ESTIMATION OF DEMAND FOR AND SUPPLY OF TRANSPORT IN RURAL TASMANIA

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This dissertation represents my own original work and contains no material which has already been published or otherwise used by me, and to the best of my knowledge it contains no copy of paraphrase of material previously written by another person or authority, except where due acknowledgement is made.

R.A. Obialor

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Rural public transport services cater to specific markets such as commuting and shopping trips, visiting friends and relatives, touring and so forth. Rural transportation generally provides services to people in rural areas as opposed to urban transportation systems that are primarily designed to shuttle people to and from work. Creating and running a rural transportation system can be a fairly simple operation but could be unprofitable. The needs of rural transportation research are many, and this study can make a significant contribution to all parties involved in the operation of rural transportation in Tasmania.

The primary aim of this study is to estimate demand and supply functions for rural transportation in Tasmania. The secondary aim will be to compare the estimated elasticities with work already done in a similar field. Typical results of this study would include items such as (a) sensitivity of revenue to changes in fares, in-vehicle time, frequency and number of cars per household, (b) the sensitivity of frequency of service to changes in revenue, fare, cost per kilometre and size of the bus.

No demand model or other methods of quantified demand predictions for small scale rural transportation system existed in Tasmania before this study. This study therefore aims at helping in understanding the patters of demand and supply of transport in Tasmania.

1.2 METHOD OF APPROACH

Two types of data can be used. The demand and supply equations can be estimated using cross-section data; that is the analysis may be based on the demand pattern at a particular point in time. The second approach is to use time series data, in which observations on the relevant variables are made over time. The cross-section approach is used in this study.

The first stage of the project concentrated on the data. Some of the data were obtained from the Australian Bureau of Statistics (ABS), while the remainder came from a survey undertaken by the writer for the purpose of this study. The survey of the private bus operators was conducted by mailing an informal questionnaire. Details of the questionnaire are set out in Appendix I.

The second stage of the analysis concentrated on the primary objective and attempts to find the combination of independent variables which best explain, in statistical terms, the dependent variable in the demand equation.

The supply equation was estimated with frequency as the dependent variable. In general, vehicle kilometres can also be used as a measure of level of service because an increase in vehicle kilometre can reflect either an increase in frequency on a given route or an increase in route coverage.

The estimation was based on twenty-two observations. As is typical of this type of analysis, data inconsistency limited the number of observations to twenty-two. The limitations of data collection were of two kinds. First, the time required to produce this report made further data collection almost impossible. With more time, also we would have improved on the present response rate of 58%. Though the result obtained from this study will be conclusive it is felt that sufficient precautions were taken to make the data problem only a minor limitation.

1.3 LAYOUT OF THE STUDY

The structure of the remainder of this study is as follows: In the next section, we will outline the structure of the private bus industry in the state and some of the results of the survey which were not necessarily accounted for by the model. It is envisaged that this section should provide the readers with information on different classes of operations, the size of the market and the cost structure of the bus industry.

Chapter two contains a description of demand theory which provides a theoretical foundation for our demand equation. The supply theory was also included in chapter two. This chapter contains reviews of empirical studies of transport demand and supply functions.

Chapter three describes the data including data obtained from the survey of the private bus industry. The methodology of the survey is discussed and data evaluation is also discussed.

Chapter four describes the estimation of the demand equation and results. Chapter five contains the estimation of the supply equation and results. Chapter six contains the conclusions and suggestions for further research.

1.4 THE STRUCTURE OF TASMANIAN PRIVATE BUS INDUSTRY

The transport department classified private bus operators into three broad groups: Primary stage operators: these are operators, operating at least one stage (scheduled) service. These operators invariably perform other work such as tours, charters and school contracts. Primary school Operators: these operators' main operations involve school contract work. Operators solely involved in charter/private work: these include those operators possessing only omnibus licences who engage in charter or private (institutional) work.

Table 1.1 Number of Private Operators by Type of Operation December 1981

	Primary School Bus Operators	Primary Stage Service Operators[(a)]	Primary Institutions[(b)]
Number of Operators	213	66	85
Number of Vehicles	438	248	125
Vehicles per Operator	2.03	3.76	1.47

Source : Transport Research Unit papers.

(a) Also includes charter operators

(b) Defined as those having an institutional-related condition on their public vehicle licences.

From Table 1.1 it can be ascertained that primary stage operators have the highest number of vehicles per operator. While primary stage operators have 3.76 vehicles per operator, the primary school operators and institutional operators have 2.03 and 1.47 respectively.

Table 1.2 illustrates the distribution of vehicles by licence category.

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Table 1.2 Distribution of Vehicles by Licence Category

Licence Category		Number of Vehicles	
Number	Type[a]	Private	Institutional
8	Coach	50	15
9	School Coach	290	--
10	Coach with Omnibus Exemption	185	--
11	Coach with Cab Exemption	9	--
12	Coach with Hire Car Exemption	4	--
13	School Coach; Omnibus Exemption	92	--
14	School Coach; Cab Exemption	5	--
15	Omnibus	51	110
	Total Vehicles	686	125
	Grand Total - 811		

Source : Transport Research Unit policy paper

(a) Exemptions usually apply to a specific traffic area.

Table 1.3 shows the distribution of fleet size in the industry as at December 1981.

Table 1.3 Distribution of Fleet Size in the Private Bus Industry January 1981

Fleet Size	Number of Operators	
	Private	Institutions
1	160	64
2	43	11
3	25	5
4	15	3
5	10	1
6	5	1
7	5	--
8	--	--
9	4	--
10	2	--
11	2	--
12	--	--
13	--	--
14	--	--
15	1	--
16	1	--
17	--	--
18	--	--
19	--	--
20	2	--
41	1	--
	279	85

Source : Transport Reserach Unit policy paper.

About 62% of the privately operated bus fleet in Tasmania is composed of single bus operations. It is worth noting that the single mean fleet size in the Tasmanian private bus sector is 2.45. By contrast, the same statistics are around 20.00 for Melbourne's private bus fleet (Usher, 1980)[1].

1.4.1 VEHICLE AGE AND TYPE

Conventional buses and light weight buses are generally used. Modified standard vans and small buses account for about 24% of vehicles used. Standard passenger vans range from 4-passenger vans to 15-passenger vans with a 138-inch wheel base. Table 1.4 shows the distribution of buses by age from a sample taken from the Tasmanian operators. This sample is compared with those published for Queensland private bus operators (Hooper and McCullum, 1979)[2]. Nearly 80% of the Tasmanian bus fleet is less than 15 years old as compared to Queensland's 65%.

1.4.2 Vehicle Utilization

The measures of vehicle utlization are revenue vehicle kilometre per vehicle, total vehicle kilometre per vehicle and revenue-vehicle hours per vehicle. These utilization indicators are used to evaluate the process by which transport services are produced in relation to inputs. The survey we carried out showed that the total annual kilometres travelled by the twenty-two stage operators is 1.12 million kilometres and the average kilometre per passenger is 1.40 (see Appendix 9). Passenger kilometre/vehicle-kilometre gives a measure of occupancy.

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(1) Usher, J.C., 1980, "A Transportation Systems Management Approach to Community Bus Operation", Australian Research Forum Papers, pp. 143-160.

(2) Hooper, P., & McCullum, J., "Private Bus Industry in Queensland", Policy Paper, 1979.

Table 1.4 Comparison of Age Distribution of Private Buses in Tasmania and Queensland

Age of Vehicle	Tasmania[a] March 1981	Queensland[b] June 1977
0 to 5 years	9.92 %	10.3 %
6 to 10 years	22.31 %	28.2 %
11 to 15 years	40.49 %	25.6 %
16 to 20 years	17.35 %	16.2 %
21 to 25 years	9.09 %	7.3 %
25 years and over	1.84 %	12.4 %
	100.00 %	100.0 %

(a) Source : T.P.U. Survey of private route operators
(b) Source : Hooper and McCullum (1979)

Given the large fixed cost associated with a bus operation, high vehicle utilization is one important aspect of the services that interests the operator.

Table 1.5 summarises the distribution of vehicle distance travelled by the sample of vehicles obtained from the survey. A comparison is made between a similar survey in 1980. It is evident from the survey that some operators combine the stage operation with freight and that form of operation cross-subsidized the passenger revenue.

1.4.3 Subsidies

The Department of Transport provides a number of subsidies directly or indirectly to various groups. Three main groups in the state qualify

Table 1.5 Distribution of Annual Distances Travelled by Private Buses in Tasmania (February 1982)

Distance travelled ('000 kms per annum)	1981/82 Number of buses[(a)]	1981/82 Percent	1979/80 Number of buses[(a)]	1979/80 Percent
0 to 5	12	11.4	0	0
5 to 10	5	4.8	0	0
10 to 15	11	10.5	2	7.14
15 to 20	16	15.2	4	14.29
20 to 25	10	9.5	1	3.57
25 to 30	4	3.8	2	7.14
30 to 35	30	28.6	1	3.57
35 to 40	7	6.7	3	10.71
40 to 60	8	7.6	8	28.57
60 to 80	0	0	6	21.43
80 and above	2	1.9	1	3.57
	105	100.0	28	100.00

(a) Source : Tasmanian Private Bus Industry, Policy Study, Policy Report.

for transport subsidies and are classified as follows[3] :

Pensioner Subsidy Scheme : Qualified pensioners pay one-half the adult fare on both public and privately operated buses. The private operators are reimbursed for the remainder of the adult fare upon receipt of a statutory declaration and claim form for the amount involved. This scheme, according the the survey cost the department about $238,760 in

(3) Tasmanian Private Bus Industry, T.P.U. policy paper, February 1982.

the 1980/81 financial year.

Unemployed Subsidy Scheme : These persons may apply for a travel concession card for half-fare travel on public and private bus services. This Scheme cost about $6,500 in the 1980/81 financial year.

The School Bus System : Both free travel and subsidized school travel is provided by the education department to students to and from school. In the case of travel provided by private operators, the operator is paid either directly by the education department or through individual schools.

1.4.4 Cost Structure

A breakdown of the cost structure in the Tasmanian private bus industry is shown in Table 1.6. An attempt is made to compare these costs with some Pennyslvanian Regions of the United States of America. This area is chosen because of its extensive costing and also its rural distribution.

Expect for general and administrative expenses and vehicle capital cost, the agreement of these costs if noteworthy. The three cost categories account for two-thirds of the total system costs. The Tasmanian operations is relatively different but it is important to note the low overhead cost for Tasmania compared to the United States.

Table 1.7 gives data on operating expenses for Tasmania and the rural section 146 project[4].

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(4) Lago, A.M., Burkhardt, J.E., 1978, "Rural Transportation Cost", TRB, Transportation Research Board, pp. 15-20.

Table 1.6 Rural Transportation Costs Attributable to Various Factors

	Percentage of Costs		
	Fixed Route Rural Systems (Pennsylvania)[a]	Fixed Route Rural Systems (Tasmania)	Demand Responsive Systems (USA)[b]
Drivers' wages and benefits	28	26	25
General & administrative expenses	38	5	20
Vehicle capital costs	6	31	14
All other costs	28	38	41
	100	100	100

Sources : (a) Saltzan, Chen and Johnson, "Analysis of Rural Transport Systems", North Carolina AIT State University, April 1978, p. 28

(b) K.P. Ceglowski, A.M. Lago and J.E. Burkhardt, "Rural Transportation Costs", TRB Transportation Research Board 661, 1978, pp. 15-20.

Table 1.7 Operation Statistics for Rural Section 146 (Pennsylvania) and Tasmania

Factor	Measures	$A Tasmania Dec. 1981	$USA Pennsylvania[a] Jan.-March 1978
Efficiency	Costs[b] per vehicle kilometre	.97	.42
	Average per passenger trips per vehicle hour	2.35 15.60	2.47 10.58
	Load factor, (percentage)	11.70	17.1
	Operating ratio (revenue : operating & administrative costs)	0.17	0.24
Effectiveness	Passengers per vehicle kilometre	0.12	0.23
	Annual passengers per service area population	3450.00	NA
Other	Monthly vehicle kilometres per vehicle	3000.00	3221

Sources : (a) Data from Section 146 Rural Transportation Program for State of Pennsylvania.

(b) Not including Capital Cost.

Despite the fact that the two sets of data do not necessarily describe comparable systems, some similarities are evident. Average passenger trips are higher for Tasmania (see Appendix 12 for methodology used in calculating the costs).

Table 1.8 shows the typical cost per kilometre for a fixed route. The cost is based on operators with a fleet size of at least five vehicles large buses with seating capacity of about 50 or more and 40,000-50,000 kilometres of annual operation per vehicle.

Table 1.8 Typical Cost Per Vehicle Kilometre for Fixed-Route Rural Transportation in the North-East of U.S.A. and Tasmania

Items	Vans (a)	Conventional Buses Large (a)	Conventional Buses Large (b)	School Bus (a)
Number of seats	12	50	50	44
Operating speed km/h	25	15	20	15
Cost per vehicle km., $				
Fuel	0.043	0.060	0.120	0.037
Oil	0.002	0.003	0.010	0.0025
Tyres and tubes	0.006	0.031	0.040	0.025
Vehicle repairs and maintenance	0.043	0.083	0.120	0.087
Driver wage and fringe benefits	0.102	0.170	0.210	0.170
Insurance and registration	0.025	0.062	0.060	0.049
Vehicle storage costs (depots)	0.012	0.012	0.030	0.012
General and administrative expenses	0.074	0.139	0.080	0.130
Vehicle capita costs	0.039	0.189	0.126	0.152
	0.345	0.759	0.786	0.523

Sources : (a) Typical cost per vehicle kilometre (FY, 1977), Transportation Research Board, National Academy of Science, No. 696.

(b) Tasmanian costs based on the survey.

Tasmania compared favourably with the United States regions. Drivers wages and fringe benefits seem to be high compared to the USA data (notes on the derivation of the figures are set out in Appendix 8).

The above cost will be higher for urban transportation. The costing of bus services in Adelaide[5], for example, estimated the unit direct operating cost as $4.60. Direct operating cost in this case is defined as those costs which are directly related to bus kilometre operated. This estimated cost includes a 'highway contribution cost' because the State Transport Authority (STA) pays a highway contribution cost based on the number of kilometres travelled.

In concluding this section, Tasmanian operators have a reasonable size of fleet to meet unexpected increases in demand. This is evident in the results of the survey shown in Table 1.1. The stage operators have almost 4.00 vehicles per operator. The costing in section 4.1.4 has some implications. Operators can simply begin to control costs using those cost estimates as a guideline and understanding which of the above factors influence costs more. For Tasmania, emphasis should be placed on vehicle capital cost because it is comparatively higher than the U.S.A..

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(5) Stack, M.J., Keal, P.D., Starrs, M.M., "The Costing of Bus Services in Adelaide", Australian Research Forum Papers, 1978, pp. 327-346.

CHAPTER TWO

THEORETICAL FRAMEWORK AND LITERATURE REVIEW

2.1 INTRODUCTION

The aim of this chapter is to outline the basic theory of demand and supply of transport which have been extensively used by economists to derive empirically estimable demand and supply functions and secondly a literature review of work done in demand functions for transport. An attempt will also be made to review the work on supply functions for transport though empirical analysis is in this area, is lacking.

2.2 DEMAND THEORY

The classical theory of consumer demand suggests that a typical consumer maximizes subject to a budget constraint, a stable utility function (which represents his preference ordering) by choosing appropriate levels of consumption of each of the commodities entering the utility function. The theory of the consumer has been examined and applied in a transport context by Domencich and McFadden (1975, chapter 3)[6], when the choice faced by the individual is between discrete alternatives. However, when the commodities in question are measured continuously (e.g., total number of trips between city pairs per week) the usual practice is to specify an a priori form for the demand functions without any explicit recognition of the underlying theory of consumer demand. A familiar example of this a priori specification is the aggregate simultaneous type model exemplified by the abstract mode approach developed by Quandt and Baumol (1960)[7].

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(6) Domencich, T.A. and McFadden, D., (1975), Urban Travel Demand : A Behavioural Analysis, (Amsterdam: North-Holland publishing Co.)

(7) Quandt, R.E. and Baumol, W.J., (1966), "The Demand for Abstract Transport Modes : Theory and Measurement", Journal of Regional Science, Vol. 6, pp. 13-26.

In the next section we will outline the theory of utility maximization. The reader should not get the impression that estimating demand functions derived from a utility function is necessarily the best approach. In many respects many demand systems have been derived using other models.

2.3 THEORY OF UTILITY MAXIMIZATION

In order to understand why it might be useful to examine the demand for transport using a demand systems approach, it is necessary to outline some of the basic results of demand theory. Its major goal is to describe the consumers decision to purchase each commodity. It is assumed that the consumer's income and the prices of all commodities have already been determined and are known to the consumer. It is also assumed that the decision has already been made as to how much income is to be spent so that there is no need to include savings in the list of possible alternative uses of income.

Assumptions are made on the consumer preference ordering such that it can be represented by a utility function that depends on the rate of consumption of each commodity available. There are n commodities. This utility function may be represented mathematically as :

$$u = f(X_1, X_2, \ldots\ldots, X_n) \tag{2.1}$$

where u is the utility index, $X_i \geq 0$ is the rate of consumption per period of i^{th} commodity and where the marginal utility of each good is positive (i.e., $\partial u/\partial X_i \geq 0$). It is assumed that the consumer attempts to choose X's that will maximize his utility index subejct to a budget constraint ($\sum_{i=1}^{n} P_i X_i = M$). This maximization task may be reviewed as a simple constrained optimization problem. The solution of which yields a set of equations :

$$X_i = \Delta_i(P_i, \ldots, P_n, M) \qquad (i = i, \ldots, n) \qquad (2.2)$$

which gives equilibrium rates of consumption of the n goods as functions of price (P's) and income or expenditure (M). These are the consumer's demand functions which also can be equivalently written as expenditure function given by :

$$P_iX_i = P_iD_i(P_i, \ldots, P_n, M) = G_i(P_i, \ldots, P_n, M) \qquad (2.3)$$

If we examined this in the context of travel demand the X's (goods) in equation 2.1 might be quantities of travel by different transport modes; the P's (prices) in equation 2.2, the cost of trip by each of the modes (possibly a generalized cost of some sort) and the M (expenditure) in 2.2, the total transport budget. The consumer is thus seen as maximizing total utility from travel subject to a transport budget constraint.

There are several properties possessed by these demand functions which are independent of the explicit form of the utility function. Four of particular interest to economists are known as homogeneity, Engel aggregation, Cournot aggregation and Slutsky symmetry[8]. Detailed discussion of these properties is outside the scope of this study.

2.4 LITERATURE REVIEW

There are several models developed for demand for transport, but most of them are devoted to urban transportation. Very little analysis has been done in the field of rural transportation. Among these, the following are outstanding.

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(8) Ibid.

2.4.1. Baumol-Quandt[9]

Perhaps the best known transportation demand model was developed in the late 1960's by Richard Quandt and William Baumol as part of the Northeast Corridor project. This model was used for forecasting demand directly and became known as the Baumol-Quandt model. It is of the following form :

$$T_{kij} = A_0 \cdot P_i^{k1} \; P_j^{k2} \; Y_i^{k3} \; Y_j^{k4} \; M_i^{k5} \; M_j^{k6} \; N_{ij}^{k7} \; f_1(H) \; f_2(C) \; f_3(D)$$

where

T_{kij} = travel by mode k between city i and j

P_i = population of city i

Y_i = median income for i

M_i = institutional character index for i

H_{kij} = travel time of the k^{th} mode

C_{kij} = travel cost of the k^{th} mode

D_{kij} = frequency of the k^{th} mode

N_{ij} = the number of modes serving i and j.

The Baumol-Quandt model uses as the form for f_1, f_2, f_3 :

$$f_1 = (H_{ij}^b)^{k_1} \; (H^r K_{ik})^{k_2}$$

$$f_2 = (C_{ij}^b)^{k_3} \; (C^r K_{ij})^{k_4}$$

$$f_3 = (D_{ij}^b)^{k_5} \; (D^r K_{ij})^{k_6}$$

b denotes the best values of the characteristics among all modes and r denotes the ratio of the value of the characteristics for the best mode. Thus for example, H^{6}_{ij} will be the travel time for car and $H^{r}K_{ij}$ will be the ratio of travel time by mode K to travel time by car.

A criticism of this model can be found in an article written by Gronau and Alcaly, 1969[10]. Detailed discussion is not shown in this report, but two main shortcomings of the model were outstanding. (a) its ambiguous formulation and (b) the need for unnecessary data collection.

2.4.2. Kraft

Another model, very similar to the Baumol-Quandt model, was developed by Kraft[11]. This model assumes that the total number of trips by mode k between i and j are related multiplicatively to the level of service variables of the given mode and competing modes, and to certain population characteristics of the cities i and j. The Kraft-Sare model assumes that both the volume of travel and the proportion using each mode are dependent on the cost and level of service of each mode, whereas most forecasting models make only the proportion of travel by each individual model dependent on the costs and level of service offered by the system. A major advantage of this model is that its form lends itself to an analysis and evaluation of potential system changes. The general form of the model is :

$$T_{kij} = A(P_i P_j)^a (ln_i \; ln_j)^b \prod_{i=1}^{n} (\text{Time } ij1)^c (\text{Cost } ij2)^d (\text{Freq } ij3)^e$$

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(10) Gronau, R. and Alcaly, R., "The Demand for Abstract Transport Modes: Some Misgivings", Journal of Regional Science, 9:2, 1969, pp. 153-157.

(11) Kraft, Gerald, 1969, "Systems Analysis Research Corp., Northeast Corridor Project", Journal of Regional Science, 10:1, pp. 120-131.

where

T_{kij} = trips made by mode k between i and j

P_iP_j = the product of the population of i and j

$In_i \; In_j$ = the product of the mean income of i and j

Time ijl = the length of a journey by mode l between i and j

Freq ijl = the frequency of service by mode l between i and j

2.4.3. Schroeder

Schroeder[12] (1970) used multiple regression analysis to determine the relative importance of standard variables such as population, distance and socio-economic variables such as employment and education, in forecasting travel demand. Results indicated that city size or closeness are important variables. Multiple regressions were then run assuming socio-economic variables, with cities over 750,000. Results gave high R^2 for both Los Angeles and San Francisco models. The best equations were :

$$\text{Passengers (SF)} = 5.2409 + 1.267P + 1.6154D$$

$$R^2 = 0.91$$

$$\text{Passengers (LA)} = 1.7987 + 1.3349P + 1.203D$$

$$R^2 = 0.89$$

where D = Distance

P = Population

The addition of education increased the R^2 value but decreased the F value.

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(12) Schroeder, D.A., "A Multiple Linear Regression Analysis of Intercity Air Passengers Travel to San Francisco and Los Angeles", Institute of Transportation and Traffic Engineering, University of California Berkeley, September 1970.

2.4.4 Brown and Watkins

The major goal of this report was to study and analyse the effects of air fare changes on both the growth of air traffic and the percentage of riders using air as a mode. Since in the long run, such variables as income, population and tastes do change, the problem was to isolate the effect of fare changes. The equation obtained in this time-series using a regression analysis was :

$$\text{Log}\ (T) = .0725 - 1.307 \log(\Delta F) + 1.19 \log(\Delta Y) - .0038 \log t$$

where

T = % change in number of trips

ΔF = % change in fares

ΔY = % change in income

t = elapsed time in years with 1937 the origin

2.4.5. Jessiman et.al., Yukubousky (Gravity-Type Model)

The gravity-type model is best illustrated by the work of Jessiman et.al.[13]. The air passenger demand model described by Jessiman was chosen for its logical appeal and practicability. A gravity theory was used. Passenger demand between two points is hypothesized as directly proportional to population and inversely proportional to impedance to travel. The impedance term (which is used in its reciprocal form as a conductance term is an exponential function of the following parameters :

- terminal to terminal non-stop travel time
- ratio of expected travel time to non-stop travel time

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(13) Jessiman, W.A., et.al., "Intercity Transportation Effectiveness Model", Peat, Marwick and Mitchell, December 1970 (NTIS PB 200469) prepared for USDOT-OST.

- access time to/from terminal to local origin or destination
- frequency of service
- fares

The model is formulated as :

$$V_{ij} = (P_i P_j)^a L_{ij} P_{Fij} S K_{Fij} K_{Fi} K_{Fj}$$

where

V_{ij} = intercity air passenger demand

$(P_i P_j)^a$ = generating power of i and j (population)

L_{ij} = conductance

P_{Fij} = modal split adjustment factor

S = time trend adjustment factor

K_{Fij} K_{Fi} K_{Fj} = attraction adjustment factor

Yukubousky[14] treated the problem of how to increase bus service to people in small cities, while not increasing the travel time of express intercity travellers. It was observed that the construction of interstate highways might reduce bus services to certain small urban areas that are currently being served only because they are on a direct route between major cities.

In summary this section has surveyed some important empirical studies on demand models for transport. The discussion was not limited only to passenger demand by bus but also by air. Different dependent variables

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(14) Yukubousky, R., 1970, "Intercity Bus Services to Small Urban Areas", Preliminary Statewide Planning Report, No. 12, N.Y. State Department of Transportation, Planning Division.

and many types of explanatory variables were used. An attempt will be made to draw together the main ideas emerging from these studies later on in this section. Discussion of which of the models best suit our studies will be deferred to Chapter Four. As some of the explanatory variables used in these studies appear relevant to this study, we will further discuss them in Chapter Three.

Two different models have been used in the studies reviewed above. Baumol-Quandt and Kraft all used the demand for abstract transport modes, while Schroeder, Brown and Watkins and Jessiman et.al. used multiple regression analysis. All these studies indicate an attempt to predict the demand for intercity or inter-urban bus or air services, given certain variables.

The type of dependent variable used in these studies has usually corresponded to the type typically used in demand forecasting models. Baumol-Quandt used choice of mode as a dependent variable while Kraft used number of trips. It is not unusual for transport economists to use different forms of dependent variables but typically the dependent variable measures the total patronage, (passengers) or total revenue.

Many types of independent variables have been used in various studies. Those typical of transport demand include socio-economic variables such as population, employment, age and sex. Others include income, fare, travel time, frequency, length of the journey, origin and distinction, cars per household and mode characteristics. It may not be appropriate to discuss all these variables here, a more detailed discussion is contained in Chapter Three. Judging from previous studies on demand analysis, some variables such as fare, population, cost per vehicle kilometer and journey length have made more impact on demand forecasting than others. We expect the same principles to apply in this study.

The preceding discussion of both theoretical and applied studies on the demand for transportation lead us to the following general formulation of the demand equation which we wish to estimate. Cross-section models of demand relate the levels of passengers at a particular point in time to a set of influences. A typical dependent variable measures total revenue (by system, area or route) while the influences are general ones affecting the entire operation rather than the individual operator.

A linear model is most commonly used and it has the following form :

$$Y_t = \sum_k \beta_k X_k t + \varepsilon_t$$

where

Y_t = patronage (or in our own case revenue) at the period t

X_{kt} = level of the k^{th} influential variable at period t.

β_k = level of influence or effect of the k^{th} variable.

ε_t = a random error term.

Model coefficients (β_k) in the general model are readily estimated using multiple regression analysis. Once estimated these models then yield revenue elasticities with respect to various influential effects (e.g. fare, time, population, etc.) using :

$$E = \frac{\partial Y}{\partial X_k} \cdot \frac{\bar{X}_k}{\bar{Y}}$$

where

E = the point elasticity of revenue with respect to the k^{th} influential variable

$\bar{X}_k$, $\bar{Y}$ = mean of the observation on influential variable and revenue

un-normalized partial regression coefficients of the explanatory variable are their partial derivatives with respect to the dependent variable.

The model we have developed may be used to explain the variables in revenue of a particular route or to obtain measures of the sensitivity of revenue to changes in various operating policies, e.g. fare, frequency and time levels (via direct elasticities) or to predict the future revenue accruing to the operators based on predicted levels of the influential effects.

We will expect that population, fare, proportion of occupied dwellings to the population and frequency would be positively related to the revenue. We also expect that increases in the number of households with one, two or more vehicles would lead to a decrease in the total revenue.

An attempt will be made at the end of Chapter Four to compare the estimated elasticities to those derived by various other Australian researchers and those derived world-wide which are reported in Transport and Road Research Laboratory Papers (TRRL 738, 1976) especially the report on the effects of fares on bus patronage. Because of variations in the types of variables used, only limited comparisons are possible. We will briefly describe the supply equation in the next section.

2.5 SUPPLY THEORY

The traditional theory of supply shows the relationship between quantity of commodity that a supplier is willing to offer at various market prices. Unlike the demand theory, the theory of supply has not been examined or widely applied in a transport context. The reasons are not known but one explanation is no doubt, lack of data and another is perhaps the fact that supply of transport is multiproduct in nature.

Although the estimation of the supply function for transport can become complex, the underlying ideas are simple. They are based on the traditional postulates of profit maximization.

2.6 DERIVATION OF SUPPLY FUNCTION

The major goal is to describe the suppliers decision to supply a commodity. It is assumed that the suppliers cost function is given. A typical supply problem may be represented mathematically as :

$$\text{Maximize} \quad \pi = PQ - \sum_{i=1}^{N} r_i L_i - \bar{k} \qquad (2.a)$$

where π is profit, P is the price of the commodity, Q is the quantity supplied, r_i and L_i are factor prices and quantity and $\bar{k}$ is the technology (in our own case several of the variables). It is assumed that the supplier attempts to supply Qs that will maximize his profit subject to a constraint

$$Q = f(L_1, \ldots, L_N, \bar{k}) \qquad (2.b)$$

$$\pi = P.f(L_1, \ldots, L_N, \bar{k}) - \Sigma v_i L_i \qquad (2.c)$$

Maximize π with respect to L_i requires :

$$\frac{\partial \pi}{\partial L_1} = P. \frac{\partial F}{\partial L_1} - r_1 = 0 \qquad (i = 1 \ldots\ldots N) \qquad (2.d)$$

which may be solved for the factor demand function :

$$L_i^d = L_i^d (P, r_1 \ldots\ldots r_N, \bar{k}) \qquad (2.e)$$

and the actual supply function

$$Q_s = F[L_1^d(P, r_1 \ldots\ldots r_N, \bar{k}), \ldots\ldots, L_N^d(P, r_1 \ldots\ldots r_N, \bar{k})\bar{k}] \qquad (2.f)$$

$$= Q_s(P, r_1 \ldots\ldots r_N, \bar{k}) \qquad (2.h)$$

Equation (2.h) represents the supply function, the estimated form of which will be discussed in Chapter Five.

Because of lack of literature in the supply models for transportation, the writer is unable to review the work already done. The dependent variable used in the present study is frequency of service and the independent variables are proportion of the population to route distance route distance, revenue, proportion of the population to the size of the bus, size of the bus, experience, age of the bus, other revenue, dummy for commuter, dummy variable for weekend, cost per kilometre and fare. Detailed discussion of these variables is set out in Chapter Three. The dependent variable will measure the frequency on the routes while the independent variables are general influences that affect the entire operation.

A linear log model used in estimating the supply equation is in the following form :

$$(\ln Y) = \alpha_1 + \alpha_2(\ln X)$$

Such a specification comes from an original multiplicative model $Y = \sigma X^{\alpha_2}$ where $\ln \sigma = \alpha_1$ also since $dy/dx = \sigma_{\alpha_2} X^{(\alpha_2 - 1)}$, then the elasticity $\eta = (dy/dx)(x/y)$ which is given by

$$\eta = \sigma X_2 X^{(\alpha_2 - 1)} \left(\frac{X^1}{\sigma X^{\alpha_2}}\right) = \alpha_2\left(\frac{\sigma X^{\alpha_2 - 1}}{\sigma X^{\alpha_2 - 1}}\right) = \alpha_2$$

The double log transformation corresponds to the economist's assumption of a constant elasticity of Y with respect to X that is given by the value of X_2.

This model is hoped to explain the variation of frequency or to obtain the sensitivity of frequency to change in various operating characteristics such as proportion of population to size of the bus, route distance, revenue, age of the bus, other revenue and so on.

We expect all the signs to be correct. We will also expect 'other revenue' cost per kilometre, experience of the operator, to be negatively related to frequency, because frequency of service should have an inverse relationship with the above explanatory variables. We can also expect revenue, route distance, age of the bus, proportion of route distance to the population to be positively related to frequency.

CHAPTER THREE

THE DATA

3.1 THE DATA

A cross-section data were used in our estimation. Most of the data used in our demand and supply equation estimation were constructed from the survey results conducted for the purpose of this study (see Appendix 1). A response rate of 58% was recorded from the survey, which is reasonable considering the difficulties of obtaining information from the rural bus operators.

Having outlined the proposed framework for our estimation in the previous chapter, it is now necessary to consider the data which are required to carry out this study. Two categories of data are needed for the estimation of the demand and supply equations.

3.2 DATA REQUIRED (Demand Equation)

This section contains a discussion on data required for the demand equation while data for the supply equation are discussed in Section 3.3. The data required to represent the nine variables, the theoretical framework, suggests we measure one of the following :

3.2.1 Population : Used as a proxy for the number of passengers carried on each route because of the lack of information on the number of people that use these routes. The Australian Bureau of Statistics publishes statistics on population for each collecting district, and the potential market was assumed to be population living within five kilometres on each side of the route.

3.2.2 Fare : The fare used in the estimation is the weighted average fare for adults, children and pensioners. We were able to obtain the fare charges from the survey. Fares from tours were considered inappropriate for the study, as they are offered on route by route basis (see Appendices 6 and 10).

3.2.3 Occupied Dwellings : Figures for the occupied dwelling and population were derived from the results of the 1981 population Census published by the Australian Bureau of Statistics (ABS) (see Appendix 7). The proportion of occupied dwellings to the population was estimated by dividing the number of occupied dwellings by the population. The figures for persons and dwellings came from the ABS Demographic Bulletin[15].

3.2.4 Frequency : The frequency of service was constructed from the scheduled bus time tables.

3.2.5 Time : Time as used in the study represents in-vehicle time or time spent from origin to destination. Time was estimated from the information provided in the arrivals and departure times.

3.2.6 Females in the Population : Number of females in the population figures were derived from the 1981 Census data. Our estimate shows that females make up about 50% of the population. Also the survey of the passengers showed that more than 50% of the passengers in rural areas of Tasmania are women.

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(15) Australian Bureau of Statistics, Demographic Bulletin, Catalogue No. 3101.0.

3.2.7 Vehicles per Household : The number of households with cars is estimated from the Census data. In general terms, the Census survey provides comprehensive information on household vehicle ownership but not use. The Census survey of vehicle ownership was made worse by classifying family car-household as vehicle ownership. Some families were said to have three vehicles or more (see Appendix 5). The term vehicle could mean motor-vehicle, utilities or even tractors. But again we cannot rule out their uses as a form of transport especially in rural areas.

3.2.8 Revenue : Revenue (the dependent variable) in the demand equation was derived from the survey of the private bus industry. Revenue in this estimate excluded 'other revenue' from other operations such as freight, mail or charter work (see Appendix 4).

3.3 DATA REQUIRED (Supply Equation)

This section will discuss the data we want to measure for the supply equation as was discussed in the previous chapter. The data required to represent the following nine types of variables are : Frequency (dependent variable), Route Distance, Stage Revenue, Bus Seat Capacity, Experience of Operator, Age of Bus, Other Revenue, Cost per Kilometre and Fares (explanatory variables).

3.3.1 Frequency : Frequency was computed from the bus time-tables. It shows the number of services provided on each route per day.

3.3.2 Route Distance : Route distance refers to the length of the route measured in kilometres. Figures were supplied by the operators.

3.3.3 STAGE REVENUE : This is revenue accruing to the operators from scheduled services only. It excludes revenues from charter work, mail or freight (see Appendix 9). Data on revenue was estimated from the survey results.

3.3.4 Ratio of Bus Seats to the Population : This data was computed from the survey results. This was estimated by dividing the bus seat capacity by the number of population. The bus seat capacity refers to the number of seats available per passenger.

3.3.5 Experience : This refers to number of years in the Bus Industry. Information on number of years of service was obtained from the survey of the private bus industry in Tasmania.

3.3.6 Age of the Bus : Age of the bus is measured in year. The data was supplied by the operators.

3.3.7 Other Revenue : This is the aggregate revenue other than the stage revenue. This revenue is derived mainly from freight, mail and other charter work.

3.3.8 Cost per Kilometre : Operating cost statistics were supplied by the operators. Cost per kilometre was estimated by dividing the annual kilometres travelled by the annual operating cost (see Appendix 13 for derivation of costs).

3.3.9 Fares : Bus operators supplied fares schedules as applying at the time of the survey for each route based on the distance (see Appendix 3).

It was not possible to construct a realistic composite public transport fare matrix, so stage fares were used in the estimate. Fares from tours were not used because they were considered inappropriate in this study.

Before evaluating the data, the writer would like to briefly show the extent to which Census data could be used for demand estimation. It was clearly stated at the beginning of this chapter that data available from the 1981 Census was used for the development of our demand model. Having said this, the real question about the reliability of this data can be answered from the resultant model performances. But it is clear that with appropriate supplementary data, the Census data should support our model.

There are data deficiencies especially in rural areas. The most important of these relates to the classification of cars as vehicles, an influence of principal importance to travel models. This influence cannot be properly captured in our model because of the information on which vehicle availability is used is neither an adequate measure of availability as such, nor of ownership. This problem could be reduced if further household-vehicle ownership structure information can be obtained. Because the relevant Census question does not differentiate between cars owned by or merely available to the household, this variable uses data that is not properly a measure of car ownership. The same problems are applicable to other variables developed from the Census data which we have used in our estimation.

3.4 EVALUATION OF THE DATA

This section will contain an assessment of the information described in the previous section. This deals specifically with reliability of the data. The order of discussion in this section follows in the previous two section.

3.4.1 Population : The reliability of these data depends on how reliable the Census figures are. However, the 'ideal' method of calculating the number of people that utilize a particular bus route will be to undertake a head count of people that get on and get off on each particular route. The population of each collecting district through which the route passes provides an approximation and perhaps a good measure.

3.4.2 Fares : Fares under this heading include adult fares, child fares and pensioner fares. An adult fare is the full fare while a child and a pensioner fare are one half of this adult fare.

The pensioner fare is less satisfactory than adult and children fares because of the difficulties in ascertaining the pensioners that qualify and those that do not. However, using weighted average fares minimizes the problem of under or over-estimation. It is felt that this difficulty will not be serious if a weighted average fare is used. Hence the weighted average used here is satisfactory.

3.4.3 Occupied Dwellings : As mentioned previously, population based on the Census count is very satisfactory. Occupied dwelling is an alternative approach to the use of population. Any serious weakness in this data will depend on the accuracy of the Census data.

3.4.4 Frequency : Frequency as we mentioned earlier was based on the bus time-tables. Although the frequency data used are accurate since they were constructed from time-tables, there are some routes which have scheduled bus time-tables, but services are provided only if there is enough demand to cover costs.

3.4.5 Time : In-vehicle time is a function of many things, such as terrain, stops, congestion etc., the accuracy of in-vehicle time is made more difficult since no information on the number of stops or congestion are taken into consideration. Even if they were, there is the tendency that they differ from time to time. The data derived therefore will be of doubtful quality.

3.4.6 Number of Females in the Population : We want to measure the effect of the travel habits of females in rural areas on the revenue of the operators. The 1981 Census data relevant to this study has already been noted. The data on occupation of the females was not available. Two limitations of this data are recognised. Firstly, it represents the situation in 1981. The year to which the Census survey relates. Secondly, the number of females in a population is a composite of old women, teenagers and children. A breakdown of this figure could have made the data more reliable.

3.4.7 Number of Cars per Household : It is likely that the difficulties will be faced in defining the data on the number of cars per household with the present Census classification. As we said earlier, the general classification of cars in the Census figures into vehicles, makes it impossible to separate cars from other vehicles. The best approach to obtaining the number of cars per household will be to approach the Motor Registration Board for information on number of family cars registered in the 1981 Census calender year. This will involve tedious manual sorting. Another difficulty will be obtaining an accurate number of cars registered specifically for family use, since family car and business car uses overlap. Hence only the aggregate of families with one, two, three and more cars can be used as an approximation.

3.4.8 Revenue : Data on revenue depends on how reliable the operators figures are. We specified earlier that operators who employed the services of an accountant apparently supplied more reliable estimates. Improvement on this data will involve approaching the taxation department to supply further information but this is very unlikely for reasons of confidentiality.

3.4.9 Route Distance : Route distance was actual distance measured in kilometres. The data required here is accurate as it involves simple calculation of the length of the route.

3.4.10 Bus Seat Capacity : This is the number of seats available in a bus. Where a conventional bus is modified to carry both passengers and freight, the number of seats available is usually reduced, and only available passenger seats were counted. This is reasonably accurate.

3.4.11 Experience : The data on number of years the operators have been in business were provided by the operators. These data could be improved by checking from the Transport Registration Branch and examining the year of first business registration.

3.4.12 Age of the Bus : Information on age of the bus was derived from the year of make. This was made available from the Transport Department Registration Branch. Data on age is quite accurate and reliable.

3.4.13 Other Revenues : Like revenue, information on 'other revenue' was provided by the operators. Again its reliability depends on how good the accounting systems are. The better the accounting system, the more reliable the data.

3.4.14 Cost per Kilometre : The cost per vehicle kilometre were not made available and had to be constructed from the information given in the survey. The accuracy of this data depends again on the accuracy of the information on the operating cost given by the operators. But the Costing Survey shown in Section 1.4.4 suggests that cost per vehicle kilometre in Tasmania is high.

3.5 CONCLUSION

Thus, most of the data used in this study are satisfactory despite the problem associated with obtaining them. Some of the data though are unreliable, but still are quite acceptable under normal circumstances. An additional weakness of these data is that the Census data are not clearly classified.

The data used in our estimation are set out in Appendices 6 to 10. While these data have been subjected to varying degrees of criticism, they do however, provide a common basis for our analysis and will enable the results of the current study to be compared directly with other research already carried out in a similar field.

CHAPTER FOUR

THE DEMAND EQUATION

4.1 INTRODUCTION

Having discussed the variables to be included in our demand equation in Chapter Two and the data to be used in Chapter Three, we turn in this chapter to a discussion of the estimation results after a brief preliminary consideration of choice of functional form and econometric matters.

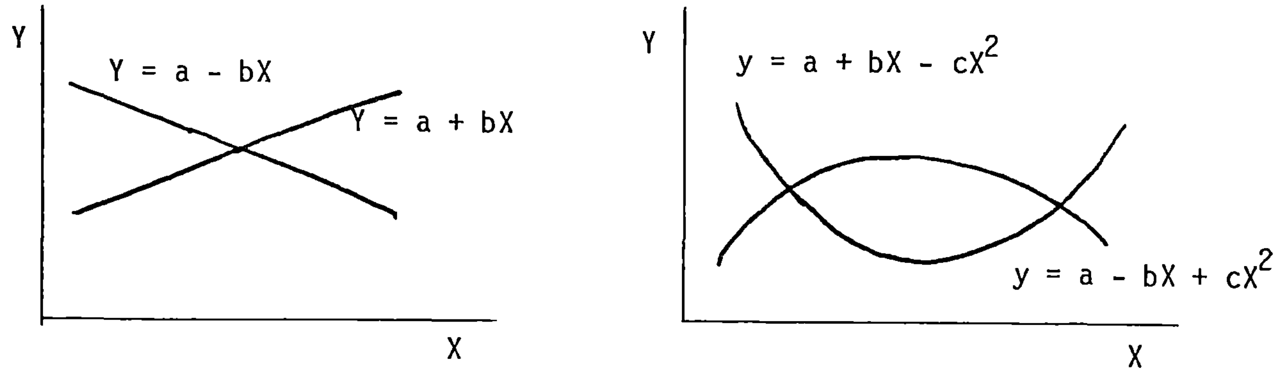
4.2 CHOICE OF FUNCTIONAL FORM

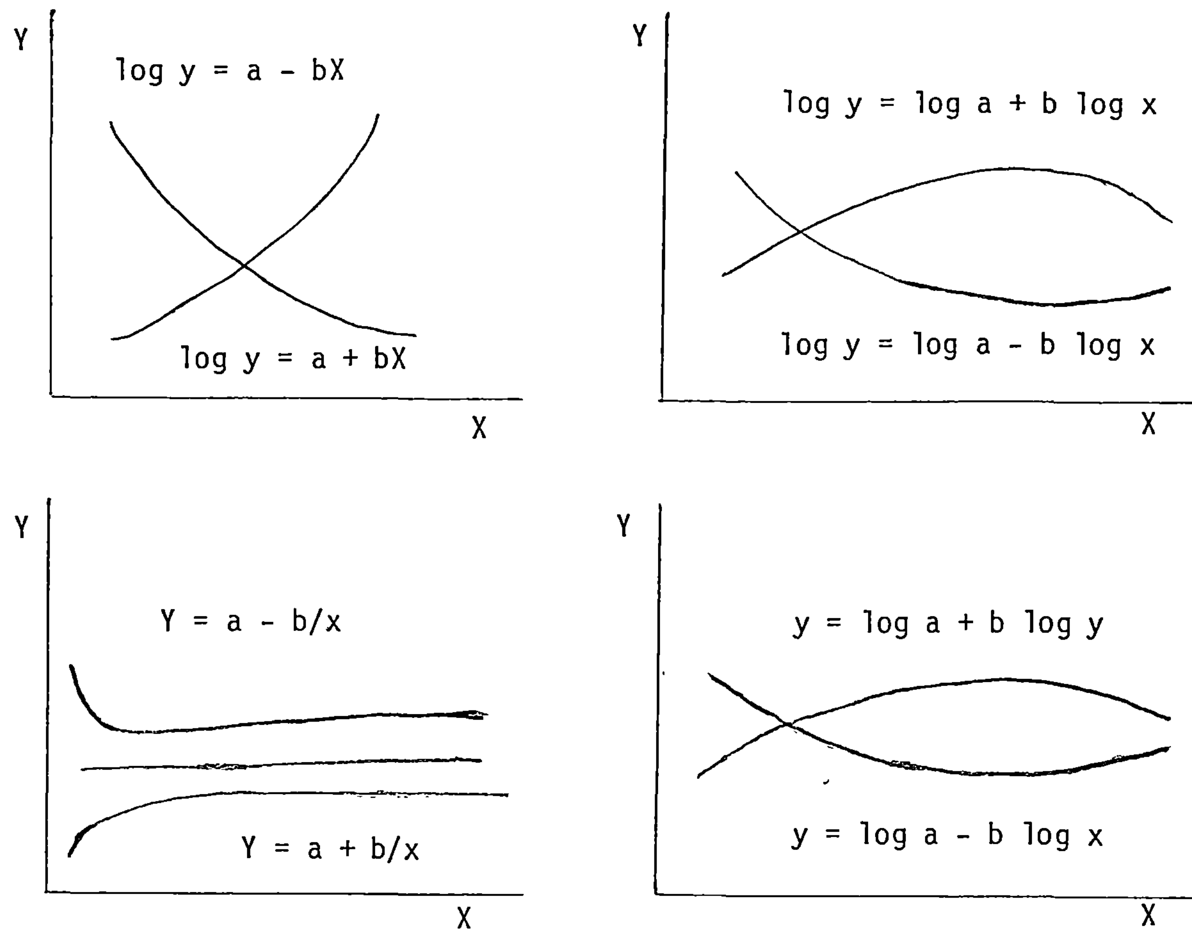
A number of functional forms are most commonly used in econometric analysis namely :

$Y = a + bX$	Linear	(4.1)
$y = a + bX + cX^2$	Quadratic	(4.2)
$y = a + b/x$	Hyperbolic	(4.3)
$\text{Log } y = a + bx$	Semi-logarithmic	(4.4)
$\text{Log } y = \log a + b \log X$	Double logarithmic	(4.5)
$y = \log a + b \log x$	Semi-logarithmic	(4.6)

The shapes of the curve for the above equations are illustrated in Figure 1. A linear function was used in our demand equation. Several

Figure 1





criteria considered in choosing the linear forms for this study, but the first and foremost is its simplicity and the ease with which the results can be interpreted.

4.3 CHOICE OF ESTIMATING TECHNIQUE AND POSSIBLE PROBLEMS

The Ordinary Least Square estimating technique was used in estimation. The principle of Least Squares is to choose the parameter values that will minimize the sum of squared derivations between the observed and estimated value.

Three special and common problems of Least Squares are considered in this section, namely : 1) Collinearity, 2) Heteroscedasticity and 3) Autocorrelation.

4.3.1 Multicollinearity : This is defined as a phenomenon that occurs in a regression model when two or more independent variables tend to move together in the same pattern. When two independent variables are perfectly correlated, the Least Square Solution is indeterminant. In general it causes the standard errors of the coefficients to be larger than it is in the case of no collinearity and may affect the results.

There are a number of ways to overcome the problems of multicollinearity. (1) In a severe case we may collect more data to reduce the multicollinearity. When we expand the data (cross-sections or time series) the phonomenon of close association between two variables may be reduced. (2) Alternatively we can make use of theoretical information obtained from other data sources and then eliminate one of the two collinear variables. (3) The other alternative is to change the functional form. (4) The last alternative is, of course, to either leave the variables in the function or to drop one of them from the model. This again depends on the objective of the study. If the objective is to predict or forecast, multicollinearity may not cause a serious problem. Also if there is no other information provided that would warrant dropping one of the variables or if economic theory suggests that the variable should be included in the function, then one may have to leave the variable in the equation although it contributes to the multicollinearity problem. After all there is no clear cut way to solve the multicollinearity phenomenon. It is simply inherent in the economic data, and one always has to keep this problem in mind.

4.3.2 Heteroscedasticity : This refers to the disturbance term ε_t in the econometric model. The classical least-square approach assumes that the error terms are independently distributed with zero mean, constant variance σ^2 and zero autocorrelations. However, the assumption of the constant variance may not always be valid. That is it may happen that the errors are mutually uncorrelated and have different variances[16]. This problem of heteroscedasticity often occurs when using cross-section data.

To develop a test for heteroscedasticity, an F-distributed ratio of two chi-square distributed random variables could be used to test if the difference between variances of the separate groups of residuals is significant. Under the usual assumption, the test on difference between variances uses a statistic

$$F(T_1 - 1, \; T_2 - 1) = \frac{S_1^2}{S_2^2}$$

where the S_i^2's are the unbiased sample estimate of the variances.

There are several ways to correct heteroscedasticity. Suppose the data has sub-groups for which the variances of the corresponding disturbance term are different. Then, if the variances of the disturbance terms within each sub-group can be assumed to be equal, the problem of heteroscedasticity can be avoided, or alternatively, a separate dummy variable may be used for each sub-group.

The other alternative is the weighted least square method, that is if the variance of the disturbance term is continually changing for each different observation.

4.3.3 Autocorrelation : This occurs when the disturbance terms at different observations are dependent on each other, then the dependency is reflected in the correlation of error term in preceding or subsequent

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(16) Klevin, L.R., 1956, Econometrics: An Introductory Analysis, (London, University Press).

observations. Autocorrelation is usually associated with time series data but it is not uncommon in a cross-section data. The most common concern of econometricians with respect to autocorrelation is the possible presence of first order autoregression among the disturbances.

The most popular test for autocorrelation is the Durbin-Watson test. The test is based on the Von-Newmann ratio of the mean square of successive differences to the variance of the least square residuals. The statistic is :

$$d = \sum_{t=2}^{T} (e_t - e_{t-1})^2 \Big/ \sum_{t=1}^{T} e_t^2$$

and called the Durbin-Watson test statistic[17].

The residuals from a least square regression can be used to calculate d, and the calculated d-value can be compared to the upper (du) and lower (dL) critical values for d from the Durbin-Watson table. The results are interpreted with the aid of Table 4.3

Table 4.1 Conclusion for use of the Durbin-Watson d Statistic

Value of the Calculated d	Conclusions
$d < dL$	positive autocorrelation
$d > (4 - dL)$	negative autocorrelation
$dL < d < du$	
$(4 - du) < d < (4 - dL)$	indeterminate
$du < d < (4 - du)$	no autocorrelation

(17) Durbin, J., and Watson, , 1950, "Testing for Serial Correlation in Least Squares Regression", Journal of Regional Science, V. pp. 41-59.

Values of d sufficiently close to zero or four indicate autocorrelation while values close to two indicate independence.

One of the best ways to correct autocorrelation would be to improve the specification of the model. But if the model is based on a well developed underlying theory, then there is no justification for changing the specification. By changing the specification, it would induce specification errors, creating biases in all of the estimated coefficients[18].

4.4 ESTIMATED EQUATION AND RESULTS

The general relationship for our study is therefore given in a linear form as :

$$REV = \alpha_0 + \alpha_1 POP + \alpha_2 FARE + \alpha_3 OCDPO + \alpha_4 FREQ + \alpha_5 TIME + \alpha_6 FEMPO + \alpha_7 VEH_1 + \alpha_8 VEH_2 + \alpha_9 VEH_{3\&4}$$

where

REV = Total Annual Revenue (stage operations only)

POP = The number of people within five kilometres on either side of the route

FARE = Weighted average fare

OCDPO = Proportion of occupied dwellings to the population

FREQ = Frequency of service on each route

TIME = In-vehicle time or time of travel from origin to destination

FEMPO = Proportion of females in the population

VEH_1 = Number of households with one vehicle

VEH_2 = Number of households with two vehicles

$VEH_{3\&4}$ = Number of households with three or more vehicles.

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(18) Intriligator, M.D., 1978, Econometric Models, Techniques and Applications, (North Holland Publishing Company, Amsterdam)

The model as introduced in the equation, permitted the inclusion of a wide variety of socio-economic variables. This basic model will also yield the elasticities between the variables. The concept of elasticity is a very important term in application of regression analysis.

As it turned out, the variables are not highly correlated with one another (see Appendix 14 for the correlation matrix).

The results of the estimates of the coefficients of the linear equation are presented in Table 4.2. In general most of the estimated coefficients attain statistical significance at the five per cent level. The R^2 and F-statistic are encouraging. Considering the consistency of sign and the level of significance for most of the variable coefficients and the fit of the estimating equation, the model then offers some promise for showing the determinants for rural bus routes.

As was expected, the population, fare, proportion of occupied dwellings to population and frequency are positively related to the total revenue. Increases in these variables should bring about increases in the revenue. On the other hand, it was expected that increases in VEH_1, VEH_2 and $VEH_{3\&4}$ would lead to a decrease in total revenue. Previous work on bus fares suggested that the coefficient sign for the fare variable should be positive, that is, increase in fare should lead to increases in revenue since demand according to these studies is price inelastic.

Recent evidence suggests a fare elasticity of -0.60[19], as opposed to 1.58 in this study. The reasons can be explained as follows :-

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(19) Ibid.

Table 4.2 Results of Demand Estimations for Rural Bus Services in Tasmania (a Cross-Section Data)

Dependent variable used is total revenue.

Independent Variables	Regression Coefficients	Mean of Independent Variables	Computed Elasticities
Constant	23099.5 (1.794)	1.0000	
POP	1.10125 (1.091)	3745.70	0.501
FARE	19907.5 (3.750)	0.652174	1.578
OCDPO	12835.7 (0.623)	0.361739	0.542
FREQ	1018.12 (4.496)	13.5217	1.673
TIME	156.987 (2.868)	61.7826	1.179
FEMPO	-135772 (-4.470)	0.474348	-7.826
VEH 1	-57.9056 (-2.776)	382.304	-2.690
VEH 2	77.0949 (4.153)	464.000	4.347
VEH 3&4	-34.4017 (-2.027)	270.870	-1.132

R^2 = 0.8588

F statistics = 8.88507

No. of observations = 22

Note (a) t-statistics are in parenthesis

(b) the variables are defined in chapter six.

Revenue = Fare x Passengers

it can be expressed alternatively as :

$$R = F \cdot X$$

Such that

$$\frac{\partial R}{\partial F} = \frac{d(Fx)}{dF} = \frac{\partial x}{\partial F}.X + \frac{\partial x}{\partial F}.F = X + \frac{\partial x}{dF}.F$$

Revenue elasticity is :

$$\frac{dR}{dF} \cdot \frac{F}{R} = \frac{\partial (Fx)}{\partial F} \cdot \frac{F}{Fx} = \frac{1}{x}(x + \frac{\partial x}{\partial F} \cdot F)$$

$$= 1 + \frac{\partial x}{dF} \cdot \frac{F}{x}$$

In other words, Revenue elasticity is one plus the ordinary Fare elasticity. For example, if the Fare elasticity were -0.60 according to White[20], then Revenue elasticity = 1 - 0.6 = 0.6. Because Fare elasticity = Revenue elasticity minus one, therefore 1.58 - 1 = 0.58. There are perhaps many explanations for the positive fare elasticity in this study. One possible explanation could be the fact that travellers in rural areas are captive passengers so that passengers are very likely to travel irrespective of fare increases. Another explanation could be the fact that Fare has a possitive relationship with Revenue so that if Fare goes up, Revenue goes up also.

Table 4.3 shows a chart showing the realization of coefficient sign expectations :

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(20) White, P.R., 1976, Planning for Public Transport, Hutchinson of London.

Table 4.3 Realization of Coefficient Sign Expectation

1. Coefficient signs completely consistent with expectation:
   - (a) population living within five kilometres on either side of the route (POP)
   - (b) frequency of service (FREQ)
   - (c) in-vehicle time or time of travel from origin to destination (TIME)
   - (d) households with one vehicle (VEH_1)
   - (e) households with three or more vehicles ($VEH_{3\&4}$)

2. Coefficient signs just consistent with expectation:
   - (a) proportion of occupied dwelling to the population (OCDPO)
   - (b) proportion of females in the population (FEMPO)

3. Coefficient signs mostly inconsistent with expectation:
   - (a) weighted average fare (FARE)
   - (b) number of households with two vehicles (VEH_2)

The fourth column in Table 4.2 shows the computed elasticities of the variables. Kraft-Domencich [21] and Nelson[22] have fare elasticities of demand for urban bus transit as between -0.1 to -0.8. Rural demand is more inelastic than urban demand, that is, it is more responsive to fare than urban bus demand because a higher proportion of trips relate to non-work purposes (e.g., social security, visiting the doctor or U.F.L.).

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(21) Kraft, G. and T.A. Domencich, Free Transit, D.L. Heath and Co. Mass. 1967.

(22) Nelson, G.R., 'An Economic Model of Urban Bus Transit Operations', paper for Institute of Defence Analysis, Arlington, VA, September 1972.

Also the absolute expenditure per trip is much higher due to greater journey length and incomes of those in rural areas are usually low. An attempt is made in the next section to compare our results with those of other studies done in a similar field.

4.5 COMPARISON OF RESULTS WITH EARLIER STUDIES

Not many studies of the way in which various independent variables influence revenue or demand for rural transportation have been carried out. We should note that there are many studies on demand for transportation in many categories of travel and there are also many cases where contradictory results are presented.

The results of earlier work is shown in Tables 4.4, 4.5 and 4.6. These tables illustrate only fare elasticities of different towns in Britain and the United States. We must note that many of the data used in this study are different from those used in the earlier stuides. This therefore limits the comparison to fares, time and frequency. Most of the fare elasticities are derived from time-series analysis.

Although the value of +0.58 obtained from this study is relatively high compared with other towns in U.K. and USA, the reason is probably the exagerated values obtained from some routes in which fares were decreased. Frequency and time in our estimate compares favourably.

4.6 CONCLUSION

For the United States, most of the values were obtained from observed patronage charges during demonstration projects. Some of the results will be biased and unreliable because the demonstration project would have introduced changes in the level of service which have not been allowed for in estimating the fare elasticity.

Table 4.4 Collected Data on Fare Elasticity of Urban Bus Studies in the United Kingdom

Town	Year	Fare Elasticity
London	1975	- 0.35
Manchester	1970	- 1.35
Stafford	1970	- 1.23
Bolton	1970	- 0.77
Leigh	1970	0.69
New Castle	1974	- 0.1 or less
Stevenger	1972	- 0.64

Source : P.H. Bly, "The Effects of Fares on Bus Patronage", Transport and Road Research Laboratory (TRRL), Laboratory Report No. 733, 1976.

Table 4.5 Collected Data on Fare Elasticity of Urban Bus Studies in the United States of America

Town	Fare	Fare Elasticity
Iowa City	1967	- 1.35
Sandiego	1972	-11.45
Denver	1973	- 1.56
Atlanta	1973	- 0.37
New York	1970	- 0.18
Boston	1964	- 0.46
Lowel	1962	- 0.60
Portland	1958	- 0.33

Source : P.H. Bly, "The Effects of Fares on Bus Patronage", Transport and Road Research Laboratory (TRRL), Laboratory Report No. 733, 1976.

Table 4.6 Service Elasticity in Australia

Elasticity with respect to:	City	Estimates	Notes
Frequency	Melbourne	+ 1.3	Bus & Train
	Adelaide	+ 0.5	Rail
	Brisbane	+ 1.2	Rail
In-vehicle Time	Melbourne	+ 1.7	Bus & Train
	Sydney	- 0.17	Bus & Train
Wait Time	Perth	- 0.07	Bus
	Sydney	- 0.10	Bus & Train
Access Time	Sydney	- 0.15	Bus & Train
Vehicle Kms.	Melbourne	+ 1.03	Train
		+ 1.18	Private Bus
		+ 1.23	MMTB

Source : Australian Transport Research Forum Paper, 1980, p. 130

The above results in both the United Kingdom and the United States of America suggest that fare elasticities are remarkably stable over time. The overall fare elasticities observed appear to be much the same in the different countries for which data is available. Fare increases will have a larger effect in supressing demand for some types of journeys than for others, though for specific types of journeys it seems unlikely that in general, any of the fare elasticities will be greater than one.

CHAPTER FIVE

THE SUPPLY EQUATION

5.1 INTRODUCTION

Before considering the estimation and the results, we will briefly mention the problems the writer encountered in estimating the supply equation. Firstly, most of the variables dealt with in this equation are in proportions. A further problem compounding the above is that data on which the model is based may be biased because of the reluctance of the operators to supply reliable information. This understandably increases the reluctance of the writer to undertake a new data collection.

Secondly, estimation of supply equations in transport has not gained popularity like the demand equation which implies that our results here are inconclusive. Also lack of empirical studies in this area limited the possibility of comparing our results with those of earlier studies.

5.2 CHOICE OF FUNCTIONAL FORM

The double log function is employed in the estimation of the supply equation. One of the distinct advantages of the double log function is that the coefficient of the independent variable X is also an elasticity of Y with respect to X. This property is shown as follows :

$$\text{Log } Y = \log a + b \log X \qquad (5.1)$$

Equation 5.1 can be expressed alternatively by :

$$Y = aX^b \qquad (5.2)$$

The elasticity of Y with respect to X is :

$$\frac{X}{Y}\ \frac{dY}{dX} = \frac{X}{aX^b} \cdot abX^{\sigma-1} = b \tag{5.3}$$

Hence this elasticity is equal to :

$$\frac{d \log Y}{d \log X} = \sigma \tag{5.4}$$

The problems associated with least squares estimation has already been described in the previous chapter. The next section will be devoted to estimation equations and results.

5.3 ESTIMATED EQUATION AND RESULTS

The model can formally be written as :

$$(\ln Y) = \alpha_1 + \alpha_2(\ln X) + \dots + \alpha_n(\ln n)$$

In summary the equation has the following relationships :

$$\ln FREQ = \alpha_0 + \alpha_1 LPDIS + \alpha_2 LRDIS + \alpha_3 LREV + \alpha_4 LPSBUS + \alpha_5 LSIBUS + \alpha_6 LEXPR + \alpha_7 LAGBUS + \alpha_8 LOTHREV + \alpha_9 DNC + \alpha_{10} DWE + \alpha_{11} LCKLM + \alpha_{12} LFARE$$

where

LPDIS = log of the ratio of the route distance to the population

LRDIS = log of route distance

LREV = log annual revenue (excluding revenue from freight, mail and charter work)

LPSBUS = log of proportion of bus seats capacity to the size of the bus

SIBUS = log of the size of the bus

LEXPR = log of experience of the operators in years

LAGBUS = log of age of the bus

LOTHREV = log of revenue from other operations (freight, mail, school and charter work)

DNC = dummy for non-commuter, 1 for commuter, otherwise 0

DWE = dummy for weekend, 1 for weekend, otherwise 0

LCKLM = log of cost per kilometre

LFARE = log of weighted average fare charged per route length.

The results estimated are given in Table 5.1.

Table 5.1 Estimated Coefficients of the Supply Equation (Log Linear)

Dependent variable used is frequency of service

Independent Variable	Estimated Elasticities	T-statistics
PDIS	2.186	2.821
RDIS	1.752	1.562
REV	0.0145	0.052
PSBUS	-0.950	-0.943
SIBUS	1.503	2.552
EXPR	-0.171	-0.367
AGBUS	0.690	1.042
OTHREV	-0.431	-1.662
DNC	1.258	2.584
DWE	-0.705	-0.701
CKLM	-0.140	-0.235
FARE	0.499	1.529

R^2 = 0.703

F-statistic = 1.38

No. of observations = 22

The results are encouraging considering the difficulties of data collection. Most of the coefficients, including revenue, experience, fare, other revenue are insignificant, but have the right signs. Table 5.2 shows a chart showing the realization of coefficient sign expectation.

Table 5.2 Realization of Coefficient Sign Expectation

1. Coefficient sign completely consistent with expectation:
   (a) the ratio of the route distance to the population (PDIS)
   (b) the proportion of bus seat capacity to size of the population (PSBUS)
   (c) age of the bus (AGBUS)
   (d) dummy for commuter (DNC)

2. Coefficient sign just consistent with expectation :
   (a) other revenue (OTHREV)
   (b) cost per kilometre (CKLM)
   (c) experience of the operator (EXPR)
   (d) revenue (REV)

3. Coefficient sign mostly inconsistent with expectation :
   (a) fare (FARE)
   (b) dummy for weekend (DWE)
   (c) size of the bus (SIBUS)
   (d) route distance (RDIS)

The second column in Table 5.1 shows the elasticities with respect to frequency. We shall briefly describe these explanatory variables and their performance.

PDIS : The parameter value has the correct sign, and is considerably higher than expected, reinforcing the accuracy of the data value used.

REV : Like in all supply functions for private transportation, the sign of this variable is positive which indicates that operators will favour revenue in order to increase frequency. But for this estimate, the significance of this variable has a plausible outcome. Reasons for this low significance could be the fact that revenue is cross-subsidized by 'other revenues' i.e., other operations such as freight and mail.

AGBUS : The relative magnitude of this coefficient is perhaps surprising. No strong conclusion is possible.

EXPR : For this type of bus operation, number of years of experience does not affect frequency of service. The sign corresponds to our initial postulation.

OTHREV : This variable has the right sign and also performed (comparatively) better than the revenue variable, but not as well as might be expected.

DNC : Dummy for non-commuter takes the value of 1 if the trip is commuter and 0 if it is not. It has the expected positive sign, indicating a strong tendency towards public transport usage for those routes not otherwise accounted for by the specification.

CKLM : Cost per kilometre has the right sign showing that cost per kilometre decreases with increases in frequency. The relative magnitude of the coefficient appears correct.

FARE : The parameter has the wrong sign but has a value almost identical to those obtained in a similar situation from models using identical data. This provides considerable support for this method of analysis but also the need for correct data analysis.

5.4 CONCLUSION

The model performance based on the plausibility of the parameter estimates is good. Those variables that effect frequency most have roughly the expected magnitude and correct signs. There is a considerable error in the prediction but this is not unexpected. The consequences of this error are not great since our basic concern is with the prediction of frequency of supply of public transport.

The useful planning parameters available from the supply model are the elasticities of the various variables. While these cannot be interpreted in quite the same way as usual demand elasticities, they can nevertheless be useful in various bus planning exercises.

CHAPTER SIX

CONCLUSION

6.1 CONCLUSIONS

The development of the demand and supply functions for rural transportation in Tasmania which we attempted in this study goes some considerable distance towards meeting the main objectives of this study. Though some of the data were incapable of supporting a comprehensive analysis but all the data used were selected with caution. There is no doubt that a more detailed data set would give added refinement to the model.

While there are concerns with the consistency of some parameters estimates, due to data deficiencies, the overall models performed well. The major conclusions to be made relates to the principal objective and that is to attempt an estimation of a demand function and a supply function for rural transportation. The secondary aim was to compare results which we obtained from our estimate with that of other researchers. Lack of studies in rural transportation limited our comparison.

Despite the above limitations the model has a considerable use in providing information about likely parameter values that could be expected for models on rural transport research. The availability of this information should significantly aid the estimation and validation of future research.

6.2 SUGGESTIONS FOR FURTHER RESEARCH

An important area in which further research is necessary is data availability. Following from the observation and also requiring separate emphasis, is the need to carefully carry out a survey of origin-destination in rural areas.

Secondly, in view of increasing broad-based financial resources devoted to rural public transport, a commonly acceptable performance evaluation of each route is essential. Special attention should be given to the development of packages addressing total transport systems against broad social and economic goals. There is also the need to develop an appropriate costing technique for the rural services in the state. This will involve at least two basic tasks; firstly an estimation of gross cost which would be incurred by serving each route and secondly an estimation of the revenue through fare payments which might be expected. The first approach should attempt a model behaviour based on real-world observations with trip making being expressed as a function of demographic factors, fare level, service frequency etc. The second approach is to rely on a household survey of possible users. But the most unfortunate thing about this sort of survey is that respondents are notoriously ready to over-estimate their likely use of potential services for a variety of reasons. By replying 'yes' they may see themselves as keeping their travel options open, helping their neighbours and visitors or perhaps improving the value of their property. In such circumstances extreme care must be taken.

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APPENDIX 1

SURVEY OF PRIVATE BUS OPERATIONS

General Guidelines

This questionnairehas four sections. Respondents are asked to complete all sections. Most questions are self explanatory, but in some cases specific directions are provided for a particular question.

A reply paid envelope has been provided in which the questionnaire may be returned.

If you have any queries concerning this survey, please contact;

Mr. Neil Aplin,
Transport Policy Unit,
G.P.O. Box 1002-K,
HOBART, 7001

Ph. (002) 38 9217

THANK YOU FOR YOUR ASSISTANCE.

SECTION A. This section seeks identification and background information on your operation. If you operate as more than one company or trading name please complete a separate form for each company. An additional form has been provided for this purpose.

NAME OF OPERATOR:

COMPANY NAME:

ADDRESS:

1. How long have you been operating buses (in Tasmania)? ... ...Years

2. What year did you commence operating your existing service?....Year

3. Is this bus operation your sole business or income earning activity? (Please tick the appropriate box) YES ☐ NO ☐

SECTION B. This section seeks information on the vehicles, staff and depots you employ to carry out your bus operations.

On the next page you are requested to complete details for each vehicle you operate. Please provide information for your fleet as at December 31st, 1980.

Use a new line for each vehicle.

Combined information will be made available to all respondents at the completion of the study.

Thank you, for your assistance in this matter. It would be appreciated if you could return this questionnaire within 3 to 4 weeks of receiving the questionnaire.

If you have any queries concerning the survey or about the study in general they may be directed to :-

Mr. Neil Aplin,
Private Bus Operations Study,
C/- G.P.O. Box 1002-K,
HOBART,
Tasmania. 7000

Phone (02) 38 9217

Yours sincerely,

(W. N. Aplin)
Senior Transport Planner.

	Office Use
2. What is the maximum number of vehicles that you regularly place in service?	
3. When does this occur? (e.g. school day mornings, afternoons etc.)	

4. DETAILS OF STAFF EMPLOYED.

This section seeks details of staff employed by you for your bus operations. The information provided is confidential and will be seen only by the study team. For each of your employees (and yourself if employed in the business) please complete the following details.

	Title of Duties e.g. Driver/Mechanic Director-driver	Av. hours per week spent working as:-			Av. Total hours work per week	Average Weekly Wage before tax
		Driver	Mechanic	Other		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						

5. DETAILS OF DEPOTS AND OFFICES.

This section seeks details of the facilities you use for your bus operations. Please complete the requested information for each facility you use.

	Description of Facility (e.g. Depot)	Location	How many buses are usually garaged here?	Is Facility Owned or rented?
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

SECTION C. - UNIFORM FINANCIAL INFORMATION - (STRICTLY CONFIDENTIAL)

This section requests information relating to capital and operating finances of your bus operations. The information will assist in determining the financial status of the private bus industry and its sectors. THE INFORMATION WILL BE TREATED IN THE STRICTEST CONFIDENCE. No individual replies will be shown to any other organisation or body outside the study team.

If you have prepared a balance sheet and a trading account for 1979/80, it would be helpful if these could also be supplied. Please complete the following information for the financial year 1979/80*. (If this does not fit in with your normal accounting period, please provide the latest information).

1. * For what date/period are you supplying information?

As at date ....(NB Preferred date is 30.6.1980*)

Period ....(NB Preferred period is 1.7.1979-30.6.1980*)

2. ASSETS.

Please state the values of your assets (related to your bus operations only as at 30.6.1980* (or nearest date)). Note leased vehicles, land and buildings should not be included.

ASSETS	PRESENT BOOK VALUE ($)	OFFICE USE
Vehicles - buses (excluding leased buses)		
- others (e.g. cars used for business)		
Land and Buildings (excluding leased)		
Garage and Office Equipment		
Ticket Machines		
Trade Debtors		
Cash		
Goodwill		
Stock		
Investments		
Other Assets		
TOTAL ASSETS		

3. LIABILITIES.

Please state the values of your liabilities as at 30.6.1980 (or nearest accounting date).

LIABILITIES	AMOUNT ($)	OFFICE USE
Paid-up Capital, Reserves, Unappropriated Profits and other Shareholders' Funds		
Borrowed money (fixed and short term including bank overdrafts)		
Trade Creditors, accrued amounts and other creditors (includes bills payable)		
Other Liabilities (including provisions for bad debts, taxation etc.)		
TOTAL LIABILITIES		

4. NET ASSETS (Total Assets less Liabilities as per balance sheet) $ ....

5. EXPENDITURE.

Please provide the expenditures your operation incurred during the financial year 1979/80* for the following items. (* or nearest yearly period)

ITEM	COMMENTS	AMOUNT $	OFFICE USE
Drivers' Wages	Figures should be net of payroll tax and workers' compensation. Include any proprietors' earnings if appropriate		
Mechanics' Wages	As Above		
Cleaners' Wages	As Above		
Administrative & Supervisory Staffs' Wages	As Above		
Workers' Compensation			
Payroll Tax			
Superannuation & Leave Provisions			
Vehicle Registration and 3rd Party Insurance			
Comprehensive Insurance			

Continued Over

EXPENDITURE (Cont.)

ITEM	COMMENTS	AMOUNT ($)	OFFICE USE
Licence Fees & Permits			
Leasing Payments - buses - other			
Interest Payments - buses - other			
Hire of Outside Vehicles	Include any costs of hiring buses or taxis for revenue		
Rent of Depots, Buildings etc.	Include any rents/franchises paid for land, buildings etc.		
Rates and Taxes	Rates or Taxes on Land/ Buildings/Depots		
Petrol	NB Please state average fuel consumption: Urban ____ Rural ____ Petrol ____ ____ Diesel ____ ____		
Distillate			
Lubricants			
Tyres and Tubes			
Repairs - Outside services - Parts & Spares			
General Administration			
Advertising			
Accounting/Audit Fees			
Allowances for Bus replacement or depreciation	Please state the type of allowance e.g. replacement, depreciation/rate of depreciation..................		
Tour Expenses - Meals - Accommodation			
Other Expenses			
TOTAL EXPENSES			

6. DISTANCE TRAVELLED AND REVENUE.

Please provide as much of the following information you are able to. Again figures should relate to 1979/80* (or nearest yearly period). If individual categories are not available please provide totals where possible to nearest dollar.

ITEM	DISTANCE TRAVELLED (Km) PETROL VEHS.	DISTANCE TRAVELLED (Km) DIESEL VEHS.	ACTUAL ANNUAL REVENUE ($)	OFFICE USE ONLY
Stage/Route Work				
. Cash Fares				
. Government Reimbursement				
- Pensioners				
- Unemployed				
. Freight				
. Periodicals				
. Mail				
TOTAL				
School Contracts				
. Education Department Contracts: Please Tick box for contract type	40 Weeks ☐ 1	42 Weeks ☐ 2		
Works/Airline/ Other Contract Work				
Charters/Tours				
Other Revenue Please List Below				
- - - - - - - - -				
- - - - - - - - -				

7. Please State your overall Profit/Loss before Tax $ __________

for Period __________

8. Were there any extraordinary items during this period (e.g. sales, purchases etc.) which made the profit/loss for the period unusual? If so please list below.

....

....

....

....

....

SECTION D. - GENERAL COMMENTS

If you have any general comments you wish to make concerning your bus operations or the industry as a whole please use the space provided below:-

THANK YOU FOR COMPLETING THIS FORM.

APPENDIX 2

CURRENT PUBLIC VEHICLE LICENCE CATEGORIES RELEVANT TO THE PRIVATE BUS INDUSTRY

(Reference Question 1 : Section B)

Licence Category Number	Type of Public Vehicle	Exemptions/Comments[1]
8	Coach	Available to carry passengers and freight on stage services and company contract routes only.
9	School Coach	Available to carry school children only on school contract services.
10	Coach	Omnibus exemption within nominated Traffic Area to additionally be used for charter and tours.
11	Coach	Cab exemption within nominated Traffic Area to additionally be used as a taxi.
12	Coach	Hire car exemption within nominated Traffic Area to additionally be used as a hire car.
13	School Coach	Omnibus exemption within nominated Traffic Area to additionally be used for charters and Tours.
14	School Coach	Cab exemption within nominated Traffic Area to be additionally used as a taxi.
15	Omnibus	Within nominated Traffic Area to be used for charters and tours only.

(1) An exemption is an extension of work permitted for the basic vehicle.

APPENDIX 3

FARES: EFFECTIVE FROM OCTOBER 7th, 1981

Fares quoted = Adult Single

Return Fare = Double Single Fare

Pensioners (All States) and Students under 16 years - half fare.

Hobart																	
60¢	Taroona																
70¢	55¢	Shot Tower															
85¢	55¢	55¢	Bonnet														
$1-10	70¢	65¢	55¢	Kingston													
$1-15	75¢	70¢	65¢	55¢	Kingston Beach												
$1-20	80¢	75¢	70¢	60¢	55¢	Blackmans Bay and Maranoa Heights											
$1-50	90¢	80¢	80¢	65¢	65¢	60¢	Howden Rd.										
$1-80	$1-15	$1-10	90¢	70¢	70¢	70¢	55¢	Margate									
$1-95	$1-35	$1-30	$1-10	90¢	90¢	85¢	55¢	55¢	Electrona								
$2-05	$1-40	$1-35	$1-15	95¢	95¢	90¢	60¢	55¢	55¢	Snug							
$2-25	$1-65	$1-55	$1-40	$1-15	$1-15	$1-05	85¢	60¢	55¢	55¢	Oyster Cove						
$2-40	$1-70	$1-65	$1-45	$1-30	$1-30	$1-25	95¢	65¢	60¢	55¢	55¢	Kettering					
$2-55	$2-00	$1-85	$1-65	$1-45	$1-45	$1-40	$1-10	85¢	65¢	60¢	55¢	55¢	Woodbridge				
$2-95	$2-25	$2-25	$2-10	$1-80	$1-80	$1-70	$1-45	$1-15	95¢	95¢	75¢	60¢	55¢	Birches Bay			
$3-35	$2-80	$2-65	$2-50	$2-25	$2-25	$2-20	$1-85	$1-55	$1-40	$1-35	$1-10	$1-00	85¢	55¢	Flowerpot		
$3-60	$2-95	$2-90	$2-65	$2-45	$2-45	$2-40	$2-10	$1-80	$1-55	$1-50	$1-30	$1-15	$1-00	65¢	55¢	Middleton	
$3-80	$3-15	$3-10	$2-95	$2-65	$2-65	$2-60	$2-35	$2-05	$1-80	$1-70	$1-50	$1-40	$1-25	90¢	60¢	55¢	Gordon

APPENDIX 4

DATA USED IN EXPLAINING THE DEMAND AND SUPPLY OF RURAL TRANSPORTATION IN TASMANIA

Route No.	REV	PASS	POP	Time	Fem/Pop
1	11538	25646	5760	48	.58
2	793	1802	662	30	.33
3	14400	18000	3280	50	.42
4	700	843	3301	55	.48
5	5988	4435	3301	55	.52
6	7114	14820	3290	60	.38
7	1000	2857	5660	30	.53
8	4820	8310	489	40	.56
9	1000	1754	5280	65	.50
10	18472	36121	4016	45	.41
11	6000	10526	4585	60	.51
12	52	95	2260	115	.50
13	3300	7174	6000	50	.46
14	30	60	1800	80	.55
15	500	11333	5622	75	.50
16	12000	14458	2264	55	.43
17	7797	19492	1020	48	.44
18	1300	2600	2540	30	.50
19	6000	11320	5761	40	.41
20	65006	40884	6050	50	.48
21	7000	15556	6960	165	.49
22	972	1944	2440	30	.44
23	5500	9649	3870	135	.49

APPENDIX 5

DATA USED IN EXPLAINING THE DEMAND AND SUPPLY
OF RURAL TRANSPORTATION IN TASMANIA

Route No.	VEH 1	VEH 2	VEH 3	VEH 4	VEH 3&4	OTREV
1	281	478	178	78	256	34341
2	268	221	99	46	143	25843
3	280	501	319	163	479	9643
4	240	293	119	55	174	14000
5	230	278	109	50	159	8840
6	278	339	110	56	166	5991
7	456	675	241	49	290	35000
8	450	540	321	50	371	16704
9	496	581	372	160	462	5524
10	380	542	212	134	344	1800
11	588	720	212	82	294	14400
12	276	223	90	48	138	4659
13	300	210	185	89	274	30000
14	338	534	162	56	218	13138
15	693	846	272	116	388	0.0
16	550	684	411	260	671	0.0
17	416	581	124	104	208	0.0
18	113	167	75	10	85	5460
19	614	693	217	132	349	19752
20	316	613	236	136	372	6500
21	732	535	186	95	218	1000
22	288	239	68	26	94	11978
23	210	179	60	40	100	7911

APPENDIX 6

DATA USED IN EXPLAINING THE DEMAND AND SUPPLY OF RURAL TRANSPORTATION IN TASMANIA

Route No.	DWE	R/DIST	SUBSIDY	DNC	EXP	FARE
1	1	40	0	1	8	.45
2	0	23	0	0	5	.40
3	0	27	0	0	14	.80
4	1	16	0	0	12	.83
5	0	12	0	0	10	1.35
6	0	25	0	1	14	.48
7	1	29	0	0	11	.35
8	0	31	0	0	17	.58
9	0	43	0	0	5	1.05
10	1	19	0	0	10	.51
11	0	33	0	1	8	.57
12	1	36	0	1	4	.55
13	0	24	0	0	2	.46
14	0	6	0	1	1	.50
15	1	33	0	0	9	.75
16	0	34	0	1	5	.85
17	1	30	0	0	14	.40
18	0	21	0	0	10	.50
19	0	47	0	1	9	.53
20	1	36	12175	1	13	1.59
21	0	120	2675	0	14	.45
22	1	17	0	1	6	.50
23	0	74	1040	0	8	.57

APPENDIX 7

DATA USED IN EXPLAINING THE DEMAND AND SUPPLY OF RURAL TRANSPORTATION IN TASMANIA

Route No.	FREQ	OLD/POP	PASS/POP	AGE OF BUS	POP/DIST
1	28	.40	4.45	20	144.00
2	2	.33	2.72	25	27.00
3	12	.38	5.49	5	121.48
4	20	.28	.26	5	206.31
5	10	.28	1.34	18	275.08
6	2	.38	4.50	8	131.60
7	10	.27	.50	8	195.17
8	20	.50	16.99	12	15.77
9	1	.57	.33	2	122.79
10	10	.29	8.99	11	211.37
11	10	.32	2.30	6	138.94
12	10	.29	0.04	17	62.78
13	22	.33	1.20	5	250.00
14	10	.56	0.03	3	300.00
15	6	.33	2.02	2	170.36
16	22	.43	6.39	3	66.59
17	8	.48	19.11	3	34.00
18	22	.33	1.09	10	120.95
19	10	.40	1.96	3	122.57
20	50	.41	6.76	4	168.06
21	10	.24	2.24	6	58.00
22	22	.30	0.80	4	143.53
23	10	.32	2.49	5	52.30

APPENDIX 8

DATA USED IN EXPLAINING THE DEMAND AND SUPPLY OF RURAL TRANSPORTATION IN TASMANIA

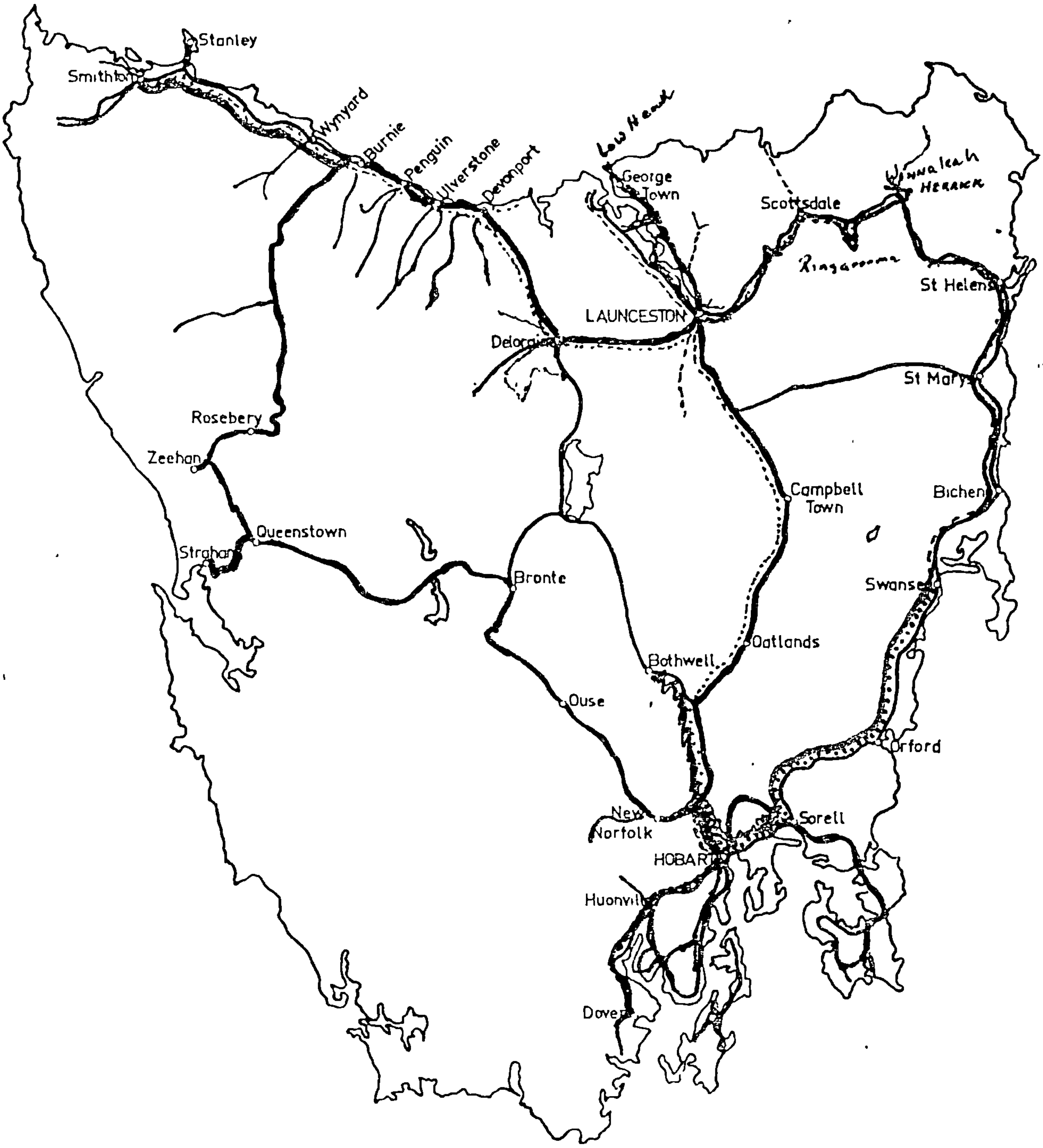
Route No.	VALUE OF BUS	SEAT CAPACITY	MANHRS/WEEK	TOTAL WAGES
1	24988	103	65	372
2	47500	146	101	366
3	80000	29	26	?
4	14500	78	54	125
5	4000	42	26	125
6	24000	90	63	280
7	56000	180	97	70
8	31500	66	45	30
9	4000	19	12	140
10	4500	57	?	280
11	4500	45	40	146
12	4000	4	19	300
13	14000	114	120	610
14	3000	39	27	260
15	20000	101	56	130
16	6000	21	15	70
17	31500	108	65	250
18	9000	12	?	350
19	16000	52	80	468
20	47600	113	458	2080
21	71000	19	53	195
22	10000	25	65	200
23	15500	170	25	114

APPENDIX 9

DATA USED IN EXPLAINING THE DEMAND AND SUPPLY
IN RURAL TRANSPORTATION IN TASMANIA

Route No.	TOTAL KMS	TOTAL PASS	TOTAL REVENUE ($)	PASS/KMS	REV/PASS ($)
1	53000	101953	45879	1.92	2.20
2	80000	66590	26636	0.83	2.50
3	19000	30053	23043	1.58	1.30
4	39000	17711	14700	0.45	1.20
5	30000	10984	14828	0.30	0.74
6	42500	27302	13105	0.64	2.08
7	127000	102857	36000	0.81	2.86
8	64000	36179	26984	0.57	1.72
9	20000	6319	6524	0.32	0.97
10	13000	40544	20272	3.12	2.00
11	13200	35789	20400	2.71	1.75
12	30000	8565	4711	0.29	1.82
13	48718	72391	33300	1.49	2.17
14	18000	26336	13168	1.46	2.00
15	44000	667	500	0.02	1.33
16	60000	14458	12000	0.24	1.20
17	62500	19492	7797	0.31	2.50
18	60000	13492	6760	0.22	2.00
19	81000	13520	25752	0.17	0.53
20	75000	48589	71506	0.65	0.68
21	58000	44972	8000	0.78	5.62
22	31000	27844	13922	0.45	2.00
23	42500	23528	13411	0.55	1.75

APPENDIX 10



MAP A 2.1 COVERAGE OF STATE BY PRIVATE ROUTE OPERATORS.

DEPARTMENT OF TRANSPORT – TASMANIA ROAD TRANSPORT – ENGINEERING BRANCH			FILE No.
TASMANIA	SCALE		DRG. No. G/4/262
	DATE	30·8·78	
	DRAWN	P. H.	APPROVED
	CHECKED		EXECUTIVE ENGINEER

APPENDIX 11

CALCULATION OF THE ELASTICITIES

The estimates of elasticities were calculated as follows :

For example, fares :

$$E_{SDF} = \frac{\partial R}{\partial F} \cdot \frac{F}{R}$$

$$= 19056.8 \times \frac{0.652174}{7880.96}$$

$$= 1.56$$

where :

E_{DSF} = elasticity of demand for fare

∂R = the estimated coefficient of the variable (fare)

∂F = the estimated mean (fare)

R = the mean of the dependent variable.

Each computed elasticity was estimated using the above specification.

APPENDIX 12

DEFINITION OF THE PERFORMANCE INDICATORS

1. Cost per vehicle kilometre - total system costs divided by the total distance travelled by all vehicles in the system (the desirability of using passenger kilometre rather than vehicle-kilometre statistics has been noted by Kidder and others who have also pointed out the difficulty in obtaining these data).

2. Cost per vehicle hour - total system costs divided by the sum of the number of tours that each vehicle is operated.

3. Load factor - the sum of the distances for each trip by each passenger divided by the sum of the seat kilometre provided by each vehicle (which is the product of the number of passenger seats times the kiometres the vehicle travelled).

4. Operating ratio - total system costs divided by total system revenues.

5. Passengers per vehicle kilometre - the number of passenger trips divided by the number of vehicle kilometres provided by all vehicles.

6. Passengers per vehicle hour - the number of passenger trips divided by the sum of the number of hours that each vehicle is operated.

7. Annual passengers per service-area population - the number of passenger trips taken per year divided by the population of the service area.

APPENDIX 13

NOTES ON DERIVATION OF FIGURES

Fuel :

An assessed figure based on estimated average consumption of petrol/diesel vehicles and converted to an hourly rate by determining an industry average speed-average distance per bus divided by average hours per bus.

Oil :

Similar to fuel.

Maintenance parts :

Usage of replacement parts over a ten-year period was assessed and costs of those parts calculated. Average distance over 10 years was calculated, cost per km derived, cost per bus hour derived from industry average speed.

Tyres and tubes :

Weighted average price of tyres/tubes used to determine assessed cost per km, again converted to bus/hour at average speed.

Administrative costs :

Figures from operators' uniform financial returns were averaged per bus, thence per bus/hour.

Fixed costs :

Registration, licence and third party insurance fees (known) and comprehensive insurance (assessed) divided by average annual bus/hours.

APPENDIX 13 (continued)

COST ELEMENTS FOR RURAL TRANSPORTATION SYSTEMS AND THEIR RELATION TO SYSTEM OPERATING CHARACTERISTICS

Cost Category	Operating Characteristics	Cost element
Operating Cost	Vehicle kilometre	Fuel, oil, tyres and tubes Vehicle parts and maintenance
	Vehicle hours	Driver wages Despatcher wages Non-volunteer labour
	Number of vehicles	Insurance Driver training Equipment Vehicle storage costs (including covered storage and shelters)
	All other operating costs	General and administrative overhead expenses
Capital cost	Vehicle kilometres and number of vehicles	Vehicle capital costs Despatching equipment capital costs (Including dispatching base, mobile equipment).

APPENDIX 14

MATRIX OF SIMPLE CORRELATION COEFFICIENTS

	REV	POP	FARE	OLDPOP	FREQ	TIME	FEMPOP	VEH 1	VEH 2	VEH 3&4
REV	1.000	.280	.620	.104	.477	-.818	-.681	-.515	.239	.312
POP		1.000	.187	.324	.109	.274	.210	.412	.345	.197
FARE			1.000	.164	.215	-.048	.126	-.076	.129	.320
OLDPOP				1.000	.104	-.177	.163	.109	.372	.383
FREQ					1.000	.256	.315	-.273	.106	.120
TIME						1.000	.205	.281	-.061	-.167
FEMPOP							1.000	.056	.163	.639
VEH 1								1.000	.812	.533
VEH 2									1.000	.716
VEH 3&4										1.000