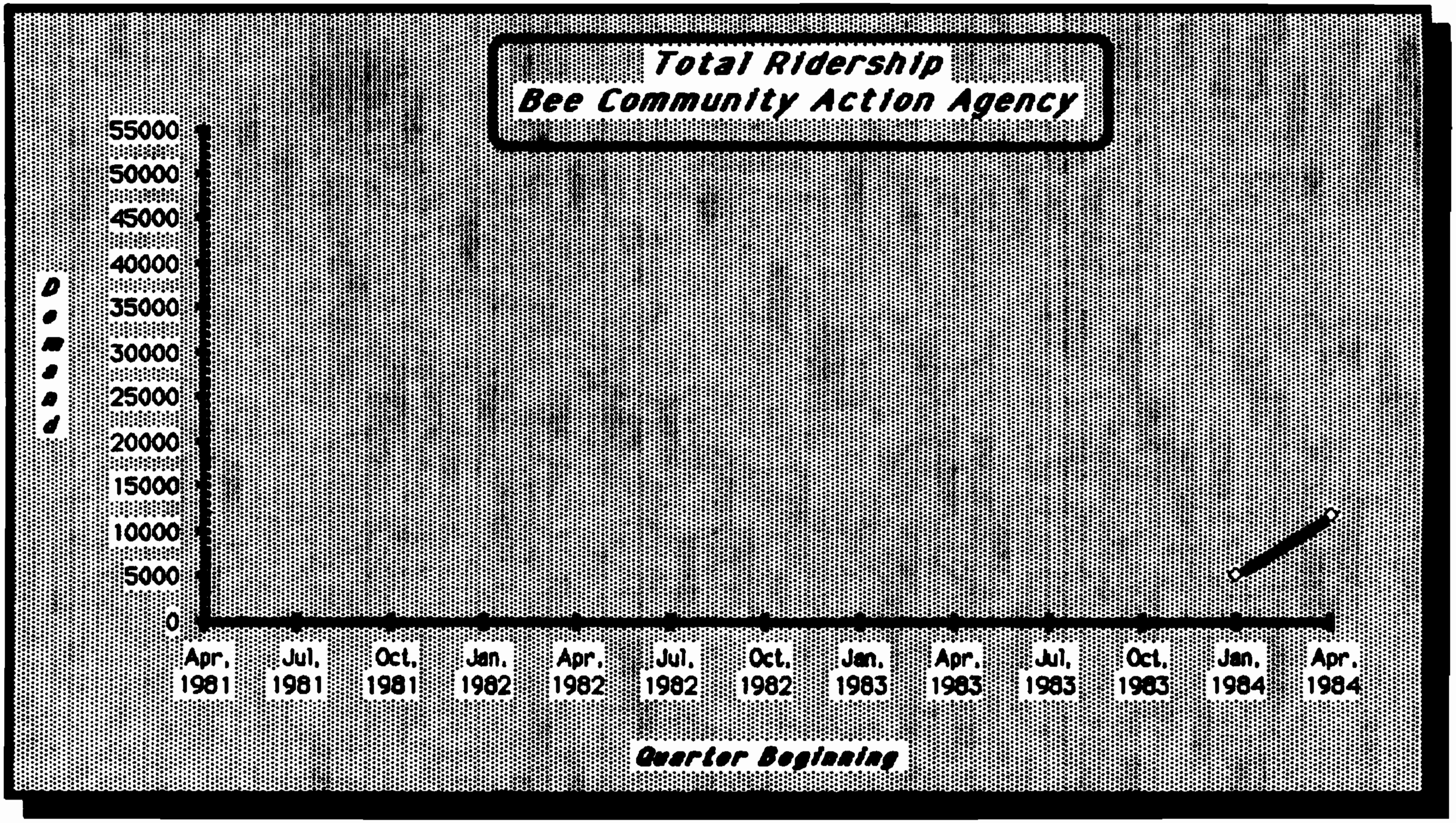
SAN PATRICIO COMMUNITY ACTION AGENCY

TOTAL DEMAND OF ONE-WAY PASSENGER TRIPS



CASE TEN: CENTS PROJECT

TOTAL DEMAND OF ONE-WAY PASSENGER TRIPS

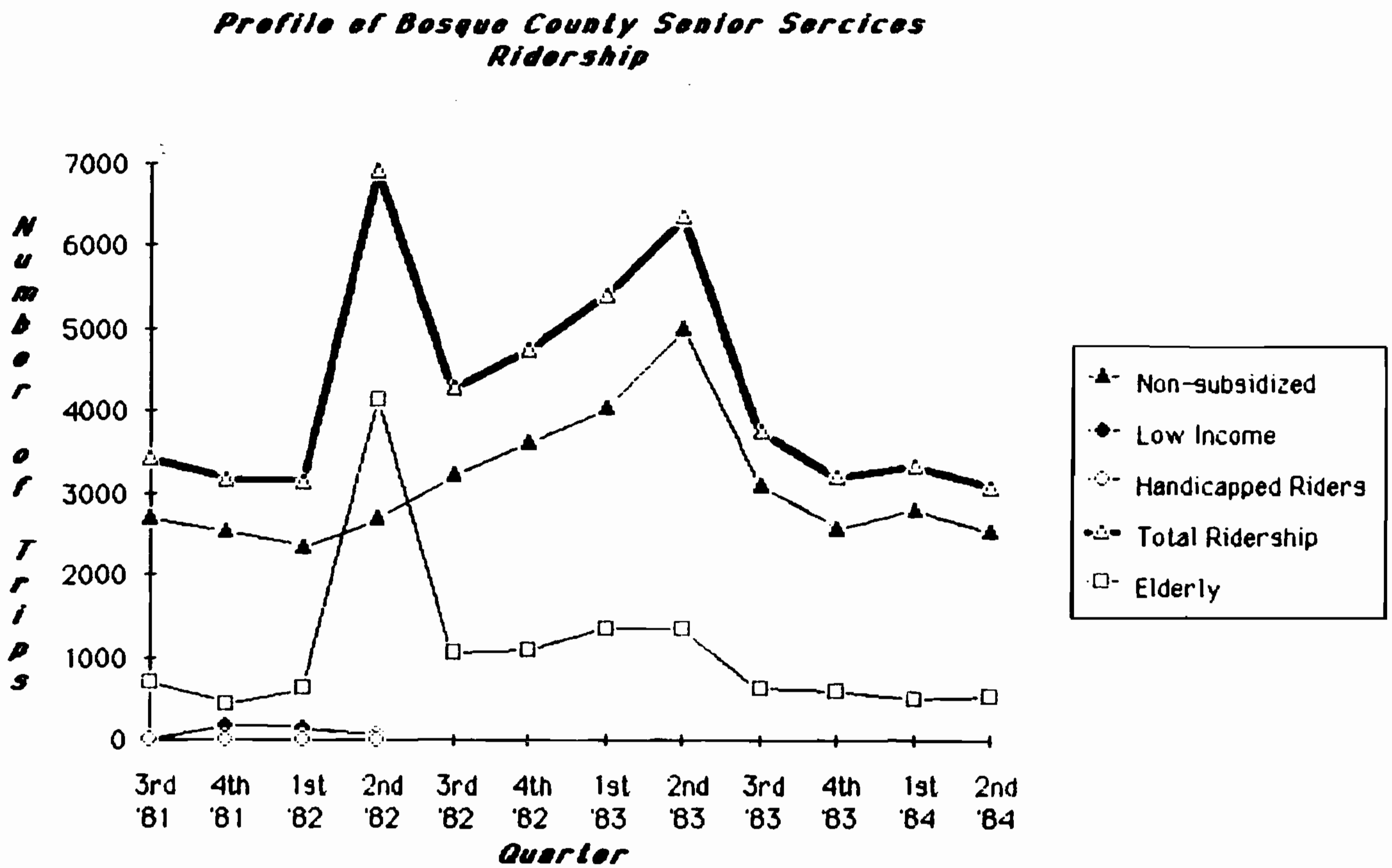


CASE NINE: BEE COMMUNITY ACTION AGENCY

APPENDIX 2.B

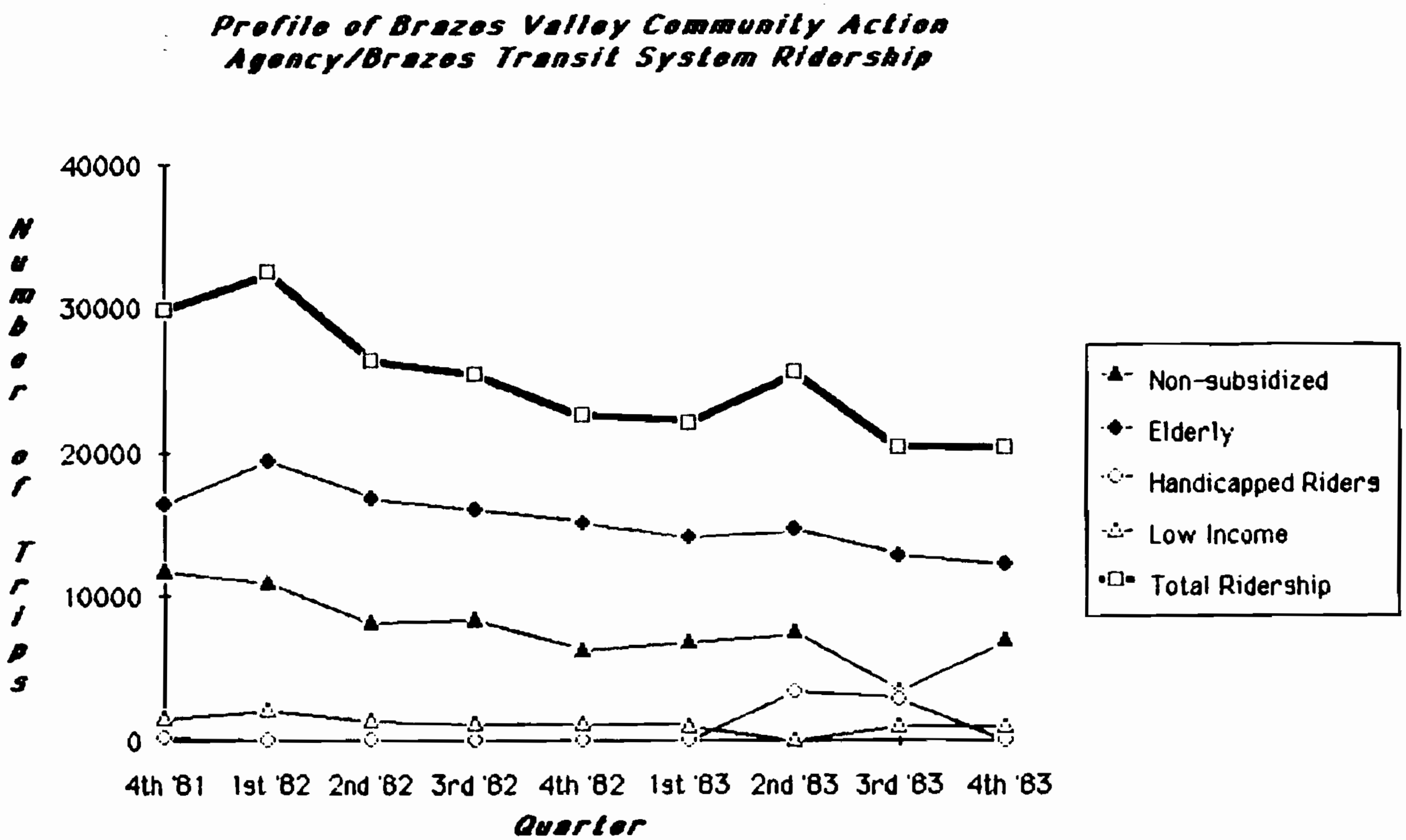
DECOMPOSITION OF TIME-SERIES DEMAND PROFILES INTO THE VARIOUS SOCIODEMOGRAPHIC CATEGORIES OF RIDERSHIP

RIDERSHIP PROFILE



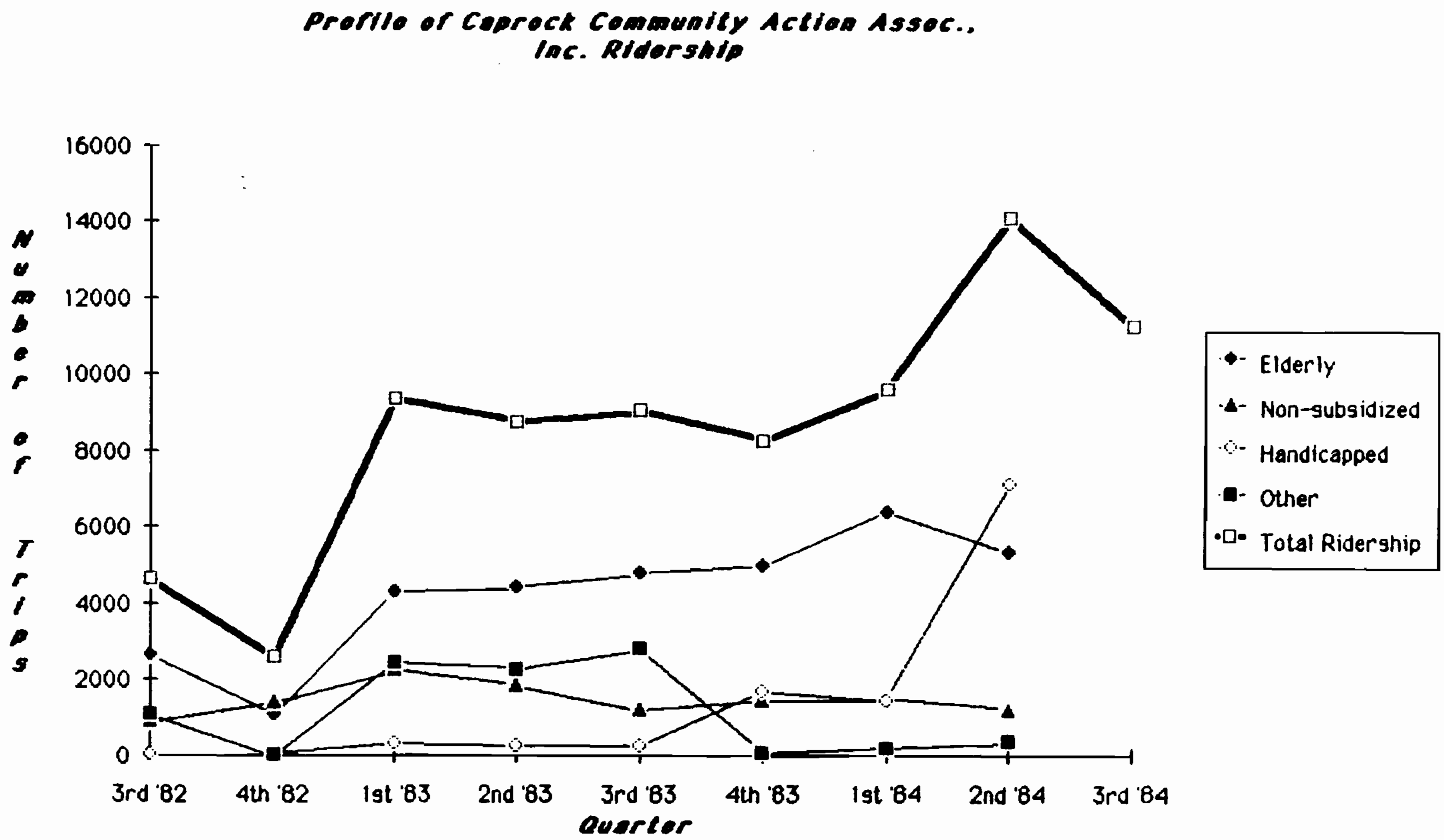
BOSQUE COUNTY SENIOR SERVICES RIDERSHIP PROFILE

RIDERSHIP PROFILE

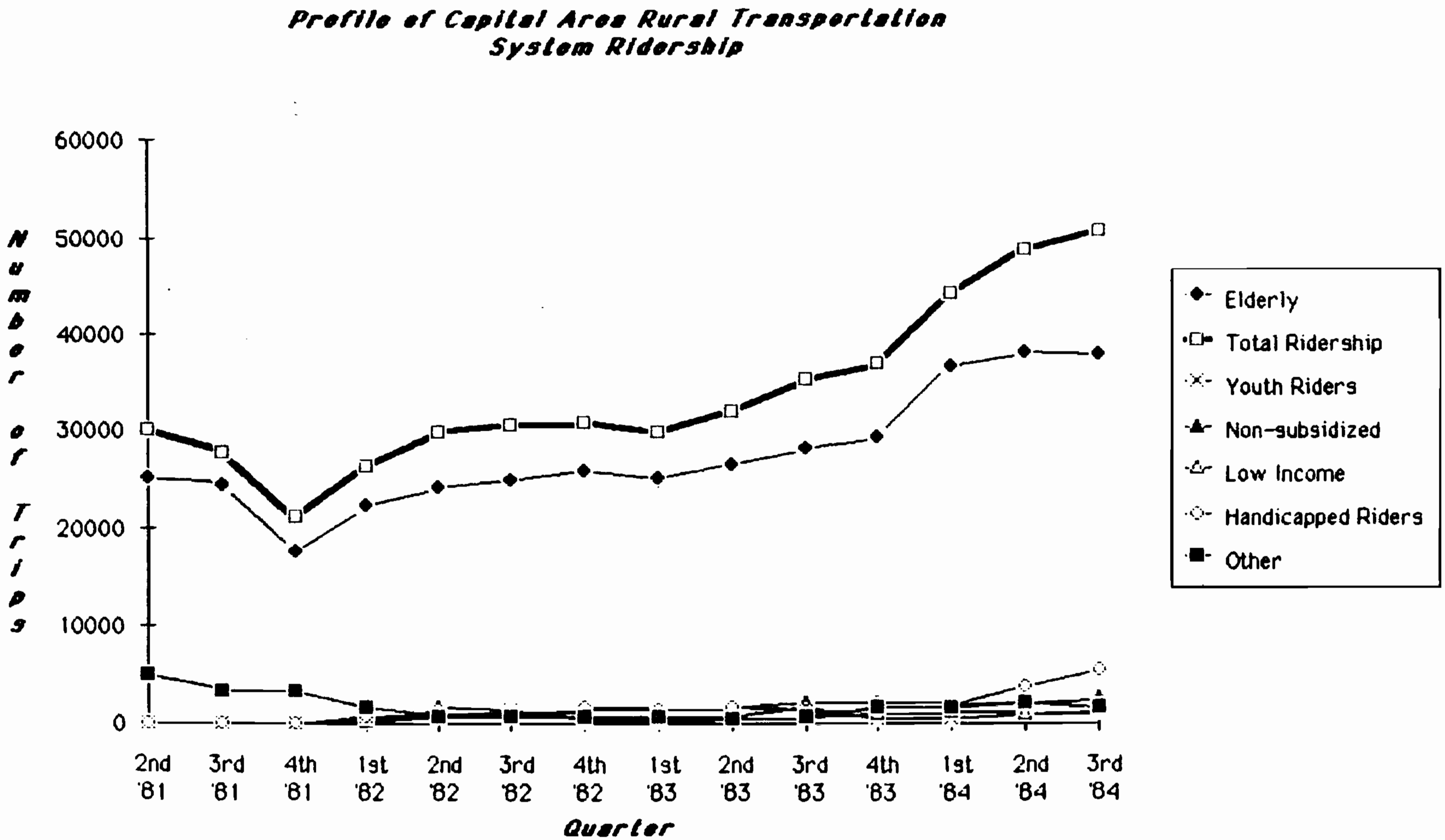


BRAZOS VALLEY COMMUNITY ACTION AGENCY/BRAZOS TRANSIT SYSTEM

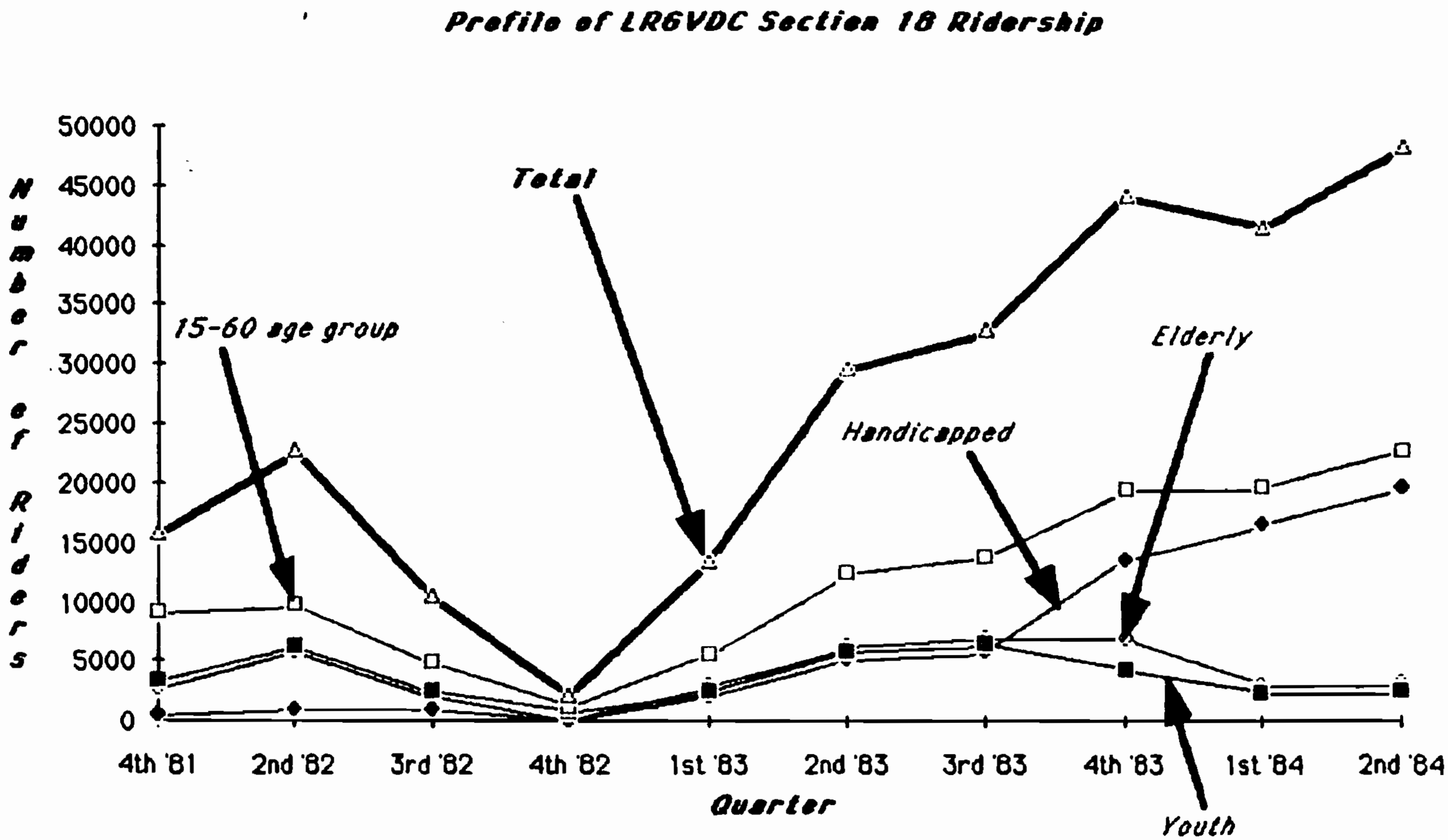
RIDERSHIP PROFILE



CAPROCK COMMUNITY ACTION ASSOC., INC.

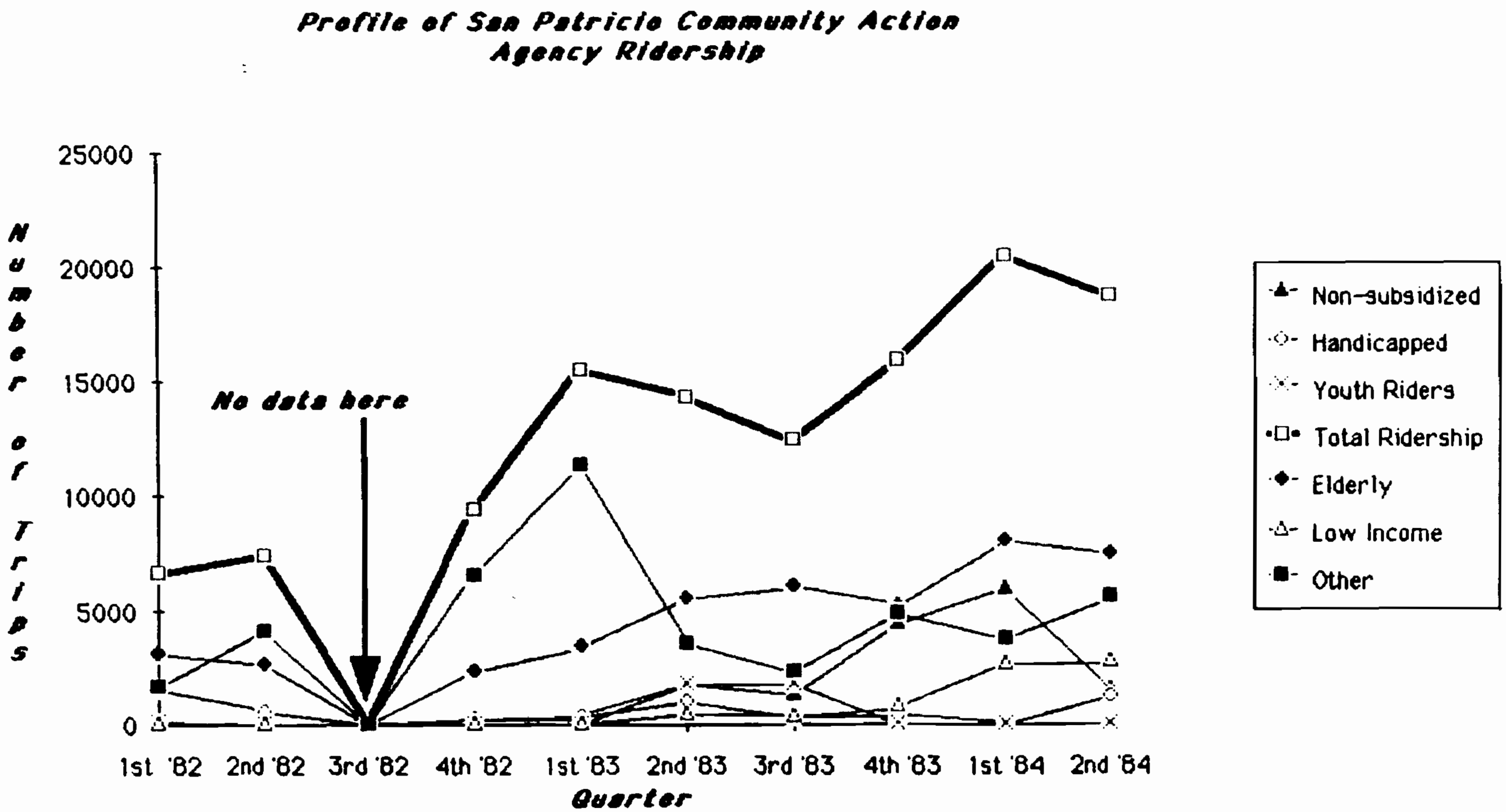

Profile of Capital Area Rural Transportation
System Ridership
60000
50000
40000
30000
20000
10000
0
Number of Trips
2nd '81
3rd '81
4th '81
1st '82
2nd '82
3rd '82
4th '82
1st '83
2nd '83
3rd '83
4th '83
1st '84
2nd '84
3rd '84
Quarter
Elderly
Total Ridership
Youth Riders
Non-subsidized
Low Income
Handicapped Riders
Other

RIDERSHIP PROFILE



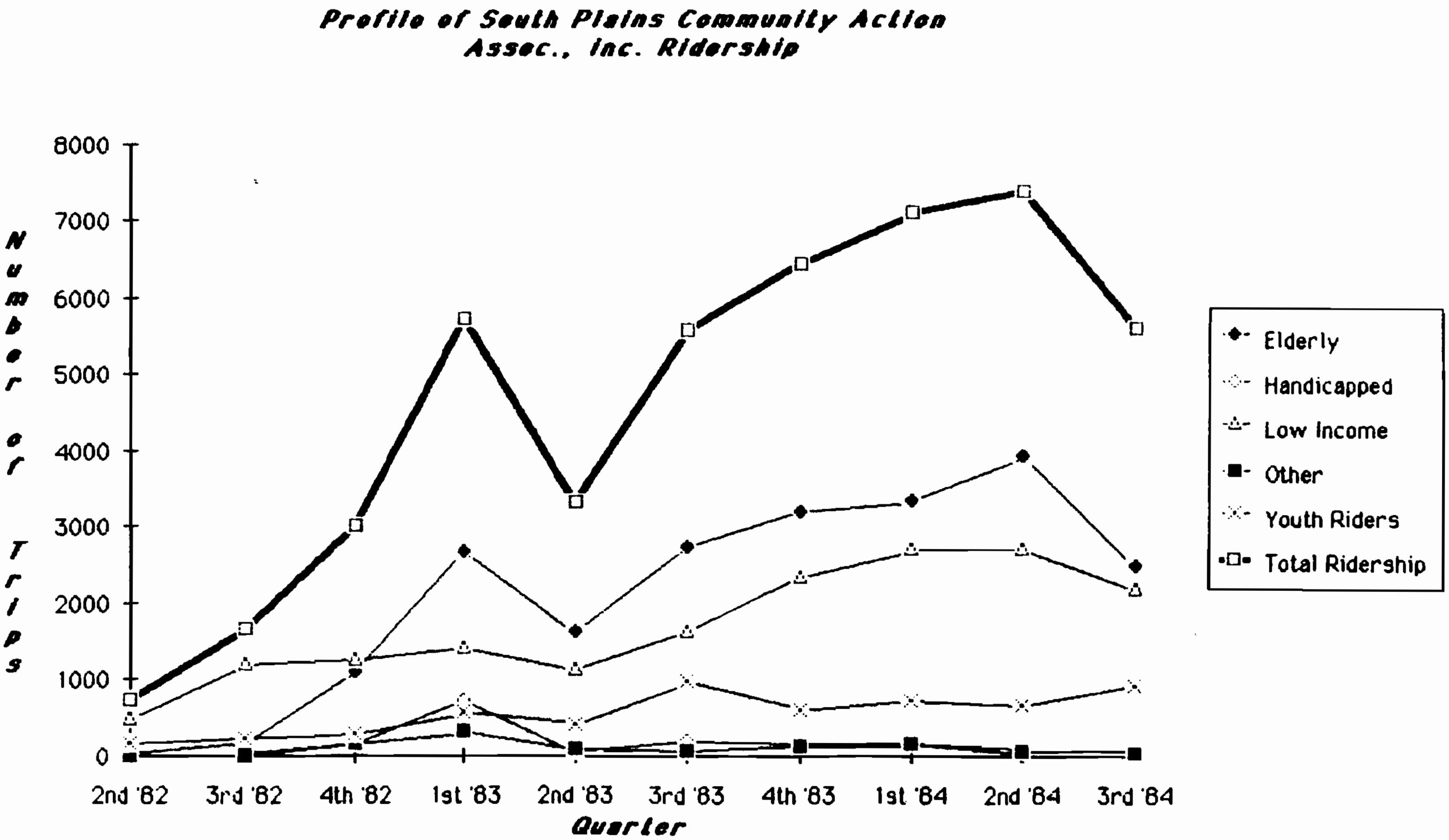
LOWER RIO GRANDE VALLEY DEVELOPMENT COUNCIL RIDERSHIP BREAKDOWN

RIDERSHIP PROFILE



SAN PATRICIO COMMUNITY ACTION AGENCY (SPARTS)

RIDERSHIP PROFILE



SOUTH PLAINS COMMUNITY ACTION ASSOCIATION, INC. (SPARTAN)

APPENDIX 2.C

FACSIMILE OF THE QUESTIONAIRE USED FOR THE "MAIL-PHONE SURVEY OF SECTION 18 CONTRACTORS"

Project #1080
Center for Transportion Research
Bureau of Engineering Research
The University of Texas at Austin
Austin, Texas 78712

Mail-phone Survey of Section 18 Contractors

I. Information Regarding Respondent

Contractor: Lower Rio Grande Valley Development Council

Do you have any sub-contractors working for you? Yes **If so, how many?** Two (2)

Name of person responding/spoken to: Gracie C.

Date and time of response/call: May 28, 1985

II. Information Regarding Area Covered

How many counties does system cover? Three (3)

Which are they? Cameron, Hidalgo & Willacy

How many square miles is this? 3,019

What are the principal characteristics of the area served?

Low income, high poverty, Mexican-American, migrants, high unemployment, two SMSA's

III. Information Regarding Service Routes

Do you have maps or any other printed information concerning service routes or system in general? Yes (refer to Attachment A)

(If so, would you be so kind as to send us any printed materials concerning your rural public transportation system, as well as this completed questionaire, to:

c/o Dr. Hani Mahmassani
Department of Civil Engineering
Ernest Cockerell, Jr. Hall
The University of Texas at Austin
Austin, Texas 78712

What type of routes do contractors follow? (i.e. fixed, demand-responsive, etc.) fixed and scheduled

If demand-responsive, do riders have to call in advance? How much in adavance do they have to call? N/A

Approximately how many routes are there? 16

What are the characteristics of the major roads and highways on which routes operate, i.e. do you operate on freeways, arterials, country roads? rural highways and country roads; very little freeway and urban highways

IV. Trip Information

How do you count trips for purposes of quarterly reports?
Per passenger trips

To the best of your knowledge, what are the purposes of the trips on your system? Shopping, medical, nutrition

Could you give me the percent of trips made for the following reasons? **Medical** 58%

*See Section VII.

Work 0%

Shopping 5%

Recreational 0%

Social Visits 0%

School 0%

Nutritional Needs ____
(i.e. meals-on-wheels, etc.)

Can you give me the average total daily aggregate demand for the previous categories of trip purposes? Same as above

Are you aware of any seasonal fluctuations in the demand of trips? Are there times when there seems to be more of a need for service than at others? Our rural fixed route system serves the rural general public. During the summer, when the kids are out of school, we tend to carry more passengers. The other two systems remain stable throughout the year.

What is the average cost per trip in your system? RPTS-$1.45 MH/MR-$2.10 SCF-$3.00

What is the average trip length in your system? RPTS-1.5 miles MH/MR-3.7 miles SCF-4.8 miles

V. Information Regarding Vehicles Used

How many vehicles are used in your system? 26

What type of vehicles are used (buses, cars, vans, etc.)? Buses and vans

What kind of operating condition are they in? In other words, is there any significant loss of operating time due to maintenance and repair of vehicles or do they require just regular maintenance? Regular maintenance

VI. Information Regarding Ridership

Who is eligible to use your service? General public, mentally ill, elderly

Who must pay to use your service? No one

Who are the major users of your service (elderly, handicapped, low income, etc.)? Elderly, low income, mentally handicapped

Are there any fluctuations in the amount of use made by certain user groups? Young school persons use the system more in the summer.

VII. General Remarks or Suggestions Regarding Survey:

*The following information is based on our July-September 1984 Quarterly Analysis. These figures do not include the Amigos del Valle, Inc. Program as they were not yet a part of the system. However, they do include statistics for a previous sub-contractor, Su Clinica Familiar, a medical clinic for the disadvantaged population. The Rural Public Transit System during this quarter was about 30% operational due to the condition of the old buses. We were awaiting arrival of new buses during this period.

CHAPTER 3. AN AREAWIDE DEMAND ESTIMATION MODEL FOR RPT

Section 3.1 Methodology for Demand Estimation

Central to the undertaking of the present research has been the goal to assess the characteristics of the demand for rural public transportation service as they have been evidenced in the Section 18 program projects in Texas. The intent is to combine and integrate the research findings gathered from primary sources, such as those as noted in the previous chapters, with secondary source data acquired mainly from the *1980 Census of Population, Texas Volumes*,[1] which is compiled by the U. S. Commerce Department's Bureau of the Census. Specifically, an exhaustive list of sociodemographic and transportation-related variables disaggregated at the level of Texas counties form the corpus of data in the analysis. It is felt that this information will identify the useful and necessary population parameters against which the Section 18 systems' operating characteristics can be compared, and thus estimating relations can be developed for calculating demand at the service area level for planning purposes.

Equally important to the task of providing estimates of both the potential and the observed demand is the measure of the availability and level of service characteristics of the system (supply). It has been noted in the data acquired from the Section 18 systems operating in Texas that there are some fairly widespread variations in the number of riders being served. The factors causing this variation include characteristics of the service provided in addition to those of the people being served. It has been possible to successfully include these factors in the estimation models in a statistically significant fashion. At the same time, it is also useful to have a qualitative appreciation of their influence on demand. A plausible assumption with respect to demand is that as the availability of service increases, more people will ride. However, after reaching a certain level of service, it is likewise safe to assume that the marginal increase in patronage is less than proportional to the marginal increase in service. Beyond this point, the provision of additional hours of service might constitute a suboptimal allocation of resources.

The use of such a level-of-service and population-needs based approach to demand estimation provides transportation planners with the parameters or estimating equations for new systems in unserved areas and also the tools by which they can increase planning effectiveness within existing systems. Some of the needs-based factors involved in the design or assessment of a rural transit system are (1) the needs of the clientele, (2) the size of the groups, (3) the location of the unserved groups, and (4) fiscal constraints associated with and the appropriateness of the available modal options.

The analytical tool employed here to develop and calibrate a mathematical demand model is multiple regression analysis, which is a general statistical technique used to analyze the relationship between a single dependent variable and several independent (or predictor) variables. The purpose of this model is to use several independent variables whose values are known to predict or estimate the unknown value of the dependent variable. Multiple regression analysis is likewise useful in examining the strength of association between the single dependent variable and the one or more independent variables. When collinearity among the predictor variables is minimal, one can identify the extent to which each of the independent variables is related to the dependent variable.

The product of this analytical aid is a regression equation for determining order of magnitude estimates of the quarterly ridership demand for Rural Public Transportation in Texas on a systemwide or countywide basis (the systems being basically comprised of one county or a group of contiguous counties). In using regression analysis a decision has to be made regarding the number of predictor variables to include in the equation. A general guiding principle is that each additional independent variable should contribute significantly to the explanatory power of the regression model.

An important consideration in the selection of this modeling technique was that it should provide an analytical tool which is not only useful to statewide level transportation planners, but also to the operations planner (i.e., transit operator, system managers, etc.). With requisite amounts of past history data and computer time, an in-depth forecast computation of rural public transportation needs can be executed rapidly and on a large scale. Although the initial data evaluation and model formulation are time consuming, this forecasting model, once developed, can be easily and systematically updated. It should also be noted that the general forecasting equations developed here can be applied in a particular situation and solved using readily available data inputs.

The appropriateness of the resulting models should, however, be assessed by the potential user for each specific area of application. There is one important limitation to consider in the application of the regression equations: since calibration was performed on cross-sectional data of transit systems throughout the State of Texas, and to the extent that the observed variability across these systems could not be explained in its entirety by the model specification, the resulting equations reflect some statewide average effects. The applicability of these equations to specific contexts depends on the extent of the deviation of the characteristics (not included in the model's specification) of the given context from the statewide averages reflected in the calibrated model parameters. However, while these models may not be very accurate for a given area, they are suitable for a preliminary analysis in most locations.

Section 3.2 Inventory of Variables Entering into the Analysis

An estimation data base consisting of 42 variables for each of the 16 transit system cases was constructed from the information gathered from the previously outlined primary and secondary sources (i.e. "Section 18 Grant Program Quarterly Reporting Forms", "Mail-phone Survey of Section 18 Contractors," "County and City Data Book 1983, 10th Ed." and "1980 Census of Population, Texas Volumes"). The following inventory lists the variables by category and gives the individual identification number (the latter refer only to the order in which they were devised as the research analysis progressed).

3.2.1 Dependent Variables

The following variables constituted the possible dependent variables that were analyzed individually for meaningful relationships, i.e. the strength of associations, with sets of other independent variables. All were calculated from the observed ridership demand, and differ in terms of time frames, ratio basis, or socio-economic category of the tripmakers.

-Initial Quarter System Total Ridership = one-way trips (see footnote number 2) (y_1)

-Average Quarterly System Total Ridership (y_2)

(With reference to the demand-related variables, the principal measures of demand employed throughout the analysis, it is useful to note that the initial quarter system ridership data is taken from the first quarter in which service was reported. It is felt that this is an adequate measure with which to forecast what the demand would initially be in a start-up operation. The average quarterly system total ridership data, on the other hand, provide a useful measure of observed demand from quarter to quarter over the operating life of the system.)

-Initial Quarter Per Capita System Ridership

-Average Quarterly Per Capita System Ridership

-Initial Quarter System Non-subsidized Ridership

-Average Quarterly System Non-subsidized Ridership

-Initial Quarter System Elderly Ridership

-Average Quarterly Elderly Ridership

-Initial Quarter System Handicapped Ridership

-Average Quarterly System Handicapped Ridership

-Initial Quarter System Youth Ridership

-Average Quarterly System Youth Ridership

-Initial Quarter System Low-Income Ridership

-Average Quarterly System Low-income Ridership

-Initial Quarter System Other (15-60 age group) Ridership

-Average Quarterly System Other (15-60 age group) Ridership

The following are also demand side dependent variables, but would be more appropriate as performance indicators of system efficiency, useful in cost modeling or considerations regarding choice of transportation vehicles:

-Initial Quarter System Ridership per Actual Vehicle Operating Hour

-Average Quarterly System Ridership per Actual Vehicle Operating Hour

-Initial Quarter System Ridership per Vehicle Route Mile

-Average Quarterly System Ridership per Vehicle Route Mile

3.2.2 Independent or Predictor Variables

The following independent variables were available for consideration for inclusion in the demand estimation equation. The group listed here are sociodemographic variables in the form of raw scores of population obtained from 1980 census data.

-System Population Density

-System Minority Population (aggregate of Black and Hispanic)

-System Old-Young Age Group Population (age 65 and over, age 18 and under)

-System Families Below Poverty Level

-System Rural Dweller Population

-System Households without Automobile

-System Total Population

-System Elderly Population (over age 65)

-System Youth Population (under age18)

-System Workers (16-64) with a Work Disability Population

The remaining sociodemographic predictor variables were calculated on a Per Capita basis, in an attempt to normalize for the effect of population.

-System Per Capita Minority Ratio

-System Per Capita Old-Young Ratio

-System Per Capita Rural Dweller Ratio

-System Per Capita Carless Household Ratio

-System Per Capita Poverty Families Ratio

-System Per Capita Disabled Workers Ratio

However, correlation and multiple regression analyses have shown that this particular set of per capita sociodemographic variables, as well as level-of-service measures expressed in per capita terms, do not possess significant explanatory power as possible determinants of demand. The effect of population itself taken as a raw score is an inherently important characteristic which should be captured in demand estimation equations.

The final group of independent variables are level-of-service measures, system supply-side characteristics which are recognized in the transportation demand literature to be inherent determinants of demand.[3]

-Initial Quarter System Maximum Vehicle Operating Hours Per Capita

-Initial Quarter System Actual Vehicle Operating Hours Per Capita

-Initial Quarter Maximum Available Vehicle Operating Hours

-Initial Quarter Actual Vehicle Operating Hours

Another service characteristic which is believed to influence travel demand in an inverse relationship is trip distance: ridership tends to decrease proportionally as trip length increases. An attempt was made to ascertain the validity of this relationship so therefore trip distance information was embodied by the following two variables:

-Initial Quarter Average System Trip Length

-Average Quarterly Average System Trip Length.

The above inventory of variables comprises most of those included in the regression analyses leading to the demand estimation models described in the sections to follow. In conclusion to this section, ***Table 3.2.1*** furnishes a list of descriptive statistics--mean, standard deviation, and standard error of the mean (i.e., the squared standard deviation divided by the number of observations)--of the inventory of variables from the sixteen transit system cases forming the corpus of data for the regression analyses.

<u>Section 3.3 Total Ridership Demand Model With Level-of-Service Measures</u>

This section describes the travel demand regression equations developed for total ridership, on a quarterly basis, in rural public transportation systems in Texas. As can be noted from ***Table 3.2.1***, there are significant variations in the levels of ridership observed on existing systems. The intervening variables which cause these variations include, as discussed earlier, the characteristics and level of the service provided. In a study by Smith,

TABLE 3.2.1. INVENTORY OF VARIABLES IN DATA BASE AND DESCRIPTIVE STATISTICS

Variable Code	Name and Unit of Analysis	Mean	Standard Deviation	Standard Error
v1	1stQuarter one-way trips	9,738.37	10,208.4	2,552.09
v2	Avg Quarterly 1way trips	11,697.84	10,193.1	2,548.27
v3	Population/square mile	41.14	42.77	10.7
v4	Sys Minority Population	49,324.31	97,587.5	24,396.9
v5	Sys Old/Young Population	53,905.62	61,328	15,332
v6	Sys Low Income Families	5,079.8	7,823.31	1,955.83
v7	Sys Rural Population	51,515.5	54,710.9	13,677.7
v8	Sys Carless Households	3,200.87	4,026.94	1,006.73
v9	1st Q'ter per capita trips	0.0984	0.087	0.0217
v10	Av Q'terly per capita trips	0.1261	0.0924	0.0231
v11	Sys per capita Minority	0.3141	0.2206	0.0552
v12	Sys per capita Old/Young	0.4312	0.0528	0.0132
v13	Sys per capita Rural	0.4501	0.1763	0.0441
v14	Sys per capita Carless HH	0.0753	0.0227	0.0057
v15	Sys per capita Low Inc. Fam	0.1139	0.0559	0.014
v15	Sys per capita handicapped	0.1286	0.022	0.0055
v17	1st Q'ter Ridership/Veh Hr	2.6605	1.8686	0.4671
v18	Av Q'terly Ridership/Vh Hr	3.0066	1.9178	0.4794
v19	1st Q'ter Rship/VehRouteMi	0.2382	0.1267	0.0317
v20	AvQ'terly Rship/VehRouteMi	0.2331	0.1291	0.0323
v21	System Total Population	132,022	145,210	36,302.6

(continued)

TABLE 3.2.1. (Continued)

Variable Code	Name and Unit of Analysis	Mean	Standard Deviation	Standard Error
v22	1stQ'ter Maxvehhrs/percap	0.0751	0.0968	0.0242
v23	1stQ'ter Actvehhrs/percap	0.0633	0.0918	0.023
v24	1stQ'ter Max Vehicle hrs.	4,829.25	3,485.46	871.3653
v25	1st Q'ter Actual Veh hrs.	3,861.624	2,721.04	680.2592
v26	1stQ'terNon-subsidzedRship	1,103.062	2,928.62	732.156
v27	AvQ'terly Non-Subsidized	1,704.593	2,901.99	725.4974
v28	1stQ'ter Elderly Ridership	4,995.19	7,736.97	1,934.24
v29	AvQ'terly Elderly Rship	5,492.05	7,420.59	1,855.15
v30	1stQ'ter Handicapped Rship	214.8124	419.6183	104.905
v31	AvQ'terly Handicapped	740.2264	1,488.2	372.051
v32	1stQ'ter Youth Ridership	446.25	987.689	246.9222
v33	AvQ'terly Youth Ridership	795.5894	1,309.22	327.304
v34	1stQ'ter LowIncome Rship	763.375	2,259.84	564.9602
v35	AvQ'terly LowIncome Rship	1,301.6	2,779.49	694.873
v36	1stQ'ter Other Ridership	1,059.562	2,512.29	628.072
v37	AvQ'terly Other Ridership	1,162.784	2,820.84	705.211
v38	System Elderly Population	14,491.2	13,867	3,466.76
v39	System Youth Population	40,063.9	488,489	12,212.2
v40	System Disabled Workers	7,456.124	8,383.93	2,095.98
v41	1stQ'ter Avg Trip Length	7.165	8.612	2.153
v42	AvQ'terly Avg Trip Length	6.7169	7.9326	1.9831

where a macro-model of rural public transit demand, which included level-of-service variables was applied to individual systems in order to assess its accuracy, it was shown that

> "...the application of the two macro-level models to two northern Wisconsin systems with markedly different levels of service has demonstrated the importance of including level of service as an independent variable. On balance, the level-of-service macro model provided more accurate estimates of demand."[4]

Similar results have been obtained in the present study of Rural Public Transportation systems in the State of Texas. ***Table 3.3.1*** provides a summary of the final models selected for demand estimation for both the initial quarter of operation and the average quarterly ridership. This table depicts the correlation matrix of the respective dependent variables (i.e. #1 and #2) and the independent variables of interest. The results of the multiple regression analysis that follow indicate high values for both the correlation coefficient (r) and the coefficient of determination (r^2). The correlation coefficient basically measures the strength of association between the dependent and predictor variables, yet its magnitude is not easy to interpret directly. On the other hand, the coefficient of determination is usually interpreted as the proportion of the variation of the dependent variable about its mean which is accounted for by the explanatory variables. When the regression model is properly applied and estimated, the higher the value of r^2, the greater the explanatory power of the regression equation. Using this interpretation, ***Table 3.3.1*** shows that each estimated equation explains approximately 88% of the observed cross-sectional variation in respective ridership. The Table also shows that, in both instances, there is an insignificant epidemic probability that the results are due to chance.

The final demand estimation models, in effect, have the following usual form of linear regression equations:

$$y = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \cdots + \beta_n\chi_n$$

In the demand estimation equations for both the initial and average quarterly ridership, it can be noted from the output in ***Table 3.3.1*** that the estimated value of the intercept (β_0) is negative. It is the case, especially here, that the intercept may have no direct managerial interpretation; however, it is a numerical quantity that is meaningful only within the range of the observed values (of the variables) used in the parameter estimation. For

TABLE 3.3.1

CORRELATION MATRIX

	1V	2V	3V	4V	5V	6V	7V	8V	21V	38V	39V	40V	24V	25V	41V	42V
1V	1.00	.95	.23	.28	.57	.37	.88	.57	.70	.74	.54	.81	.73	.68	-.36	-.32
2V	.95	1.00	.37	.48	.70	.55	.86	.69	.77	.81	.67	.88	.73	.68	-.38	-.35
3V	.23	.37	1.00	.78	.76	.77	.40	.75	.69	.64	.78	.49	-.12	-.14	-.32	-.32
4V	.28	.48	.78	1.00	.92	.99	.48	.93	.80	.75	.94	.59	.07	.07	-.19	-.20
5V	.57	.70	.76	.92	1.00	.96	.76	1.00	.97	.95	1.00	.82	.27	.30	-.26	-.25
6V	.37	.55	.77	.99	.96	1.00	.56	.96	.86	.83	.97	.66	.15	.15	-.20	-.21
7V	.88	.86	.40	.48	.76	.56	1.00	.74	.87	.90	.72	.90	.52	.61	-.24	-.21
8V	.57	.69	.75	.93	1.00	.96	.74	1.00	.96	.94	1.00	.81	.27	.29	-.26	-.25
21V	.70	.77	.69	.80	.97	.86	.87	.96	1.00	.99	.96	.88	.35	.40	-.29	-.27
38V	.74	.81	.64	.75	.95	.83	.90	.94	.99	1.00	.93	.93	.40	.45	-.25	-.22
39V	.54	.67	.78	.94	1.00	.97	.72	1.00	.96	.93	1.00	.79	.24	.27	-.26	-.26
40V	.81	.88	.49	.59	.82	.66	.90	.81	.88	.93	.79	1.00	.51	.59	-.27	-.23
24V	.73	.73	-.12	.07	.27	.15	.52	.27	.35	.40	.24	.51	1.00	.87	-.24	-.25
25V	.68	.68	-.14	.07	.30	.15	.61	.29	.40	.45	.27	.59	.87	1.00	-.24	-.25
41V	-.36	-.38	-.32	-.19	-.26	-.20	-.24	-.26	-.29	-.25	-.26	-.27	-.24	-.24	1.00	.99
42V	-.32	-.35	-.32	-.20	-.25	-.21	-.21	-.25	-.27	-.22	-.26	-.23	-.25	-.25	.99	1.00

Number of cases: 16
Number of missing cases: 0

MULTIPLE REGRESSION RESULTS:

DEPENDENT VARIABLE: 1

INDEPENDENT VARIABLES: 7 24

MULTIPLE CORRELATION: .9383 F(2, 13) = 47.817 p = 0.000
R-square: .8803

BETA for var 7 =	.687	B = .128	t(13) = 6.122	p = 0.000
BETA for var 24 =	.376	B = 1.102	t(13) = 3.355	p = .005

INTERCEPT = -2182.340

Analysis of variance:

	SS:	MS:	df:	F:	p:
REGRESSION	************	688049000.00	2	47.82	0.000
RESIDUAL	187059100.00	14389200.00	13		
TOTAL	************				

MULTIPLE REGRESSION RESULTS:

DEPENDENT VARIABLE: 2

INDEPENDENT VARIABLES: 3 7 24

MULTIPLE CORRELATION: .9413 F(3, 12) = 31.107 p = 0.000
R-square: .8861

BETA for var 3 =	.220	B = 52.331	t(12) = 1.879	p = .082
BETA for var 7 =	.520	B = .097	t(12) = 3.834	p = .003
BETA for var 24 =	.489	B = 1.430	t(12) = 3.905	p = .002

INTERCEPT = -2350.643

Analysis of variance:

	SS:	MS:	df:	F:	p:
REGRESSION	************	460306100.00	3	31.11	0.000
RESIDUAL	177571000.00	14797600.00	12		
TOTAL	************				

instance, when all the independent variables in the equation are equal to zero, then $y = \beta_0$. Given the results obtained from the regression analysis in the present instance, this would mean that the demand would assume a negative value, clearly an impossible event. However, as it is quite improbable for the independent variables to have a value of zero for any meaningful application of the model, then this may, in effect, have no managerial significance. One of the inherent limitations of the models developed here is that their application must follow the usual guidelines for the use of regression models, namely that the values of the independent variables forming the basis for prediction be well within the range of observed values (used in model estimation).

Equations 3.3.1 and ***3.3.2*** were found to provide the best overall fit to the observed demand (initial, y_1, and average quarterly, y_2). The multiple regression results indicate that the relationships are statistically significant. More importantly, the two equations constitute logical relationships between the inputs and outputs, particularly since level-of-service measures are included in the specification (i.e. maximum vehicle hours of operation):

$$y_1 = -2182.34 + 0.128(\text{rural pop.}) + 1.102(\text{max. veh. hrs.}) \qquad \textit{(Equation 3.3.1)}$$

$$y_2 = -2350.643 + 52.331(\text{pop. density}) + 0.097(\text{rural pop.}) + 1.430(\text{max. veh. hrs.}) \qquad \textit{(Equation 3.3.2)}$$

Statistically speaking, the multiple regression results in ***Table 3.3.1*** indicate that these are very good models, with high r^2 values in both instances, and clearcut overall significance according to the F-test. The rural dweller population variable (v7), is the strongest of the predictor variables in both instances, according to the standardized "beta" coefficient. This coefficient reflects the impact on the dependent variable of a change of one standard deviation in the corresponding independent variable, thus creating a common, standardized, unit of measure which captures the relative "influence" of each of the explanatory variables. That the calibrated models establish empirically that the system rural dweller population is the most important determinant of demand is, to be sure, no surprise. This result actually strengthens our confidence in the model's plausibility, in addition to providing an analytical tool to determine the effect of rural population, in conjunction with that of other variables, on demand. It is also worth noting that there is minimal collinearity among the independent variables in these equations, as can be readily verified by in the correlation matrix shown in ***Table 3.3.1***.

The next strongest predictor variables of ridership demand in the present models are the level-of-service or supply measures which, in both cases, are captured by the Initial Quarter Maximum Available Vehicle Operating Hours variable (v24). It would be of interest, possibly to planners and transit managers, to note that this particular variable proved to have more explanatory power than its counterpart, the Initial Quarter Actual Vehicle Operating Hours (v25), in estimating the total initial and average quarterly ridership demand. Whereas variable v24 represents the total supply capacity, in vehicle-hours, of the system, the difference between it and v25 is due to such factors as vehicle breakdowns, malfunctions, etc. and possibly unplanned vehicle operator absence due to illness. The use of variable v24 in the demand estimation equations is rather convenient, insofar as this variable lends itself to planning functions with much greater accessibility than its counterpart, v25, which is a measure of service availability that depends on unplanned events which cannot readily be anticipated.

Of particular interest is the fact that ***eqs. 3.3.1*** and ***3.3.2*** differ with respect to the inclusion of independent variable v3 (population density) in the equation for y_2, the Average Quarterly System Total Ridership *(eq. 3.3.2)*, but not in that for y_1, the Initial Quarter System Total Ridership *(eq. 3.3.1)*. This decision is based on the analysis of the data, which demonstrated that the inclusion of v3 in ***eq. 3.3.2*** did significantly enhance the explanatory power of the model; the same was not true for ***eq. 3.3.1***.

The variable in question is the population density of the area served by the system. In interpreting the above findings, it is necessary to consider the nature of the two measures of demands involved; namely, the initial quarter versus the average quarterly demand statistics. The basic difference in these two demand models is that the y_1 demand corresponds to the initial point,when service is begun, in a dynamic process; whereas the y_2 demand is representative of the behavior of the demand over time.

The significance of the effect of population density on average quarterly demand, but not on its initial value, can most plausibly be attributed to the role of the information diffusion process in the evolution and growth of transit system ridership. The characteristics of such a diffusion process are likely to be different in high-density areas versus low-density areas. Awareness among the community of the availability of service is more likely to be diffused by a "word-of-mouth" process rather than by any type of mass media information. The survey conducted for this report did in fact find that some of the transit managers did not advertise due either to a lack of means or out of a precautionary attitude of not generating a surplus demand. Thus, it is plausible that in higher density areas, information concerning the availability of rural public transportation circulates faster than in lower density areas (much like the spread of an epidemic), thereby explaining the above results.

In conclusion, the research findings reported in this section provide analytical tools with which planners and transit managers can forecast levels of overall rural transit ridership demand based on logical, quantifiable and easily available independent predictor variables--namely, the rural population and levels-of-service measures. Models that incorporate level-of-service measures as variables are appropriate for use in estimating demand when there are predetermined levels of service availability. This would be the case when some budgetary constraint is known that could conceivably determine how much service can be provided. Furthermore, it can be used in the context of a decision-making procedure, in conjunction with a system sizing model, to determine the appropriate amount of service supply in a particular area. This would require the simultaneous solution (using some iterative procedure) for compatible levels of service supply and demand.

Section 3.4 Total Ridership Demand Estimation Model For Use in Forecasting the Demand for RPT in Unserved Areas

The above service availability measures are indeed a critical element to the demand estimation procedures: the latter must be sensitive to system supply characteristics inasmuch as it would be false to assume a supply-independent demand; or, just as it would be to assume unlimited service availability. The fact that the majority of the Section 18 rural transit systems operating in Texas are operating, to differing extents, some form of demand-responsive passenger service further underscores the need to include supply measures in the analysis.

However, it should be recognized that some approximate estimates of potential demand might be needed, for planning purposes, in the absence of service-supply measures, as in the case of presently unserved areas, for example. Furthermore, service availability might fluctuate widely due to budgetary constraints and other transportation resource availability.

These facts motivate in part the development of a demand estimation model built solely on sociodemographic predictor variables. One of the expressed objectives in developing the estimating models is to identify useful parameters of the Texas Section 18 Systems specifically to support future transportation studies and strategic planning functions. These parameters would thus be valuable in demand estimation and forecasting in areas where rural public transit operations have yet to be implemented.

Table 3.4.1 summarizes the results of multiple regression analyses performed with population descriptors as the independent variables. As would be expected from the preceding analysis, the rural dweller population variable, v7, emerged as the strongest predictor of ridership (both initial and average). Moreover, the following equations that were obtained constitute equally logical relationships between the inputs and outputs:

$$y_1 = 1267.08 + 0.164 \text{ (rural pop.)} \quad \textit{(equation 3.4.1)}$$

$$y_2 = 3438.61 + 0.160 \text{ (rural pop.)} \quad \textit{(equation 3.4.2)}$$

These same equations can be applied as macrosystem models for estimating statewide demand. It is worth noting that variable v7, rural dweller population, yields the highest r^2 values among all the independent variables considered, while being highly colinear with most other relevant socio-demographic variables.

The use of ***equations 3.4.1*** and ***3.4.2*** for forecasting purposes, however, would have to made under the assumption that service availability in the "new" unserved areas would be comparable to that currently provided, on average, in the existing systems included in the data base from which the demand equations were calibrated.

By plotting the result of ***equation 3.4.2*** using the 1980 system rural population as input, against the actual demand for the 16 systems studied, as shown in ***figure 3.4.1.***, an indication of the goodness of fit between the predicted and the observed demand is obtained. The chart illustrates a fairly evident trend for demand as a linear function of rural population. The residual error of the computed regression equation, i.e. the differences between the predicted and the observed average quarterly total system demand would presumably be due to system-specific factors within the individual transit system, principally the level of service, and also perhaps to the characteristics of management. In addition, the change in system rural population from 1980 to the time from which observed demand data were collected would be a (relatively minor) factor contributing the residual error of the estimate.

Thus, ***equations 3.4.1*** and ***3.4.2*** can potentially be utilized as the forecasting tools in a systemwide demand estimation for RPT in Texas. One additional qualification to the recommended utilization of these models must, however, be made. Large constant values in the estimator equations render them impractical for use in

TABLE 3.4.1

MULTIPLE REGRESSION RESULTS:,

DEPENDENT VARIABLE: 1

INDEPENDENT VARIABLES: 7

MULTIPLE CORRELATION: .8813   F(1, 14) = 48.699   p = 0.000
R-square: .7767

BETA for var 7 = .881   B = .164   t(14) = 6.978   p = 0.000

INTERCEPT = 1267.080

Analysis of variance:

	SS:	MS:	df:	F:	p:
REGRESSION	************	************	1	48.70	0.000
RESIDUAL	349033400.00	24931000.00	14		
TOTAL	************				

MULTIPLE REGRESSION RESULTS:

DEPENDENT VARIABLE: 2

INDEPENDENT VARIABLES: 7

MULTIPLE CORRELATION: .8605   F(1, 14) = 39.955   p = 0.000
R-square: .7405

BETA for var 7 = .861   B = .160   t(14) = 6.321   p = 0.000

INTERCEPT = 3438.611

Analysis of variance:

	SS:	MS:	df:	F:	p:
REGRESSION	************	************	1	39.95	0.000
RESIDUAL	404393000.00	28885200.00	14		
TOTAL	************				

estimating demand on a countywide basis inasmuch as a substantial number of counties in Texas have total rural populations close to or within the 1,267 - 3,440 range of constant values contained in the estimator equations. The effect of large constant values on ridership demand projections made with the rural population parameters of individual counties would obviously lead to considerable overestimation. It is therefore more practical to utilize these equations for predicting the ridership demand in existing or potential systems where the

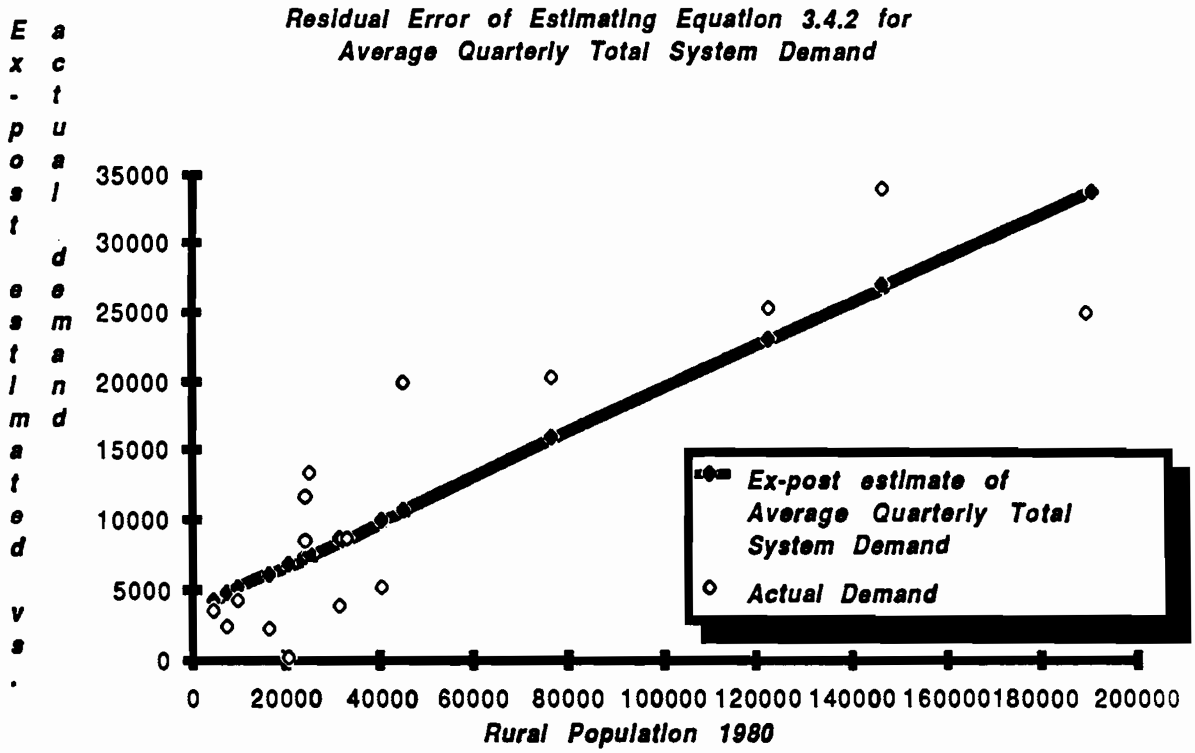


Figure 3.4.1

population characteristics are closer to the central tendency exhibited by the systems included in the data set that formed the basis for calibrating these equations. This would imply that for use in feasibility studies of areas where service does not exist, it would first be necessary to design systems that encompass several contiguous counties, thus having greater levels of rural population. In this case, ***equations 3.4.1*** and ***3.4.2*** would then provide more accurate estimates of potential ridership.

In order to circumvent the tendency toward overestimation with the application of ***equations 3.4.1*** and ***3.4.2*** to areas with rural populations below 5,000 inhabitants (as would happen at the level of countywide projections), an alternative simple trip rate model is found to be practical for use in such instances.

The scattergram in ***Figure 3.4.2*** illustrates the *average quarterly total system ridership per rural population* plotted against the system rural dweller population in 1980 (v7). As can be noted in the chart, the 16 systems form two distinct groupings: systems with less than 50,000 rural population, and those with greater than 50,000 rural population. It is worth pointing out that the systems with greater than 50,000 rural dwellers characteristically have a narrow dispersion of average quarterly trip rates, thus the resulting forecasts computed with the average rate from this group will have smaller variances.

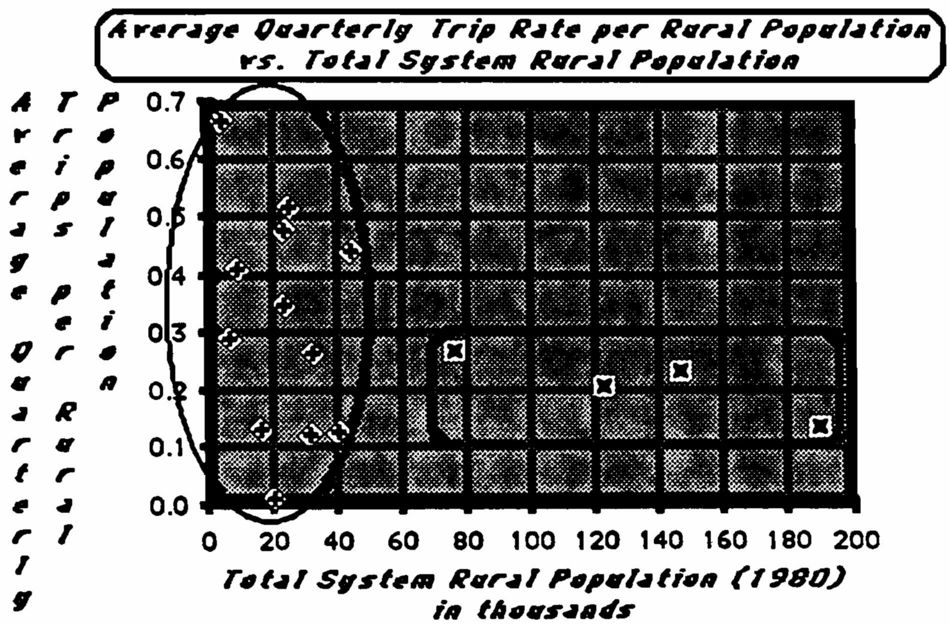


Figure 3.4.2

Based on this rank categorization of systems, it is then possible to compute average trip rates for large and small systems by using the following formula:

$$(\sum \text{Average Quarterly Trips}) / (\sum \text{Rural Residents}),$$

where the summations are taken over all systems in a particular size category.

The results from applying this formula are rates for *Average Quarterly System Total Ridership* per *Rural Population* of **0.194** for systems with greater than 50,000 rural residents and **0.288** for those with less than 50,000. The data on which these rate calculations are based can be found in ***Table 3.4.2*** on the following page. These rates will then serve as the forecasting aids to determine the average quarterly trips on a countywide level in the following chapter.

Section 3.5: RPT Demand Characteristics of Specialized Market Segments

It would be useful for planning and policy decisions to characterize the demand patterns of particular population subgroups which constitute specialized market segments for RPT service. Given that statistics on the ridership subgroups were readily available in connection with the RPT demand variables included in the data base developed in this study, it was possible to perform an exploratory analysis of this information. However, from among the subgroups listed in ***figures 3.5.1*** and ***3.5.2***, characterizations of the demand by elderly, low-income, and handicapped ridership only are possible at this point.

It is initially useful to identify the major components of the total demand variables (y_1 and y_2) and the relative contribution of each component to the total. This is shown in ***figures 3.5.1*** and ***3.5.2***, derived from mean systemwide figures, and therefore presenting a macro-level perspective, which may or may not correspond to a particular system.

Elderly ridership:

It is apparent that Section 18 RPT system ridership consists of a majority proportion of elderly riders, who outnumber those from any other segment. This can be explained in part by the fact that service providers are targeting this segment of the market, in view of the transportation-captive nature and travel dependent needs of a sizeable portion of the elderly population. The survey conducted for this report found that the majority of the trip purposes on the transit systems were associated with medical and nutritional needs of the aged. Such related services

TABLE 3.4.2. TRIP RATE FOR SYSTEMS GREATER THAN/LESS THAN 50,000 RURAL POPULATION

case	avg. trips	rurpop
2	24,936	190,010
4	33,869	146,870
5	25,097	122,900
14	20,394	77,129
Sum	104,296	536,909
Rate of Trips/Rurpop:	0.194	
1	4,219	10,338
3	8,592	33,189
6	13,254	25,731
7	5,077	40,665
8	177.5	21,029
9	11,648	24,615
10	19,955	45,412
11	3,764	32,084
12	8,435	24,459
13	2,274	7,935
15	3,365	5,093
16	2,109	16,789
Sum	82,869.5	287,339
Rate of Trips/Rurpop	0.288	

are also eligible to receive federal support in the form of Aid to Elderly Americans, thus providing transit operators with an additional source of funding.

With reference to age composition of the population, there are substantial differences in the age distributions of the populations of Texas counties. In some counties the residents average more than twice the age of those of others. Hamilton, Loving, and Mills counties, for example, have populations whose median ages are more that 45. In general, the demographic trend of the aged population

> ...has increased spectacularly in number because of lower death rates, longer life expectancies, and net in-migration into the state. Older persons continued to increase at a more rapid rate than the rest of the state's population between 1970 (8.9 percent of the state population) 1980 (9.6 percent).[5]

Statistical analyses performed with the data for the subcategory of elderly ridership failed to uncover any reliable relationships between predictor variables and demand.

It can be is noted, however, from the correlation matrix in ***table 3.3.1*** that there is an extremely high correlation coefficient (0.99) between total system population (v21) and the system elderly population (v38). This would indicate that the Section 18 systems are already operating in counties where the aged population has a strong impact on the overall age composition of the service area. The interaction of these variables (i.e., multicollinearity), therefore, with the variable for the population of rural residents precludes their combination as a set of independent variables for predicting demand.

Low-income ridership:

Plausible statistical relationships were established for low-income ridership demand. Both Initial Quarter System Low-Income Ridership and Average Quarterly System Low-income Ridership proved to be very reliable functions of System Minority Population. Both dependent variables y_{34} and y_{35} (Initial Quarter and Average Quarterly System Low-income Ridership, respectively) yielded r^2 coefficients of 0.95 when analyzed in the following equations:

$$y_{34} = -352.471 + 0.023 \text{ (minority pop.)}$$

$$y_{35} = -65.284 + 0.028 \text{ (minority pop.)}$$

Physically-impaired ridership:

The analysis of the ridership demand for the physically-impaired population unfortunately did not yield any statistically significant relationships with the variables included in the data set. It may prove useful to obtain information regarding this user segment from the more specialized agencies providing services to this sector. One characteristic that is apparent from *figures 3.5.1* and *3.5.2*, however, is that the handicapped ridership demand more than doubled in size over the long run in the systems considered. Note that the Initial Quarter Handicapped Ridership constitutes 3% of the total ridership demand, whereas the Average Quarterly Handicapped Ridership grows to 7% of the total demand. This would suggest that there is a potentially important demand for RPT by this segment of the population, one that develops in strong proportions over time.

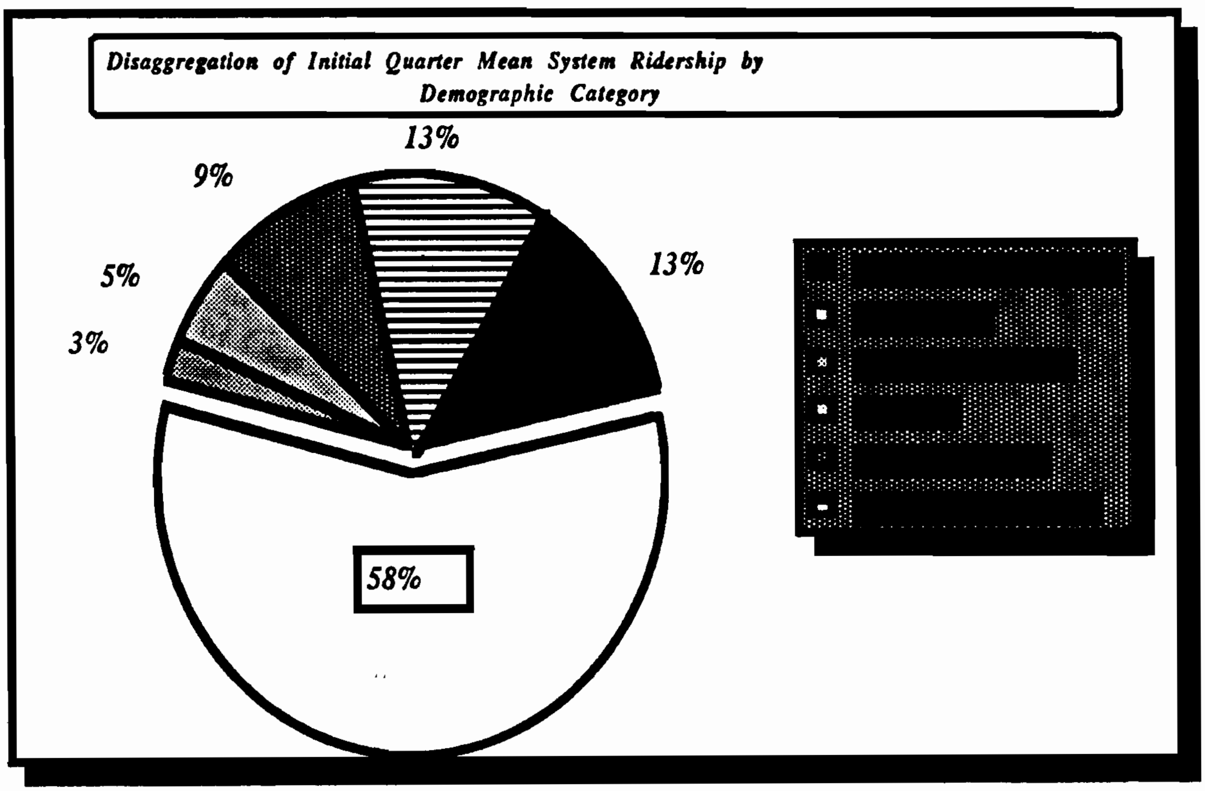


Figure 3.5.1

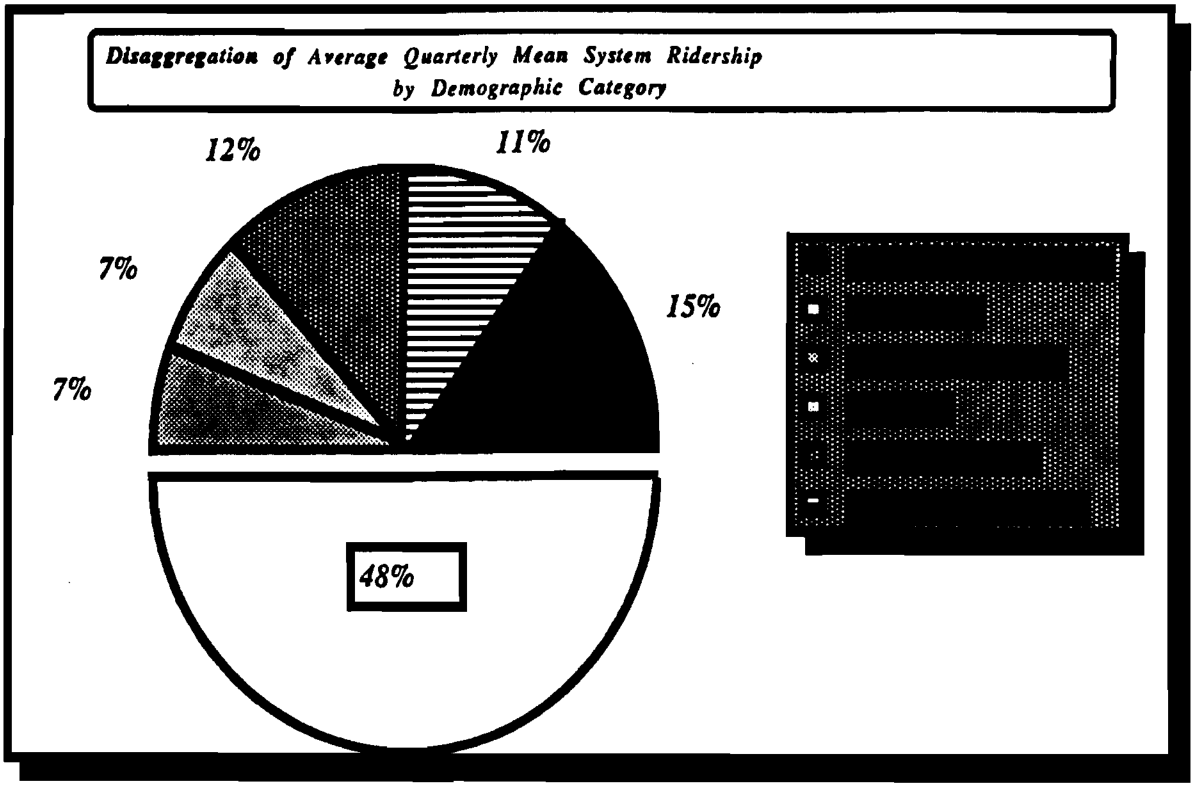

Disaggregation of Average Quarterly Mean System Ridership
by Demographic Category
12%
11%
7%
15%
7%
48%

Figure 3.5.2

Section 3.6 Notes to Chapter Three

[1]The 1980 Census Data which served as the principal source of information for the majority of the independent sociodemographic variables used in the present study were found in either the *County and City Data Book 1983*, 10th Edition, U. S. Department of Commerce, Bureau of the Census, or from the *1980 Census of Population, Texas Volumes*, U. S. Department of Commerce, Bureau of the Census. The following is a list of the specific chapters of the 1980 Census which were consulted in acquiring the data base herein analyzed: (1) Chapter A, Volume I, General Housing Characteristics, Part 45, Texas; (2) Chapter C, Volume 1, General Social and Economic Characteristics, Part 45, Texas; (3) Chapter B, Volume 1, General Population Characteristics, Part 45, Texas; (4) Chapter A, Number of Inhabitants, Part 45, Texas; and (5) Population 1920, Volume II, General Report and Analytical Tables.

[2]The analysis of the rural public transit ridership demand has been consistently and uniformly expressed throughout this report in terms of one-way passenger trips. This is the counting method employed by the service providers in filing the "Section 18 Grant Program Quarterly Reporting Forms." Insofar as these reporting forms served as the unique source of information regarding demand numbers for the various Texas RPT systems studied in the present report, and, given the fact that the findings herein are destined to be ultimately utilized within the same context from whence they originated, it is quite justifiable to have expressed the demand in said numerical terms.

A "one-way passenger trip" is strictly defined in this reporting system as what is recorded every time a passenger boards a vehicle. For example, when a person boards a vehicle to go to a medical center where she gets off, this is one trip. She could then board a vehicle again and travel to a shopping center, for instance, which is one trip. Finally, from the shopping center she boards a vehicle for the return trip home (one trip), and thus will have made a total of three trips for the day.

[3]Smith, Robert L., "Evaluation of Rural Public Transportation Demand Models That Include Level-of-Service Measures" (abridgment) in *Transportation Planning Techniques for Small Communities*, Transportation Research Record No. 638, Washington, D.C., 1977. Pp. 49-51.

[4]*Ibid.*, p. 51.

[5]Skrabanek, R. L., and Steve H. Murdock, "The Age Composition of the Texas Population," in *Texas Business Review*, The Bureau of Business Research, The University of Texas at Austin. May-June 1983, p. 146.

CHAPTER 4. AN IMPLEMENTATION OF THE MODEL: 1985 STATEWIDE DEMAND ESTIMATION FOR RPT

Section 4.1 Application of the Trip Rate Model At the County Level to Estimate Current Statewide Demand

The equations developed in the previous chapter are useful forecasting tools insofar as they capture the principal determinants of demand, namely sociodemographic characteristics and service availability or level of supply. It is frequently the case, however, that supply-side measures are unavailable, such as the case in unserved areas; or, due to ever-changing budgetary constraints and resource availability, they are in a perennial state of flux. Thus, there is a definite need for a simple tool with which estimates of demand can be obtained. It is believed that ***equations 3.4.1*** and ***3.4.2*** are such simple yet adequate forecasting tools, and could be implemented at the system level in order to estimate the current statewide demand for RPT.

A further word of caution may be in order with regard to the interpretation of the results of the application of the demand estimation equations. These equations were derived from systemwide ridership demand data without taking into consideration the detailed local characteristics of demand, service resources, route locations and frequencies, etc. It is nonetheless useful to apply such models, calibrated on a cross-section of systems, to obtain demand predictions for a particular system or subsystem, and assess its performance relative to the known observed value for that system.As seen in ***Figure 3.4.1,*** the sociodemographic predictor variable of total system rural population provides an adequate ex-post estimate of the observed total system ridership demand, and can thus be expected to yield similarly satisfactory projections.

Transportation planners and policymakers will hopefully have the opportunity for further refinement and calibration of these forecasting tools with the eventual expansion of the data base to include more RPT systems, and by submitting it to new statistical analyses such as those herein developed and utilized. In addition, it would be helpful to obtain more disaggregate data, at the household or individual tripmaker level, to gain a better understanding of travel behavior in rural areas. From the perspective of the scope and objectives of the present research, it is felt that ***equations 3.4.1*** and ***3.4.2*** can be used with reasonable confidence for making preliminary demand estimation analyses in any ***system level*** context, in the absence of information on service availability (in which case ***equations 3.3.1*** and ***3.3.2*** would be appropriate).

Comparisons with historical data indicate that the results are associated with the upper limit of the demand and tend to overestimate it. It may therefore be appropriate to interpret them as representative of the potential consumer base for the transit service. There are, however, a number of intervening factors, tangible and intangible alike, that also influence demand which must be taken into consideration.

As has been noted, the availability of service within the system is by far the most influential factor, other than the total system rural population, in determining demand. The residual error present in the resulting estimation from these equations will mostly be due to level-of-service factors.

Results of the analyses likewise demonstrate a significant interaction on the part of the variable which captures equations system population density with respect to the determination of average quarterly total system ridership demand.

In spite of the fact that other independent variables of sociodemograhic subgroups were not found to enter into the particular analysis (of average quarterly total system demand) utilized here in a statistically meaningful way, it is nevertheless logical to assume that characteristics of the total system elderly population exert influence over the demand. Two findings to keep in mind are that: 1) the subgroup of elderly rural public transportation patrons comprise approximately 50% of the overall ridership; and 2) the very high correlation coefficients of the elderly population with the total system populations studied (= 0.99), and with that of the rural population (= 0.90). It is felt that this latter factor is indicative of the interaction of elderly population characteristics already being captured, to some degree, in the rural population variable.

Finally, intangible factors such as the idiosyncratic characteristics of management, for example, with respect to the individual operations of the rural transit systems are assumed to play a significant role on the service and supply-side aspects of demand.

Equations 3.4.1. and ***3.4.2*** would most suitably be utilized on a *transit system level* basis. Their derivation stems from data taken transit systems operating within Texas. The techniques used in arriving at them more precisely depict macrosystem and average values. For the task at hand, i.e. the projected estimates of total ridership demand at the *individual county level*, the estimator equations would yield unrealistic estimates in many instances due to low levels of rural population in a good number of Texas counties. As is stated in the previous chapter, for these reasons it has been necessary to develop and employ a trip rate model based on the ratio of *average quarterly total system trips per rural population* in order to perform the total ridership demand estimation for the counties of Texas.

The task of developing demand estimation equations as has herein been conceptualized and carried out represents a "top-down" process in the sense that the best most accurate forecasting equations are obtained when the two best sources of data were available (i.e. rural population and level-of-service measures). The next best are those with the only population parameters being available at the principal level of analysis: the transit system level. Finally, a slight modification of this latter approach--as is the the trip rate model--yields useful estimations of the demand in county level areas.

A reversal of this process would assuredly be one viable alternative for the subsequent utilization of these models by transportation planners. The usage of a "bottom-up" process would hence begin with a) the following estimates for ridership at the county level, in order to be able to b) design rural transit systems based on groupings of contiguous counties, at which point ***equations 3.4.1*** and ***3.4.2*** would suitably provide estimates of potential demand; finally, c) various scenarios can be carried out of what the latent ridership demand might be in view of supply level characteristics and, with reference to the average quarterly demand, system population density; the most accurate demand predictors obtained, namely ***equations 3.3.1*** and ***3.3.2*** would then be used at this stage of the service planning process.

The census data regarding current population statistics were taken from what were considered to be the best available estimates.[1] The estimates were associated with the total population in general; therefore, it was necessary to assume that the per capita rural population in 1985 was the same as the 1980 figure in order to make this five-year projection. One drawback to this, of course, is the fact that the migration trends, if any, are ignored.

Thus, this chapter is concluded with the demand estimation information that is found in ***table 4.1.1***.

Section 4.2 Notes to Chapter Four

[1]TEXAS DEPARTMENT OF HEALTH, Population Data System, State Health Planning and Resource Development

TABLE 4.1.1

1985 COUNTY LEVEL DEMAND ESTIMATION FOR RURAL PUBLIC TRANSPORTATION

TEXAS COUNTIES	ESTIMATED RURAL POPULATION 1985	ESTIMATED AVERAGE QUARTERLY TOTAL SYSTEM RIDERSHIP DEMAND
ANDERSON	26,006	7,490
ANDREWS	2,583	744
ANGELINA	34,575	9,958
ARANSAS	11,851	3,413
ARCHER	7,666	2,208
ARMSTRONG	2,063	594
ATASCOSA	15,140	4,360
AUSTIN	12,616	3,633
BAILEY	3,602	1,037
BANDERA	8,499	2,448
BASTROP	15,430	4,444
BAYLOR	1,233	355
BEE	12,643	3,641
BELL	34,230	9,858
BEXAR	57,459	11,162
BLANCO	5,325	1,534
BORDEN	866	249
BOSQUE	11,386	3,279
BOWIE	28,306	8,152
BRAZORIA	77,551	15,064
BRAZOS	11,173	3,218
BREWSTER	2,109	607
BRISCOE	2,599	749
BROOKS	2,451	706
BROWN	15,469	4,455
BURLESON	10,397	2,994
BURNET	13,677	3,939
CALDWELL	11,446	3,296
CALHOUN	9,090	2,618
CALLAHAN	10,013	2,884
CAMERON	55,519	10,785
CAMP	5,582	1,608
CARSON	6,896	1,986
CASS	25,802	7,431
CASTRO	6,309	1,817

(continued)

TABLE 4.1.1. (Continued)

TEXAS COUNTIES	ESTIMATED RURAL POPULATION 1985	ESTIMATED AVERAGE QUARTERLY TOTAL SYSTEM RIDERSHIP DEMAND
CHAMBERS	23,265	6,710
CHEROKEE	23,283	6,715
CHILDRESS	1,179	340
CLAY	7,061	2,036
COCHRAN	2,317	668
COKE	3,253	938
COLEMAN	4,558	1,315
COLLIN	41,625	12,005
COLLINGSWORTH	1,629	470
COLORADO	11,466	3,307
COMAL	17,190	4,958
COMANCHE	8,920	2,573
COOKE	14,662	4,229
CORYELL	20,391	5,881
COTTLE	2,908	839
CRANE	1,086	313
CROCKETT	979	282
CROSBY	9,810	2,829
CULBERSON	705	203
DALLAM	2,082	600
DALLAS	10,141	2,925
DAWSON	4,408	1,271
DEAF SMITH	6,176	1,781
DELTA	4,884	1,409
DENTON	42,944	12,385
DE WITT	9,669	2,789
DICKENS	3,554	1,025
DIMMIT	5,117	1,476
DONLEY	4,353	1,255
DUVAL	5,351	1,543
EASTLAND	8,437	2,433
ECTOR	16,498	4,758
EDWARDS	2,391	690
ELLIS	34,067	9,825
EL PASO	22,540	6,501

(continued)

TABLE 4.1.1. (Continued)

TEXAS COUNTIES	ESTIMATED RURAL POPULATION 1985	ESTIMATED AVERAGE QUARTERLY TOTAL SYSTEM RIDERSHIP DEMAND
ERATH	8,884	2,562
FALLS	11,115	3,206
FANNIN	17,633	5,085
FAYETTE	15,766	4,547
FISHER	5,956	1,718
FLOYD	6,173	1,780
FOARD	2,111	609
FORT BEND	49,237	14,200
FRANKLIN	7,013	2,023
FREESTONE	9,575	2,761
FRIO	4,422	1,275
GAINES	4,965	1,432
GALVESTON	15,638	4,510
GARZA	1,446	417
GILLESPIE	8,031	2,316
GLASSCOCK	1,435	414
GOLIAD	5,671	1,636
GONZALES	10,053	2,899
GRAY	4,925	1,420
GRAYSON	31,125	8,977
GREGG	21,290	6,140
GRIMES	8,271	2,385
GUADALUPE	24,647	7,108
HALE	14,340	4,136
HALL	2,231	643
HAMILTON	5,524	1,593
HANSFORD	2,810	810
HARDEMAN	2,489	718
HARDIN	29,040	8,375
HARRIS	102,639	19,938
HARRISON	27,844	8,030
HARTLEY	2,022	583
HASKELL	3,811	1,099
HAYS	18,188	5,245
HEMPHIL	2,364	682

(continued)

TABLE 4.1.1. (Continued)

TEXAS COUNTIES	ESTIMATED RURAL POPULATION 1985	ESTIMATED AVERAGE QUARTERLY TOTAL SYSTEM RIDERSHIP DEMAND
HENDERSON	40,921	11,802
HIDALGO	90,744	17,627
HILL	18,632	5,374
HOCKLEY	10,230	2,950
HOOD	20,646	5,954
HOPKINS	13,762	3,969
HOUSTON	16,594	4,786
HOWARD	7,934	2,288
HUDSPETH	3,417	985
HUNT	26,692	7,698
HUTCHINSON	10,807	3,117
IRION	1,604	463
JACK	3,604	1,039
JACKSON	7,954	2,294
JASPER	26,690	7,697
JEFF DAVIS	1,882	543
JEFFERSON	14,347	4,138
JIM HOGG	537	155
JIM WELLS	12,563	3,623
JOHNSON	38,998	11,247
JONES	6,539	1,886
KARNES	6,036	1,741
KAUFMAN	23,635	6,816
KENDALL	8,939	2,578
KENEDY	703	203
KENT	1,053	304
KERR	16,085	4,639
KIMBLE	1,518	438
KING	439	127
KINNEY	2,733	788
KLEBERG	4,723	1,362
KNOX	5,253	1,515
LAMAR	18,098	5,220
LAMB	11,866	3,422
LAMPASAS	6,682	1,927

(continued)

TABLE 4.1.1. (Continued)

TEXAS COUNTIES	ESTIMATED RURAL POPULATION 1985	ESTIMATED AVERAGE QUARTERLY TOTAL SYSTEM RIDERSHIP DEMAND
LA SALLE	1,716	495
LAVACA	12,754	3,678
LEE	8,259	2,382
LEON	10,380	2,994
LIBERTY	34,276	9,885
LIMESTONE	10,274	2,963
LIPSCOMB	4,042	1,166
LIVE OAK	8,483	2,447
LLANO	8,180	2,359
LOVING	81	23
LUBBOCK	30,639	8,836
LYNN	5,882	1,696
MCCULLOCK	2,858	824
MCLENNAN	34,016	9,810
MCMULLEN	770	222
MADISON	7,248	2,090
MARION	8,648	2,494
MARTIN	5,106	1,473
MASON	3,850	1,110
MATAGORDA	18,150	5,235
MAVERICK	13,832	3,989
MEDINA	14,446	4,166
MENARD	2,388	689
MIDLAND	11,971	3,452
MILAM	12,344	3,560
MILLS	4,626	1,334
MITCHELL	3,899	1,124
MONTAGUE	9,379	2,705
MONTGOMERY	143,893	27,952
MOORE	4,826	1,392
MORRIS	12,720	3,668
MOTLEY	1,897	547
NACOGODOCHES	20,963	6,046
NAVARRO	14,563	4,200
NEWTON	14,275	4,117

(continued)

TABLE 4.1.1. (Continued)

TEXAS COUNTIES	ESTIMATED RURAL POPULATION 1985	ESTIMATED AVERAGE QUARTERLY TOTAL SYSTEM RIDERSHIP DEMAND
NOLAN	5,422	1,564
NUECES	17,355	5,005
OCHILTREE	1,601	462
OLDHAM	2,314	667
ORANGE	35,381	10,204
PALO PINTO	9,067	2,615
PANOLA	16,661	4,805
PARKER	36,613	10,559
PARMER	8,036	2,318
PECOS	6,558	1,891
POLK	25,331	7,306
POTTER	103,442	20,094
PRESIDIO	5,628	1,623
RAINS	5,555	1,602
RANDALL	9,387	2,707
REAGAN	866	250
REAL	2,695	777
RED RIVER	12,011	3,464
REEVES	3,060	883
REFUGIO	5,427	1,565
ROBERTS	1,336	385
ROBERTSON	9,450	2,725
ROCKWALL	10,171	2,933
RUNNELS	4,737	1,366
RUSK	30,682	8,849
SABINE	9,537	2,751
SAN AUGUSTINE	6,165	1,778
SAN JACINTO	14,992	4,324
SAN PATRICIO	17,914	5,166
SAN SABA	3,629	1,047
SCHLETCHER	3,195	921
SCURRY	5,980	1,725
SCHAKELFORD	4,383	1,264
SHELBY	18,719	5,399
SHERMAN	3,011	868

(continued)

TABLE 4.1.1. (Continued)

TEXAS COUNTIES	ESTIMATED RURAL POPULATION 1985	ESTIMATED AVERAGE QUARTERLY TOTAL SYSTEM RIDERSHIP DEMAND
SMITH	63,476	12,330
SOMERVELL	5,227	1,507
STARR	19,708	5,684
STEPHENS	3,346	965
STERLING	1,273	367
STONEWALL	2,405	694
SUTTON	1,605	463
SWISHER	4,958	1,430
TARRANT	29,706	8,567
TAYLOR	12,311	3,551
TERRELL	1,747	504
TERRY	4,625	1,334
THROCKMORTON	2,038	588
TITUS	11,930	3,441
TOM GREEN	11,810	3,406
TRAVIS	57,187	11,109
TRINITY	7,700	2,221
TYLER	15,509	4,473
UPSHUR	14,444	4,166
UPTON	4,965	1,432
UVALDE	9,743	2,810
VAL VERDE	3,438	992
VAN ZANDT	27,973	8,068
VICTORIA	20,501	5,913
WALKER	19,440	5,607
WALLER	13,454	3,880
WARD	6,008	1,733
WASHINGTON	11,980	3,455
WEBB	5,437	1,568
WHARTON	21,927	6,324
WHEELER	4,628	1,335
WICHITA	6,190	1,785
WILBARGER	2,406	694
WILLACY	8,795	2,537
WILLIAMSON	44,131	12,728

(continued)

TABLE 4.1.1. (Continued)

TEXAS COUNTIES	ESTIMATED RURAL POPULATION 1985	ESTIMATED AVERAGE QUARTERLY TOTAL SYSTEM RIDERSHIP DEMAND
WILSON	14,234	4,105
WINKLER	2,060	594
WISE	21,803	6,288
WOOD	20,667	5,960
YOAKUM	3,971	1,145
YOUNG	6,579	1,897
ZAPATA	9,052	2,611
ZAVALA	3,621	1,044
CONCHO	3,062	883

CHAPTER 5. ELASTICITY OF DEMAND FOR RPT TO SYSTEM SUPPLY CHARACTERISTICS

Section 5.1 Elasticity of Demand to Maximum Hours of Operation

The demand models developed in Chapter 3 have clearly substantiated that demand is a function of system supply characteristics (captured in the hours of operation in the models of Chapter 3). It would therefore be very useful for planning purposes to analyze the relative responsiveness or sensitivity of the demand to changes in supply. Such is captured by the concept of elasticity which is, in effect, one of the most integral aspects of demand analysis.

Elasticity of demand measures the magnitude of the sensitivity of the quantity demanded of a product (or, as in this case, of a service like RPT) to a change in some determinant of demand (hours of operation). The elasticity of demand for RPT in Texas has been found to possess distinct characteristics which vary in a systematic manner.

Based on information given in the quarterly reporting forms, it was possible to compute elasticity coefficients for a group of ten of the RPT systems. In these cases, the nature of the information provided was such that demonstrable changes in system supply (and resulting demand) could be observed. Sufficient data was available so that the effect of increased supply on demand could be analyzed both in terms of breakpoint values and average values on either side of the breakpoint. The latter mentioned calculation is a version of the following modified arc elasticity formula:

$$\epsilon = \frac{\text{\% change in average ridership demand}}{\text{\% change in average supply of service (vehicle hours)}}$$

Note: average values based on three quarterly observations on either side of a demonstrable supply change

The utilization of this formula yields an estimate of the responsiveness or sensitivity of the quantity demanded at the midpoint of the range defined by the two points on the demand curve. In this case, however, average values based on three quarters' observations on either side of the breakpoint serve as an adjustment to compensate for any fluctuations in demand that are cyclical or seasonal in nature. Moreover, this technique also adjusts for any possible time lag which might occur from the quarter in which the supply was increased to the quarter in which the concomitant effect on demand was evidenced and subsequently stabilized. One would not expect the demand to react instantaneously to supply changes.

Arc and modified arc elasticity coefficients were derived for supply characteristics: actual and maximum hours of operation. Thus, four different sets of elasticity coefficients were evaluated and are listed in ***Table 5.1.1***.

A data base for correlation and regression analysis was constructed for the ten cases in which elasticity coefficients were computed. Although this represents relatively too few cases for a rigorous statistical analysis to be conducted, it became apparent that some useful relationships do exist.

The dependent variables analyzed in this new data base are as follows:

-Arc Elasticity $\text{Coefficient}_{\text{actual hours}}$

-Arc Elasticity $\text{Coefficient}_{\text{max hours}}$

-Modified Arc Elasticity $\text{Coefficient}_{\text{actual hours}}$

-Modified Arc Elasticity $\text{Coefficient}_{\text{max hours}}$

The independent or predictor variables are:

-Initial Quarter System Total Ridership

-Average Quarterly System Total Ridership

-System Rural Dweller Population

-Initial Quarter Maximum Available Vehicle Operating Hours

-Initial Quarter Actual Vehicle Operating Hours

-System Elderly Population (over age 65)

Results obtained from the correlation matrix (***Table 5.1.2***) show an inverse relationship between the four sets of elasticity coefficients and the two sets of demand variables. This can be fundamentally interpreted to mean that the greater the number of patrons served, the more inelastic the demand is; that is to say, the larger the system demand, the less responsiveness to changes in system supply. Thus, elasticity is inversely proportional to system size.

In spite of the fact that few cases entered into the regression analyses, statistically significant relationships were produced in terms of dependent and independent variables, and the equation obtained in ***Table 5.1.2*** yielded notable values with respect to the correlation coefficient and the coefficient of determination. It is necessary to clarify that the equation developed here is not intended for prediction purposes, but rather more as a means of illustrating the relation between the elasticity and the system characteristics, thereby gaining insight into the nature of the underlying demand function (the elasticity coefficient variable is a function of the supply and demand variables to begin with). The reason it has been singled out, however, is because it demonstrates that the variable "maximum hours of operation" constitutes the most statistically relevant relationship with the modified arc elasticity coefficient. This is further indication that this variable is the most appropriate measure of system supply and hence can be operationalized for the analysis of the elasticity of demand which is the subject of the following section.

TABLE 5.1.1. ELASTICITY COEFFICIENTS

SYSTEM	ARC ACTUAL	ARC MAXIMUM	MODIFIED ARC-ACTUAL	MODIFIED ARC-MAX.
LRGVDC	0.17	0.25	0.36	0.53
Rolling Plains	0.23	0.26	0.35	0.38
Brazos Transit	0.63	0.86	1.33	-2.15
CARTS	0.69	0.9	1.04	1.27
Caprock	0.73	0.73	0.27	0.23
SPARTAN	1.94	3.69	3.63	7.35
Bosque	2.71	3.2	1.59	4.23
SPARTS	2.78	3.35	1.22	1.39
City of Cleburne	3.12		7.8	6.3
CCSWT	29.64	17.75	11.15	31.44

TABLE 5.1.2

CORRELATION MATRIX

	1V	2V	3V	4V	5V	6V	7V	8V	9V	10V
1V	1.00	.83	.99	.97	-.25	-.20	-.28	.26	.08	-.15
2V	.83	1.00	.86	.89	-.32	-.34	-.31	.08	-.05	-.23
3V	.99	.86	1.00	.98	-.31	-.26	-.34	.25	.08	-.20
4V	.97	.89	.98	1.00	-.35	-.30	-.37	.21	.04	-.23
5V	-.25	-.32	-.31	-.35	1.00	.94	.96	.69	.74	.90
6V	-.20	-.34	-.26	-.30	.94	1.00	.89	.74	.75	.86
7V	-.28	-.31	-.34	-.37	.96	.89	1.00	.63	.69	.77
8V	.26	.08	.25	.21	.69	.74	.63	1.00	.98	.80
9V	.08	-.05	.08	.04	.74	.75	.69	.98	1.00	.84
10V	-.15	-.23	-.20	-.23	.90	.86	.77	.80	.84	1.00

Number of cases: 10
Number of missing cases: 0

MULTIPLE REGRESSION RESULTS:

DEPENDENT VARIABLE: 4

INDEPENDENT VARIABLES: 5 8

MULTIPLE CORRELATION: .7226 F(2, 7) = 3.825 p = .075
R-square: .5222

BETA for var	5 =	-.959	8 =	-.001	t(7) =	-2.648	p = .032
BETA for var	8 =	.874	8 =	.003	t(7) =	2.411	p = .045

INTERCEPT = 1.676

Analysis of variance:

	SS:	MS:	df:	F:	p:
REGRESSION	443.29	221.64	2	3.82	.075
RESIDUAL	405.64	57.95	7		
TOTAL	848.93				

It can be noted that a negative elasticity coefficient is associated with this variable for one of the systems plotted in ***Table 5.1.1.*** The *-2.15* value of this coefficient indicates that a 1% change in maximum available vehicle hours was followed by approximately 2% change in the level of ridership in the *opposite* direction. Given that the present analysis of elasticity of demand has been performed from only data showing an increase in the service supply level, the negative coefficient in this instance indicates a decrease in ridership in response to an increase in the maximum vehicle operating hours. The explanation for this seemingly counter-intuitive result can be seen in the corresponding elasticity with respect to actual operating hours. Effectively, while the theoretical maximum operating hours were increased (presumably through vehicle acquisition), this did not translate into increased actual service hours, due to factors such as breakdowns or inadequate resources, etc.... The resulting decrease in actual service hours was accompanied by a decrease in ridership, resulting in the negative elasticity calculated above.

Section 5.2: Analysis of the Elasticity of Demand

Figure 5.2.1 represents a scattergram plot of the supply-demand coordinates that the preceding elasticity coefficients of demand are based on. Each point is identified by the system name and the corresponding elasticity coefficient. Close inspection of the chart reveals a somewhat systematic and proportional relationship between the size of the demand and the size of the elasticity coefficient. By convention, when the coefficient is a number greater than 1, the demand is said to be *elastic,* meaning that a one percent increase in supply yields a relatively greater percent increase in demand; and when the coefficient is less than 1, it is said to be *inelastic.* Should the coefficient turn out to be 1, then the demand is said to be unitary or of *unitary elasticity.* It may be observed from ***figure 5.2.1*** almost all systems with an average quarterly demand of less than about 8,000 one-way passenger trips have an inherently elastic demand. On the other hand, those systems with greater than 8,000 one-way passenger trips per quarter on average have a demand that is relatively not as sensitive to variations of the supply characteristics.

It is worth noting that these elasticities constitute a "data base" which might give planners meaningful insights into supply effects in the context of simplified analyses. One could use these reported values, with caution, for similar systems. Hence, this is being offered as a useful guideline in terms of system size and type of service.

In addition to the more obvious factor of the numerical size of the demand as a determinant of elasticity, there are other ones which can be characterized as being either endogenous or exogenous factors which influence the elasticity of demand for Rural Public Transportation.

An endogenous factor which can be considered to determine the the elasticity of ridership demand demand is the type of transportation network utilized by the system. Results obtained from the "Mail-phone Survey" (please refer to Chapter Three) indicate that those larger systems where the demand has been fundamentally characterized as being inelastic are those which have definitely larger proportions fixed-route service. The areas in which these fixed-route systems operate are those in which population density is more concentrated and can thus be efficiently served by this particular type of service.

It is interesting to note that the only system that does not fit within the classification of systems by demand elasticity and the inherent relationship that appears to exist with this type of transportation service network is the Rolling Plains Campus of the Texas State Technical Institute. This very small system which displays a

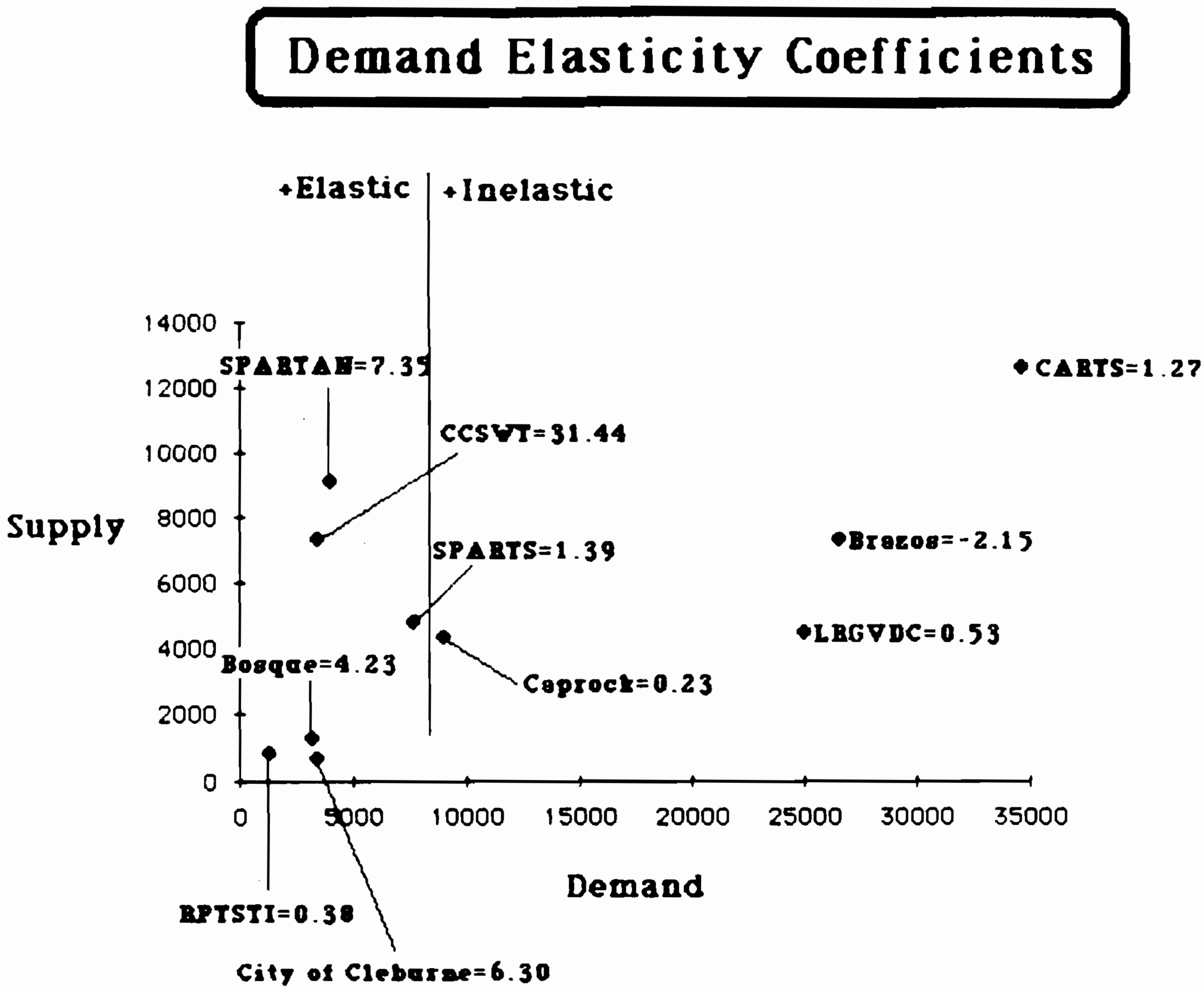

Demand Elasticity Coefficients
+Elastic
+Inelastic
14000
12000
10000
8000
6000
4000
2000
0
Supply
SPARTAN=7.35
CCSWT=31.44
SPARTS=1.39
Bosque=4.23
Caprock=0.23
CARTS=1.27
Brazos=-2.15
LRGVDC=0.53
0
5000
10000
15000
20000
25000
30000
35000
Demand
RPTSTI=0.38
City of Cleburne=6.30

Figure 5.2.1

characteristically inelastic ridership demand is almost entirely a fixed-route system. In addition, it is not a typical Section 18 RPT system in that it is not targeted to the traditional market segments served by such systems.

In areas of lower population density the demand-responsive system is the predominant type of service. It has been found that, with regard to these smaller systems, the demand is more sensitive to supply changes, and would thus tend to provide considerably more benefits from increases in the service supply characteristics. This implies that each additional maximum hour of operation is marginally more effective or useful in generating demand and hence serving a greater ridership demand than would be possible in systems which primarily demonstrate an inelasticity of demand. It can be said that these systems have a proportionally higher latent demand above the observed demand, and as such they are currently operating at suboptimal levels of service.

The effect of general economic conditions and, specifically, the curtailment in government funding with respect to the Section 18 Rural Transportation Programs is one example of an exogenous factor which may influence demand elasticity. If rural transit systems are in need of additional revenues sources in order to cover operating costs, the most viable alternative is the implementation of a fare system. Brazos Transit, for example, is a system where the majority of the ridership (the general public) is not covered by the federally funded contract and hence must pay to use the service. Such conditions are deemed to be important determinants of demand when, as in this instance, despite an increase in supply, the demand decreases.

In addition to the considerations revolving around the issue of fare systems, there is also an evident discrepancy between the maximum available vehicle hours and the actual vehicle operating hours in this instance. What this factor suggests, and perhaps ought to underscore, is the conclusion that simply increasing maximum hours of operation (which is tantamount to the addition of further capital resources, both human and vehicular) is not, in and of itself, enough to increase demand. There must also be some provision to ensure that the vans, cars or buses are actually out on the road in order to realize this goal.

CHAPTER 6. CONCLUSIONS

Section 6.1 Summary of Findings

This study has revealed the extent of the demand for rural public transportation in Texas counties. This demand is evidenced by the current usage patterns in existing Section 18 RPT systems in Texas. Three principal sources of data, primary as well as secondary, were used to form the data base employed in this research:

1. Census data, for sociodemographic variables;

2. Section 18 contractors' quarterly reporting forms, submitted to the SDHPT, for ridership information;

3. A mail-phone survey of these contractors/operators, conducted by the Center for Transportation Research, for data on the RPT systems' service characteristics.

This data base represents the best currently available sources of information on Section 18 RPT systems in Texas.

The major trends contained in the ridership information were analyzed, revealing the sustained evolution and growth in the demand for these services over time. In addition, the composition of this ridership was analyzed across the existing systems, indicating that elderly passengers account for the largest fraction of trips (about 50%) served by these systems. This underscores the vital nature of the service provided by these systems.

The analysis leading to the development of systemwide and countywide demand forecasting methodologies determined that the two principal determinants of the observed ridership demand served by current RPT systems are: 1) sociodemographic characteristics, captured by the size of the rural dweller population in the service area, and 2) supply characteristics, particularly service availability, captured by the offered vehicle hours of operation. Analytical regression equations were developed to predict both the initial quarter demand (upon service introduction) as well as an average quarterly figure over the longer run.

In addition, equations that do not include service availability variables were developed as an acceptable alternate in the absence of supply information, such as in unserved or unreliably served areas. To avoid issues associated with erroneous predictions with an equation with a large constant coefficient in areas the size of which falls below the range reflected in the estimation data set, average trip rates were calculated, for small and large systems separately. These rates were utilized to develop estimates of the expected current potential demand for RPT for all counties in Texas, revealing the extent of unmet demand in these areas relative to those with existing service.

The available ridership information also allowed some insights into specialized market segments for RPT, particularly the elderly, low-income and physically impaired ridership. Parameters useful for planning purposes were compiled on these segments.

Another useful contribution of this research is the examination of the elasticity of demand to service supply, the latter expressed in terms of the vehicle hours of operation (both "theoretical" maximum as well as actual values). These elasticities were calculated for those existing systems which experienced expansion of service availability during the observation period. In addition to the usefulness of these elasticities for planning purposes, analysis of the observed values revealed an inverse relation with system size, whereby smaller elasticities were associated with the larger RPT systems.

In summary, this study has contributed to the characterization of the demand for RPT in Texas, and to the documentation of its extent and magnitude. It has also developed easy-to-use procedures for forecasting the demand for such services, as well as a set of useful planning parameters regarding various aspects of this demand.

Section 6.2 Recommendations and Suggestions for Further Research

In these concluding remarks, it is useful to underscore the strengths and pitfalls encountered in the development and subsequent application of the forecasting models which have constituted the principal objective of this study, and to point to some aspects that could benefit from further attention in future work. The data was analyzed using standard methodology; regression analysis is of course well established in the study of travel demand, and is noted for its versatility with respect to the time span over which forecasts and projections can be made. The regression model is equally suitable for forecasting a present need as well as in the context of making short, medium or long term projections (provided of course that no major structural or technological changes take place to alter the underlying relationships). While the data base development and model formulation and calibration activities may be somewhat time-consuming, any subsequent application of the regression model to generate forecasts is quick and relatively simple. This offers an advantage in terms of being able to systematically and easily update projections, as needed. It is further worth noting that in terms of computer resource requirements, the present study was conducted with no further data processing capabilities than a microcomputer (Apple Macintosh model).

It is felt that the supply-sensitive demand models developed in this study are internally consistent with respect to managerial decisions (by the service provider), which can be effectively reflected in the level-of-service measures included in the model specification. The inputs to the model also have a measure of external consistency since the rural population variable used could reflect environmental changes in the service area. Naturally, if any significant shift were to occur among the variable relationships, then the predictive capability of the model would be weakened in light of such shifts. However, this is not anticipated to happen in the RPT context, at least not in the medium-term future, where rural public transportation demand can reasonably be expected to remain a function of rural population and service supply.

Regarding further development of the methodology developed in this study, three principal directions are worthy of note:

1. Expanding the data base to include more Section 18 RPT systems, such as the new systems initiated in Texas since the initiation of this study, as well as from other states.

2. Addressing in greater detail the evolution process of ridership over time in RPT systems, particularly the build-up (or loss) of ridership following the introduction of new service or major system changes, including the magnitude of the time lags that might be associated with this demand response. This would require high quality time-series data over a long period, and would involve separating seasonal patterns from responses to service quality improvements or marketing and promotional activities.

3. Developing a disaggregate individual or household level data base that would yield better insights into the travel behavior and needs of rural residents, including the specialized market segments identified in earlier chapters. Despite the widespread interest in and development of travel behavior studies at the individual level, tripmaking in non-metropolitan areas has received very little attention from researchers and sponsoring agencies. Such knowledge is needed to provide a firm and sound basis for planning and policy decisions in this arena.