IN DEPTH STUDY OF THE BURKHARDT / LAGO MODEL REGARDING THE DEMAND FOR RURAL PUBLIC TRANSPORTATION TO THE SIX PROPOSED REGIONAL BUS SYSTEMS IN KANSAS

by

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I. INTRODUCTION

The lack of adequate, effective (25)* transportation services is now recognized by numerous Federal and State agencies as one of the major problems facing the elderly, handicapped, and other transportation disadvantaged persons in rural areas. Although many rural counties now have adequate all -weather road systems, some persons and communities still remain isolated from the mainstream of American society because of their inability to travel. Often, this immobility is due to the inability to pay the price for existing transportation services; other times, however, transportation services are non-existent for persons not owning automobiles.

The Kansas Department of Transportation Planning and Development Department has become involved with preliminary implementation stages of a project wherein a statewide rural public transportation system is to be initiated as a two year demonstration project. The project is funded with $500,000 from the United States Department of Transportation Federal Highway Administration, specifically from Section 147 of the Federal - Aid Highways Act of 1973. The project, Statewide Rural Public Transportation System for the State of Kansas, was submitted as a joint proposal by the Kansas Department of Transportation Planning and Development

* Numbers in parenthesis refer to the LIST OF REFERENCES, section VII.

Department and the Kansas Social and Rehabilitation Services Department. Part of the author's duties, as Planner at the Kansas Department of Transportation, were to assist in the project evaluation and implementation process. Thereby, the author has worked extensively in the refinement of the statewide network for the Section 147 project.

As an aid to the Section 147 project implementation process, an estimate of demand for each of six proposed regional bus systems is a necessary tool. Burkhardt and Lago (7) developed a handbook for the prediction of rural public transportation demand for the State of Pennsylvania. The purpose of their handbook was to develop a tool for local planners to estimate the demand for public transportation systems in rural, or predominantly rural areas. Their model utilized characteristics for prediction or estimation of demand that are most highly adaptable to those of the six proposed regional public transportation systems in Kansas.

This thesis is an in - depth study of the Burkhardt / Lago model. The model is discussed with respect to its development, application in Pennsylvania, application in Arkansas, and use in estimation of demand for the six proposed rural public transportation systems in Kansas.

The hypothesis presented here is that the Burkhardt / Lago Model is the best currently available model for utilization on the Kansas Rural Public Transportation Network.

II. LITERATURE REVIEW

A. State of the Art Overview

(1) The Nature of Rural Public Transit Demand

In a nationwide study by the United States Department of Transportation Office of Policy and Plan Development (41) it was found that the demand for rural public transit service is very low. The primary trip purposes served were those of persons seeking access to shopping, medical care, or social services. While the destinations of such trips were usually small in number and quite concentrated, often a single town; origins were usually more numerous and disbursed because the potential riders tend to be more scattered and isolated than the general population.

There are three major approaches to determine the need for rural transit (43) :

1. An Opinion Survey;
2. A Demonstration Program; and
3. Calculation of the present average-travel behavior through the use of a mathematical model.

Opinion surveys tend to be time consuming and over - estimate the demand for transit. Demonstration projects tend to be very costly; therefore, should not be embarked upon without a prior demand estimate. The mathematical models range in nature from very simple to very complex. Within this range, it was expected that a model could be found which would yield a meaningful estimate for the demand for rural transit at a minimal cost and length of time.

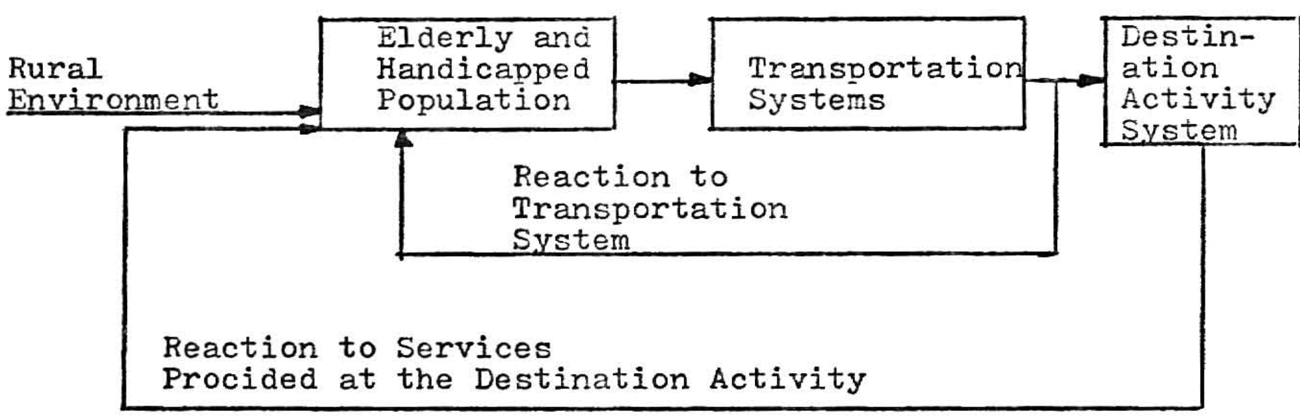
(2) The Nature of the Rural Public Transit Ridership

Section 16 (b) (2) of the Urban Mass Transportation Act of 1964 defines a public transportation dependent person as any individual who, by reason of illness, injury, age, congenital malfunction, or other permanent or temporary incapacity or disability, is forced to look to others for fulfillment of their travel needs (47) . Of the 20 million elderly persons in the United States in 1970, approximately 27 percent or 5.4 million lived in rural areas (41). The transportation consequences for the rural elderly are relatively clear. Their isolation is more acute and their income conditions tend to be significantly worse than their urban counterparts. Their need for transportation is more serious in that they have less access to social services and / or lower incomes with which to purchase such services (38). The plight of the rural handicapped is quite the same as that of the rural elderly (46).

B. Duscussion of Models

Addressing the question of predicting the demand for region-wide transportation systems, Dunbar (10) states that the conventional urban transportation planning (UTP) type of model will not capture the full range of travel impacts, and is typically cumbersome and resource consuming in its application; therefore, a new type of model is needed. Unfortunately, little demand information is available to aid in systems implementation decision (31). However, from the experiences of rural transit operators, the components of demand may be shown as follows (30) (31) :

FIGURE I COMPONENTS OF RURAL PUBLIC TRANSIT DEMAND (31)



To put the components of rural public transit into mathematical terms a number of mathematical formulas have been utilized. Not all of the mathematical formulas can be utilized for all systems. There must be a set of criteria by which a selection can be made.

As a result of a literature scan with Mr. E. D. Landman of the Kansas Department of Transportation the following set of evaluation criteria was developed for the comparative analysis of models for estimation of rural public transportation demand (9) (17) (18) (19) (20) (21).

The evaluation process:

1. Are the variables basic and available?
   If yes, then continue to #2;
   If no, then disregard model;
2. Establish criteria for the variables, and prepare budget guidelines;
3. Are the criteria and budget acceptable?
   If yes, then continue to #4;
   If no, then disregard model;
4. Survey expert group criticisms;
5. Are the criteria met?
   If yes, then continue to #6;
   If no, then disregard model;

6. Are the parameters stable over the sample space?
   If yes, then continue to #7;
   If no, then disregard model.
7. Are the model coefficients reasonable; is the equation plausible; and is the equation usable?
   If yes then model is good;
   If no, then disregard model.

The evaluation process with respect to Kansas takes on the following interpretation:

1. Are the variables basic and available?
   The independent variables are basic if they are those which are known throughout the state of the art to have a causal effect on rural public transportation ridership. The most common variables are: service area population, number of service miles, frequency of service, trip purpose, and level of service (17) (18) (19) (20).
   Due to the budget constraints of the Statewide Section 147 Project, the independent variables are available if their values can be found in the library and file systems, or available files, maps, etc. of State of Kansas offices.
2. Establish criteria for the variables, and prepare budget guidelines.
   The variables must be readily quantifiable. The limited budget available for the retrieval of data for the variables dictates that the data has to be obtained from records,

available files, maps, etc. not from extensive field surveys and computer use.

3. Are the criteria and budget acceptable?
   The criteria and cost of obtaining the variables are acceptable if they fall within the quidelines set forth in # 2.

4. Survey expert group criticisms (from literature and interviews):
   The experts indicate that a model set wherein a portion of the set can be tested with present data resulting within 10% of the actual present ridership is a worthwhile planning tool (17) (18) (19) (20).

5. Are the criteria met?
   The criteria are met if a portion of the model is testable under the criteria established in # 4.

6. Are the parameters stable over the sample space?
   The parameters are stable over the sample space if the independent variables of the model give reasonable results to changes that occur in Kansas. The pertinent characteristics in Kansas which vary slightly over the sample space are population density and number of route miles. The population density in the western part of the state is less than the population density in the eastern part of the state; correspondingly there are greater distances between service areas in the western part of the state than in the eastern part of the state.

7. Are the model coefficients reasonable; is the equation plausible; and is the equation usable?

   The model coefficients are reasonable if they allow the model to portray the relative importance of the independent variables, having a causal relationship to demand. In which case the parameters set within the model need to be stable over the time period of the projections.

   The equation is plausible if it has a reasonable number of independent variables resulting in an expression of demand.

   The equation is usable if the technical skill required to run the model is no greater than that gained through a high school Algebra II course.

The following models were selected from the literature because they are designed to mathematically derive an estimate of rural public transit demand. The four models tested are the ones found to be the most appropriate at this time as a result of the literature search and extensive interviews with experts in the field (17) (18) (19) (20) (21). An evaluation of those four models utilizing the evaluation process is hereby made.

The evaluation process for:

(A) Notess, Popper, and Zapata Transit Demand Model (31)

$D = a \times A \times P$

where, D = demand estimate in the region (annual transit trips) a = dimensionless design parameter

A = annual average transit trips per capita for "similar" rural areas

P = population of the region

1. Independent variables A and P are basic to the nature of the demand of rural public transportation ridership; however, a dimensionless design parameter is known in the field as a fudge factor which tends to reduce the usefulness of the model.

   Values for independent variables A, annual average transit trips per capita for similar rural areas, cannot be found in the State of Kansas library and file system; therefore, they are not available.

   The reply to the evaluation process #1 is "No". At this point the model was disregarded as a candidate for utilization on the Kansas system.

The evaluation process for

(B) Notess, Popper, and Zapata Demand Estimate Based on Participation Rates (31)

$Tp = (POP) \times (Rp) \times (Fp)$

where, Tp = number of trips for purpose, p

POP = elderly population in the region

Rp = participation percentage of elderly for purpose, p ($0 < R < 1.0$)

Fp = frequency of travel for purpose, p

1. Independent variables POP, Rp, and Fp are basic to the nature of the demand of rural public transportation ridership.
   Values for independent variables Rp and Fp cannot be found in the State of Kansas library and file system; therefore, they are not available.
   The reply to the evaluation process #1 is "No". At this point the model was discarded as a candidate for utilization on the Kansas system.

The evaluation process for:

(C) Hartgen Demand Forecasting Utilizing Barrier Effects (14)

Elderly Transit Trips per Week = Elderly Population x (.906 Base Use +.037 QIE + $.087\sum_{j=1}^{n} b_j$)

where, Elderly Population = number of person 60 years or over in service area

Base Use = major trips purpose of ridership

Quality Improvement Effect = values given for the attributes of the service

b_j = adjusted level for barrier j

= (b_j) (% seeing b_j) from pre-calculated tables

1. Independent variables: Elderly Population, Base Use, Quality Improvement Effect, and Barrier Removal Effect are basic to the nature of the demand of rural public transportation ridership.

Values for independent variables Base Use, Quality Improvement Effect, and Barrier Removal Effect cannot be found in the State of Kansas library and file system; therefore, they are not available.

The reply to the evaluation Process # 1 is "NO". At this point the model was discarded as a candidate for utilization on the Kansas system.

The evaluation process for:

(D) The Burkhardt / Lago Model for Prediction of Rural Public Transportation Demand.

The formula for the fixed - route macro system demand estimation model is:

$$\log RTPASS/M = -0.353 + 0.407 \log B\ MILES + 0.533 \log FREQ. + 0.611 \log RESTPOP - 0.123 \log COMPBMS$$

where, RTPASS/M = the number of round trip passengers per month for the system;

B MILES = the total vehicle miles per month for all vehicles of the system;

FREQ. = the average monthly round trip frequency of service along the fixed routes of the system (found by dividing the total monthly bus miles by the total round trip route mileage);

RESTPOP = the number of persons living in townships and boroughs (counties) along the routes who can use the system; and

COMPBMS = the sum of the monthly bus miles of all other fixed-route and demand -responsive systems operating in the service area. Not applicable to Kansas Statewide System.

1. Independent variables B MILES, FREQ., RESTPOP, and COMPBMS are basic to the nature of the demand of rural public transportation ridership. (17) (18) (19) (20) (21)

   Values for the independent variables of the model can be found in the State of Kansas library and file system; therefore, they are available.

The reply to the evaluation process #1 is "Yes". At this point model evaluation continued to the evaluation process #2.

2. The independent variables are readily quantifiable; they are expressed as numerical values.

   The model falls within the budget guidelines since data for the variables can be retrieved as records from available files, maps, etc. and does not require surveying and computer operations.

3. The criteria and budget for the variables are acceptable since they fall within the guidelines set forth for #2.

4. The demand-responsive portion of the model set was tested in two areas. The results in both cases came well within 10% of the actual ridership of the systems. One area tested was Washington County Arkansas, where the number of round trip passengers per month for the system was 633 people. The result is a 10% difference from the actual ridership. The other area tested was Region 6 of the Statewide Section 147 Project Network in Kansas, where the number of round trip passengers resulting from the model as used with the data was 4,701 and the resulting actual

number of round trip passengers per month for the system was 4,832 people. The result is 2.7 % different than the actual ridership. The model was developed utilizing actual data from 29 systems operating in Pennsylvania and others scattered throughout the nation in order to test the model (see IV. A. The Pennsylvania Experience). A discussion of these other applications of portions of the Burkhardt / Lago Model Set is presented in Section IV; Use of the Burkhardt / Lago Model in Other Areas.

Since a portion of the model was tested with present data and the result was within 10 % of the actual present ridership, the model was considered to be a worthwhile planning tool.

5. Since the model meets the "worthwhile planning tool" criteria, the reply to # 5 was "YES" and the evaluation process of the model continued to # 6.

6. The parameters of a model are stable over the sample space if the independent variables of the model are sensitive to changes that occur in different regions in Kansas. The characteristics pertinent in Kansas which vary slightly over the sample space are population density and the number of route miles. Population density is reflected in the independent variable RESTPOP, and the number of route miles is reflected in the independent variable BMILES.

One method used to show the effect of change in variables on the model is through a sensitivity analysis. The sensitivity analysis for this evaluation includes a range of variables wider than one would normally expect within Kansas. For applying the Burkhardt / Lago model equation, the values for the independent variables were taken from data of Region 6 (data of Region 6, Tables VII and VIII, pages 70 and 76) of Section 147 Project Network. Table I shows the numerical effect on the demand that occurs as a result of changes in the independent variables RESTPOP, BMILES, and FREQ. The graph of these numerical values, Figure II, shows the comparative effects of change in independent variables on the number of round trip passengers per month. From the graph one can see that all three curves of the variables have similar values. This signifies that the three independent variables had a similar effect. Since the variables are essentially of equal weight, a change in one variable, such as a small value for RESTPOP in western Kansas due to the low density of population, will adjust the effect of the value of RTPASS/M to a lower value to accommodate the less dense population. Therefore, the parameters are stable over the sample space, and correspondingly easily changed in order to meet conditions that may change in the future.

The reply to # 6 is "YES". The model evaluation process continued to # 7.

7. Through the sensitivity analysis of # 6 it was shown that the model portrays the relative importance of the independent variables.

The model has three independent variables appropriate to the Statewide Section 147 program in Kansas, which is a reasonable number of variables for such a model. Experience has shown that the number of variables should be kept to a minimum; two to three variables has been found to be most satisfactory for regression analysis (9).

The technical skill required to run the model is no greater than that gained through a high school Algebra II course; therefore it is a usable equation.

The reply to # 7 is "YES". The Burkhardt / Lago Model was concluded to be acceptable for use on the Kansas Network. Thus, of the four models selected by preliminary screening, the Burkhardt / Lago Model was the only one that fit the "Kansas " criteria, which was closely related to availability of data currently on file.

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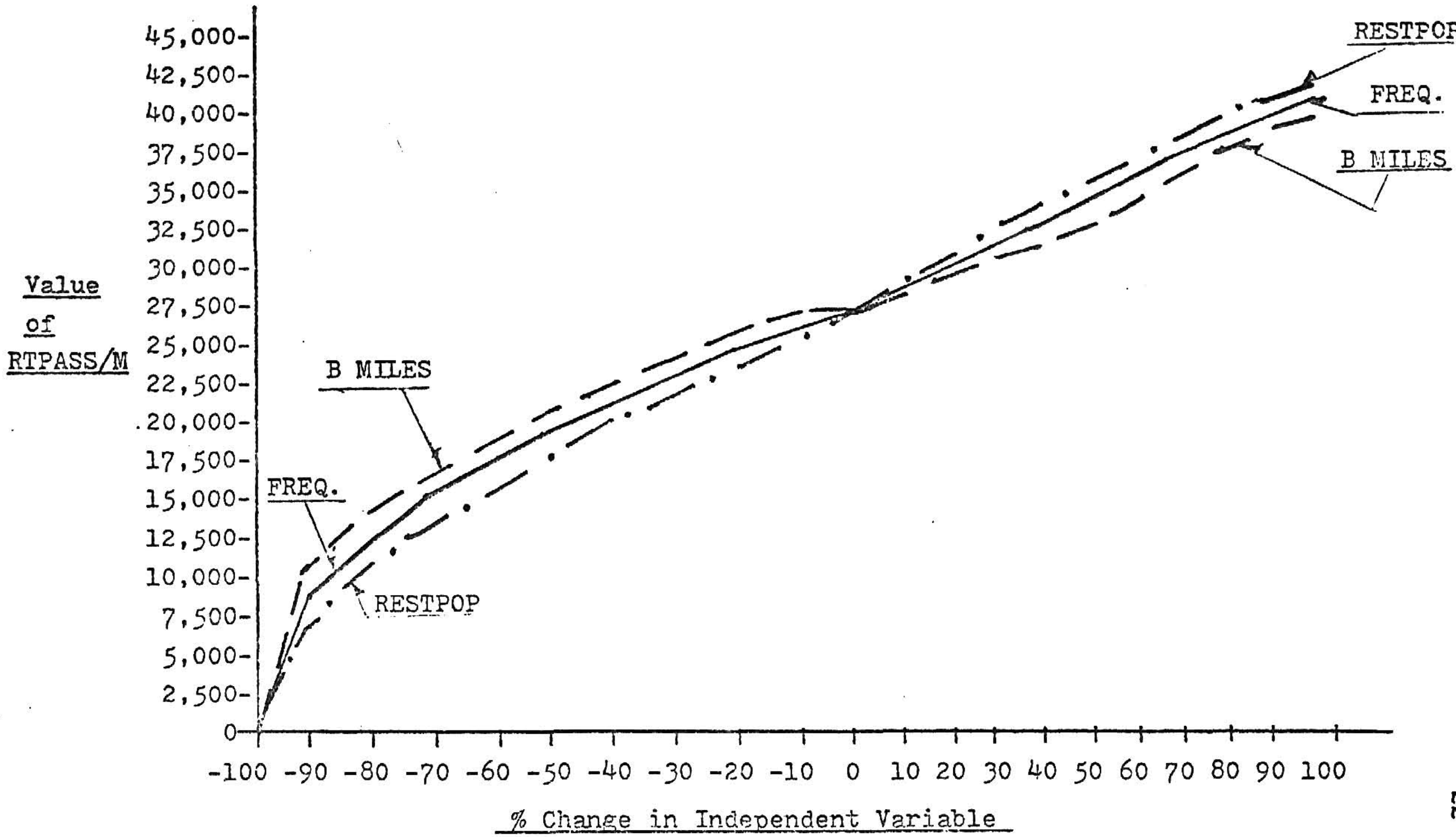
TABLE 1

SENSITIVITY ANALYSIS - Effect of Change in Independent Variables on the Number of Round Trip Passengers per Month (RTPASS/M) in Kansas Region 6

% Change in Independent Variables	Value of RTPASS/M from Change in RESTPOP	% Change in RTPASS/M	Value of RTPASS/M from Change in B MILES	% Change in RTPASS/M	Value of RTPASS/M from Change in FREQ.	% Change in RTPASS/M
- 100	0	-100.0	0	-100.0	0	-100.
- 90	6,731	- 75.5	10,762	- 60.8	8,056	- 70.7
- 80	10,280	- 62.6	14,276	- 48.1	11,468	- 58.3
- 70	13,173	- 52.1	16,834	- 38.8	14,468	- 47.4
- 60	15,703	- 42.9	18,932	- 31.1	16,866	- 38.6
- 50	17,997	- 34.5	20,730	- 24.6	18,993	- 30.9
- 40	20,119	- 26.8	22,325	- 18.8	20,936	- 23.8
- 30	22,105	- 19.6	23,774	- 15.6	22,725	- 17.3
- 20	23,983	- 12.7	25,100	- 8.7	24,401	- 11.2
- 10	25,775	- 10.5	26,333	- 4.2	25,984	- 5.5
0	27,485	0.	27,485	0.	27,485	0.
10	29,134	6.0	28,574	4.0	28,920	5.2
20	30,726	11.8	29,605	7.7	30,290	10.2
30	32,270	17.4	30,584	11.3	31,608	15.0
40	33,760	18.6	31,521	14.7	32,885	19.6
50	35,213	28.1	32,419	18.0	34,119	24.1
60	35,801	30.3	33,281	21.1	35,310	28.5
70	38,010	38.3	34,111	24.1	36,467	32.7
80	39,364	43.2	34,914	27.0	37,601	36.8
90	40,701	48.1	35,686	29.8	38,699	40.8
100	41,986	52.8	36,442	32.6	39,765	44.7

FIGURE II Graph of the Effect of Change in Independent Variables on the Number of Round Trip Passengers per Month (RTPASS/M) in Region 6



III. DESCRIPTION OF THE BURKHARDT / LAGO MODEL

A. Development of the Model

The Burkhardt / Lago Model for predicting the demand for rural public transportation is a result of research performed by Ecosometrics Incorporated under contract to the Bureau of Advance Planning, Pennsylvania Department of Transportation. It was financed in part through a planning and research grant from the Federal Highway Administration under the provisions of 23 USC 307 (c) (2). The results of this research effort were made public in April of 1976.

During the project, various alternative methods of predicting the demand for rural transportation systems were investigated. Using data from approximately 100 existing systems (7), simulation models of factors influencing the number of riders were developed. It was found that reliable estimates of demand could be produced using a small number of variables which would describe the characteristics of the area and people served along with the attributes of the transportation system.

Methods for predicting demand were devised for entire transportation systems and for individual components (routes or sectors) of those systems. Also, separate methods (7) were devised for demand responsive and fixed - route systems since the factors affecting demand are significantly different for each type of system. During the development of this set of models the following characteristics were noted regarding selected variables: (7)

Monthly Bus Miles : The more service (bus miles) is provided, the more people will ride the system. This increase is not proportional; the bus miles will increase faster than the number of riders. There will exist a point where the cost of adding bus miles will be greater than the return obtained from additional passengers.

Availability of Service: For fixed-route systems, this factor can be expressed as frequency (the number of times per day or per week that a particular route is served); for demand - responsive systems, it is the reservation time (the number of hours or days between a call for a ride and pick - up). The increase in patronage is less than proportional to the increase in service.

Population Served: As the population served by the transit system increases, the number of riders will increase, but at a slower rate than the increase in population (7). Indications are that as major increases in density occur, the relationship is less valid; which is why this factor is designed for the rural or low density areas (7).

Other Transportation Systems: As the service provided by other transportation systems increases, the number of riders which will be attracted to the system will decrease; however, the decrease in patronage is less than the increase in competition (7).

Distance: As the average trip-distance increases, the number of passengers will decrease. The decrease in passengers will occur at a greater rate than the increase in distance for fixed - route systems and at a rate smaller than the increase in distance for demand - responsive systems. This means that increases in distance will have more of a negative impact on fixed route than on demand - responsive services.

Fares: As the cost of the trip increases, the number of riders will decrease. The percent decrease in riders will be smaller than the percent increase in fares.

In order to put these characteristics into a meaningful relationship logarithmic regressions were necessary.

In multiple linear regression the values of the partial regression coefficients for the independent variables denote the amount of increase in the value of the dependent variable which would correspond to a one percent increase in the independent variable, which also is known as the elasticity of travel.

The formula for the fixed - route macro system demand estimation model is :

$$\log RTPASS/M = -0.353 + 0.407 \log B\ MILES + 0.533 \log FREQ + 0.611 \log RESTPOP - 0.123 \log COMPBMS$$

where, RTPASS / M = the number of round trip passengers per month for the system;

B MILES = the total vehicle miles per month for all vehicles of the system;

FREQ = round - trip frequency found by dividing the total monthly bus miles by the total round trip route mileage;

RESTPOP = the number of persons living in townships and boroughs (counties) along the routes who can use the system; and

COMPBMS = the sum of the monthly bus miles of all other fixed - route and demand - responsive systems operating in the service area.

B. Purpose of the Model

The Burkhardt / Lago Model was devised to be a planning tool (7). The greatest benefit of the demand equations is that they provide a "ball - park" estimate of the number of people which may utilize a particular transit system according to specific area and system conditions (7). The equations allow one to experiment with different levels of service to evaluate alternative system configurations for a particular area as long as they are close to known systems and the present economic and social environment.

This set of models was selected for use in identifying the demand for public transportation in rural areas due to its great adaptability to the rural transit system circumstance. These equations for demand are relatively simple to use; are not time consuming; utilize variables which are relevant to most rural transit situations, and which are easily found in records of standard operating data; and are sensitive enough to reflect potential results of proposed system changes.

C. Use of the Model

The fixed route portion of the Burkhardt / Lago Model can be used to predict the demand of actual or potential services that operate on a fixed route and schedule on a county-wide or system-wide basis. In order to run the model, the following data about the area served is needed (7) :

Service Area (usually county or region) Population: the number of persons served by the system;

High Probability Population: the number of persons who will most likely use the system, often defined as the elderly and the handicapped (or whatever group the service is restricted to);

Other Transportation Systems in the Area: the number of bus miles provided by all other fixed route and demand-responsive systems;

Bus Miles: the total number of vehicle miles traveled by all vehicles of the system during an average month;

Frequency: the number of times per day, or per month that service is provided on a particular route; and

Network: the routes currently being used or proposed for use on the fixed route system.

With this information, the mathematical computation can be performed. To see the effect of changes in the route network, number of bus miles, frequency of service, or any other combinations of service characteristic, the researcher may re-run the equation with changes in selected variables and compare results.

IV. USE OF THE BURKHARDT / LAGO MODEL IN OTHER AREAS

A. The Pennsylvania Experience

The major purpose of the Pennsylvania study was to serve as a testing process for the Burkhardt / Lago Model to develop coefficients for the independent variables (B MILES, FREQ,RESTPOP, and COMPBMS) in the macro fixed route system demand forecasting equation. Data from actual observations of 29 rural transit operations in Pennsylvania were used.

(1) Study Area Description

The transit operations observed were located in seven rural counties where transportation services were currently in operation (7). These included private transit companies, a rural public transportation demonstration program of the Department of Agriculture, the transportation components of public social service programs sponsored by the Department of Public Welfare, and those private social service agencies which had applied to the Pennsylvania Department of Transportation for capital grants under Section 16 (b) (2) of the Urban Mass Transportation Act of 1970 (47). Any system serving an urban area had to provide a substantial proportion of their route miles in rural areas in order to be included in the study; and no urban area with a population of greater than 80,000 was used.

(2) Procedures

The procedures utilized during the Pennsylvania study were those of observation of already existing systems. The observations were made from records of the various systems kept by the State of Pennsylvania. These records were verified and updated through telephone calls to the system operators. The systems were selected by the following criteria:

Transit companies providing inter city services to SMSA's or to cities of greater than 80,000 population were excluded from the system; while systems serving an urban area had to provide a majority of their route miles in rural areas;

Data on the operations of the systems must be readily available;

The systems must serve a variety of purposes (single purpose systems such as those taking riders to one certain hospital or merely to a nutrition program site were not included for they were considered to be too limited in scope of service to be adequately representative of systems which the State of Pennsylvania would sponsor); and systems that provided less than 25 trips per month were excluded as being nonrepresentative (this figure had been established through work with systems sponsored by the Department of Agriculture).

Upon completion of the process of selection of the study systems, the systems were analysed with respect to their ridership characteristics and the reasons for the levels of patronage. The following list of variables were tested for their relationship to the estimation of system-wide rural public transportation service (7):

One Way Passengers per Month: for the Pennsylvania Department of Agriculture systems, the recorded number of trips on monthly statistical data summary sheet for March of 1975 was used; for systems reporting to the Pennsylvania Department of Transportation, the average daily passengers multiplied by the number of days per month for weekly and weekend service in 1974 was used;

Reservation Time : the average time in days required by system policy between a call for service and the actual trip was used;

Fare per Passenger: the total farebox revenues were divided by the total number of one-way passengers (in cents);

Monthly Bus Miles: for the Department of Agriculture systems the total given on the monthly summary sheets was used; while for the systems reporting to the Department of Transportation the sum of the weighted average daily weekday and weekend bus miles for an average month was used;

<u>Round Trip Route Miles</u>: this entailed the sum of the round trip mileage of all routes run on an average day;

<u>Frequency of Service</u>: this was the monthly bus miles as previously expressed divided by the monthly sum of the average daily round trip route miles;

<u>Restricted Population</u> : this item included the population served by each system, defined as the county population for the demand-responsive systems or the township and borough population along the route minus all persons specifically excluded from using the system (for fixed route systems); in cases where the general public may use the service the county population and the restricted population are identical;

<u>Car Ownership</u>: this figure included the percent of households in the county owning one or more automobiles in 1970; (for future work this author would recommend to check and make sure that a count of the number of pick-up trucks per household was also included in this figure)

<u>Taxi Service</u>: this figure consisted of the number of taxis registered currently in the service area according to the records of the Pennsylvania Public Utilities Commission; (telephone calls to selected taxi companies were made for verification);

<u>Competing Bus Miles</u> : this number was the sum of all fixed route and demand-responsive monthly bus miles

in the county minus the monthly bus miles of the system being considered;

County Population Density: this number is the 1970 population of the county divided by the total square miles of land area in the county;

High-Probability Users of the Transit System: for systems with no restriction in the population to be served, this variable consists of the number of elderly persons 65 years of age or older plus the number of persons who are poor as defined by the 1969 income adjusted by the family size, age, and sex of the head of the family, number of persons under the age of 18, and a farm or non-farm status who are not elderly; in instances of system patronage restrictions, the high probability users were defined to be restricted population users;

Per Capita Income: this item was the aggregate 1969 money income of all persons in a county divided by the 1970 county population;

Percent Poor: this was the number of persons in the county who were poor in 1969 as previously described divided by the total county population; and

Percent Elderly: this was the number of persons in the county who were 65 years of age or older in 1970 divided by the total county population.

(3) Results

As a result of this testing process, the set of variables was reduced through a multiple linear regression technique to a number which would have the most meaningful effect upon ridership of the system. For a fixed route system these variables were: the total vehicle miles per month for all vehicles of the system; the average monthly round trip frequency of service along the fixed route of the system; the number of persons living in townships and boroughs along the routes who can use the system; and the sum of the monthly bus miles of all other fixed route and demand responsive systems operating in the service area. These variables were the ones to be utilized for the fixed route system-wide ridership estimation.

For a demand-responsive system these variables were: the total vehicle miles per month for all vehicles of the system; the average time in days required between a call for service and the time a vehicle arrives; and the number of persons in the county who are likely to be users of the system. These variables were the ones utilized for a demand-responsive system-wide ridership estimation.

The actual model which resulted from the effort for the system-wide fixed routes demand estimate is presented on the following page.

The equation for the system-wide fixed route is as follows (7):

$$\log RTPASS/M = -0.353 + 0.407 \log B\ MILES + 0.533 \log FREQ + 0.611 \log RESTPOP - 0.123 \log COMPBMS$$

where,

RTPASS = the number of round trip passengers per month for the system;

B MILES = the total vehicle miles per month for all vehicles of the system;

FREQ = the average monthly round trip frequency of service along the fixed routes of the system (found by dividing the total monthly bus miles by the total round trip route mileage);

RESTPOP = the number of persons living in townships and boroughs (counties) along the routes who can use the system; and

COMPBMS = the sum of the monthly bus miles of all other fixed route and demand-responsive transit systems which were operating in the service area.

The equation for the demand-responsive system-wide demand estimate is as follows (7):

$$\log RTPASS/M = -1.879 + 1.099 \log B\ MILES - 0.217 \log RESVTIME + 0.194 \log HIPROPOP$$

where, RTPASS/M = the number of round trip passengers per month for the system;

B MILES = the total vehicle miles per month for all vehicles of the system;

RESVTIME = the average time in days required between a call for service and the time a vehicle arrives; and

HIPROPOP = the number of persons in the county who are likely to be users of the system.

B. The Arkansas Experience

The Arkansas test run of the model took place in Washington County, Arkansas. In Washington County a demand-responsive county-wide rural public transportation system utilized the demand-responsive system-wide portion of the demand estimation model by Burkhardt / Lago.

(1) Study Area Description

Washington County is located in the northwestern corner of Arkansas. Fayetteville is the major center of trade and personal services in Washington County, and of the entire northwestern section of the state of Arkansas. In Washington County there is a rural public transportation system whose purpose is to serve the needs of those people who are 60 years of age or older in the rural areas of Washington County. This system is a demand-responsive operation.

(2) Procedures

The procedures utilized in the Arkansas model run were those of running the Burkhardt / Lago demand-responsive system-wide model using information on Washington

County into the model. In Washington County the actual values of the independent variables used were:

B MILES	=	5,030
RESVTIME	=	.16
HIPROPOP	=	125

(3) Results

The result from this run of the model was a RTPASS/M of 570 persons. For the same period of time the actual number of round trip passengers per month for the system was 633 people. This means that the number of passengers estimated by the model was 10 percent lower than the actual ridership on the system. The Washington County Planning Department decided to utilize this model in estimation of future demand for the system, and in testing the effects of various possible system improvements or changes (21).

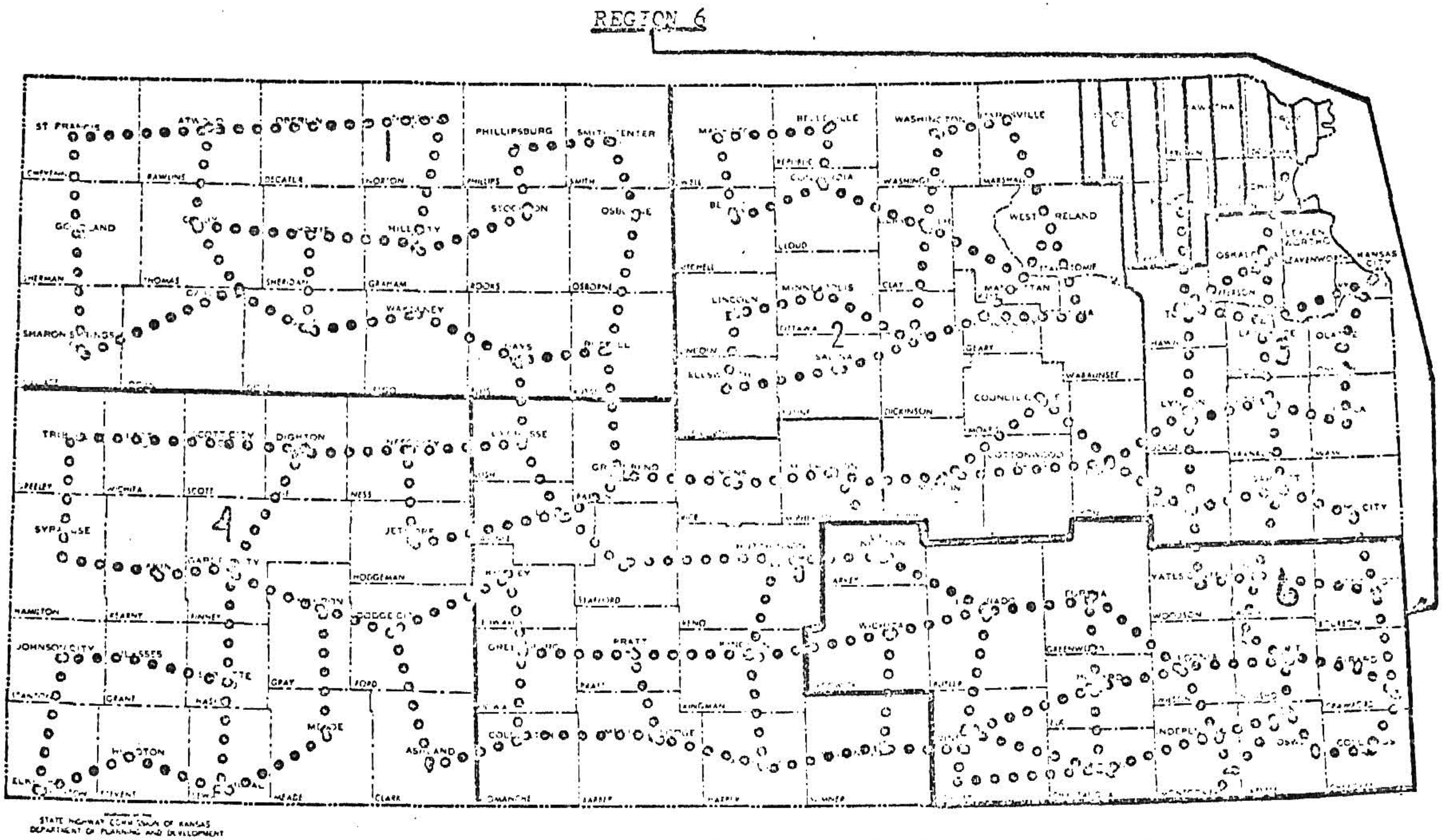
C. The Kansas Region 6 Experience

The Kansas Region 6 test run took place in the 16 southeastern Kansas counties comprising Region 6 of the Section 147 Project's Statewide Rural Public Transpotation System. In this area several demand-responsive rural public transportation systems exist. The systems surveyed were ones which operate United States Department of Transportation Urban Mass Transportation Administration vehicles funded under UMTA Section 16 (b) (2) program. The demand-responsive system-wide portion of the demand estimation model by Burkhardt / Lago was used with existing systems' data (see Figure III).

(1) Study Area Description

Region 6, located in the southeast portion of Kansas, covers 16 counties, predominantly of a rural nature. These systems are providing rural public transit services to those who are 60 years of age and older and those who are handicapped. The systems are demand-responsive operations.

FIGURE III SIX REGIONAL BUS SYSTEMS IN KANSAS (25)



Bus Routes for the Six Systems

Counties Excluded from Study Area

(2) Procedures

The procedures in the Kansas Region 6 model run were those of running the Burkhardt / Lago demand-responsive system-wide model using information from the files of the Kansas Department of Transportation Planning and Development Department for the values of the independent variables from which to run the model.

Table II shows the number of passengers, percentage of handicapped passengers, and number of miles of service per month for the UMTA Section 16 (b) (2) systems.

Table III indicates from the UMTA Section 16 (b) (2) systems data the trip purpose, number of trips, and percentage of trips.

Table IV shows the result of applying the demand-responsive system equation portion of the Burkhardt / Lago model with the data related to the UMTA Section 16 (b) (2) vehicles for Region 6.

TABLE II Data For Running the Demand-Responsive Portion of the Burkhardt / Lago Model for Region 6 UMTA Section 16 (b) (2) Funded Vehicle Dial - Ride Service (11)

# of Passengers	% of Handicapped	Miles per Month
Bourbon County		
158	3	392
Butler County		
822	79	1,850
Cowley County		
385	1	1,844
Crawford County		
858	8	2,285
Harvey County		
228	2	1,727
Labette County		
574	94	925
Montgomery County		
244	10	272
Sedgwick County		
1,563	49	6,013
Total		
4,832	43	15,308

TABLE III UMTA Section 16 (b) (2) Funded Vehicle
Region 6 Trip Purposes (11)

Purpose	# of Trips	% of Trips
Medical	772	6
Employment	4,077	33
Nutrition	636	5
Social / Recreation	1,920	15
Education	2,053	17
Shopping / Personal	1,604	13
Other	1,402	11
Total	12,464	100

TABLE IV Results of Applying Demand-Responsive System Macro Equation and Related Data for UMTA Section 16 (b) (2) Funded Vehicles in Region 6

log RTPASS/M = -1.879 + 1.099 log B MILES - 0.217 log RESVTIME + 0.194 log HIPROPOP

= -1.879 + 1.099 log (15,308) - 0.217 log (1) + 0.194 log (80,440)

log RTPASS/M = 3.6719

RTPASS/M = 4,701 *

Actual Trips per Month on Systems = 4,832

* The value of RTPASS/M is 3% different than the actual number of trips experienced with the federally funded vehicles.

(3) Results

The result from this run of the model was a RTPASS/M of 4,701. For the same period of time the actual number of round trip passengers per month was 4,832. This means that the number of passengers estimated by the model was 2.7 percent lower than the actual ridership on the system.

V. USE OF THE BURKHARDT / LAGO MODEL IN KANSAS

A. Study Area Description - Statewide System

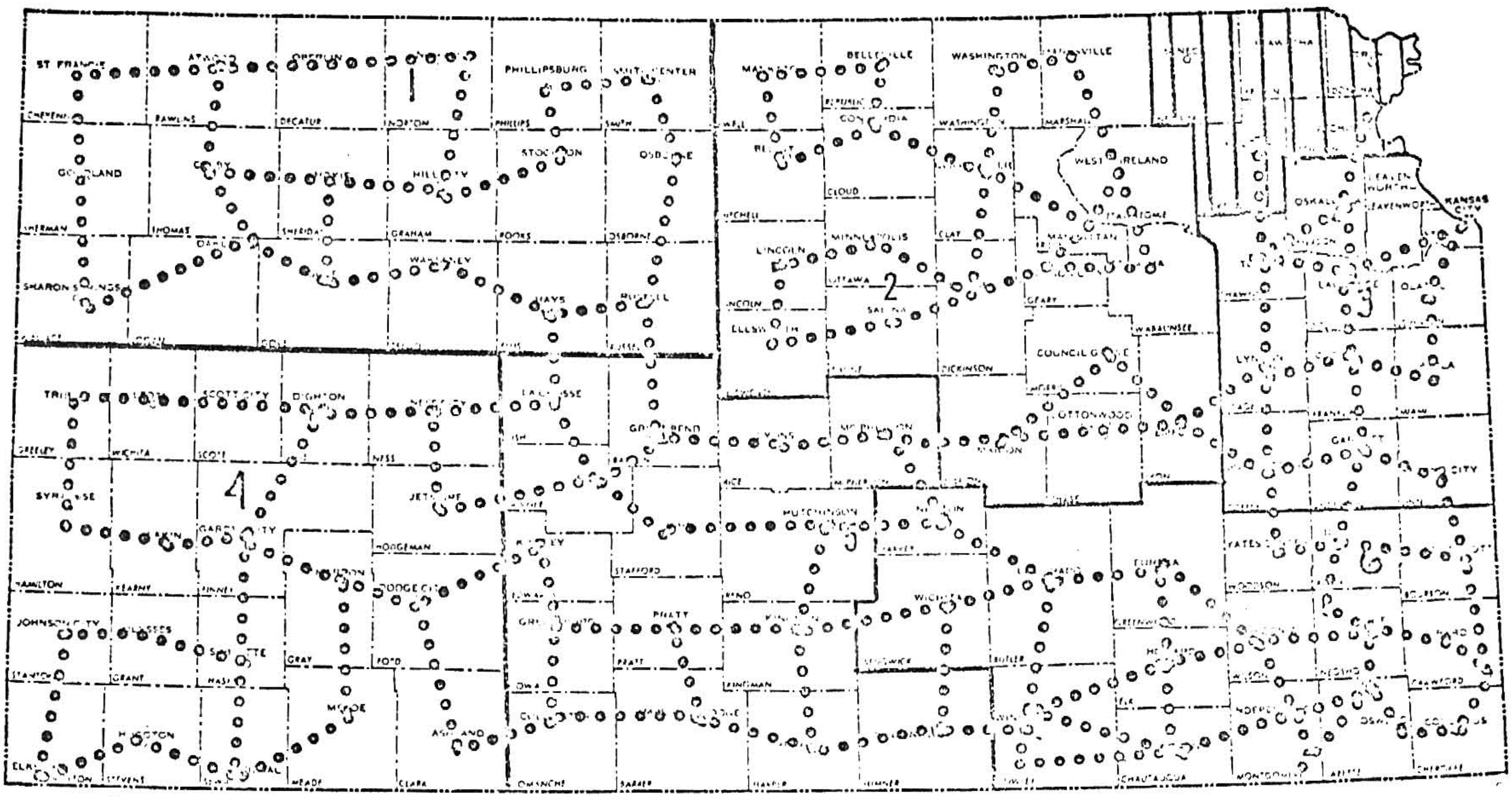
The study area encompasses virtually the entire state of Kansas, excluding only the five counties in the extreme northeastern corner of the state. These five counties are excluded from this study since they are included in another system-wide transit study also funded by FHWA Section 147 funds. The study area comprises six regional bus operations as proposed in the Kansas Statewide Rural Public Transportation Demonstration Project sponsored by Section 147 of the Federal Aid to Highway Act of 1973 (25)(see Figure IV). This system is to operate in predominantly rural areas.

Studies by the Kansas Department of Transportation and the Kansas Department of Social and Rehabilitative Service have pointed out gaps in the transportation network in Kansas (25). Most Kansans must depend heavily upon the private automobile to provide a mode of transportation to needed services. The automobile is wonderful for those who are able to operate them; however, there are elderly and handicapped individuals in the State of Kansas who are not functionally able to operate such vehicles. Even in areas that do provide public transportation, there exists a need to connect the services offered in the various communities.

In many areas in Kansas, systems for rural public transit exist; however, these are often found to leave out certain portions of the population. The Kansas Department of Transportation (refer to Figure IV "Six Regional Bus Systems in Kansas"), has attempted to develop regional transit systems which could serve as links to "service centers", usually the county seat, and existing transit systems. In the proposal the use of six regional bus systems to link the existing services across county lines and serve as feeder systems to private carriers was hoped to be an asset in overcoming the barrier of isolation in the rural areas (25).

The network for the Section 147 Project was derived to connect the service centers of the region in a manner, which would avail the towns offering the greatest number of services to the greatest number of elderly and handicapped population that would be needing those services. The kinds of services receiving priority were health services, social services, shopping and employment. With these priorities in mind, the towns were connected. The project network, as shown in Figure IV, stays within the state boundaries. This is due to the fact that that project is funded for serbice within the state of Kansas. If at some point in time the service becomes of a permanent nature it would be essential for planners to look into possible connection

FIGURE IV SIX REGIONAL BUS SYSTEMS IN KANSAS (25)



STATE HIGHWAY COMMISSION OF KANSAS
DEPARTMENT OF PLANNING AND DEVELOPMENT

○○○○○○ Bus Routes for the Six Systems

Counties Excluded from Study Area

of the Kansas network with transit operations in neighboring states. At such time the Burkhardt / Lago model can again be used, changing the values for the independent variables B MILES, RESTPOP, FREQ, and COMPBMS to accomodate the suggested change in the network. Thus, the network and the model can be adapted to a changing system, or to merely the addition or subtraction of a single link adding or deleting another town to, or from, the network.

The network for the Statewide Section 147 Project fits into the overall Kansas Transportation System primarily in one way. It is to be used to implement the goal of providing social services for those who are most likely not to have any means of transportation (those 60 years of age or older and the handicapped) with transportation to essential activities.

With the national concern for the conservation and the threat of an energy shortage, such a public transit network could be transformed into one for use by any member of the regions' population, if necessary. Therefore, as a portion of the Section 147 project the network is meant to play a general social welfare role. If public transportation for the general populace became desirable, the Section 147 project network would take on a role as a major transit service operator.

B. Procedures

The procedures utilized in the Kansas model run were those of running the Burkhardt / Lago fixed-route system-wide model with library information received through the U.S. Bureau of the Census, the Kansas Department of Transportation, and the Kansas Department of Social and Rehabilitative Services to apply the model to the six proposed regional bus systems in Kansas (25). The values for the variables and results of the equations run for the State are contained in the following tables.

The independent variables for the Kansas systems were defined as follows (the values for the independent variables of each region are shown in Table VI) :

BMILES = the total number of miles on the regional bus route for the particular region, as shown in the Section 147 Proposal;

FREQ = as per the Section 147 Proposal guidelines it was determined that each regional route would be serviced once a week, or four times each month;

RESTPOP = as per the objectives of the Section 147 demonstration project the target population groups as potential riders were the elderly, 60 years of age or older, and those who were physically or mentally handicapped in each particular region (handicapped as determined by the Kansas Department of Social and Rehabilitative Services definition); and

COMPBMS = there are no competing public transportation services on these fixed routes, for these routes were devised to link areas wherein there was no existing service in 1976.

Taxi cab service, dial - a - ride type systems, public carriers, and other public transit systems do occur on varying scales throughout the state of Kansas. However, none of these systems offer the kind of service proposed in the Statewide Section 147 project, due to the nature of the system network. The value for COMPBMS in Kansas for the Statewide Section 147 Project test in 1976 was therefore "0".

C. Results

The results of running the Burkhardt / Lago Model for estimating the demand of the system - wide fixed route transit operation in each of the six Statewide Section 147 project regions are shown in Table VI. The value of RTPASS/M for Region 1 is 14,000; the value of RTPASS/M for Region 2 is 21,208; the value of RTPASS/M for Region 3 is 15,845; the value of RTPASS/M for Region 4 is 10,515; the value of RTPASS/M for Region 5 is 21,772; and the value of RTPASS/M for Region 6 is 27,485 (see Figure V). Region 6 having the largest population and the greatest number of route miles also has the greatest number of round - trip passengers per month. Region 4, having the smallest population and the second least number of miles of route, has the smallest number of round trip passengers per month.

TABLE V Values for Independent Model Variables by Region

REGION	BMILES	FREQ	RESTPOP	COMPBMS
1	3,744	4	28,878	0
2	2,828	4	68,300	0
3	2,940	4	41,311	0
4	2,872	4	21,439	0
5	4,472	4	52,544	0
6	4,184	4	80,440	0

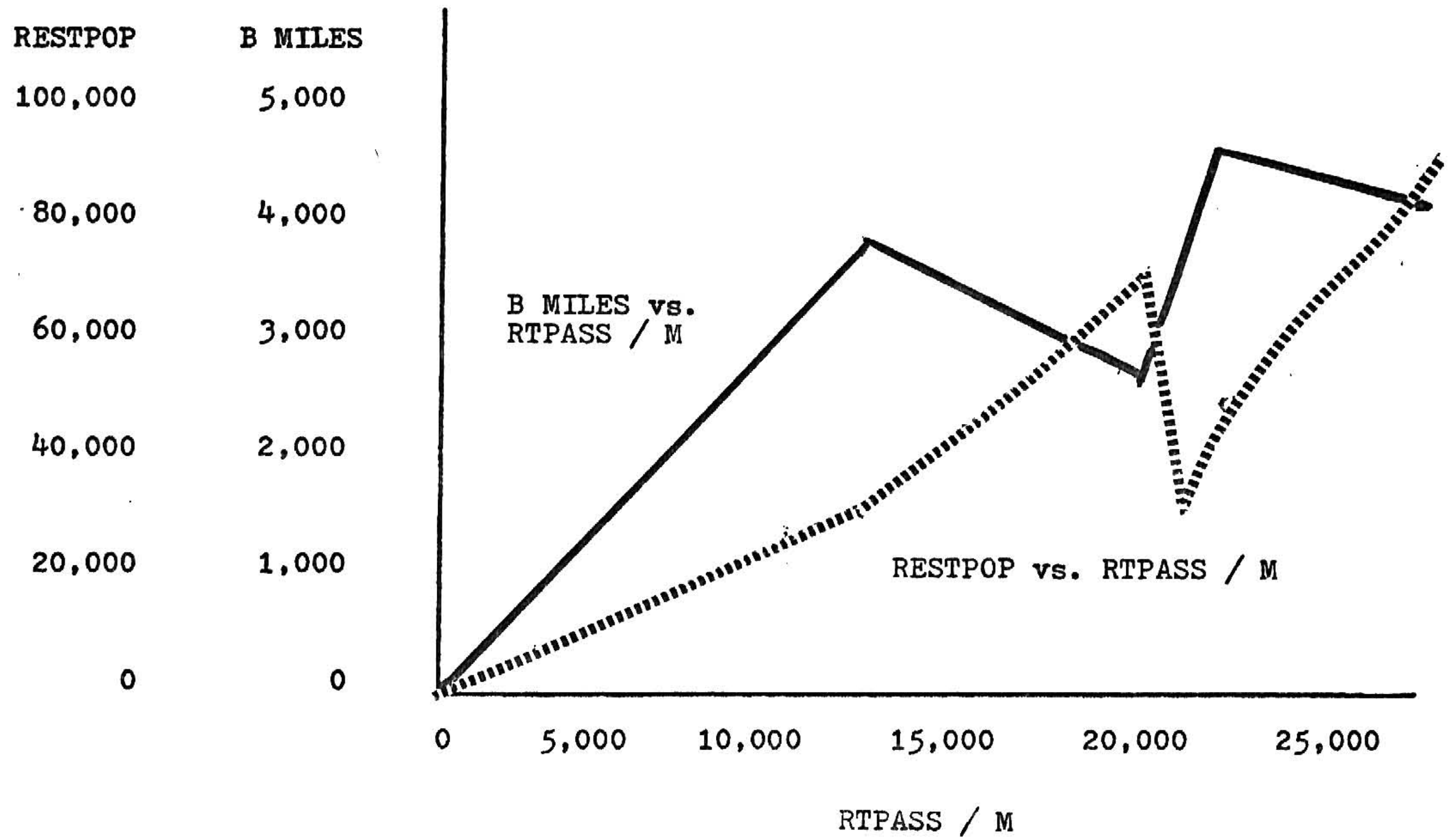
TABLE VI Macro Fixed Routes Equation and Related Data by Region

$$\log RTPASS/M = -0.353 + 0.407 \log B\ MILES + 0.533 \log FREQ + 0.611 \log RESTPOP - 0.123 \log COMPBMS$$

REGION	B MILES	FREQ	RESTPOP	COMPBMS	RTPASS/M
1	3,744	4	28,878	0	14,047
2	2,828	4	68,300	0	21,208
3	2,940	4	41,311	0	15,845
4	2,872	4	21,439	0	10,515
5	4,472	4	52,544	0	21,772
6	4,184	4	80,440	0	27,485

FIGURE V GRAPH OF B MILES, RESTPOP, VS. RTPASS / M

USING DATA FROM THE SIX KANSAS REGIONS



VI. CONCLUSION OF THE IN - DEPTH STUDY

A. Summary

The literature was searched and four models were selected as possible candidates for a Kansas model. A set of criteria and an evaluation process were selected for a comparative analysis of these four models for estimation of rural public transportation demand. From that process, the Burkhardt / Lago Model for Predicting Rural Public Transportation Demand was determined to be the best model currently available for use on the Kansas system.

The Burkhardt / Lago Model had been developed in Pennsylvania as a planning tool so that one could experiment with different levels of service to evaluate alternative system configurations and service levels for a particular area. During the development process, data from 29 rural public transit systems in Pennsylvania plus data from other systems scattered throughout the United States had been used to shape the model parameters.

In this study, the demand - responsive portion of the model was tested in both Arkansas and Region 6 of Kansas. The results of the tests were both within 10 percent of the actual values of RTPASS/M, which is also well within generally acceptable guidelines. The fixed route portion of the Burkhardt / Lago Model was applied to the statewide Section 147 program network.

Sensitivity analyses were run on all of the model parameters, and their results were analysed in relationship to their applicability for use throughout Kansas. The results of this application are shown in Table VI.

B. Conclusions

The overriding conclusion of this in - depth study of the Burkhardt / Lago Model for Prediction of Rural Public Transit Demand is that it is the best model available for use with the statewide Section 147 program network and available data. Also, the model is adaptable and can be used in instances where either the system network changes or the purpose of the service changes. Some examples of this use would be : the possible re - evaluation of the statewide network from that of fulfilling social service obligations to that of providing general transit service in which case the values of the variables, particularly the RESTPOP would need to be changed; this model could be used in an instance where one of the regions would decide that it wanted to provide a more localized service, in which case it would be necessary to expand the network and possibly also increase the number of times a week that the service is available.

The following conclusions were made about the model itself:

1. Values for the independent variables, B MILES, FREQ, RESTPOP, and COMPBMS, can be found in the State of Kansas library and file system; therefore are readily available for the user of the model.
2. The model is applicable for sketch planning since data

for the variables can be retrieved as records from available files, maps, etc. and does not require extensive surveying or computer operations.

3. Since the model was tested with present data in Arkansas and in Region 6 of Kansas and the results both times were within 10% of the actual present ridership, the model was considered to be a worthwhile planning tool.
4. The sensitivity analysis performed on the model variables signified that all three independent variables used in the model had a similar, reasonable effect upon the out - put of the model. Therefore, the parameters are stable over the range of conditions encountered throughout Kansas, and correspondingly easily projected in order to meet future conditions.
5. The equation is easily used since the technical skill required to run the model is no greater than that gained through a high school Algebra II course, and results can be obtained with manual calculations.

VII. LIST OF REFERENCES

1. American Institute of Planners. 1976. Journal of the American Institute of Planners. Washington, D. C.

2. Baerwald, John E. 1976. Transportation and Traffic Engineering Handbook. Institute of Transportation Engineers, Englewood Cliffs, New Jersey.

3. Bhatt, Kiran U., M. A. Kemp, R. F. Kirby, R. G. McGillway, and M. Wahl. 1976. Para -Transit: Neglected Options for Urban Mobility. Federal Highway Administration. United States Department of Transportation. Washington, D.C. 53, 141 p.

4. Brand, Daniel. 1973. Travel Demand Forecasting: Some Foundation and Review. Highway Research Board Report 143. Washington, D. C.

5. Bruton, Robert. 1974. Rural Transit Operations and Management. Office of Policy and Plan Development. United States Department of Transportation. Washington, D.C.

6. Burkhardt, Jon E., 1969. The User Benefits of the Raleigh County, West Virginia Free Bus System. RMC Report UR - 070. Bethesda, Maryland.

7. Burkhardt, Jon E., and A. M. Lago. 1976. Handbook for Predicting the Demand for Rural Public Transportation. Ecosometrics, Inc. Bethesda, Maryland. A Report for the Pennsylvania Department of Transportation in Philadelphia, Pennsylvania.

8. Conference of Biological Editors, Committee on Form and Style. 1964. Style Manual for Biological Journals. Second Edition. American Institute of Biological Sciences, Washington, D. C.

9. Draper, N. R. and H. Smith. 1966. Applied Regression Analysis. John Wiley and Sons, Inc. New York City, New York.

10. Dunbar, Fredrick C. 1976. Quick Policy Evaluations With Behavioral Demand Models. Transportation Research Board Paper P63 b. Washington, D. C.

11. Files of the Kansas Department of Transportation Planning and Development Department regarding United States Department of Transportation Urban Mass Transportation Administration. Section 16 (b) (2) Projects. 1975 - 1976. State Office Building. Topeka, Kansas.

12. Files of the Kansas Services of the Handicapped Office. 1975 Present Developmentally Disabled Population for the State of Kansas by Region and County. State Office

Building. Topeka, Kansas.

13. Grecco, W. L. 1976. Transportation Planning for Small Urban Areas. United States Department of Transportation Urban Mass Transportation Administration. Washington, D. C. 4 Chapter.

14. Hartgen, David T. 1976. Incorporating Barrier Effects In Elderly and Handicapped Transit Demand Forecasts. PRU Preliminary Draft Report. New York State Department of Transportation. New York City, New York.

15. Hartgen, David T. and C. A. Keck. 1975. Forecasting Dial - A - Bus Ridership in Small Urban Areas. Transportation Research Board Paper 88. Washington, D. C. 3, 5, 10 p.

16. Institute of Public Administration. 1975. Transportation for Older Americans. Prepared for the Administration on Aging. Washington, D. C.

17. Interview with Mr. Jon E. Burkhardt of Ecosometrics, Inc. of Bethesda, Maryland. December 15, 1976 at the United States Department of Transportation Federal Highway Administration Section 147 Program Workshop in Kansas City, Missouri.

18. Interview with Mr. E. D. Landman, Assistant Engineer of Planning and Development - Kansas Department of Transportation. State Office Building. Topeka, Kansas. December, 1976.

19. Interview with Dr. W. G. Roeseler, Head, Department of Urban and Regional Planning, Texas A & M University. Bryan, Texas. November 1976.

20. Interview with Mrs. William Shaeffer, Director of the Marshall County Agency on Aging. October 14, 1976. Marysville, Kansas.

21. Interview with Mr. John Squires of Washington County, Arkansas Planning Department. December 14, 1976 at the United States Department of Transportation Federal Highway Administration Section 147 Program Workshop in Kansas City, Missouri.

22. Kansas Department of Transportation. 1975 - 1976. Official Highway Map. State Office Building. Topeka, Kansas.

23. Kansas Department of Transportation. 1975. Official Mileage Chart. State Office Building. Topeka, Kansas.

24. Kansas Department of Transportation. 1977. Rail Planning Work Statement and Application for Planning Assistance. Kansas Department of Transportation Planning and Development Department. State Office Building. Topeka, Kansas.

25. Kansas Department of Transportation. 1976. Statewide Rural Public Transportation System for the State of Kansas, Demonstration Project Proposal of Section 147 of the Federal Aid Highway Act of 1973. State Office Building. Topeka, Kansas.

26. Kansas Department of Transportation. 1975. Transportation Perspectives in Kansas. Kansas Department of Transportation Planning and Development Department. State Office Building. Topeka, Kansas.

27. Krukeberg, Donald A. and A. L. Silvers. 1974. Urban Planning Analysis: Methods and Models. New York Department of Transportation. New York City, New York. 3,4,7 p.

28. Larson, Thomas D. and P. M. Lima. 1975. Rural Public Transportation. Traffic Quarterly. ENO Foundation for Transportation. Westport, Connecticut. 369 - 384 p.

29. McKelvey, Douglas J. 1976. Coordination Considerations for Rural Public Transportation. Transportation Institute North Carolina A & T State University. Greensboro, North Carolina.

30. Missouri Transportation Associates. 1976. Transportation for the Elderly and Handicapped in Missouri. Prepared for the Older Adult Transportation Service, Inc. Columbia, Missouri.

31. Notess, Charles B., R. J. Popper, and R. N. Zapata. 1976. The Demand for Special Transit to Serve the Rural Elderly. Transportation Research Board Paper 18 b. 1,4,5,6,13,14 p. Washington, D. C.

32. Petersen, Arthur E. Jr. 1976. Consideration in Driver Selection and Training. Transportation Institute. North Carolina A & T State University. Greensboro, North Carolina.

33. Polederos, S. G. 1975. Integrating State and Local Funding with Federal Funding: Rhode Island: Senior Citizen Transport (SCT) in Toward a Unification of National and State Policy on the Transportation Disadvantaged. Edited by W. G. Bell and W. T. Olsen, Florida State University. Tallahassee, Florida.

34. Russell's Official National Motor Coach Guide for the United States, Canada, Mexica, and Central America. 1975. Russell's Guides, Inc. Cedar Rapids, Iowa.

35. Saltzman, Arthur. 1974. Predicting Rural Public Transportation. Transportation Institute. North Carolina A & T State University. Greensboro, North Carolina.

36. Schauer, Peter M. 1975. Marketing and Promotion of the Older Adults Transportation Service in Missouri. Paper presented at the First National Conference on Rural Public Transportation, Washington, D. C. unpublished paper available from Mr. Peter Schauer, OATS, Inc. 9th and College, Columbia, Missouri.

37. Smerk, George, et. al. 1971. Mass Transit Management A Handbook for Small Cities. Graduate School of Business. Indiana University. 131, 135 p. Bloomington, Indiana.

38. United States Bureau of the Census. 1973. Some Demographic Aspect of Aging in the United States. United States Government Printing Office. Population Reports, Series P - 23, No. 43, Washington, D. C. Table 12, 14 p.

39. United States Department of Commerce. 1970. General Population Characteristics of Kansas. Bureau of the Census, Washington, D. C.

40. United States Department of Health, Education, and Welfare. 1975. Transportation for the Elderly: the State of the Art. Administration on Aging. United States Government Printing Office. Publication No. (ODH) 75 - 20081. Washington, D. C. 5, 6 p.

41. United States Department of Transportation. 1973. Rural Transit Operation and Management. The Office of Policy and Plan Development, Office of the Secretary of the Department of Transportation. Washington, D. C. 3,4,10 p.

42. United States Department of Transportation. 1973. Short Range Transit Planning. Urban Mass Transportation Administration, United States Department of Transportation. Washington, D. C. III - 17, V - 12, 13, 14, 15, 18, 19, 10 p.

43. United States Department of Transportation, Federal Highway Administration. 1969. The Transportation Needs of the Rural Poor. Washington, D. C. 11, 14 p.

44. United States Department of Transportation , Federal Highway Administration. 1975. Planning Handbook - Transportation Services for the Elderly. Washington, D. C. I - 2, 4, 5, 6, II - 1, 12, 24 p.

45. United States Department of Transportation, Urban Mass Transportation Administration. 1973. The Handicapped and Elderly Market for Urban Mass Transit. Report No. UMTA - MA - 06 - 0034 - 73 - 3. 41, 58 p. Washington, D. C.

46. United States Department of Transportation, Urban Mass Transportation Administration. 1976. Transportation Problems of the Elderly and Handicapped. Volume I. Washington, D. C. 1 p.

47. United States Department of Transportation, Urban Mass Transportation Administration. 1976. Urban Mass Transportation Act of 1964 and Related Laws as amended through February 5, 1976. United States Government Printing Office No. 050 - 014 - 00007 - 0. Washington, D. C.

48. University of Kansas. 1974. A study for services for the elderly (untitled). Institute for Social and Environmental Studies. Lawrence, Kansas. 5 p.

49. Williamson, James. 1976. Promotional Considerations for Rural Public Transit. Transportation Institute. North Carolina A & T University. Greensboro, North Carolina.

VIII. TABLES OF DATA

Location 1	Location 2	Bus Route Miles
Region 4:		
Tribune	Leoti	22
Leoti	Scott City	24
Scott City	Dighton	24
Dighton	Garden City	54
Garden City	Lakin	25
Lakin	Syracuse	28
Syracuse	Tribune	34
Johnson	Elkhart	47
Elkhart	Hugoton	34
Hugoton	Liberal	33
Liberal	Sublette	34
Sublette	Ulysses	36
Ulysses	Johnson	23
Liberal	Meade	40
Meade	Cimarron	36
Cimarron	Garden City	34
Garden City	Sublette	37
Dodge City	Ashland	51
Ashland	Coldwater	15
Dodge City	Kinsley	19
Jetmore	Ness City	26
Ness City	La Crosse	19
Jetmore	Larned	23
	Total Region 4 Route Miles	718
	Freq.	4
	B Miles	2,872

Location 1	Location 2	Bus Route Miles
Region 5:		
La Crosse	Great Bend	36
Great Bend	Russell	40
La Crosse	Larned	36
Larned	Great Bend	24
Larned	Jetmore	47
Larned	St. John	32
Great Bend	St. John	52
Great Bend	Lyons	31
St. John	Hutchinson	53
Lyons	Hutchinson	62
Lyons	McPherson	30
McPherson	Newton	31
Hutchinson	Newton	36
Hutchinson	Kingman	38
Kingman	Wichita	44
Wellington	Wichita	32
Wellington	Anthony	43
Anthony	Kingman	70
Kingman	Pratt	35
Pratt	Medicine Lodge	60
Medicine Lodge	Anthony	38
Medicine Lodge	Coldwater	42
Coldwater	Greensburg	48
Greensburg	Pratt	31
Greensburg	Kinsley	27
Newton	Wichita	27
Wichita	El Dorado	34
Newton	El Dorado	39

Total Region 5 Route Miles	1,118
Freq.	4
B Miles	4,472

TABLE VII Bus Route Miles Between Key Locations (23)
By Region *

Location 1	Location 2	Bus Route Miles
Region 1:		
St. Francis	Atwood	42
St. Francis	Goodland	36
Goodland	Sharon Springs	33
Sharon Springs	Colby	63
Hoxie	Colby	66
Colby	Oakley	24
Colby	Atwood	58
Colby	Hill City	130
Oakley	Gove	32
Gove	Wakeeney	44
Wakeeney	Hays	35
Hays	Russell	30
Hays	La Crosse	34
Russell	Great Bend	40
Stockton	Hays	80
Russell	Osborne	47
Atwood	Oberlin	29
Oberlin	Norton	35
Stockton	Phillipsburg	23
Phillipsburg	Smith Center	29
Smith Center	Osborne	26
	Total Region 1 Route Miles	936
	Freq.	4
	B Miles	3,744

* These figures indicate number of route miles between various points on the network as per the FHWA Section 147 Project.

TABLE VII continued

Location 1	Location 2	Bus Route Miles
Region 2:		
Mankato	Beloit	28
Mankato	Belleville	32
Belleville	Concordia	18
Beloit	Concordia	33
Washington	Marysville	22
Washington	Clay Center	33
Clay Center	Manhattan	82
Clay Center	Abilene	36
Minneapolis	Abilene	44
Minneapolis	Lincoln	31
Lincoln	Ellsworth	57
Ellsworth	Salina	36
Salina	Abilene	27
Abilene	Manhattan	44
Junction City	Manhattan	19
Junction City	Alma	34
Alma	Westmoreland	29
Westmoreland	Marysville	44
Westmoreland	Manhattan	58

Total Region 2 Route Miles	707
Freq.	4
B Miles	2,828

TABLE VII continued

Location 1	Location 2	Bus Route Miles
Region 3:		
Kansas City	Lawrence	40
Lawrence	Oskaloosa	23
Oskaloosa	Topeka	31
Topeka	Lawrence	30
Topeka	Lyndon	31
Lyndon	Ottowa	72
Ottowa	Lawrence	50
Ottowa	Paola	98
Paola	Kansas City	45
Lyndon	Burlington	60
Burlington	Garnett	46
Garnett	Mound City	40
Garnett	Iola	30
Yates Center	Garnett	24
Mound City	Fort Scott	14
Topeka	Holton	33
Oskaloosa	Atchison	30
Emporia	Lyndon	38

Total Region 3 Route Miles	735
Freq.	4
B Miles	2,940

Location 1	Location 2	Bus Route Miles
Region 6:		
Eureka	El Dorado	16
Eureka	Howard	58
Howard	Sedan	28
Eureka	Winfield	80
Winfield	Arkansas City	14
Arkansas City	Sedan	51
Winfield	El Dorado	49
Eureka	Ferdonia	45
Ferdonia	Howard	82
Ferdonia	Independence	56
Independence	Sedan	37
Independence	Coffeyville	22
Independence	Parsons	60
Coffeyville	Parsons	39
Parsons	Oswego	20
Oswego	Columbus	15
Columbus	Pittsburg	24
Pittsburg	Girard	30
Girard	Chanute	90
Chanute	Parsons	70
Chanute	Ferdonia	30
Chanute	Iola	18
Iola	Fort Scott	82
Iola	Garnett	30
	Total Region 6 Route Miles	1,046
	Freq.	4
	B Miles	4,184

TABLE VIII Population Data by Region and County

County	60 Years +	Handicapped	RESTPOP	Total
Region 1:				
Cheyenne	981	157	1,138	4,256
Decatur	1,313	197	1,510	4,988
Ellis	2,813	937	3,750	24,730
Gove	716	157	873	3,940
Graham	867	184	1,051	4,751
Logan	703	144	847	3,814
Norton	1,775	288	2,063	7,279
Osborne	1,917	247	2,164	6,416
Phillips	1,875	318	2,193	7,888
Rawlins	945	170	1,115	4,393
Rooks	1,687	289	1,976	7,628
Russell	2,009	382	2,381	9,428
Sheridan	700	154	854	3,859
Sherman	1,200	309	1,509	7,792
Smith	1,972	265	2,237	6,757
Thomas	1,365	265	1,630	7,501
Trego	944	177	1,121	4,436
Wallace	368	88	456	2,215

Total Region 1 60 Years +	24,150
Total Handicapped	4,728
Total RESTPOP	28,878
Total Population	122,071

TABLE VIII continued

County	60 Years +	Handicapped	RESTPOP	Total
Region 2:				
Chase	918	139	1,057	3,408
Clay	2,598	391	2,989	9,890
Cloud	3,423	537	3,960	13,466
Dickinson	4,642	920	5,562	19,993
Ellsworth	1,620	277	1,897	6,146
Geary	2,522	948	3,470	28,111
Jewell	1,692	241	1,933	6,099
Lincoln	1,353	186	1,539	4,582
Lyon	5,328	1,189	6,517	32,071
Marion	3,481	596	4,077	13,935
Marshall	3,613	541	4,154	13,139
Mitchell	2,006	316	2,322	8,010
Morris	1,762	264	2,026	6,432
Ottowa	1,657	247	1,904	6,183
Pottawatomie	2,632	498	3,130	11,755
Republic	2,429	325	2,754	8,498
Riley	4,201	1,546	5,747	56,788
Saline	6,728	1,789	8,517	46,592
Wabaunsee	1,630	262	1,892	6,397
Washington	2,492	361	2,853	9,249

Total Region 2 60 Years +	56,727
Total Handicapped	11,573
Total RESTPOP	68,300
Total Population	310,744

TABLE VIII continued

County	60 Years +	Handicapped	RESTPOP	Total
Region 3:				
Anderson	2,147	327	2,474	8,501
Coffey	2,206	333	2,539	7,397
Douglas	6,065	2,286	8,351	57,932
Franklin	4,333	796	5,129	20,007
Jefferson	2,369	486	2,855	11,945
Johnson	urban population data not applicable to rural model			
Leavenworth	6,996	1,883	8,879	53,346
Linn	2,212	318	2,530	7,770
Miami	4,128	799	4,927	19,254
Osage	3,096	531	3,627	13,352
Shawnee	urban population data not applicable to rural model			
Wyandotte	urban population data not applicable to rural model			

Total Region 3 60 Years +	33,552
Total Handicapped	7,759
Total RESTPOP	41,311
Total Population	199,504

County	60 Years +	Handicapped	RESTPOP	Total
Region 4:				
Clark	725	110	835	2,896
Finney	2,141	868	2,999	18,947
Ford	3,596	934	4,530	22,587
Grant	548	261	809	5,961
Gray	820	184	1,004	4,516
Greeley	275	82	357	1,819
Hamilton	500	120	620	2,747
Haskell	411	154	565	3,672
Hodgeman	491	107	598	2,662
Kearny	433	124	557	3,047
Lane	516	114	630	2,707
Meade	963	197	1,160	4,912
Morton	413	139	552	3,576
Ness	1,127	185	1,312	4,791
Scott	782	238	1,020	5,606
Seward	1,657	623	2,280	15,744
Stanton	265	94	359	2,287
Stevens	566	175	741	4,198
Wichita	401	110	511	3,274

Total Region 4 60 Years +	16,630
Total Handicapped	4,809
Total RESTPOP	21,439
Total Population	115,949

TABLE VIII continued

County	60 Years +	Handicapped	RESTPOP	Total
Region 5:				
Barber	1,640	272	1,912	7,016
Barton	4,862	1,316	6,178	30,663
Commanche	687	110	797	2,702
Edwards	1,100	172	1,272	4,581
Harper	2,130	320	2,450	7,871
Kingman	1,894	392	2,286	8,886
Kiowa	1,086	158	1,244	4,088
Mc Pherson	4,963	952	5,915	24,778
Pawnee	1,895	319	2,214	8,484
Pratt	2,249	377	2,626	10,056
Reno	10,573	2,621	13,694	60,765
Rice	2,809	463	3,272	12,320
Rush	1,249	204	1,453	5,117
Stafford	1,585	240	1,825	5,943
Sumner	5,039	927	5,966	23,553

Total Region 5 60 Years +	43,701
Total Handicapped	8,843
Total RESTPOP	52,544
Total Population	216,823

TABLE VIII continued

County	60 Years +	Handicapped	RESTPOP	Total
Region 6:				
Allen	3,757	582	4,339	15,043
Bourbon	3,977	597	4,564	15,215
Butler	6,274	1,457	7,731	38,659
Chautauqua	1,451	202	1,653	4,642
Cherokee	4,720	850	5,570	21,549
Cowley	7,388	1,330	8,718	35,012
Crawford	8,696	1,492	10,188	37,850
Elk	1,307	163	1,470	3,858
Greenwood	2,613	356	2,969	9,141
Harvey	5,034	1,064	6,098	27,236
Labette	4,635	971	5,606	25,775
Montgomery	9,563	1,767	11,330	39,949
Neosho	4,336	708	5,044	18,812
Sedgwick	urban population data not applicable to rural model			
Wilson	3,033	513	3,546	11,317
Woodson	1,421	193	1,614	4,789

Total Region 6 60 Years +	68,205
Total Handicapped	12,235
Total RESTPOP	80,440
Total Population	308,847

IX. VITA

I, Joan Marguerite Roeseler was born on December 7, 1954 in Kansas City, Missouri. Most of my life was spent in Kansas City. Upon graduation from Shawnee Mission South High School in 1971, I attended the University of Kansas where I received a B.S. Degree in Business Administration in January of 1975. I worked as a planner for W.G. Roeseler, AIP, Consulting City Planner in Kansas City after receiving my degree from K.U. I presently work part - time for the Kansas Department of Transportation as a planner.

IN DEPTH STUDY OF THE BURKHARDT / LAGO MODEL REGARDING THE DEMAND FOR RURAL PUBLIC TRANSPORTATION TO THE SIX PROPOSED REGIONAL BUS SYSTEMS IN KANSAS

by

JOAN MARGUERITE ROESELER

B.S., University of Kansas, 1975

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF REGIONAL AND COMMUNITY PLANNING

Department of Regional and Community Planning

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1977

The lack of adequate, effective transportation services is now recognized by numerous Federal and State agencies as one of the major problems facing the elderly, handicapped, and other transportation disadvantaged persons in rural areas. Although many rural counties now have adequate all-weather road systems, some persons and communities still remain isolated from the mainstream of American society because of their inability to travel. Often, this immobility is due to the inability to pay the price for existing transportation services; other times, however, transportation services are non-existent for persons not owning automobiles.

The Kansas Department of Transportation Planning and Development Department has become involved with preliminary implementation stages of a project wherein a statewide rural public transportation system is to be initiated as a two year demonstration project. The project is funded with $500,000 from the United States Department of Transportation Federal Highway Administration, specifically from Section 147 of the Federal - Aid Highways Act of 1973. The project, Statewide Rural Public Transportation for the State of Kansas, was submitted as a joint proposal by the Kansas Department of Transportation Planning and Development Department and the Kansas Social and Rehabilitation Services Department.

As an aid to the Section 147 Project implementation process, an estimate of demand for each of the six proposed regional bus ayatems is a useful tool. Mr. Jon E. Burkhardt and Mr. Armando M. Lago of Ecosometrics, Inc. of Washington, D.C. developed a handbook for the prediction of rural public transportation demand for the state of Pennsylvania. The purpose of this handbook is utilization by local planners to estimate the demand for public transportation systems in rural, or predominantly rural areas. This model appears to utilize characteristics for prediction or estimation of demand that are most highly agaptable to those of the six proposed rural public transportation systems in Kansas.

This thesis is an in depth study of the Burkhardt / Lago model. The model is discussed with respect to its development, application in Pennsylvania, application in Arkansas, and use in estimation of demand for the six proposed rural public transportation systems in Kansas. In conclusion, the results of the model are analized in an effort to refine the scope of the applicability of the model, as a planning tool.