MAJOR CENTER - REMOTE COMMUNITY

AIR PASSENGER TRAVEL

A FORECASTING MODEL

by

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I hereby declare that I am the sole author of this thesis.

I authorize the University of Manitoba to lend it to other institutions or individuals for the purpose of scholarly research.

Signature ____________

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

1.1 Object of Study

Most of the transportation demand model development work presently being done and that of the past has dealt basically with high-density population areas. The major studies of North America have been performed in such high-density areas as the Northeast Corridor and California in the United States, and the Quebec-Windsor corridor in Canada. Little work, especially in Canada, has been focused around low-density-area--high-density-area demand projection models.

The purpose of this study is to formulate a general model which can be used to predict two-way air travel demand for intercity air travel between a major population center and remote (or low-density) center. In the development of this model, the relationships of factors which determine the demand for intercity passenger transportation will be investigated in the hope that the resulting model can be used as a predictive tool for other similar remote-major center areas.

The major Canadian cities follow a general linear distribution pattern across the breadth of Canada. These major population centers act as "hubs" around which low-density areas radiate. Since most major Canadian centers are close to the United States border, the resultant Canadian radiation pattern is that of one-half of a wheel.

Because of the vastness of the country, low population and resource-oriented economies, the remote communities of Canada, specifically those in the northern reaches of the provinces, have tended to develop as isolated communities with the major transportation and social communication mode being air travel. The spokes of the Canadian half wheel thus prove to be the air routes between the major center and remote communities.

At this time it is necessary to define the concept of "remote" community as used in this paper.

It is not the same as that used by the Manitoba Government, for example, in regards to its policy toward northern "remote" communities. Manitoba's definition of remoteness means isolation from major centers year round by any all-weather means save air travel.

The author's definition, although it includes such "remote" communities, does not restrict itself to the above. Remoteness is defined as those communities which are isolated from major centers, and to some extent from each other, by distance, by lack of a combination of multiple choice of ground transport modes, routes and schedules, and which are generally "islands" in terms of economic development and growth, although there may be some form of transportation to them, other than air.

In other words these are "island" communities which are at least 300 miles away from a major center and are linked if at all by long and slender transport threads to the major centers.

At the outset of this study it was felt that possibly some of the factors influencing the demand for air travel are not the same between major-center-to-remote-community models, as between major-center-to-major-center air travel.

It was hoped to gather and analyze as many factors as possible in the development of the model, and then draw conclusions based on the developed model.

1.2 Assumptions and Limitations

As stated in section 1.1, this study will concentrate on developing a demand model for "remote" and major center intercity passenger air travel. The data utilized was that of communities in Manitoba and the historic time span was eleven years. Since politics has a vital role in the development of the Canadian North (specifically Manitoba), it follows that it has some effect on air travel. This aspect was considered and discussed within the study; however, it was decided that either it was a nonquantifiable factor or the required data was unavailable at present, and, given these limitations it was left out of the data set. This aspect is one of several which was recommended for further investigation.

1.3 Outline of the Investigation

The format adopted in this study was of a development nature. Chapter 2 reviews some current literature on transportation demand model formulation. Chapter 3 discusses multiple regression, the use of multiple regression for model building and the analysis theory and procedures for selecting the "best" regression equation. The author discovered that literature on this subject was dispersed among many books and papers. No one book seemed to contain all the required background and information that would enable a researcher without a highly formulated statistical background to utilize and understand regression analysis as a tool in model building without lengthy library searching. These chapters and the bibliography references compile the information which will aid in further development of the derived demand model. In Chapter 4 the model chosen for investigation is introduced. Chapter 5 contains the case study and model development. Chapter 6 briefly discusses a method for developing a supply model which would complement the demand model. Chapter 7 contains conclusions drawn from the demand study, and discusses the application of the model in the real world, where such factors as the energy crisis may affect air travel. Chapter 7 also discusses some implications of governmental policy directives on air travel, and gives recommendations for future research.

CHAPTER TWO
REVIEW OF SOME CURRENT LITERATURE

2.1 Introduction *

There are many factors which affect transportation systems and their environment. The objective of transportation planners and researchers is to relate all or most of these elements to one another to ascertain their role within the system. The basic tool utilized to describe their interplay is model formulation. This chapter discusses some of the current literature with regards to intercity transportation demand models and traces, in part, the evolution of these models.

The types of demand models vary from the basic gravity model, which is part of the macro-model family and is based on data collected in aggregate forms, to demand models based on data representing differences in income, tastes and other variables at the individual or micro level. This micro-level concept can be referred to as the behavioural approach, since it sets travel demand in terms of functions consistent with theories of consumers' choice. Different models help to bound or identify the transportation system and its environment and help the analyst in analyzing the interactions of the components of the transportation system.

2.1.1 Macro Models

2.1.1.1 The Gravity Model (Analytic Method)

One of the oldest models used for intercity travel predictions is the gravity model. It is based on Newton's law of gravity and states that the interaction between two places (i and j) is the product of the mass of the two places divided by the distance between them, or mathematically

$$T_{ij} = \frac{P_i P_j}{D_{ij}} \qquad (1)$$

*T.L. Sulymko's review of demand model literature (1971), was utilized in preparing sections of this chapter.

With reference to transportation demand, the dependent variable T_{ij} is usually represented in terms of the number of trips generated between cities i and j. The number of trips generated between i and j is increased proportionally by the attraction exerted by the product of the populations and impeded by the distance between them.

Soon the relationship was developed to

$$T_{ij} = \frac{P_i P_j}{D^2_{ij}} \tag{2}$$

which was the form seen to bear a direct resemblance to Newton's law of gravity. The measure of distance, which is said to be the measure of impedance between i and j, has often been modified as a cost in dollars or time.

2.1.1.2 Extensions on the Gravity Model

As the need for understanding the demand for travel grew, many variations of the gravity model developed. They included such variables as trip purpose, income, industrial indices, employment, convenience factors, and many others. Multiple regression has been the typical method used to determine the relationship of all pertinent variables to each other and their effect on demand predictions.

The Northeast Corridor study (Systems Analysis and Research Corporation, 1963, pp. V-44-48) was one of the most comprehensive applications of the gravity model. Within the scope of this study, eight equations were developed for estimating the volume of travel between specific population centers for each mode of transportation (automobile, rail, bus and air) and for each of the two main purposes for travel, namely personal and business trips. This study utilized such socio-economic factors as income, population, employment and location attractiveness, such transportation factors as travel time and cost, and determined the interrelationship between these factors for different modes of service. The relationships were expressed as elasticity measures, wherein elasticity was referred to as the percentage change in travel associated with a one percent change in any influencing factor.

As a large scale application of the extended gravity model, the Northeast Corridor study was useful for demonstrating the need for determining an aggregation of travel for all modes. Initial gravity models were used to determine demand for travel by one mode only. In an improvement on this, the Northeast study computed the demand for travel by each mode and then aggregated these results to a total demand estimate.

2.1.1.3 The Generalized Version of the Gravity Model

Previous conventional gravity models lacked any methods for inserting into the model the demand for alternative destinations. Blackburn (Blackburn, 1967, pp. 111-122) extended the conventional gravity approach by introducing substitution terms wherein the destination of the traveller is a function of the attractiveness of different possible destinations available to him. Blackburn assumed that the total number of trips originating from zone "i" is positively related to the gravitational influences of all zones (Meyer and Staszheim, 1971, pp. 143); since trips are made to satisfy certain needs, the existence of alternative destinations which may satisfy these same needs might be expected to influence the number of trips to any one particular destination.

Blackburn succeeded in formulating a model which incorporated this concept, and tested it on data from seventeen California city pairs; however, given the considerable complications introduced because of nonlinearities in functions and the corresponding difficulties in their estimation and statistical inference, it still remains an open issue whether a full-scale passenger demand model should include substitutions which arise from the availability of alternative destinations.

2.1.1.4 The Abstract Mode Model

In the past, demand was modeled one mode at a time. Quandt and Barmal (Quandt and Barmal, pp. 13-26) attempted to represent the demand for transportation by a single equation which reflected passenger choices for all modes. Instead of considering only existing modes, Quandt and Barmal hypothesized that a mode could be thought of in abstract terms such as cost, departure frequency, travel time and other convenience factors. For practical purposes model neutrality was assumed; i.e., the decision to travel is based only on service characteristics of transport systems and no account is made for individual personal preferences. The decision to travel and the choice of a mode can be regarded as depending on the absolute performance level of the "best" mode on each criterion and/or the performance of each mode on each criterion relative to the "best" mode.

The major advantage of the abstract mode model is the ability to predict demand by using one common data base to consider the effects of alternative modes which may or may not presently exist. The one model equation can predict the effect of changes in service on all existing modes, and, because of the abstract definition of the modes, it can also predict demand for new types of modes.

There are, however, problems with regard to the use of this model, one being the fact that it yields estimates of parameters which have higher variances than individual or specific mode models. A possible reason for this is the assumed basis for modal competition using only those modes which exhibit the "best" individual service characteristics, such as price, travel time, etc. Thus, while a mode may be highly competitive because of an overall service level, it may not qualify in the model because it is not the "best" with regard to any one characteristic. The reverse is also true: a model which has one excellent characteristic but is poor in others enters into the equation. One way to overcome this is to include all prices, times, etc. for <u>all</u> types of modes. This process, however, increases the risk that, as the number of variables increases, the difficulty of satisfying statistical tests of significance increases, and the model becomes quite lengthy.

2.1.2 Behavioural Models

2.1.2.1 Nonlinear Models

Blackburn (Blackburn, 1966, pp. 47-89) was one of the first to introduce the concept of individual choice to model development. Although the mathematical procedures become significantly more complex, this approach has value because it is based on consumer theory principles and does not rely on trying to fit curves to past aggregated data. Blackburn postulated differences in individuals' underlying utility functions and income levels, and thus their responses to service characteristics of different modes (Meyer and Straszheim, 1971, p. 147). Blackburn's model is broken down into two parts. Part one refers to modal choice, which is dependent upon an individual's implicit and explicit cost for travelling on a particular mode. The second part concerns generating traffic volumes by the summation of individual desires for modal choice and amount of travel.

Blackburn summarizes his approach (Blackburn, 1966, p. 48) in the following manner. Individual differences can be represented by permitting parameters of an individual demand function to vary across individuals. If the number of individuals is large, the joint variation of these parameters across individuals may be represented well by a multivariate probability distribution. The individual is now a random variable being a function of random variables. The aggregate demand is simply given as proportional to the expected value of the individual demand.

The results of Blackburn's method are considered to be reasonable (Brown, 1968, p. 24). The relative disadvantage of the model developed by Blackburn, utilizing this approach, is its relative complexity and extensive use of computer time.

2.1.2.2 A Semi-Markov Demand Model

As an extension of the behavioural approach, Brown (Brown, 1968) introduced a type of semi-Markov model, which interrelates consumer attributes and attributes of the entire system. In brief, the model is dependent upon only three parameters and calibration is based on estimation with *a priori* information about the parameters.

The three parameters are:

1) travel portion of annual income;
2) impedance or reluctance to spend large sums of money;
3) sensitivity to price differences in mode choice.

For more information the reader is referred to the bibliography.

2.2 Summation

The purpose of this review was to make the reader generally familiar with some of the types of intercity transportation demand models recently developed. For the mathematical procedures and precise detail of these models, the reader is referred to the appropriate references. The models mentioned are by no means all inclusive. A complete list, given new and continuing developments, would be immense. The bibliography lists some of the sources within which more information may be found.

In particular reference to application of models for air travel forecasting studies in Canada, the reader is referred to such studies as the Intercity Passenger Transport Study of the Canadian Transport Commission, dated September 1970. The demand model developed by the study group is the Canadian cousin of major-corridor studies of the United States, Europe and Japan. Another is the soon-to-be presented study by R. Manastersky of the University of Manitoba, within which a major Canadian intercity air travel demand model is developed.

In concluding this section, it must be stated that although the term "model" is a very popular one today and much is being written about it, a model is nothing more than a mathematical representation of observed physical or sociological facts. The investigatory work on models must be seen within the general framework of the systems approach. It is a tool with built-in advantages and disadvantages or faults, thus requiring much forethought by the researcher before he chooses and uses it.

CHAPTER THREE
MULTIPLE REGRESSION

3.1 Multiple Regression and Model Building

Once the decision to build a forecasting model was made, the first step was to consider techniques which might be applicable. The decision was made to utilize multiple linear regression analysis as the tool.

At this stage it was worthwhile to have a summary review on regression techniques and model building. This would serve as a background to the study and consolidate pertinent information on regression analysis, specifically for those who, with a limited statistical background, may wish to utilize it as a tool.

The use of multiple linear regression techniques for model building is very useful, but also very dangerous when improperly used and interpreted. Prior to tackling a large problem by multiple regression methods, it is vital to preplan the project as far ahead as possible, to specify the objectives of the work, and to provide check-points as the work progresses.

Three main types of mathematical models are often used by engineers and scientists;

1.) The functional model;
2.) The control model;
3.) The predictive model;

3.1.1 The Functional Model (Drapper, Smith, 1966, p. 234)

When the true functional relationship between a response and the independent variables in a problem is known, then the experimenter is in an excellent position to understand, control and predict the response. In practice, however, there are very few situations in which such models can be determined, and even in those situations the functional equations are normally very complicated, difficult to use and interpret, and usually are of nonlinear form. Under such circumstances the linear regression procedures do not apply or else linear models can be used only as approximations to the correct models in iterative estimation procedures.

3.1.2 The Control Model (Drapper, Smith, 1966, pp. 234-235)

The functional model is not always suitable for controlling a response variable. There are circumstances where the activities of the system have uncontrollable variables no matter how clearly they are specified in the functional model. A model which contains variables under the control of the experimenter is essential for control of a response.

A useful control model can sometimes be constructed by multiple regression techniques (if care is taken); however, there are many situations where designed experiments are not feasible: for example, an experiment conducted in the market place could be well designed and handled, but the uncontrollable factors would make any calculated mathematical effect of the controlled variables so confusing as to be useless. Thus the practitioner is led to the use of the predictive model.

3.1.3 Predictive Models (Drapper, Smith, 1966, pp. 235-236)

If the functional model is very complex, and if the ability to obtain independent estimates of the effects of the control variable is limited, one can often obtain a linear predictive model which, though it may be in some senses unrealistic, will at least reproduce the main features of the behaviour of the response being studied. These predictive models are very useful and help give real insight into the problem. Multiple regression techniques make their greatest contributions in these predictive model formulations. These techniques provide guidelines for further experimentation, pinpoint important variables, and are very useful as a variable-screening device.

Multiple regression should, however, be used very carefully, for it is easy to misuse or misunderstand the techniques and results. An organized plan must be formulated which will approach the model planning in a practical and effective manner.

Figure 1 spells out the steps to be followed, where the plan is divided into three stages--planning, development and maintenance.

MATHEMATICAL MODEL BUILDING

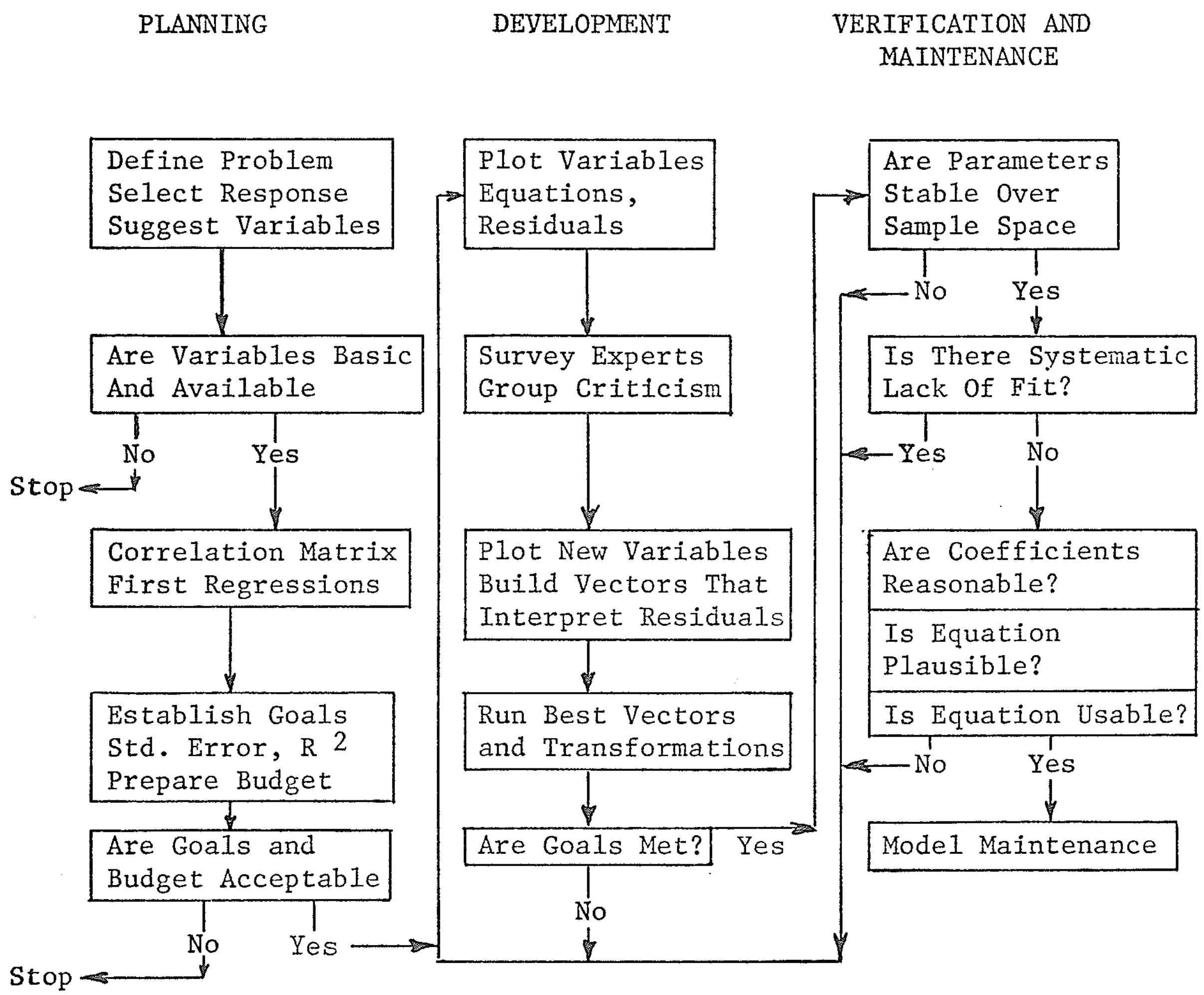

FIGURE 1

(Drapper, Smith, p. 236)

3.2 Regression Analysis Theory

Below is a brief outline of regression analysis theory. For more details, the reader is referred to specific references in the bibliography.

An estimating regression function (Rosin, 1972, p. 20) may be written as:

$$\hat{Y} = a + b_1 \; (x_1 - \bar{x}_1) + b_2 \; (x_x - \bar{x}_2) + \ldots b_m \; (x_m - \bar{x}_m) \qquad (3)$$

where:

$\hat{Y}$ - an estimate of the true expected value of the dependent variable, given the values of the m independent variables

$x_1 \ldots x_m$ are the m independent variables

$\bar{x}_1 \ldots \bar{x}_m$ are the means of the m independent variable

$a, b_1 \ldots b_m$ are the estimated regression coefficients.

the primary purpose is to test the relationship between the dependent and independent variables, based on n sets of observed values.

The method of least squares is used to estimate the regression coefficients, determined so that Z is minimized where

$$Z = \sum_{i=1}^{n} \; (Y_i - \hat{Y}_i)^2 \qquad (4)$$

and Y_i - the observed value of the dependent variable for the i^{th} observation, which accompanies the observed values of $X_{1i}, X_{2i}, \ldots X_{mi}$.

$\hat{Y}_i$ - the estimated value of the dependent variable (computed from the estimated regression) for the same values of $X_{1i}, X_{2i}, \ldots X_{mi}$.

There are several computer programs available which utilize the multiple regression analysis procedure. The most basic one is Multilinear Regression Analysis (STATS 18) which is available in the University of Manitoba Computer Center's Statistical Package. The basic procedure required statistical inference tests such as F and T tests, and residual analysis can be obtained from Drapper & Smith, 1966.

3.3 Selection of the "Best" Regression Equation

There are two opposing criteria of selecting a resultant equation using regression techniques, namely:

1. To make the equation useful for predictive purposes the model should include as many X's as possible so that reliable fitted values can be determined.

2. Due to the costs involved in obtaining information on a large number of X's and later monitoring them, the equation should include as few X's as possible.

The compromise between these two extreme objectives is what is normally called selecting the best regression equation. There is no one statistical procedure for arriving at one unique answer; rather, personal judgment and experience must be used as a necessary tool for obtaining satisfactory results. There are several procedures and combinations of procedures for solving regression problems. Unfortunately, they do not all necessarily lead to the same solution, although in many instances they will achieve the same answer.

The procedures, all in general use today, are:

1) all possible regressions;
2) backward elimination;
3) forward elimination;
4) stagewise regression;
5) stepwise regression;

For detail on the first four procedures the reader is referred to the bibliography.

3.3.1 The Stepwise Regression Procedure (Drapper & Smith, 1966)

This procedure is an improved version of the forward-selection procedure. The improvement means the re-examination at every stage of the regression of the variables incorporated into the model in previous stages. A variable which may have been the best single variable to enter at an early stage may, at a later stage, be superfluous because of the relationships between it and other variables now in the regression. To check on this, the partial F criterion for each variable in the regression at any stage of calculation is evaluated and compared with a pre-selected percentage point of the appropriate F distribution. This provides a judgment on the contribution made by each variable as though it had been the most recent variable entered, irrespective of its actual point of entry into the model. Any variance which provides a nonsignificant contribution is removed from the model. This process is continued until no more variables will be admitted to the equation and no more are rejected.

In a theoretical sense, the all-regressions procedure is best in that it enables us "to look at everything". However, in the practical sense, the stepwise procedures are the best to use, and thus were utilized for this thesis work, while specifically the computer program used was STATS 27 - Stepwise Regression Analysis.

With this review of model building and regression analysis, the study now enters the actual model choice and development phase.

CHAPTER FOUR
MODEL CHOICE

4.1 De Vany, Garges Model (De Vany, Garges, 1972)

Predictions of the past, based on economic theory show that the determinants of passenger demand for air travel between two cities are the income of consumers, the population of cities and the cost of an air trip in time and money relative to the cost of other modes. A formulation of this theory is illustrated by the model developed by A.S. De Vany and E.H. Garges based on study of 576 domestic U.S. city pair data.

The model that was considered is

$$\ln Q_{ij} = a + b_1 \ln F_{ij} + b_2 \ln t_{ij} + b_3 \ln M_{ij} + b_4 \ln I_{ij} + b_5 \ln P_{ij} \quad (5)$$

where:

The dependent variable, "$\ln Q_{ij}$", is the natural log of domestic passenger trips between (both directions) city i and city j, not including international passengers on a domestic leg of an international flight.

The fare variable, "$\ln F_{ij}$", is the log of the fare for a one-way flight in coach service between i and j, divided by the distance between i and j. The constant b_1 is, therefore, the fare elasticity of demand, expressing the percentage change in the quantity of passengers travelling between i and j that will be included by a change in the fare per mile of travel. The parameter b_1 should be negative according to theory.

The time variable, "$\ln t_{ij}$", is the log of the scheduled trip time per mile for the best direct flight. The constant b_2 therefore is the elasticity of demand with respect to the time cost and should be negative.

The term, "ln M_{ij}", is the log of the one-way distance between the cities. Since cross-sectional data with varying trip distances between cities is used, fare and time is normalized by expressing them in units per mile. Adding distance into the equation translates these averages into total cost per trip. Thus, the coefficient b_3 expresses the change in trips as total cost of the trip increases with distance, holding fare and time per mile constant. This should be negative.

The income term, "ln I_{ij}", is log of the product of income in cities i and j. This is a convenient way to express income when two cities are involved. Using the product reduces the two income figures to one, which characterizes the travel area rather than the individual cities. The coefficient of the log of the income product, b_4, should be positive.

The term for population, "ln P_{ij}", combines the population of the two cities forming the pair into a single number. Since Q_{ij} is total number of trips rather than trips per capita, there is some reason to believe that increasing the population of one or both cities will increase passenger trips. The coefficient of the log of the population term should be positive.

4.2 Thesis Model

The use of the logarithm form has proved to give better statistical results than other formulations (Brown, Watkins, 1968). The thesis model will thus be of the logarithm form.

For purposes of this thesis investigation, it was realized that there may be different economic theories involved in remote areas and travel to and from remote areas, in terms of elasticities or signs of the constants and importance of variables, than those of the De Vany, Garges model. Thus, for major-center--remote community intercity travel, the general model investigated, in natural log form, was:

$$\ln Q_{ij} = K_1 + p\ln P_j + d\ln D_{ij} + f\ln F_{ij} + t\ln T_{ij} + \ldots \quad (6)$$

or

$$Q_{ij} = e^{K_1} \times P_j^{\,p} \times D_{ij}^{\,d} \times F_{ij}^{\,f} \times T_{ij}^{\,t} \times \ldots \quad (7)$$

where:

Q_{ij} = Annual demand for intercity passenger air transportation, major center – remote community.

K_1 = A constant for the demand model.

p = The elasticity of the demand for air travel with respect to the population.

P_j = The population variable.

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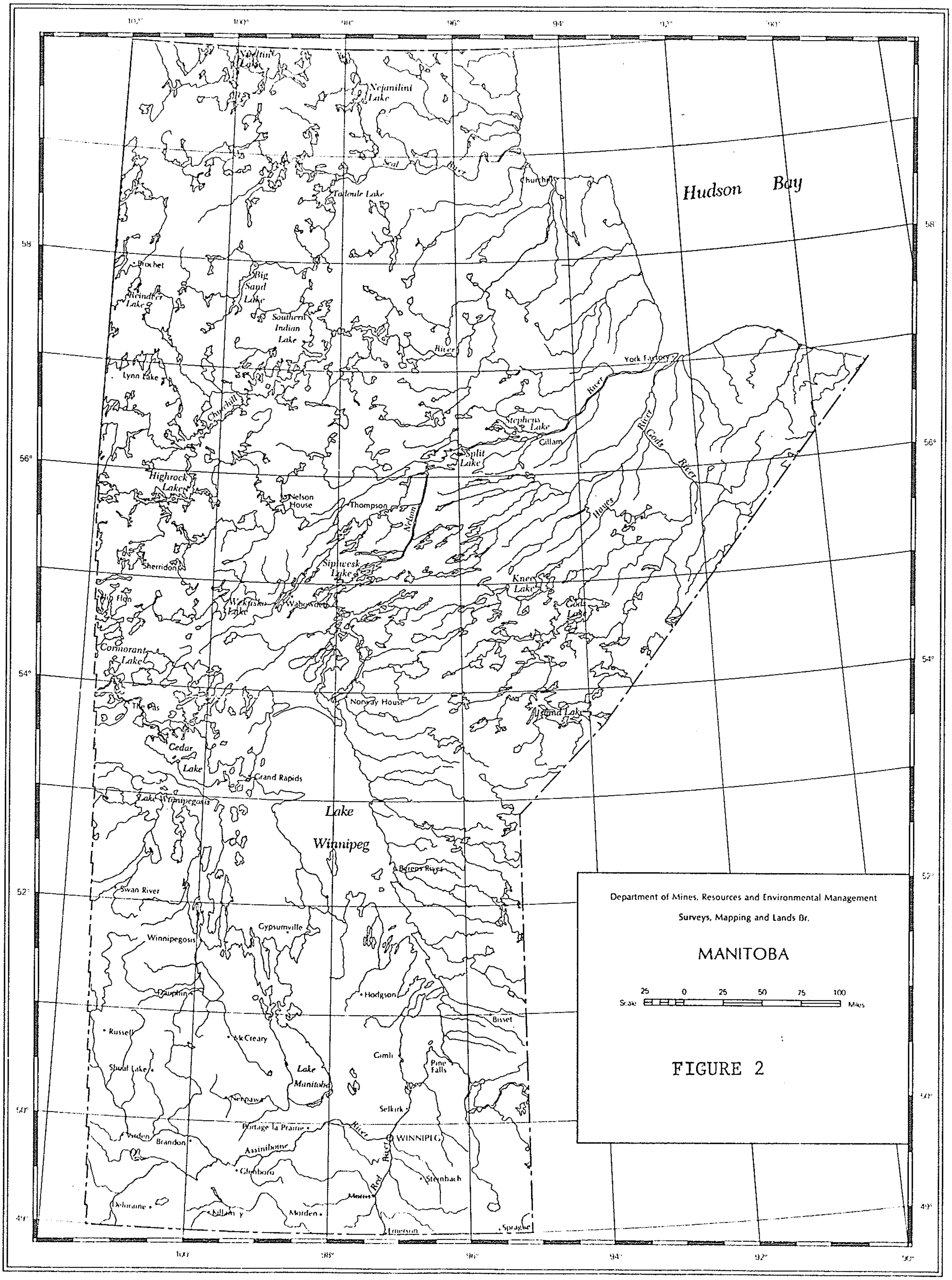
Preconceived notions on the importance of variables and signs were temporarily disregarded until analysis of results, thus leading to a developing theory based on actual data analysis.

4.3 Important Variables

The variables which this author considered vital to obtain, and which should be analyzed if the study were to be thorough were:

Population statistics on study cities.
Income statistics of these cities.
Employment statistics on these cities, with possible breakdowns into age groupings, sex, and types of employment - warehousing, mining, retailing, etc.
Intercity telephone statistics.
Community services, or lack of them, in the remote communities (hospitals, schools, psychiatrists, etc.), for which people must travel to major centers.
Recreational and tourist statistics.
Basic air statistics - fare, distance, travel time, frequency, capacity, etc.
Alternative mode statistics.
Investment figures and government grant statistics.

The difficulty of obtaining some of these detailed statistics, for a long period of time for remote communities is apparent. It was questionable if all of these types of detailed data are even available; however, the effort was made.



Hudson Bay
Nejanilini Lake
Seal River
Tadoule Lake
Churchill
Brochet
Reindeer Lake
Big Sand Lake
Southern Indian Lake
River
Lynn Lake
Churchill
York Factory
River
Stephens Lake
Gillam
Gods River
Split Lake
Highrock Lake
Nelson House
Thompson
Nelson
Hayes
Sherridon
Sipiwesk Lake
Knee Lake
Flin Flon
Wekusko Lake
Wabowden
Cormorant Lake
The Pas
Norway House
Cedar Lake
Grand Rapids
Lake Winnipegosis
Lake Winnipeg
Berens River
Swan River
Gypsumville
Winnipegosis
Dauphin
Hodgson
Bisset
Russell
McCreary
Gimli
Shoal Lake
Lake Manitoba
Pine Falls
Neepawa
Selkirk
Portage la Prairie
River
WINNIPEG
Virden
Brandon
Assiniboine
Red River
Glenboro
Steinbach
Morris
Deloraine
Killarney
Morden
Emerson
Sprague
Department of Mines, Resources and Environmental Management
Surveys, Mapping and Lands Br.
MANITOBA
Scale
Miles

FIGURE 2

CHAPTER FIVE
CASE STUDY

5.1 Choice of Study Areas

The case study that was chosen was Manitoba, Canada. In precise terms the City of Winnipeg serves as the major center, and the remote (low density) communities used are:

Churchill
Flin Flon
Lynn Lake
The Pas
Thompson

The basic reason for choice of this area was that the author is a resident of Manitoba, doing his research at the University of Manitoba in Winnipeg, thus being in a position to gather and evaluate the data more readily. Some reasons for the choice of the five remote or northern communities were:

1) Availability of O-D air data for these cities on a time series basis.
2) Service by a single common air carrier.
3) Variety of community growth patterns.

The similarities of Winnipeg--Northern Manitoba communities to other Canadian areas, namely Quebec City--northern Quebec communities, Vancouver--northern B.C. communities, Edmonton--northern Alberta communities, Toronto--northern Ontario communities ...., plus to a certain extent U.S., European and Australian major center to remote area air travel indicate the possible application of model results to these areas. Other areas of the world, for example, the U.S.S.R., Africa, Asia and South America may have different trends due to individual problems and social-economic-political systems.

At this point it would be valuable to take a brief look at the history of air travel in Manitoba, specifically the north, and a historical view of the communities to be analyzed, in order to give the analysis perspective.

5.2 History and Transportation

5.2.1 Air Transportation in Manitoba

The climatic, geological and physical size extremes of Northern Manitoba have posed grave problems to the development of northern communities. This, combined with the isolated remoteness of the communities, has produced a need for better transportation services than can be provided by water, highway or rail transport. Air transport, especially for passenger service, is a must for these northern communities.

Air transportation emerged as a significant factor in the north after World War I. Many of the pilots returning from overseas purchased war surplus aircraft and began careers in civil flying. These pilots flying small aircraft equipped with skis or pontoons and with little or no navigational assistance played a major role in the exploration and development of many mining areas which where inaccessible by land or water (Royal Commission of Inquiry into Northern Transportation in Manitoba, 1969, p.p. 179-180).

In the 1920's air expeditions were sent to the Arctic to establish police posts and to assist in exploration of the country. Aircraft also began to play an increasing role in forest protection and aerial photography. By 1930 almost all the northern mining communities were supported by air service. The expansion of air transportation continued despite the economic depression of the 1930's and frontier aviation became essential to life in the North.

World War II caused further development of smaller airlines to be curtailed through restrictions on flying, a decrease in mining development and the inability to purchase new aircraft. Many of the existing companies suspended operations.

The post-war increase in mineral exploration and resource development and the establishment of defence facilities (such as Fort Churchill) in the North caused a dramatic increase in air traffic. To meet this increased demand for services, smaller operators purchased surplus aircraft and employed pilots and ground maintenance crews trained during the war years. The post-war boom which reached its peak in the mid-1950's provided the impetus for the establishment of modern air transport in Northern Canada.

In Manitoba, Central Northern Airways Limited, the forerunner of TransAir, was organized in 1947. It acquired the routes and equipment formerly operated by Canadian Pacific Airlines to Lac du Bonnet, Norway House, Gods Lake, Ilford, Sherridon, Flin Flon, and The Pas. By 1957 scheduled services were offered between Winnipeg and Churchill, with intermediate stops at Dauphin, The Pas, Flin Flon and Lynn Lake. Service was subsequently extended to Thompson and various points into the Northwest.

Presently TransAir is the only major class 1 (Class 1-Scheduled air carriers who offer public transportation of persons, mail and/or goods by aircraft, serving designated points in accordance with a service schedule and a toll per unit) carrier servicing all the northern communities of Churchill, Flin Flon, Lynn Lake, The Pas and Thompson.

There are constant complaints about the level of service provided to these northern communities. TransAir has been steadily upgrading the service to the point where in 1973 jet service (Boeing 737-200C) is now provided from Winnipeg to the previously mentioned northern communities. The frequency of runs and direct routing to these communities is, however, limited by physical and economic constraints. Runway and airport facility limitations and extreme seasonal weather conditions are some of the physical constraints on air service. (For detailed actual airport facilities in the study area, the reader is referred to The Canadian Air Pilot West, 1972).

From the economic point of view, TransAir's position is that it already is losing money on some of these northern flights (charters and the eastern routes, specifically the Toronto route, make up these losses), and a further expansion of service to levels proposed by the communities is unprofitable. (It should be pointed out that some improvement in frequency, especially to Thompson is presently being implemented, though at the cost of discontinuance of a night flight from Flin Flon to Winnipeg).

5.2.2 Historical Overview

Manitoba a province of almost 1,000,000 people, covers an area of 251,000 square miles (land surface, 211,775 square miles; water surface, 39,225 miles). Located at the geographic center of Canada, it naturally becomes a transhipment point (specifically the City of Winnipeg) of the Confederation. With its 400-mile coastline on Hudson's Bay, which opens to the Atlantic, its major railway systems and its road networks, transportation becomes an important industry for the province.

The southern sector of the province is based mostly on agriculture while the north has an economy based on forestry, mining, energy resources (specifically hydro) and tourism (tourism includes fishing and hunting).

In general, the Province has a slow stable rate of growth with rural population decreases and outprovince migration offset by the growth of urban centers.

WINNIPEG

The City of Winnipeg with a population of 540,000, is the largest and basically the only metropolitan center for the province. It is Canada's fourth largest metropolis, and is Canada's grain marketing center and the financial and transportation hub of Western Canada. Both transcontinental railways have their western headquarters in Winnipeg; this together with the International Airport and road net configuration are reasons for the "hub" concept.

The city is undergoing a steady growth process, which, though slower than many other metropolitan areas of Canada is sufficient for industrial expansion and still promotes a calmer way of life than is found in the eastern metropolises.

Because it is the capital of the province, with most governmental agencies centered there, and because of its financial and transport "hub" concept, Winnipeg is a natural take-off point into Manitoba's North.

CHURCHILL

Churchill, 1,000 miles by rail north of Winnipeg, is situated at the mouth of the Churchill River on the shore of Hudson Bay. It is the terminus of the Hudson Bay Railway, a secondary main line of the C.N.R. which extends through 500 miles of wilderness between The Pas and Churchill. There is no road link between Churchill and Winnipeg.

Churchill is Canada's most northerly deep sea port, through which millions of bushels of grain are shipped each year from western Canada to Europe. Wheat shipments in 1971 totalled 27 million bushels, and the storage capacity of the grain elevators at Churchill is 5,000,000 bushels. The Churchill--Hudson Bay Route is about 1,000 miles shorter than through Montreal and federal investigations are underway to see if the 3½ month shipping season can be extended, and the port improved.

Churchill is also the northern area headquarters for a number of Federal Government departments and agencies.

FLIN FLON

The mining center of Flin Flon is located at the northern end of P.T.H. # 10, 550 road miles northwest of Winnipeg. Flin Flon was incorporated as a city in 1970, and together with the adjoining Saskatchewan community of Creighton has a population of over 10,000.

The economy of the city is based primarily on the operation of Hudson Bay Mining and Smelting Co. Ltd. The company, incorporated in 1927, owns and mines zinc, copper, calcium, gold and silver properties in the area. In terms of production, it operates the third largest copper smelter and third largest zinc refinery in Canada.

The all-weather paved road connecting Flin Flon to the U.S.A. and the availability of high-standard hunting and fishing lodges, and abundant wildlife, are prime tourist attractions. The Hansan Lake Road, connecting Flin Flon to Prince Albert, Saskatchewan, makes possible an interchange of tourists and sportsmen in this part of the north. Flin Flon is also connected to Winnipeg by a C.N. rail line.

LYNN LAKE

Lynn Lake is located 150 miles north of Flin Flon at the terminus of a branch line of the Canadian National Railway. The community was designated a local Government District in 1951.

The economy is based mainly on the nickel-copper-cobalt mining operations of Sheritt Gordon Mines Ltd., which moved to the present site more than 15 years ago. A new mine at Fox Lake, located 30 miles south of Lynn Lake, was officially opened in 1970.

The fishing industry in Lynn Lake is also significant. Lynn Lake is a gathering and redistribution point for fresh and frozen fish, which is brought in from the area and reshipped by rail to commercial markets.

The numerous lakes in the area offer excellent sport fishing, which is attracting an increasing number of tourists who fly into surrounding lodges and camps by chartered or private aircraft. An all weather highway is presently nearing completion of the construction and improvement stages.

THE PAS

The town of The Pas is located 450 miles northwest of Winnipeg on Provincial Trunk Highway No. 10 and is a Divisional point of the Canadian National Railways and the link between the Prairie Provinces and the Port of Churchill.

Historically the town has been an administrative and distribution center for the northern areas and more recently has entered the food processing and forest products industry. A major forest products development, Churchill Forest Industries, was established at The Pas in 1968-69.

The town is a regional center for a number of provincial government services and is the headquarters for the Northern Manpower Corps. In addition it is the "Gateway to the North" for fishing and hunting expeditions.

THOMPSON

Thompson was incorporated as Manitoba's newest city in July, 1970. The city is located 407 air miles north of Winnipeg, and was carved out of virgin bush land only a few years ago.

Road access to the rest of the Province is provided by Provincial Road #391, an all-weather paved highway. Two routes are available to the south from this highway - Ponton and Grand Rapids on Provincial Trunk Highway No. 6. Rail service is supplied by the Canadian National Railway.

The economy and existence of the City of Thompson is mainly dependent on the operation of International Nickel Co. Ltd., in what constitutes the free world's second largest nickel producing complex. This multi-million dollar development, started in 1956-57, accounts for a large percentage of Manitoba's total mineral (metal) production.

Thompson is also emerging as the administrative and regional center for Northern Manitoba. A number of provincial and federal offices are now located there and it is the head office location of the Normen Regional Corporation, an organization promoting the economic planning and development of the North. The new provincial policy of decentralization also means the relocation of major branches of the Department of Northern Affairs from Winnipeg to Thompson by the summer of 1974.

With this background of information the study now proceeded to the model development phase.

5.3 Model Development Phase 1

5.3.1 The Data

In order to collect data for this particular study area many sources were consulted. Some of the sources were: Statistics Canada, Manitoba Bureau of Statistics, Ministry of Industry and Commerce, Manitoba Ministry of Finance, Department of Northern Affairs, Manitoba Ministry of Labour, Ministry of Tourism, Recreation and Cultural Affairs, Canada Manpower, Manitoba Health Services Commission, Ministry of Mines, Resources and Environmental Management, Federal Department of Taxation, C.T.C., Manitoba Transit Board, Greyhound, Greygoose, Manitoba Transit Co., TransAir, C.N. Rail, Dept. of Settlements Studies (U of M), Russell Bus Guide, The Chambers of Commerce and Mayors' Offices of each city, important companies such as Inco in Thompson, Provincial Archives & Libraries, and University Libraries.

After months of persistent investigation, it was concluded that the only entities which had and/or were in a position to give basic time series data were TransAir, and Statistics Canada. Data from most other agencies was confidential, unformulated or non-existent.

The only "social-economic" data available at this time was population. No consistent data such as income or employment was available at this point. A great disappointment was the fact that such historic data as the health services provided from Winnipeg to the north, and tourist statistics for each community were not available. It was also hoped that the number of phone calls could be used as an index for attractiveness; however this data also proved to be unavailable for the North.

The historical volume data was obtained from C.T.C. and Statistics Canada reports. Other mode data was compiled from C.N. schedules, and Russell Bus Guide schedules, with all data in raw form.

The data was tabulated for the years 1961 (the first year TransAir offered Class 1 service to Thompson) through 1971. The input variables used were:

Variable 1 Q_{ij} - City pair volume (number of passengers per year), Winnipeg - Northern City (both directions). C.T.C.

Variable 2 P_j - Populations of Northern City each year. Statistics Canada and Manitoba Health Commission.

Variable 3 D_{ij} - One way - straight line air distance (miles) between Winnipeg - Northern City. C.T.C., air maps.

Variable 4 F_{ij} - One way economy fare (¢/mile), based on straight line air distance. TransAir.

Variable 5 T_{ij} - Shortest one way travel time (min/mile) based on straight line air distance. TransAir.

Variable 6 FL_{ij} - Frequency - number of one way flights per week. TransAir.

Variable 7 $\frac{T_{ij}}{\sum TT}$ - Ratio of shortest air travel time to sum of shortest other mode travel time, or combination of other mode travel time. Russell Bus Guide, TransAir, C.N.

Variable 8 C_{ij} - One way capacity - seats per week. TransAir.

Another variable-namely D/T, the ratio of number of direct flights to total flights was tabulated but was not utilized due to inconsistency of the data.

The 8 variables discussed were tabulated for 5 city pairs, and 11 years, thereby giving 55 observations (Table 1, Appendix A), and then these observations were used as the input data file for the regression analysis program.

Figure 3 graphically illustrates the historical evolution of the number of passenger trips through the years for all city pairs. The growth pattern for 4 of the individual pairs appears to be fairly regular while the Churchill - Winnipeg pair shows more fluctuations.

5.3.2 Development Stages and Output Analysis-Phase 1

Since the form of the model is:

$$\ln Q_{ij} = K_1 + p\ln P_j + d\ln D_{ij} + f\ln F_{ij} \quad \ldots\ldots\ldots \tag{6}$$

The first step was to change the data to ln form using a WAT 5 program.

A total of 28 runs were made in developing this phase of the forecasting model. Some of the important ones are discussed below.

RUN 1: The 8 by 8 matrix containing all possible simple correlation coefficients was the first output examined. The simple correlation coefficient expresses the degree of association between the variables. Examination of this table was made prior to any detailed analysis in order to determine the following two entities: Any strong relationships between independent and dependent variables can be readily evaluated. Also, any high intercorrelations between independent variables can be discovered at this early stage of model building. High intercorrelation can often result in a degeneration of the least squares regression procedure and yield meaningless results.

High correlations between the dependent variable and independent variables were:

Volume to Capacity = 0.75281

Volume to Fare = 0.60371

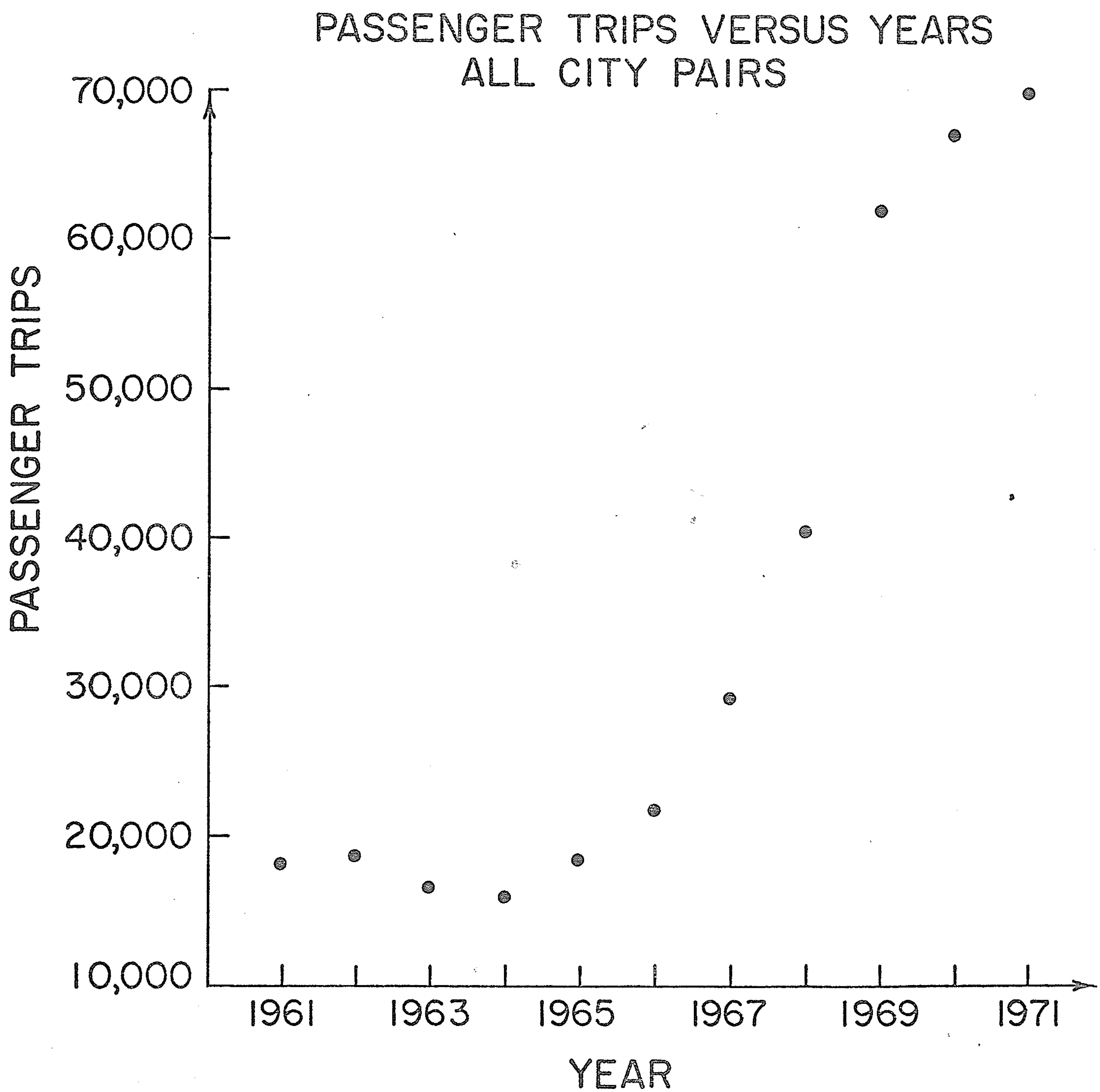

PASSENGER TRIPS VERSUS YEARS
ALL CITY PAIRS
PASSENGER TRIPS
70,000
60,000
50,000
40,000
30,000
20,000
10,000
1961
1963
1965
1967
1969
1971
YEAR

FIGURE 3

High Intercorrelations were:

Capacity to Frequency = 0.73204

Travel Time to $\frac{Tij}{\Sigma TT}$ ratio = 0.72248

RUN 2: The effect of "capacity" was examined in this run. Frequency was omitted from the input file. The program output along with the outputs for the next five runs are shown in Table 2; analysis will follow.

RUN 3: "Frequency" was considered with all the other independent variables. "Capacity" was deleted from the input file.

RUN 4: All independent variables except "Frequency" and "Travel Time" were included in this run.

RUN 5: All independent variables except "Frequency" and "$\frac{Tij}{\Sigma TT}$" ratio was included in this run.

RUN 6: All independent variables except "Capacity" and "Travel Time" were included in this run.

RUN 7: All independent variables except "Capacity" and "$\frac{Tij}{\Sigma TT}$" were included in this run.

5.3.3 <u>Summary of Initial Model Development, Analysis Program Output-Phase 1</u>

On examining Table 2, it was concluded that capacity (variable 8) should be retained instead of frequency (variable 6). The runs in which frequency was included in the input file showed a consistently higher standard of error of estimates, and the multiple correlation coefficient was consistently lower. It was also concluded at this time that both travel time and $Tij/\Sigma TT$ ratio had small significance in the model.

The following variables were left, namely:

Variable 8	-	capacity
Variable 4	-	fare
Variable 2	-	population
Variable 3	-	distance

RUN	R	F	STAND. ERROR OF EST.	VAR. REG. COEF.	STAND. ERROR OF REG. COEF.	COMPUTED T-VALUE
2	.932	58.694	0.269	8 0.529	0.070	7.559
				4 5.521	0.710	7.781
				2 0.145	0.081	1.787
				3 0.089	0.294	0.301
				5-0.795	0.313	-2.541
				7 0.917	0.372	2.463
3	.908	42.010	0.311	4 7.054	0.796	8.866
				6 0.754	0.136	5.553
				2 0.071	0.094	0.752
				5-1.529	0.333	-4.591
				7 1.539	0.425	3.619
				3 0.522	0.349	1.494
4	.924	62.214	0.281	8 0.600	0.068	8.879
				4 4.545	0.629	7.228
				2 0.239	0.076	3.135
				3-0.296	0.266	-1.112
				7 0.062	0.168	0.369
5	.930	62.734	0.280	8 0.556	0.073	7.673
				4 4.502	0.605	7.436
				2 0.237	0.076	3.118
				3-0.343	0.248	-1.381
				5-0.098	0.141	-0.701
6	.867	32.771	0.366	4 5.265	0.824	6.393
				6 0.826	0.160	5.155
				2 0.272	0.099	2.746
				7-0.241	0.208	-1.158
				3-0.309	0.354	-0.071
7	.883	38.332	0.344	4 5.414	0.730	7.415
				6 0.719	0.151	4.752
				2 0.228	0.093	2.448
				5-0.431	0.153	-2.814
				3-0.240	0.311	-0.771

TABLE 2
INITIAL RUNS ON PHASE 1

However, observing the sign of the coefficient of fare to be positive, it was decided that at this time fare should not be retained in the equation, although it had a high correlation. A forecasting model which includes fare as a positive correlation would mean that as fare goes up volume goes up. This may be a fact of real life, (volumes are increasing and fares are increasing, due to rising costs, better levels of service, etc.) but not a tool to be used for travel prediction. More will be said about fare in subsequent sections.

Therefore, the final variables arrived at were 8, 2 and 3. These variables passed the statistical inference tests.

Next the program was written to change the Q_{ij} actual and Q_{ij} estimated to Antilog and the residuals, and the percent-error in the residuals analyzed. Analysis of the percent-error $\pm$, greater than 20% showed the R was only .837, and the standard error of estimate was .393. This was considered unsatisfactory.

Thus the data was reconsulted. Initially it was attempted to isolate incentives for travel to the North by just considering the population changes of Northern cities. In tabulation of the data, though all cities show an increase in travel, two cities, namely Churchill and Flin Flon, have actually lost population from 1961 to 1971, (though the population losses for Churchill seem to follow a general trend with the ups and downs of air travel).

In order to improve on the model, it was decided to incorporate the population changes of Winnipeg (a steady rise) which would show that some of the increases in air travel would be caused by the increase in Winnipeg's population counts, which seems logical. The population of Winnipeg and the northern cities was cross multiplied, and the square root of the product derived and tabulated as variable 9.

Investigation of Run 9 (all 9 variables) showed a high - 0.99831 correlation between $\sqrt{P_i P_j}$ and P_j. Further analysis showed that $\sqrt{P_i P_j}$ should be used instead of P_j, indeed investigation of residuals showed that the % error has been lowered.

At this stage, it was decided to leave variable 4 (Fare) in the equation just to see the R range that could be attained. Obviously variable 4 is colinear with the demand, and although it of itself gives little insight into the reasons for increased air travel, it improves the correlation and gives a smaller standard error of estimate. There may be certain factors within the fare variable which could explain part of the increase in air travel (such as better levels of service, increased consumer income-ability and willingness by the travelling public to pay the higher fares, etc.).

With the inclusion of fare, variable 3 (distance) was insignificant, thereby the final 3 variables kept for Phase 1 were: Capacity (8), Fare (4), and $\sqrt{P_i P_j}$ (9).

The validation of Phase 1 was performed, including the statistical inference tests, at a 95% confidence level, and examination of parameter behaviour with check runs. Statistically the model proved valid.

5.3.4 Conclusions on Phase 1

Thus the model to this point was of the form:

$$\begin{aligned} \ln Q_{ij} = -10.76213 &+ 0.58045 \text{ (ln Capacity)} \\ &+ 3.94036 \text{ (ln Fare)} \\ &+ 0.62850 \text{ (ln } \sqrt{P_i P_j}) \end{aligned} \qquad (8)$$

A residual check carried out showed normal distribution; however, the sign (and inclusion) of the fare variable was unsatisfactory; thus further data collection and development was indicated.

5.4 Model Development Phase 2

5.4.1 Fare Investigation

At this time the fare variable in the equation was reinvestigated. In most major studies, fare has been shown to be an important variable. The question remains in this study: Will fare changes affect growth of traffic, will they, and what is the proportionate effect, if any, on air passenger demand of a given percentage change in fares, other things being equal?

Most people will agree that traditionally the Marshallan law of demand applies to air travel: i.e., people will buy more at lower prices and less at higher prices, if other things are not different or do not change. But other things, namely, population, income and tastes, are different and do change, thus the question is what is the net effect of fare holding other variables constant. The two methods normally utilized to study fare are analysis of time series and cross-sectional data for city pair markets.

Brown and Watkins, in their demand air travel study (1968) investigated these two methods of fare analysis. The reader is referred to their study listed in the bibliography for further explanation.

As will be seen, there was a vigorous analysis of fare in this study case, to see if similar relationships will hold.

5.4.1.1 Fare in the Study Case

In this particular study, time series and cross-sectional data were combined to give one data base.

Initial analysis of data showed that over the 11-year period undepreciated fare has basically remained the same or has increased as trips have increased (only Thompson has experienced a slight decrease in fare).

It was also noted that contrary to the Marshallan law of demand, cities with lowest fare (¢/mile) did not necessarily have highest number of passenger trips. In fact, the reverse seemed to happen as was illustrated in the Phase 1 model.

Thus the data was reconstructed and new forms of fare and distance variables entered. Fare was depreciated to 1961 dollars and actual available shortest route distances between Winnipeg and northern communities for each year calculated (the air distances used here were obtained from TransAir and were slightly different from those of C.T.C.).

The fare depreciation was based on the national consumer price indexes obtained from Ottawa (Price indexes of Manitoba, specifically Winnipeg, were also compared, but the differences were negligible).

The National consumer price indexes were as follows:

1961	$1.00
1962	.99
1963	.97
1964	.95
1965	.93
1966	.90
1967	.87
1968	.83
1969	.80
1970	.77
1971	.75

5.4.1.2 Fare for Each City Pair

When taken separately on an individual time series basis, the outcome showed a general correlation between depreciated fare (¢/mile) and passenger trips, with the elasticity sign appearing to be negative.

The question remained, if all time series data were to be combined with cross sectional data and entered into the regression analysis, what would be the significance of the new fare variables of the demand equation? Would there be a magnitude problem in regards to fare?

5.4.2 New and Reconstructed Data

At this stage six new forms of fare variables were entered in the input file. (Note: for convenience sake the population variable (9) was removed, and will be re-introduced under a different number). The new variables were:

Variable 9 $F_{ij}*$ - One way economy fare (¢/mile) depreciated, based on straight line air distance.

Variable 10 $\%F_{ij}*$ - Per cent change (from 1961) of depreciated fare, based on straight line air distance.

Example: $F_{ij}*$ 1961 Churchill = 10.686

$\%F_{ij}^* = 100\%$

F_{ij}^* 1962 Churchill = 10.579

$\%F_{ij}^* = 98.999\%$

F_{ij}^* 1963 Churchill = 10.365

$\%F_{ij}^* = 96.996\%$

Variable 11 ΔF_{ij}^* Actual ¢/mile change (from 1961) of undepreciated fare, based on straight line air distance.

Example:

F_{ij}^* 1961 Churchill = 10.686

$\Delta F_{ij}^* = 0.000$

F_{ij}^* 1962 Churchill = 10.579

$\Delta F_{ij}^* = 0.107$

F_{ij}^* 1963 Churchill = 10.365

$\Delta F_{ij}^* = 0.321$

Variable 12 $F_{i}^{*}{}_{j}^{*}$ One way economy fare (¢/mile) depreciated, based on actual shortest route distance available each year.

Variable 13 $\%F_{i}^{*}{}_{j}^{*}$ Per cent change (from 1961) of depreciated fare, based on actual shortest route distance available each year.

Variable 14 $\Delta F_{i}^{*}{}_{j}^{*}$ Actual ¢/mile change (from 1961) of depreciated fare, based on actual shortest route distance available each year.

A different form of travel time and a slight variation of Variable 14 was also entered at this time, namely:

Variable 15 $T_{i}^{*}{}_{j}$ Shortest one way travel time (min./mile), based on actual shortest route distance available each year.

Variable 16 $\Delta F_{i}^{*}{}_{j}^{*}$ A slightly different format of Variable 14. This variable was entered to see what effect bringing in 0.0 closest to the true $-\infty$, will have on results.

These inputs are listed in Table 3, Appendix A. Also a different format of Population Variable was entered as Variable 18. (for convenience sake the old population variable (9) was re-entered as Variable 17).

Variable 17 $\sqrt{P_iP_j}$ Square Root of the cross product of the population of Winnipeg and each northern community each year.

Variable 18 P_iP_j Cross product of the population of Winnipeg and each northern community each year.

At this time, income data was also finally obtained. It was derived and compiled from multiple sources and required substantial cross checking due to different reporting criteria. The new income variables entered were:

Variable 19	$I_i \times I_j$	Cross Product of the total income of Winnipeg and each northern community each year.
Variable 20	$\sqrt{I_i \times I_j}$	Square Root of the cross product of the total income of Winnipeg and each northern community each year.
Variable 21	$I_i^* \times I_j^*$	Cross Product of the total depreciated (to 1961) income of Winnipeg and each northern community each year.
Variable 22	$\sqrt{I_i^* \times I_j^*}$	Square Root of the cross product of the total depreciated (to 1961) income of Winnipeg and each northern community each year.

A new distance variable was also introduced namely:

Variable 23	D_{ij}^*	One way (miles) actual shortest route distance available each year.

These 7 new variables are incorporated in Table 4 in Appendix A.

5.4.2.1 Magnitude of Fare

Before proceeding to the analysis of output, some consideration of the fare magnitude was carried out.

Since the individual time series implied some correlation with the number of passenger trips, and combination with the cross-sectional data did not, the implication may arise that fares for individual northern communities would have to be weighed in some manner if the Marshallan economic theory was to hold.

Various techniques for arriving at the weighted factors were considered. No technique, however, was considered reliable as a prediction tool and thus weighted factors were not utilized in this case. They did not prove useful since the sign of the fare variable remained contradictory. It was also the strong opinion of this author that fare did not have a significant impact on air travel to the remote communities.

5.4.3 Development Stages and Output Analysis - Phase 2

All variables were now changed to ln form, and the status of the input file now was a total of 23 variables, 1 dependent and 22 independent. The development process entailed about 40 Group runs with 8 selections per run, some important runs are subsequently discussed.

The 22 independent variables that should be investigated and included were:

Capacity	-	Variable 8
Frequency	-	Variable 6
Fare	-	Variables 4,9,10,11,12,13,14,16
Travel Time	-	Variables 5,15
Population	-	Variables 2,17,18
Income	-	Variables 19,20,21,22
L.S. $\left(\frac{T_{ij}}{\sum TT}\right)$	-	Variable 7
Distance	-	Variables 3,23

Looking to the matrix and the correlation coefficients of the first run showed that:

Highest correlations between the dependent variable and independent variables listed were:

Volume to Capacity (8)

Volume to Frequency (6)

Volume to Fare (10)

Volume to Travel Time (15)

Volume to Population (17)

Volume to Income (20)

Volume to L.S. $\left(\frac{T_{ij}}{\sum TT}\right)$ (7)

Volume to Distance (23)

High intercorrelations between independent variables were:

Capacity to Frequency	= +.73204
Travel Time to $\frac{T_{ij}}{\sum TT}$	= +.79856
Capacity to Fare (10)	= -.70281
Population to Income	= +.81025

Previous investigation (borne out with runs on Phase 2 data) showed that retaining capacity gave better results than frequency.

The next step was to decide whether to use Travel Time or L.S. $\left(\frac{T_{ij}}{\Sigma TT}\right)$.

Investigation showed that variable 7 (L.S.) gave consistently better results than the Travel Time variables.

An interesting aspect discovered at this time was that the Distance variables 3 or 23, though they in themselves have an almost insignificant correlation with the dependent variable, were consistently added third in line of importance and reduced the sum of figures significantly (see Table 6-Appendix A). Another interesting aspect was that the sign of the regression coefficient was positive. More will be said of the distance variable in subsequent sections.

The intercorrelation between Capacity (8) and Fare (10) was also investigated . It is interesting to note that it has a high negative interrelationship with capacity, namely that as capacity increases fare decreases. Table 7 - Appendix A of grouping 5 through 8 showed that Fare (10) was consistently entered last.

Also using selected runs with variables

8, 19, 23, 7
8, 20, 23, 7
10, 19, 23, 7
10, 20, 23, 7

listed in Table 8-Appendix A showed that using capacity gave a higher correlation coefficient and lower standard error of estimate. Thus variable 10 was discarded.

All other forms of fare variables including a new variable no. 24, gave poor results and were discarded.

Since it was shown that Capacity (8) and Fare (10) had a high intercorrelation, a trial was run to see if capacity could be incorporated with distance and see if there still is a high correlation between the new variable and fare. Among the manipulations tried were:

Variable 25 $C_{ij} \times D_{i^*j}$ The cross product between Capacity and the actual shortest route distance available each year.

This manipulation did not have any effect on the high inter-correlation and did not give satisfactory results.

Another variable put into the input file was:

Variable 26 $\frac{T_{ij}}{\Sigma TT} \times D_{i^*j}$ The cross product of the "Level of Service" and the actual shortest route distance available each year.

Succeeding runs proved that the use of Variable 26 did not have any better effect on the resulting equation than did the original level of service variable - variable 7 (these variables are included in Table 5 in Appendix A).

With the completion of these efforts, it was concluded that fare, in this study case had no significance within the general model.

Left to be investigated was the high correlation between income and population, which resulted in a degeneration of the least squares regression procedure.

Using the selected runs of just variables

8, 19, 23, 7
8, 20, 23, 7
8, 21, 23, 7
8, 22, 23, 7
8, 17, 23, 7
8, 18, 23, 7

and analyzing the results (Table 8-Appendix A) shows that income gives better multiple correlation coefficients and lower standard errors of estimate.

Investigation between which distance variable to use,namely 3 or 23 consistently showed that variable 23,(actual shortest route distance available each year) gave better results.

Finally it was proven that of the income variables, variables 19 or 20 gave the best and comparable results, with variable 19 giving a slightly higher F-value.

Thus, this form of the Income Variable was retained. The form is $\underline{I_i \times I_j}$ which happens to be in the same format as the Garges-De Vany study.

5.4.4 Summary of Model Development, Analysis Program Output-Phase 2

The final selection of variables still remaining were:

Variable 8	Capacity
Variable 19	Cross product of income of Winnipeg and northern community
Variable 23	Actual shortest route distance
Variable 7	Level of Service, $\frac{T_{ij}}{\Sigma TT}$

The reduction of sum of squares by variable 7 proved to be only 0.020, thus suggesting that it is insignificant. However, for this stage variable 7 was retained and validation done on equations utilizing variables 8, 19, 23, 7 and variables 8, 19, 23. Both equations were validated by statistical testing.

Residual analysis utilizing plot theory obtained from Drapper and Smith, 1966, was also carried out.

Validation for both equations showed that they passed the F and T tests, parameter behaviour during update procedure was stable, and the residuals were fairly normally distributed.

5.4.5 The Final Forecasting Model

5.4.5.1 Additional Analysis

Since the contribution of Level of Service to the equation is small, and most trips to the north (further explanation of this topic will follow subsequently) are for business reasons, it was decided to utilize only the variables 8, 19, 23.

The model thus developed was:

$$\ln Q_{ij} = -18.27443 + 0.43984 \text{ (ln Capacity)} + 0.48074 \text{ (ln } I_i \times I_j) + 1.05986 \text{ (ln Actual Shortest Route Distance)} \quad (9)$$

or

$$Q_{ij} = e^{-18.27443} \times (C_{ij})^{.43984} \times (I_i x I_j)^{.48074} \times (D_{i^*j})^{1.05986} \quad (10)$$

where $e^{-18.27443} = K = 1.15486 \times 10^{-8}$

and the Multiple Correlation Coefficient (adjusted) = 0.882

Standard Error of Estimate (adjusted) = 0.339

Having decided on this final model, it was decided to see if any significant trends would develop in the coefficients and intercepts when time series data was segmented.

The following groups were used:

1961-1962, 1961-1964, 1961-1966, 1961-1968, 1961-1970, 1961-1971.

These nine sets of data were then run separately. No significant trends in any of the intercepts was discovered and the regression coefficient showed increasing good stability.

It was also decided to check the final general equation against the five city-pairs. Since 11 observations are not enough for 26 variables, the 4 pertinent variables had to be pulled from the input file and a new program set. The results were:

RUN 1 Winnipeg-Churchill showed that capacity was entered first, then distance, then income. The multiple correlation coefficient was 0.841 with a S.B. of .147.

RUN 2 Winnipeg-Flin Flon showed that income was entered first, then distance, then capacity. The multiple correlation coefficient was 0.956 with a S.B. of 0.118.

RUN 3 Winnipeg-Lynn Lake showed that income was entered first, then capacity, then distance. The multiple correlation coefficient was 0.995 with a S.B. of 0.094.

RUN 4 Winnipeg-The Pas showed that income was entered first, then distance, then capacity. The multiple correlation coefficient was 0.981 with a S.B. of 0.158.

RUN 5 Winnipeg-Thompson showed that income is entered first, then capacity, then distance. The multiple correlation coefficient was 0.964 with a S.B. of 0.256.

Analyzing the last previous 5 runs showed that overall the <u>income</u> variable is the most significant variable for all city pairs except

Churchill (Churchill historically had high income and population fluctuations). To see the effect on the model by discarding Churchill from the input file, another series of runs were performed.

After analysis, the outcome showed that the best combination of variables was still 8, 19, 23, with the signs stable. The major difference was that Income was entered before Capacity and there was a decrease in the distance coefficient.

Without Churchill, the equation was:

$$\begin{aligned} \ln Q_{ij} = & -19.82805 + 0.60808\ (\ln I_i \times I_j) \\ & +0.34704\ (\ln \text{Capacity}) \qquad \text{(eqn. 11)} \\ & +0.61541\ (\ln \text{Actual shortest route distance}) \end{aligned}$$

$R = .920$

Standard Error of Estimate = 0.315

All T and F tests passed and parameters were well within the 95% confidence level.

The model developed was retained as equation 9 even though equation 11 had a larger R and smaller error of estimate. There are some arguments for discarding the Churchill data, since the economic history of Churchill has been volatile. While it has had its moments of imminent prosperity, the predictions of its economic potential have however never been fulfilled. The loss of the armed forces base and the hesitation of the federal government to expand the deep port facilities have had depressing effects on its economic growth, all of which has manifested itself in the fluctuations of air travel through the years.

For purposes of all-inclusiveness, it was however decided to retain Churchill in the input data, as it also was decided not to discard per year data just because errors of residuals that year were high. It was left for future study, to decide whether selective discarding of city or years which do not exactly fit the equations is sound reasoning in major-remote community model formulations.

As a further check, 1970 (1 year data) data for Gillam - a new northern community in Manitoba was obtained and applied against the model.

for 1970

Income of Gillam = \$6,957 x 1,000

Income of Winnipeg = \$1,468,416 x 1,000

Capacity = 292 seats/wk.

Distance = 460 Miles.

The results showed Q_{ij} estimated trips as 4,629 trips, while Q_{ij} historical was 4,495 thus the per cent error is only +3%.

5.4.5.2 Adjusting the Constant (K) Value

The equation (eqn. 9) as it stood was:

$$\ln Q_{ij} = -18.27443 + 0.43984\,(\ln \text{Capacity}) + 0.48074\,(\ln I_i \times I_j) + 1.05986\,(\ln \text{Actual shortest route distance}) \qquad (9)$$

When converted to the Antilog form the equation was:

$$Q_{ij} = e^{-18.27443} \times (C_{ij})^{.43984} \times (I_i \times I_j)^{.48074} \times (D_{i}*_{j})^{1.05985} \qquad (10a)$$

or

$$Q_{ij} = 1.15486 \times 10^{-8} \times (C_{ij})^{.43984} \times (I_i \times I_j)^{.48074} \times (D_{i}*_{j})^{1.05986} \qquad (10b)$$

which fits in the equation

$$Q_{ij} = K \times C_{ij}{}^{b} \times (I_i \times I_j)^{c} \times D_{i}*_{j}{}^{d}$$

where $K = e^{a}$

The value of the constant term K is not material. In the developed equation the value was small. If for appearance sake one wishes K to approach 1.000 then the following or similar operation can be followed:

$$Q_{ij} = 1.15486 \times 10^{-8} \times (C_{ij})^{.43984} \times (I_i \times I_j)^{.48074} \times (D_{i}*_{j})^{1.05986} \qquad (10c)$$

Changing the distance units to hundreds of miles and income cross product to billions, then:

$$N^* = \frac{I_i \times I_j}{10^{12}} \qquad \text{(eqn.10c.1)}$$

and $$D_i{}^*{}_j{}^* = \frac{D_i{}^*{}_j}{10^2} \qquad \text{(eqn.10c.2)}$$

$$Q_{ij} = \underbrace{1.15486 \times 10^{-8}}_{e^a} \times (N^*)^{.48074} \times (10^{12})^{.48074}$$
$$\times (D_i{}^*{}_j{}^*)^{1.05986} \;\ldots\ldots\ldots \times (10^2)^{1.05986} \qquad (10d)$$

$$Q_{ij} = 1.15486 \times 10^{-8} \times 587{,}327.0448 \times 131{,}74071 \times (N^*)^{.48074}$$
$$\times (D_i{}^*{}_j{}^*)^{1.05986} \;\ldots\ldots \qquad (10e)$$

$$Q_{ij} = \underbrace{.900}_{e^a} \times \ldots\ldots \qquad (10f)$$

thus the K value is now up to .900. Further manipulations could make it even closer to 1.000.

Such unit manipulations are standard procedure for adjusting K values. The author felt no need for doing so since it is strictly a cosmetic operation.

5.4.5.3 Attractiveness Factors

The purpose of this study was to develop a general model for inter-city air travel. Individual models were not developed, though the pertinent variables were tested against individual city-pairs (section 5.4.5.1).

The one general model could however be extrapolated into individual city-pair models very easily by the use of an attractiveness factor.

Within the developed model it would look like this:

$$Q_{ij} = (KA_{ij}) \times (C_{ij})^{.43984} \times (I_i \times I_j)^{.48074}$$
$$\times (D_i{}^*{}_j)^{1.05986} \qquad (10)$$

where $K = 1.15486 \times 10^{-8}$

and A_{ij} = individual attractiveness factor for each city-pair

A_{ij} is just the average for each city pair of the ratio of $\frac{\text{actual trips}}{\text{computed trips}}$ over the 11 year time span.

For the five city pairs, averaged over 11 years, the attractiveness factors are:

A_{ij}	Churchill	=	1.2521
A_{ij}	Flin Flon	=	.7776
A_{ij}	Lynn Lake	=	.7740
A_{ij}	The Pas	=	1.2028
A_{ij}	Thompson	=	1.2802

These factors can then be applied against equation 12 and a separate equation, formulated from the general model is obtained for each city pair. These equations will yield a higher R^2 and lower standard of estimate for each city pair.

Example: For Thompson

Without A_{ij}	With A_{ij}
R = .964	R = .988
S.E.= .256	S.E.= .251

Since the purpose of this study was to derive one general equation, and not specific individual city-pair equations, this analysis is terminated here.

5.5 Conclusions on the Final Forecasting Model

The model chosen was equation 9.

The signs of the regression coefficients were as they should be namely:

As capacity increases, air trips increase, as cross product of income increases air trips increase.

As distance from major center increases, air trips increase. The distance relationship is the reverse of that established in the De Vany & Garges Study ; however, in this thesis case the more remote the communities, the less access by other modes is available. The time cost to travel by other modes becomes very high the greater the distance, and since most trips to remote areas are for business purposes (due to the economic structure and base of the communities, i.e., mining) air travel becomes more attractive the greater the distance.

As previously stated the level of service $\left(\frac{Tij}{\Sigma TT}\right)$ variable, which compared air travel to other modal travel proved to be of slight significance. The fact that there is almost no competition from other modes due to remoteness, distance, separations, and low population densities implies that level of service in this format does not have a significant effect on an air demand model.

Most air trips to the North are done for business reasons; in point of fact, according to data obtained from the Department of Tourism in Manitoba, during the summer months of June, July, August and September of 1970 67% of trips were for "business reasons" while the rest were for vacation or tourist reasons. It is interesting to note that for automobile travel the reverse occurred, namely, 62% of 1970 summer north trips were for vacation purposes and the rest for business.

Also the majority of trips to the North occur in the summer months. According to the Tourism Department 1970 Statistics, 65% of total trips occur in the summer.

The implication obtained from these statistics is that most air travel is for business purposes, the majority of trips occur in the summer, and winter trips are almost all for business purposes. Conversations with TransAir and government representatives confirmed these observations.

Thus, since there seems to be no viable competitive mode to air travel in the North, and since most trips are for business reasons, fare should not be a significant variable to include in the model.

The final aspect to be considered was the high sensitivity of air transportation demand and the economic growth of the remote northern communities to political decisions of the federal and provincial governments. Although this author felt that politics had a strong effect on the North, there was no good gauge found to measure the effects of governmental political policies on northern travel. The necessary statistics such as investments and expenditures were not available-indeed it is doubtful whether such statistics are even presently maintained or that they would be released for study because of political implications. In the conclusion, some governmental policy decisions affecting northern communities and therefore affecting air travel to and from Northern Manitoba will be discussed.

CHAPTER SIX
THE DECISION MODEL

6.1 Introduction

After a demand or forecasting model has been developed, the next logical step of a systems approach for analyzing travel would be to develop a decision model.

As stated in the introduction, the actual development of the decision model for Northern Manitoba will be precursory. The development of a specific decision model is a separate field for a thesis study unto itself. Thus in this thesis the intent is to show one method of approach for decision model building and some associated pitfalls.

The primary purpose of this section was to provide information to aid in making decisions regarding the route scheduling in an optimal manner.

We assume that TransAir, the only major carrier servicing the northern cities, is interested in satisfying the travel demands of its passengers in an optimal manner (with a limited fleet). Minimization of travel time was the objective of this decision model. By analyzing the decision model's output, it can be decided which plane should service which city-pair and the sequence of dropping off passengers that the plane should follow. One limitation of this study model was that no pickup of passengers at transhipment nodes was included.

The correct routing and scheduling of planes plays a major role in the economical operation of an airline company. This governs the quality of service and the number of planes required, which is the principal determinant of the cost to the passenger. If the demands can be satisfied in the most optimal manner, while minimizing travel time, the costs of system operations are also minimized.

The proposed system is based on the summer TransAir schedule of 1971. The volumes and travel times were computed in the following way:

Assume Jet-Boeing 737-200C service. The plane has a normal capacity of 115 passengers. The volumes for Winnipeg to Northern city air travel for 1971 are:

Wpg.-Churchill	= 3240	trips/yr.	x 1 yr./365 days	x 1.24	= 11	trips/day
Wpg.-Flin Flon	= 4015	"	"	"	= 13	"
Wpg.-Lynn Lake	= 5970	"	"	"	= 20	"
Wpg.-The Pas	= 6210	"	"	"	= 21	"
Wpg.-Thompson	=14710	"	"	"	= 50	"

The yearly volumes were first converted to trips/day, then multiplied by a factor of 1.24. The reasons for using this factor are:

1) Since most scheduled flights are only 5 to 6 days per week, multiplying the demand by 124% increases the travel demand per day to a more realistic actual weekly demand.

2) Since the schedules consulted were for summer months, when traffic is the most frequent, using just the average demand per day over the whole year would give low estimates for the daily summer traffic.

3) Multiplication by 124% would also bring the total traffic to 115 trips per day which is the capacity of a 737, thus creating a situation where potentially one jet plane can carry all the passengers, and service all the cities. This was done to expand the alternatives.

The air travel time or speed was based on the 737-jet, namely 407 miles/hr. An unloading and loading time was set at a cumulative of 30 minutes.

Wpg.-Churchill	(total travel time)	= 92 + 30 = 122	minutes
Wpg.-Flin Flon	"	= 56 + 30 = 86	"
Wpg.-Lynn Lake	"	= 74 + 30 = 104	"
Wpg.-The Pas	"	= 48 + 30 = 78	"
Wpg.-Thompson	"	= 60 + 30 = 90	"
The Pas-FF	"	= 11 + 30 = 41	"
FF-LL	"	= 22 + 30 = 52	"
LL-Thompson	"	= 26 + 30 = 56	"
The Pas-LL	"	= 29 + 30 = 59	"
The Pas-Thompson	"	= 28 + 30 = 58	"

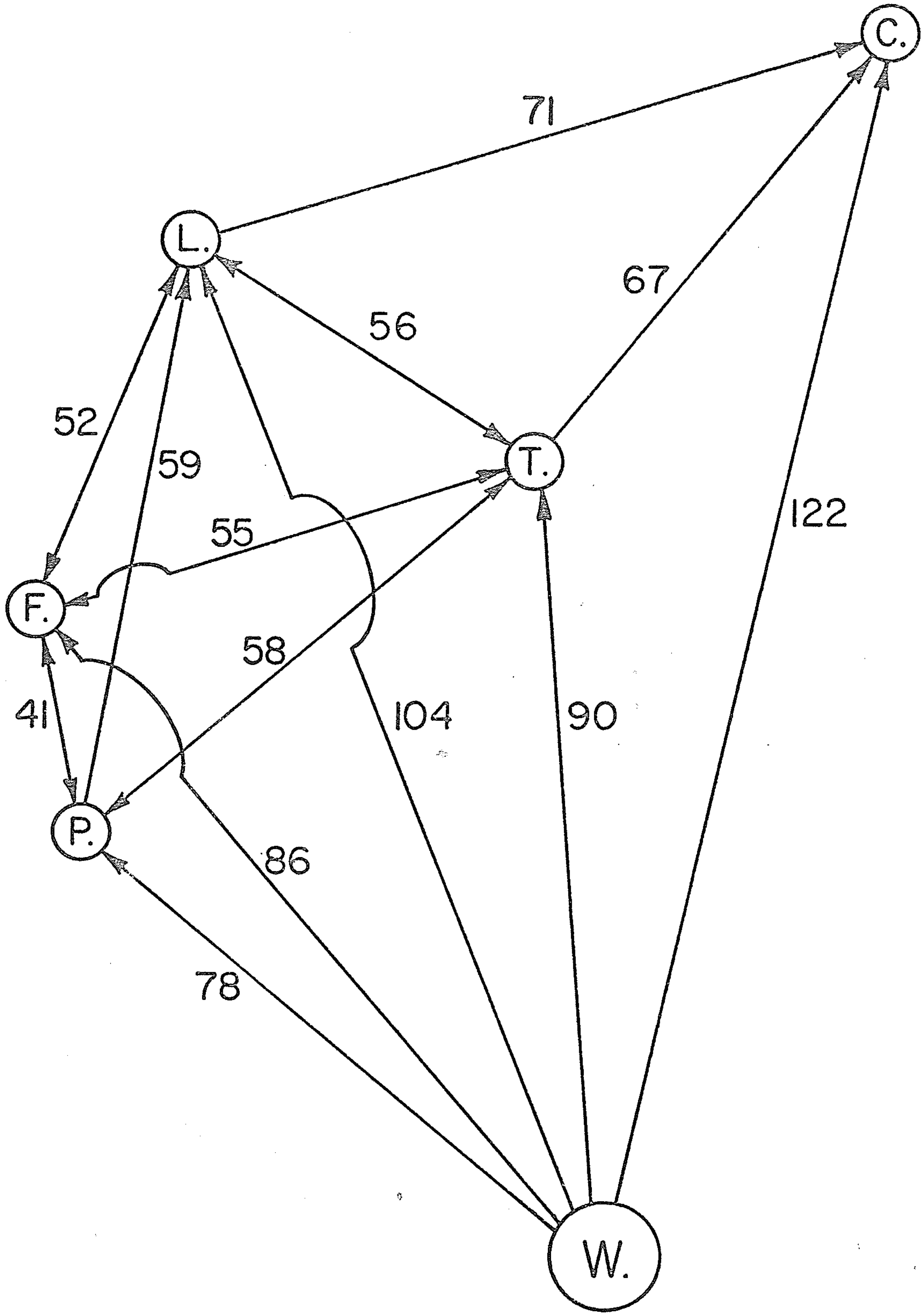


FIGURE 4
HYPOTHETICAL NETWORK CONFIGURATION

Thompson-FF (total travel time) = 25 + 30 = 55 minutes
Thompson-Churchill " = 37 + 30 = 67 "

Figure 4 shows a hypothetical network configurations of most of the routing options available in an ideal case. Only the Churchill-Flin Flon and The Pas routes were not included, since they would pass almost directly over Thompson, and thus were not considered as viable alternatives.

6.1.1 Model Development

The network configuration of Figure 4 shows the three types of points or "network nodes" that were used. The source (Winnipeg) is the node at which all the supply for the system is initially found. The "Transhipment points" (FF. LL. PAS. THOM.) are nodes which have a demand but can also have excess supply units allocated through them to satisfy system demands in the most optimal manner. The "sink" (Churchill) is a node from which no supply can be allocated.

The objective of the decision model was to minimize cost. Therefore, the objective function for the linear program used was:

$$\text{MINIMIZE} \sum_{i}^{n}\sum_{j}^{m} C_{ij}\, X_{ij} \qquad \text{(eqn. 11)}$$

where X_{ij} = supply allocated from node I to node J

C_{ij} = unit travel time in flying from node I to node J.

MPS linear programming was utilized, and a transhipment technology table (Table 10) was drawn up. The first decision showed the obvious, that the most beneficial (least cost in time) routing for passengers travelling from Winnipeg to the Northern cities is a direct flight. The total cost was 10678 minutes and the routes and volumes were as follows: XWP - 21, XWF - 13, XWL - 20, XWT - 50, XWC - 11. Where W=Winnipeg, P=The Pas, F=Flin Flon, L=Lynn Lake, T=Thompson, and C=Churchill.

Looking at the demand for travel to each city, and considering that the seating capacity of a Jet-Boeing 737 is 115, the conclusion then reached with this type of routing is that no flight would be

	XWP	XWF	XWL	XWT	XWC	XPF	XPL	XPT	XFP	XFL	XFT	XLP	XLF	XLT	XLC	XTP	XTF	XTL	XTC	DUDE
(SOURCE) W	1	1	1	1	1															115
P	-1					1	1	1	-1			-1				-1				-21
F		-1				-1			1	1	1		-1				-1			-13
L			-1				-1			-1		1	1	1	1			-1		-20
T				-1				-1			-1			-1		1	1	1	1	-50
(SINK) C					-1										-1				-1	-11
	78	86	104	90	122	41	59	58	41	52	55	59	52	56	71	58	59	56	67	MINIMIZE

TABLE 10

TRANSHIPMENT TECHNOLOGY TABLE

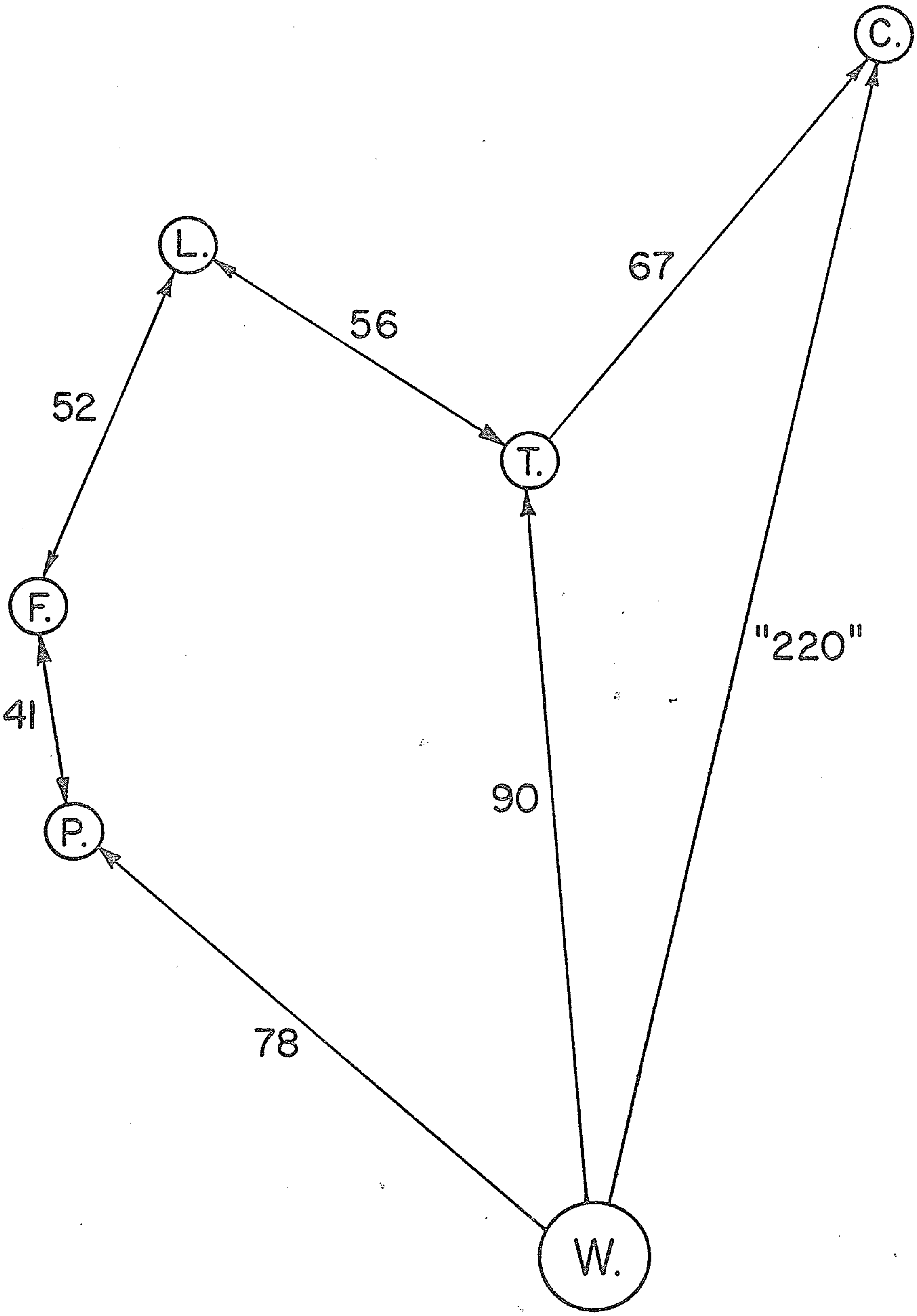


FIGURE 5

TRANSAIR-1971-NETWORK CONFIGURATION

even half full-and therefore not economical to run. Of course, Trans-Air does not offer direct daily jet flights to all these cities.

The next step in establishing a decision criterion was to reproduce the 1971 schedules and routes of TransAir.

Figure 5 shows that in 1971 direct daily jet service between Winnipeg and all northern communities was not available. Figure 5 also shows the new travel time given to the Winnipeg-Churchill direct route, which is due to the fact that no jet service is available, only AO propeller service. The new travel time cost for this route is 220 minutes.

Decision Run 2, utilizing these new costs showed that the total travel time cost is 12,332 minutes which is 1,654 minutes greater than run 1. The routing was changed and is: XWP-34, XPF-13, XWT-81, XTL-20, XTC-11, meaning that all demands are satisfied and the routing recommended is:

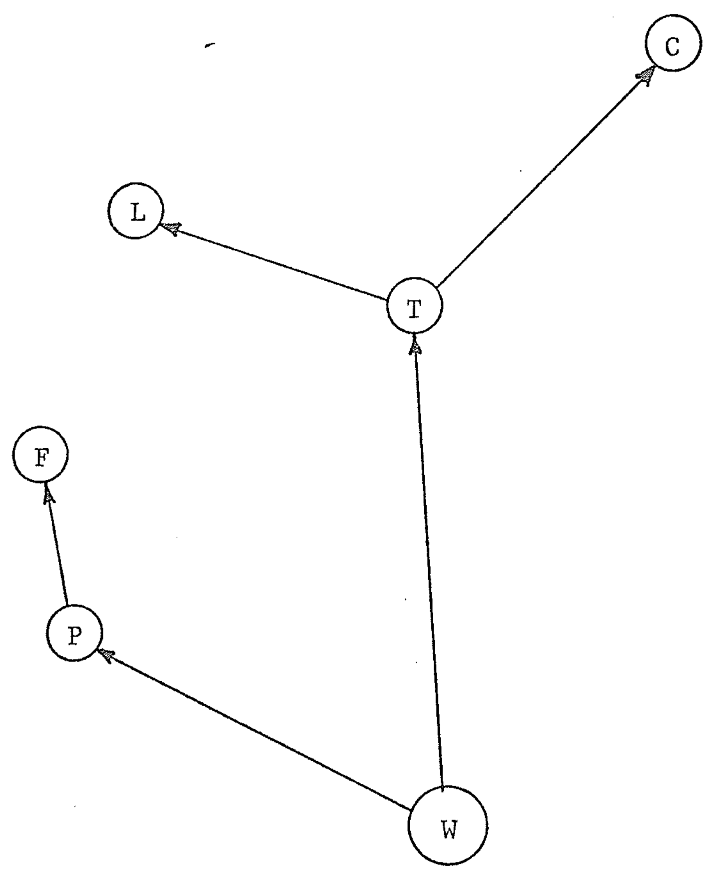


FIGURE 6

DECISION NETWORK CONFIGURATION

As a point of information the actual flight routing and frequency for the summer air travel of 1971 (effective June) is listed:

Jet service was offered between Winnipeg-The Pas, continuing to Lynn Lake on a basis of 7 flights per week (1 per day). The flights also continued to Thompson 6 days a week.

Winnipeg-Thompson direct jet service was offered 15 times a week (2 extra flights on Tuesday and Thursday and one extra flight on Monday, Wednesday, Friday and Saturday). On Tuesday, and Thursday one of the flights continued to Churchill, while on Monday, Tuesday, Wednesday, Thursday, Friday and Saturday, one of these flights continued to Lynn Lake.

According to the schedule there were no direct JET flights from Winnipeg to Churchill (though there were 2 direct jet flights from Churchill to Winnipeg).

6.1.2 Load (Capacity) Factor

Regional airlines normally try to schedule service for routes where the load ratio or factor is anticipated to be 0.65. The load factor of 0.65 was given by TransAir. Air Canada works on a 0.70 load factor. TransAir also told this author that a 0.65 factor gives them a very good profit margin, while the break-even point is about 0.48. On this basis, the Winnipeg-Thompson flights fulfill the 0.65 criterion and are profitable.

The others would seem not to; however, it should be pointed out that no inter-northern city demand was included in the data (only Winnipeg-northern cities). All inter city data was not available and thus could not be included in the model. The partial data that was available was analyzed, but still implied that only the Winnipeg-Thompson flights had a load factor which fulfills the 0.48 requirement for jet service where the capacity is 115 passengers.

There are a variety of other reasons which may affect the arrived at load factors. Some of these are:

1) The 1.24 factor may not be sufficient to represent the summer demand over the average demand.

2) The number of flights in the summer (for which this study was utilized) is considerably higher than in the winter schedule. If the decrease in capacity is more than the decrease in demand, and with fewer direct flights, a build up on demand may be possible.

3) Not all demands were included in the city-pair analysis, namely the demand for travel between inter-northern cities such as Flin Flon to Lynn Lake, or the domestic portions of international flights, or continuation of travel (demand) into the further northern regions (into the Arctic or northern areas of adjoining provinces).

4) The travel times and capacities are based on jet aircraft, while the daily load factors were derived from a total number of travellers by all types of class 1 carrier aircraft (slower and small propeller aircraft).

All these elements would increase the load factor. The exact average load factors for the whole year could not be calculated by this author in this study, since all the information necessary was not available. Right near the end of the thesis work, the author, however, was able to obtain from TransAir some raw data taken from a survey of TransAir's passenger and freight traffic for the summer months of June, July and August of 1971.

Analysis showed that the total combined jet load factors for these months were:

Winnipeg-Thompson	-	.50
Thompson-Lynn Lake	-	.45
Thompson- Churchill	-	.45
Winnipeg-The Pas	-	.45
The Pas-Flin Flon	-	.45

If one assumes that the three month summer figures (jet load factors) are representative from one year to another, then TransAir appears to be operating just on the break-even point during the summer months. Other seasonal statistics were not available; however, after adjusting to a smaller number of flights because of lower demand, the load factors would probably remain in the 0.40 to 0.50 range.

Analysis of the above summer load factors show that using just one-season schedules, averaging of demand over the whole year, averaging demand for a type of aircraft, and not including "Transhipment" pick-up would give misleading and erroneous results for an individual type of service - namely, jet service. The correct supply model must include more detailed schedule data, "particular" aircraft type demand data, and transhipment pickups. The inclusion of these factors should produce a useful model.

6.2 Recommendations for the Decision Model

Knowing the forecasted demand for air travel, and utilizing the decision model methodology, optimum routing for minimizing travel time costs for passengers can be studied and most optimum routes pin-pointed (given that all pertinent OD data is available). In the case of new technology, such as V/STOL, the shortened (decreased) travel time--both in air time and terminal time (also airport to CBD--central business district) can be put into the network diagram and decisions on optimum routing achieved.

One factor that has not been discussed is the actual operating costs of the airlines. Because of insufficient demand and high costs of operation - both fixed and variable, some routes cannot be economically feasible except at extremely high fare levels. The purpose of companies such as TransAir is not only to serve the travel demands of the public, but also to produce profit margins for the company shareholders.

Figure 7 shows the historic development of TransAir's number of passengers carried and revenue earned since 1963. The big reason for TransAir operating in the black in recent years is the lucrative Toronto and U.S. charter runs.

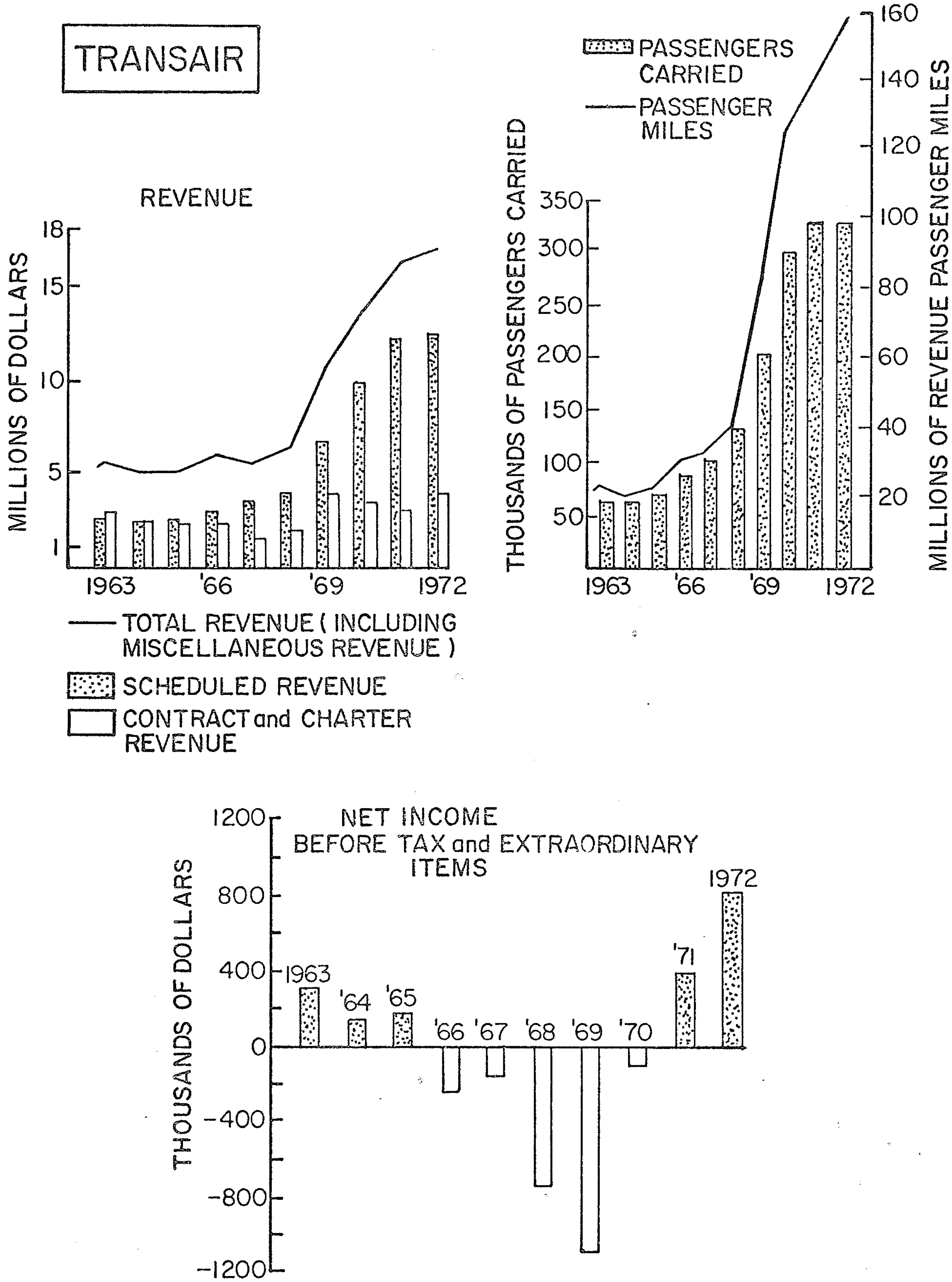


FIGURE 7
REFERENCE 46

In regard to Northern Manitoba, TransAir claims that some of the routes are unprofitable and the frequency of service should be curtailed. The load factors seem to corroborate this fact.

If the provincial government wishes to maintain the level of service and/or prevent higher fares for these low-demand-volume northern cities, a possible solution may lie in the subsidy area.

CHAPTER SEVEN
CONCLUSION

7.1 Summary and Discussion of the Final Model

Through the use of regression analysis techniques a forecasting model has been established which appears reliable. As stated on page 45, the final model was equation 9 namely:

$$\ln Q_{ij} = -18.27443 + 0.43984\ (\ln \text{Capacity}) + 0.48074\ (\ln I_i \times I_j) + 1.05986\ (\ln \text{Actual shortest route distance}) \quad (9)$$

This model, proven to be statistically valid, is a practical tool for transportation planners. The exclusion of nonsignificant variables is correct for the following reasons:

1. Population by itself was not utilized since it is included in the income variable.

2. Fare and its variations were not utilized. It had a high intercorrelation with capacity and provided poorer results. Also because of the "captive" nature-namely no viable or competitive alternative of transport, of the remote or in this case northern traveller, fare does not have an appreciable influence on air travel.

3. Air travel time proved insignificant. Again the reason was the lack of alternative modes.

4. Frequency was highly intercorrelated with capacity, and since capacity gave better results, frequency was discarded.

5. Level of Service or the ratio of shortest air travel to shortest other mode travel times was of low significance. The contribution of it to the equation was small in this case, however, it was looked at closely because if there are other viable transport alternatives in other study areas the level of service could prove significant. In such a case, fare and other variables may become important also.

All other variables and forms considered in the data set proved insignificant.

The three independent variables left in the equation were Capacity, Income and Distance.

Capacity

Capacity proved to be highly significant in the model. The sign of the coefficient was positive, inferring that as capacity increases, the number of trips will increase. Looking at the relatively low load factors of the 1971 TransAir summer schedule one would infer that there are plenty of empty seats available, thus implying that travel demand in this study case should not be so sensitive to capacity. The matter is not quite that simple.

After the completion of the Master's course requirements, the author recently had the good fortune to obtain an engineering position with the Manitoba Department of Northern Affairs. Work demands have enabled him to personally travel all the air routes of TransAir and those of other carriers in Northern Manitoba. Interesting observations were made during these travels namely:

Most weekend flights to all five northern destinations were booked solid. For personal, social, family and business reasons many people travel from and to the north on Fridays through Mondays. On these days people come to Winnipeg to go to the theatre, and other social and entertainment (WHA hockey) events. People also come to Winnipeg for medical appointments. Most business trips to the north also seem to come at the end or beginning of the week. Travellers appear to lengthen their stay in the north or in Winnipeg over several days. There appears to be little inclination or reason for same day return flights.

On Tuesday, Wednesday and Thursday, however, the number of seats filled is small. These are obviously the "stay over" days.

Frequency or the number of flights available on weekends also has a direct effect on capacity and air travel demand.

Given the above information, one would assume that TransAir should make adjustments in schedules and number of flights, and thus improve service, and operating profits. Again the answer is not that simple. First of all TransAir's schedules are licensed, and regulated by government agencies. Being a regional carrier TransAir is approved routes and schedules which meet and service the needs of the people of the region, in this case Northern Manitoba. Thus for political, social, economic development and health service reasons, the low load factor days of Tuesday, Wednesday and Thursday must still receive certain levels of service. For economic reasons, TransAir cannot afford to purchase more planes to put on the high demand days. Since the cost of purchasing, servicing and maintaining modern airplanes is high, because there would be a 50% disuse factor during the week caused by the low demand days, and because of the need for interconnecting flight schedules, with their corresponding long travel times, turn around times and the basic low one way-one day turn around factor, it is unrealistic for TransAir to invest in a large number of new flights or planes.

All these factors negate the seemingly low load factors and make the effect of capacity (number of seats available) on air travel demand significant.

Income

The cross product of incomes of major center and remote communities has a high significance on air travel demand. As in other traditional studies, as income increases so does air travel demand (De Vany, Garges Study). The income variable can take various forms. In this study case, the best form was the undepreciated cross product. In the Windsor-Quebec Intercity Passenger Transport Study the income variable was based on the fraction of families with annual incomes greater than $12,000. Fractional breakdowns are not maintained by Statistics Canada, or by the Department of National Revenue for the small communities of Northern Manitoba. If they were available, then the fraction used would have been less than $12,000 since the average income in Manitoba is less than that of the East. Other reasons for using a smaller dollar fraction would be the fact that a high percentage number of trips to and from the North are for business reasons, and that there are no viable alternative modes thereby compelling the residents to utilize air transport even though their incomes are low.

Use of the income variable appears to be the one best method of assessing the relationship between the economic growth of communities and the increase in air travel. Municipal taxes contribute to the operation, and to some degree the expansion, of air facilities in the communities. As more people can afford air travel, and as communities become richer and more growth prone, they can demand, afford and obtain better air service.

When separate models were compared for individual city pairs, the most important independent variable four out of five times was income, thus implying that demand shifts from year to year can be generally measured by the yearly income shifts of the communities.

<u>Distance</u>

In the De Vany model as in many others, as distance increases, air travel demand decreases. In the study case model the reverse was true-as distance increases air travel increases.

This "anti-gravity" distance phenomenon of travel demand was also observed by T. Sulymko (T.G.L. Sulymko, 1971) in his study of a low density demand model. If one considers shorter routes, it seems logical that other modes of travel (bus, rail, auto) become more attractive. The travel time differential decreases between the modes and the fare by the alternative modes is considerably less. Thus, for short haul distances, the demand for air travel is small. As distances increase, however, the time saved by air travel becomes a significant factor in an individual's choice of mode. Also, many of the regional medium haul routes extending to resource centered communities in Canada's North, specifically in this study case, Northern Manitoba do not have alternative transportation systems which are as well developed as those further south. Since the distance variable in the study case was in medium haul range, namely 300 to 800 mile range (a long haul range would be for flights over 1,000 miles), it is stated that the demand for air travel may increase with distance because of the mere lack of adequate competition in these areas from other modes or the lack of any closer major center which may draw away the travel demand of northern communities (remembering the half wheel development pattern of Canada, there are no major centers north of the remote communities which may draw away traffic from, in this case, Winnipeg). In other words no viable intervening or competitive opportunity centers exist.

7.2 Implications and Applications of the Model

The model appears to be valid for the time period of the data set; however, as all transportation planners are aware, the demand and need for transportation is multifaceted, arising from and affected by changing phenomena. Within the scope of this premise one may ask how well the model will hold up under strong economic stresses such as recession or, at this particular time, the energy crisis.

Given the parameters or variables included in the equation, this author feels that the model can handle such phases relatively safely.

Recession

If there is a recession, then money will become tight. The economic base of the communities will either be reduced or remain static (jobs, incomes, retail and wholesale indexes will drop). This will be accompanied by a drop in investment or risk capital. Airline companies will not invest capital into new planes and routes. People will be less able to afford to fly and have fewer opportunities (seats) to do so. The populace will become less demanding of air travel needs, as they slowly get used to doing without and adjust to reduced air service. This falls within the theory of supply and demand. Of course, after the recession, better service will be demanded and obtained. The model will work.

The Energy Crisis

A very current topic on the minds of people today is the energy crisis. The shortages of fuel have already had an effect on the airline companies of North America. Schedules have been reduced and the larger airships (such as the Boeing 747 which consumes large quantities of fuel) have been withdrawn from certain routes. If the energy crisis persists, then in Manitoba one can foresee Trans-Air withdrawing some of its jet airplanes and reducing schedules. Jets use appreciably larger quantities of fuel (and more expensive mixtures) than propeller driven aircraft and demand high service and maintenance costs in dollars and time. TransAir would consolidate its jet routings and schedules so as to maximize earnings (and load factors) and minimize costs (given that the regulatory government agencies allow them to do so). Propeller aircraft would become more economical, and other prototypes will be brought out of mothballs to fill in schedule gaps. It should also be realized that if the energy crisis persists, then other industries will also be affected and a recession would be in the making.

The problem with the energy crisis is that a sudden curtailment of air service would be immediately felt. There would be a lag time before people adjusted to the poorer level of service. This would no doubt arouse the ire of many people. Hopefully other modes will at this point receive more incentive to improve service and become more competitive with air travel. In such a case, the level of service variable should then be reintroduced into the model (equation 9).

It must be granted that there will be short range stresses on the model, which should level off, making the model valid over a long range period. If these stresses continue, then the model must be re-investigated and changed as need be. In any event, constant re-evaluation of the model is required in any systems approach.

The one factor not discussed yet is the effect of governmental policy decisions on air travel demand (and supply).

7.3 Government Policies

Governments, both Federal and Provincial, contribute funds for the construction, maintenance and operation of airports. They license and regulate the regional air carriers. They construct, develop and subsidize alternative modes of transport. Some airlines are also subsidized by the government (although in the study case TransAir has never received a subsidy on any of the routes). They control community and area development programs. All these factors illustrate the fact that governmental policies have a great effect on the development of remote communities and on air travel to and from these communities.

7.3.1 The Federal Position

The Ministry of Transport has a public assistance program available for community group airports. This assistance program is based on the recognized need for the airport to:

a) accommodate a certain class of air carrier service;
b) relieve isolation;
c) provide an emergency landing facility;
d) provide access to recreational areas;
e) relieve congestion at major airports.

The airports are classified into feeder, local industrial, local intermediate, small local or remote groups. The policy is not a development one but strictly an assistance program.

Normally the provincial government or municipality applies for assistance, and after an economic review of the area, project assistance may or may not be granted. This grant would have a large effect on the supply aspects of air travel, eventually causing a shift in the demand curve.

7.3.2 The Provincial Position

The Province of Manitoba has a combination of development and assistance programs for community airstrips. The Department of

Industry and Commerce and M.O.T. administers the airstrips in the southern section of the province, and the municipal airstrips of the north, while in the north, for remote communities, the Provincial Department of Northern Affairs has jurisdiction over policy matters.

In general the policy for remote communities is to provide facilities for twelve months of air transportation (VFR) for all northern communities of one hundred or more persons without access by road or rail.

The potential regional centers of Norway House and Garden Hill (Island Lake) should have higher class airstrips. These airstrips would link up the eastern, central and northern Manitoba communities with both Winnipeg and Thompson on a scheduled and lower cost basis.

Centers without all-weather access with populations of five hundred or more would have lower standard airstrips. These strips would facilitate scheduled passenger service and flight service, and reduce access costs and the generally high costs of living in the north. These strips would link up to the regional airports and to main airports at Thompson, Flin Flon, Lynn Lake, Churchill, The Pas and Gillam.

The other type of airdrome would be the airstrips used for exploration and development purposes in northern Manitoba. These strips would be authorized by the provincial government but financed by the development or exploration companies involved. They would be available to the general public on an emergency basis only, and upon completion of the exploration or development project the control could revert to the provincial government.

This policy is a development one, and though it has listed justification purposes it is not a hard policy. Therefore, it becomes extremely susceptible to politics. The communities request the airstrip development and depending (among other factors) on the influence of community council, corporations, etc. the actual design, class and capital expended can thus be affected.

This therefore brings into the supply portion a variable which is not considered in the demand equation.

The government may also influence the growth of communities through such programs as winter works, development grants, manpower programs, PEP, etc. Even internal departmental policies will have an effect on air travel. The decentralization program of government departments to the north (an example is the relocation of sections of the Department of Northern Affairs to Thompson and other communities) will also effect the air travel demands of the communities. A major increase of business and personal trips between Winnipeg and Thompson is foreseen as soon as the move is made.

7.4 Recommendations for Further Study

The next step is to test the demand equation for other major center--low density areas in Canada such as in Ontario, Alberta, British Columbia, Saskatchewan, etc. Depending on results, the model should then be tested on other nations such as the United States, Australia and Western Europe.

Since politics and government policies no doubt have an effect on air travel, some index or measure of it should be added into the model. At the time of this writing no indices in data form were available. The newly formed Manitoba Bureau of Statistics, however, is compiling information which the author feels can be useful. This information will include employment indices for northern communities, industrial investment indices and hopefully some figures on government investment in the communities on a year to year basis. One or a combination of such indices should be added into the input data set to see if it will become a significant variable.

Also, as data becomes available in the small remote communities of Northern Manitoba, the historical and OD data should be compiled and entered into the data set, and the model tested on these small communities.

On the supply aspect of air travel, a separate detailed study should be undertaken to ascertain the supply functions of major center-remote community air travel. This supply model will complement the forecasting model developed.

The forecasting model developed here appears to work. Testing it against Gillam produced only a 3% error. System analysis, however, requires that the transportation planner constantly re-evaluate the model. It may be found that another model using different techniques may give better results. In any case, the model developer and transportation planner must rely on his good judgment and retain an open and objective mind with regard to the real-world pitfalls, shortcomings and advantages of his model.

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APPENDIX A

TABLES

	1	2	3	4	5	6	7	8
City-pair Wpg.-	Qij #pass. Trips	Pj Pop.	Dij Distance (miles)	Fij Fare (¢/mi.)	Travel Time (min./mi.)	Number Flights per wk.	Air Tij / T.T.	Capacity seats / week
1961								
Churchill	5415	3932	623	10.754	.313	5	.085	282
Flin Flon	3240	12833	378	9.259	.556	6	.230	132
Lynn Lake	1660	2118	505	9.307	.574	5	.187	111
The Pas	3050	4671	325	8.923	.369	12	.157	436
Thompson	4675	3449	407	11.057	.491	6	.147	304
1962								
C	5430	3710	623	10.754	.313	5	.085	325
FF	2995	12640	378	9.259	.556	6	.230	132
LL	1680	2120	505	9.307	.574	6	.187	132
PAS	2445	4683	325	8.923	.354	12	.150	436
Thomp	5985	4280	407	11.057	.491	6	.154	304
1963								
C	4565	3567	623	10.754	.377	5	.103	241
FF	2840	12458	378	9.259	.251	12	.104	396
LL	1905	2129	505	9.307	.327	6	.104	264
PAS	2060	4719	325	8.923	.385	7.5	.163	165
Thomp	5225	5195	407	11.057	.319	9	.167	241
1964								
C	3330	3480	623	10.754	.401	4	.114	176
FF	3255	12263	378	9.259	.251	6	.127	264
LL	1715	2140	505	9.307	.317	6	.107	264
PAS	2025	4773	325	8.923	.369	6	.195	132
Thomp	5515	6189	407	11.057	.504	6	.161	132
1965								
C	3715	3481	623	10.754	.217	5	.062	220
FF	4020	12081	378	9.259	.238	9	.118	330
LL	2385	2160	505	9.307	.307	6	.103	264
PAS	2635	4872	325	8.923	.369	6	.190	132
Thomp	5515	7325	407	11.057	.504	6	.161	132
1966								
C	4970	3579	623	10.754	.465	5	.132	325
FF	4280	11911	378	9.259	.397	7	.196	283
LL	2735	2189	505	9.307	.446	7	.150	283
PAS	3525	5031	325	8.923	.354	12	.183	651
Thomp	6045	8989	407	11.057	.479	6	.153	390
1967								
C	5945	3857	623	10.754	.474	6	.137	390
FF	4825	11757	378	9.259	.423	6	.209	390
LL	3680	2263	505	9.307	.455	6	.153	390
PAS	4120	5076	325	8.923	.354	12	.183	780
Thomp	10445	11610	407	11.057	.479	6	.147	390
1968								
C	5690	4460	623	10.754	.474	7	.139	455
FF	4815	11602	378	9.259	.423	8	.216	373
LL	5155	2372	505	9.307	.446	8	.154	373
PAS	5570	5201	325	8.923	.354	15	.195	681
Thomp	19165	15000	407	11.057	.258	10	.114	587
1969								
C	7195	3970	623	10.754	.329	7	.097	322
FF	6300	11458	378	10.053	.291	7.5	.149	345
LL	7930	2528	505	10.099	.347	10	.120	460
PAS	8225	5480	325	9.846	.292	7	.161	322
Thomp	32245	18000	407	11.057	.283	2.15	.125	989
1970								
C	5050	3182	623	10.754	.353	7	.104	280
FF	8015	11323	378	10.053	.278	7	.148	701.5
LL	9515	2741	505	10.495	.248	13	.086	1184.5
PAS	12525	6000	325	9.846	.185	7	.104	701.5
Thomp	31595	19000	407	10.663	.172	18	.074	1885.5
1971								
C	6525	2991	623	10.754	.144	8	.062	470
FF	8405	11201	378	10.663	.265	7	.141	805
LL	12785	3012	505	10.495	.248	13	.081	1495
PAS	12930	6062	325	9.846	.185	7	.104	805
Thomp	28885	19145	407	10.663	.147	16	.059	1840

TABLE 1

DATA - PHASE I

	9	10	11	12	13	14	15	16
	Fare (¢/mi.) Direct Dep.	Fare (%) Direct Dep.	Fare (Actual Change) Direct Dep.	Fare (¢/mi.) Actual Dep.	Fare (%) Actual Dep.	Fare (Actual Change) Actual Dep.	Travel Time (min/mi) Actual Distance	Fare Var. same as Var. 14
1961								
C	10.686	100.000	0.000	10.686	100.000	0.000	.311	S
FF	9.333	100.000	0.000	8.621	100.000	0.000	.517	A
LL	8.935	100.000	0.000	8.438	100.000	0.000	.521	H
PAS	9.034	100.000	0.000	9.034	100.000	0.000	.374	E
Thomp	11.029	100.000	0.000	8.982	100.000	0.000	.399	
1962								
C	10.579	98.999	.107	10.579	98.999	.107	.311	
FF	9.240	99.004	.093	8.534	98.991	.087	.517	A
LL	8.846	99.004	.089	8.354	99.005	.084	.521	S
PAS	8.944	99.004	.090	8.944	99.004	.090	.374	
Thomp	10.919	99.003	.110	8.892	98.998	.090	.399	
1963								
C	10.365	96.996	.321	9.847	92.149	.839	.356	V
FF	9.053	97.000	.280	9.053	105.011	-.432	.253	A
LL	8.667	97.001	.268	8.667	102.714	-.229	.314	R.
PAS	8.763	97.000	.271	8.763	97.000	.271	.389	1
Thomp	10.699	97.008	.330	10.699	119.116	-1.717	.319	4
1964								
C	10.152	95.003	.534	7.762	72.637	2.924	.305	E
FF	8.867	95.007	.466	8.867	102.853	-.246	.253	X
LL	8.488	94.997	.447	8.489	100.604	-.051	.304	C
PAS	8.583	95.008	.451	8.583	95.008	.451	.374	E
Thomp	10.478	95.004	.551	8.533	95.001	.449	.409	P
								T
1965								
C	9.938	93.000	.748	9.938	93.000	.748	.179	L
FF	8.680	93.003	.653	8.680	100.684	.059	.240	O
LL	8.310	93.005	.625	8.310	98.483	.128	.295	W
PAS	8.402	93.004	.632	8.402	93.004	.632	.374	E
Thomp	10.257	93.000	.772	8.353	92.997	.629	.409	R
1966								
C	9.617	89.996	1.069	8.008	74.939	.974	.385	L
FF	8.400	90.003	.933	8.400	97.436	.221	.400	N
LL	8.042	90.006	.893	8.042	95.307	.396	.428	O
PAS	8.131	90.004	.903	8.131	90.004	.903	.358	F
Thomp	9.926	89.999	1.103	8.084	90.002	.898	.389	
1967								
C	9.297	87.002	1.389	7.741	72.441	2.945	.392	M
FF	8.120	87.003	1.213	8.120	94.189	.501	.427	I
LL	7.774	87.006	1.161	7.774	92.131	.664	.437	N
PAS	7.860	87.005	1.174	7.860	87.005	1.174	.358	U
Thomp	9.596	87.007	1.433	7.814	86.996	1.168	.389	S
1968								
C	8.869	82.996	1.817	7.385	69.686	3.194	.392	N
FF	7.747	83.007	1.586	7.155	82.995	.501	.394	O.
LL	7.416	82.999	1.519	7.004	83.005	1.434	.404	
PAS	7.498	82.998	1.536	7.498	82.998	1.536	.358	
Thomp	9.154	82.999	1.875	9.154	101.915	-.172	.257	
1969								
C	8.549	80.002	2.137	8.121	75.997	2.565	.311	A
FF	8.107	86.864	1.226	8.107	94.038	.514	.293	L
LL	7.757	86.816	1.178	7.757	91.929	.681	.333	L
PAS	7.975	88.278	1.059	7.975	88.278	1.059	.296	O
Thomp	8.824	80.007	2.205	8.824	98.241	.158	.282	W
								E
								D
1970								
C	8.228	76.998	2.458	7.817	73.152	2.869	.333	
FF	7.803	83.607	1.530	7.803	90.512	.818	.280	F
LL	7.759	86.838	1.176	7.393	87.616	1.045	.226	O
PAS	7.676	84.968	1.358	7.676	84.968	1.358	.187	R
Thomp	8.115	73.579	2.914	8.115	90.347	.867	.172	
1971								
C	8.014	74.995	2.672	8.014	74.995	2.672	.144	
FF	7.600	81.431	1.733	7.600	88.157	1.021	.267	
LL	7.557	84.578	1.378	7.201	85.340	1.237	.226	
PAS	7.477	82.765	1.557	7.477	82.765	1.557	.187	
Thomp	7.904	71.666	3.125	7.904	87.998	1.078	.147	

TABLE 3

DATA - PHASE II

	17	18	19	20	21	22	23
	$\sqrt{Pi \times Pj}$ Sq. Root of Cross Product of Populations	$Pi \times Pj \times 10^2$ Cross Product of Populations	$Ii \times Ij \times 10^9$ Cross Product of Incomes	$\sqrt{Ii \times Ij} \times 10^3$ Sq. Root of Cross Product of Incomes	$Ii^* \times Ij^* \times 10^9$ Cross Product of Dep. Incomes	$\sqrt{Ii^* \times Ij^*} \times 10^3$ Sq. Root of Cross Product of Dep. Incomes	Dij* Actual Shortest Route Distance
1961							
C	43285.078	18735980.	2277866.	47726.99	2277866	4772699	627
FF	78197.953	61149245.	12565344.	112095.24	12565344	11209524	406
LL	31769.333	10092270.	3446817.	58709.60	3446817	5870960	557
PAS	47177.659	22257315.	4237890.	65099.08	4237890	6509908	321
Thomp	40539.465	16434485.	6215572.	78838.90	6215572	7883890	501
1962							
C	42331.194	17919300.	2338128.	48354.20	2291366	4787066	627
FF	78135.267	61051200.	13126074.	114569.08	12863552	11342338	406
LL	31999.375	10234600.	3625519.	60212.78	3553067	5961065	557
PAS	47559.321	22618590.	4720651.	68787.00	4626236	6801993	321
Thomp	45466.911	20672400.	7547128.	86874.18	7396180	8600544	501
1963							
C	41781.453	17456898.	2438974.	49385.97	2292636	4790439	660
FF	78082.938	60969452.	13832054.	117609.75	13002130	11408145	375
LL	32278.981	10419326.	3907360.	62508.88	3672918	6063361	526
PAS	48057.035	23094786.	5314011.	72897.25	4995169	7071033	321
Thomp	50422.545	25424330.	9182296.	95824.30	8631358	9294957	408
1964							
C	41541.931	17257320.	2595526.	50946.26	2335969	4839895	820
FF	77982.188	60812217.	16033625.	126623.95	14430261	12029275	375
LL	32576.464	10612260.	4270052.	65345.63	3843046	6207835	526
PAS	48651.112	23669307.	6195761.	78713.16	5576185	7477750	321
Thomp	55399.685	30691251.	11449599.	107002.80	10304638	10165266	501
1965							
C	41806.819	17478101.	2771855.	52648.41	2383795	4896302	627
FF	77883.696	60658701.	17912374.	133837.12	15404641	12446852	375
LL	32932.294	10845360.	4674933.	68373.48	3998423	6358734	526
PAS	49459.389	24462312.	7426209.	86175.46	6386540	8014318	321
Thomp	60645.548	36778825.	15747714.	125487.62	13543034	11670348	501
1966							
C	42673.120	18209952.	3160557.	56218.83	2560051	5059695	753
FF	77848.037	60603168.	22275848.	149250.96	18043436	13432586	375
LL	33373.091	11137632.	5571495.	74642.44	4512911	6717820	526
PAS	50594.197	25597728.	9522191.	97581.71	7712974	8782354	321
Thomp	67628.420	45736032.	23805477.	154290.23	19282435	13886120	501
1967							
C	44568.543	19863550.	3538734.	59487.26	2689438	5175392	753
FF	77812.949	60548550.	25058003.	158297.20	19044082	13771856	375
LL	34138.615	11654450.	6803895.	82485.72	5170960	7176258	526
PAS	51128.661	26141400.	12142454.	110192.81	9228265	9586777	321
Thomp	77324.964	59791500.	35546833.	188538.68	27015593	16402865	501
1968							
C	48213.608	23245520.	4147034.	64397.47	2861453	5344990	753
FF	77762.217	60469624.	30803049.	175507.97	21254103	14567161	406
LL	35160.865	12362864.	8473524.	92051.75	5846732	7640295	557
PAS	52064.971	27107612.	14908324.	122099.65	10286743	10134270	321
Thomp	88419.455	78180000.	51733545.	227450.09	35696146	13878357	408
1969							
C	45779.504	20957630.	4786444.	69184.13	3063324	5534730	660
FF	77773.249	60486782.	35617724.	188726.58	22795343	15098126	375
LL	36531.236	13345312.	10979950.	104785.26	7027168	8382821	526
PAS	53785.611	28928920.	21754845.	147495.24	13923100	11799619	321
Thomp	97479.229	95022000.	68248642.	261244.41	43679130	20899552	408
1970							
C	41221.208	16991880.	5004362.	70741.51	2952573	5447096	660
FF	77759.128	60464820.	39946789.	199866.93	23568604	15389753	375
LL	38258.254	14636940.	16691206.	129155.74	9841911	9944992	552
PAS	56603.887	32040000.	28174498.	167852.61	16622953	12924650	321
Thomp	100727.359	101460000.	90140185.	300233.55	53182709	23117983	408
1971							
C	40199.966	16160373.	5200583.	72115.10	2912329	5408633	627
FF	77733.961	60519603.	41259052.	203123.24	23105069	15234243	375
LL	40340.843	16273836.	20016471.	141791.08	11205863	10634331	552
PAS	57230.225	32752966.	36751348.	191706.41	20580754	14377980	321
Thomp	101705.671	103440435.	91438380.	302387.80	51205492	22679085	408

TABLE 4

DATA - PHASE II

	24	25	26
	$F^{\sim}_{ij}$ Fare undep. based on actual distance	$\ln (C_{ij} \times D_i{}^{a}{}_j)$ cross product of capacity & actual distance	$\ln \left[\frac{T_{ij}}{\Sigma T} \times D_i{}^{a}{}_j \right]$ log of cross product of L.S. and actual distance
1961			
C	.1960	12.0828	3.9758
FF	.0862	10.8892	4.5367
LL	.0844	11.0321	4.6460
PAS	.0903	11.8490	3.9199
Thomp	.0898	11.9336	4.2993
1962			
C	.1069	12.2247	3.9758
FF	.0862	10.8892	4.5367
LL	.0844	11.2054	4.6460
PAS	.0903	11.8490	3.8743
Thomp	.0898	11.9336	4.3458
1963			
C	.1015	11.9770	4.2192
FF	.0933	11.9083	3.6635
LL	.0894	11.8412	4.0019
PAS	.0903	10.8773	3.9574
Thomp	.1103	11.4961	3.7087
1964			
C	.0817	11.8798	4.5377
FF	.0933	11.5028	3.8633
LL	.0894	11.8412	4.0304
PAS	.0903	10.6542	4.1366
Thomp	.0898	11.0994	4.3902
1965			
C	.1069	11.8345	3.6603
FF	.0933	11.7260	3.7898
LL	.0894	11.8412	3.9923
PAS	.0903	10.6542	4.1107
Thomp	.0898	11.0994	4.3902
1966			
C	.0890	12.4079	4.5991
FF	.0933	11.5723	4.2973
LL	.0894	12.1239	4.5814
PAS	.0903	12.2499	4.0731
Thomp	.0898	12.1827	4.3393
1967			
C	.0890	12.5902	4.6363
FF	.0933	11.8930	4.3615
LL	.0894	12.2314	4.3880
PAS	.0903	12.4307	4.0731
Thomp	.0898	12.1827	4.2993
1968			
C	.0890	12.7444	4.6508
FF	.0862	11.9280	4.4739
LL	.0844	12.2442	4.4518
PAS	.0903	12.2950	4.1366
Thomp	.1103	12.3863	3.8397
1969			
C	.1015	12.2668	4.1592
FF	.1013	11.7704	4.0231
LL	.0970	12.3965	4.1450
PAS	.0997	11.5460	3.9450
Thomp	.1103	12.9080	3.9319
1970			
C	.1015	12.1270	4.2288
FF	.1013	12.4801	4.0164
LL	.0960	13.3906	3.8601
PAS	.0997	12.3246	3.5080
Thomp	.1054	13.5532	3.4076
1971			
C	.1069	12.5936	3.6603
FF	.1013	12.6177	3.9679
LL	.0960	13.6234	3.8002
PAS	.0997	12.4622	3.5080
Thomp	.1054	13.5288	3.5922

TABLE 5

DATA - PHASE II

GROUP NO.	VARIABLES IN ORDER OF ENTRY	MULTIPLE CORR. COEFF.	INTERCEPT
1.	8,19,23,7,17,10,15	.895	-9.51609
	8,20,23,7,17,10,15	.895	-9.50686
	8,17,23,21,7,10,15	.891	-6.503034
	8,17,23,22,7,10,15	.816	-5.89220
	8,19,23,7,17,5,10	.901	-2.53200
	8,20,23,7,17,5,10	.894	-2.52375
	8,17,23,21,7,10,5	.897	0.66739
	8,17,23,22,7,10,5	.896	0.84896
2.	8,19,23,7,18,10,15	.896	-8.63387
	8,20,23,7,18,10,15	.896	-8.62429
	8,18,23,21,7,10,15	.892	-5.23065
	8,18,23,22,7,10,15	.817	-5.07320
	8,19,23,7,18,5,10	.902	-1.23433
	8,20,23,7,18,5,10	.902	-1.22586
	8,18,23,21,7,10,5	.898	1.93940
	8,18,23,22,7,10,5	.897	2.14228
3.	8,19,3,7,17,15,10	.890	-5.63301
	8,20,3,7,17,15,10	.890	-5.62413
	8,17,3,21,10,7,15	.885	-2.02992
	8,17,3,22,10,7,15	.885	-1.80586
	8,19,3,7,5,10,17	.902	1.35511
	8,20,3,7,5,10,5	.834	1.36283
	8,17,3,31,10,7,5	.827	4.98775
	8,17,3,22,10,7,5	.897	5.23171
4.	8,19,3,7,18,15,10	.891	-4.44607
	8,20,3,7,18,15,10	.891	-4.43713
	8,18,3,21,10,7,15	.886	- .88658
	9,18,3,22,107,15	.886	- .64045
	8,19,3,7,5,10,18	.896	-1.76969
	8,20,3,7,5,10,18	.903	2.68509
	8,18,3,21,10,7,5,	.829	6.34274
	8,18,3,22,10,7,5,	.829	6.60255

TABLE 6

INITIAL GROUP RUNS OF PHASE II (DISTANCE)

GROUP NO.	VARIABLE IN ORDER OF ENTRY	MULTIPLE CORR. COEFF.	INTERCEPT
5.	8,19,23,7,17,10	.893	-12.75335
	8,20,23,7,17,10	.893	-12.74426
	8,17,23,21,7,10	.890	- 9.12253
	8,17,23,22,7,10	.889	- 8.98109
	8,19,23,7,17,10	.893	-12.75335
	8,20,23,7,17,10	.893	-12.74426
	8,17,23,21,7,10	.890	- 9.12253
	8,17,23,22,7,10	.889	- 8.98109
6.	8,19,23,7,18,10	.893	-12.22032
	8,20,23,7,18,10	.893	-12.21084
	8,18,23,21,7,10	.890	- 8.66206
	8,18,23,22,7,10	.889	- 8.50569
	8,19,23,7,18,10	.893	-12.22032
	8,20,23,7,18,10	.893	-12.21084
	8,18,23,21,7,10	.890	- 8.66206
	8,18,23,22,7,10	.889	- 8.50569
7.	8,19,3,7,17,10	.882	-13.50037
	8,20,3,7,17,10	.879	-13.49099
	8,17,3,21,10,7	.879	- 9.64652
	8,17,3,22,10,7	.879	- 9.44080
	8,19,3,7,17,10	.882	-13.50037
	8,20,3,7,17,10	.882	-13.49099
	8,17,3,21,10,7	.879	- 9.64652
	8,17,3,22,10,7	.879	- 9.44080
8.	8,19,3,7,18,10	.883	-12.99127
	8,20,3,7,18,10	.883	-12.98159
	8,18,3,21,10,7	.880	- 9.21561
	8,18,3,22,10,7	.879	- 8.99403
	8,19,3,7,18,10	.883	-12.99127
	8,20,3,7,18,10	.883	-12.98159
	8,18,3,21,10,7	.880	- 9.21561
	8,18,3,22,10,7	.879	- 8.99403

TABLE 7

INITIAL GROUP RUNS OF PHASE II (CAPACITY)

RUN	R	F	Stand. Error of Est.	Var.	Reg. Coeff.	Stand. Error of Reg. Coeff.	Computed T-Value
1.	.891	51.826	0.329	8	0.324	0.096	3.377
				19	0.509	0.067	7.647
				23	0.868	0.214	4.062
				7	-0.402	0.179	-2.250
2.	.891	51.815	0.329	8	0.324	0.096	3.375
				20	1.018	0.133	7.645
				23	0.868	0.214	4.061
				7	-0.402	0.179	-2.250
3.	.877	44.763	0.349	10	-1.674	0.775	-2.160
				19	0.529	0.077	6.851
				7	-0.622	0.167	-3.730
				23	0.653	0.241	2.706
4.	.877	44.770	0.349	10	-1.675	0.775	-2.160
				20	1.058	0.154	6.852
				7	-0.622	0.167	-3.729
				23	0.653	0.241	2.706

TABLE 8

INITIAL GROUP RUNS OF PHASE II (FARE)

RUN	R	F	Stand. Error of Est.	Var.	Reg. Coeff.	Stand. Error of Reg. Coeff.	Computed T-Value
1.	.891	51.826	0.329	8	0.324	0.096	3.377
				19	0.509	0.067	7.647
				23	0.868	0.214	4.062
				7	-0.402	0.179	-2.250
2.	.891	51.814	0.329	8	0.324	0.096	3.375
				20	1.018	0.133	7.645
				23	0.868	0.214	4.061
				7	-0.402	0.179	-2.250
3.	.881	46.694	0.343	8	0.425	0.094	4.541
				21	0.530	0.075	7.058
				23	0.934	0.229	4.081
				7	-0.400	0.186	-2.142
4.	.880	46.230	0.345	8	0.427	0.094	4.543
				22	1.056	0.151	7.003
				23	0.932	0.230	4.055
				7	-0.396	0.187	-2.118
5.	.854	36.523	0.377	8	0.610	0.092	6.602
				17	1.028	0.180	5.716
				23	0.677	0.238	2.829
				7	-0.263	0.202	-1.302
6.	.852	35.893	0.380	8	0.610	0.093	6.556
				18	0.506	0.090	5.622
				23	0.686	0.241	2.846
				7	-0.267	0.203	-1.313

TABLE 9

COMPARISON OF INCOME AND POPULATION