THE UNIVERSITY OF MANITOBA

A DEMAND MODEL FOR CANADIAN DOMESTIC INTERCITY AIR PASSENGER TRAVEL

by

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Roman A. Manastersky

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CHAPTER I

INTRODUCTION

1.1 General Purpose and Scope of Study

The purpose of this thesis is to develop a mathematical demand model that could be used to forecast future passenger volumes to be carried on domestic air services. With the establishment of a reliable predictive tool, reliable forecasts of the growth of air travel can then be made which in turn would aid in decision making regarding the expansion of ground facilities and/or air service between cities.

The scope of the study is limited to air travel between highly-populated urban areas since travel between these cities represents a large portion of the total passenger-miles flown in Canada and since the growth of air travel in sparsely populated urban areas is often erratic and highly sensitive to developments often difficult to predict. Most of the air travel included for analysis was along an east/west axis since inspection of certain pairs of cities (termed city-pairs) along a north/south axis with substantial volumes of traffic revealed strong regional biases and consequently these were excluded (interior British Columbia with Vancouver and Victoria, northern Manitoba with Winnipeg and northern Ontario with cities in southern Ontario).

1.2 Specific Objectives

The growth of air travel is not always consistent and long term trends can be obscurred by year-to-year fluctuations. Simple linear extrapolations of short term trends cannot produce sufficiently reliable estimates of longer-term future growth.

An air traffic forecast arrived at by projection of past trends does not explicitly take into account the way in which various social, economic and operational conditions affect the development of traffic. Where past trends have been smooth and persistent, and there is reason to expect that the influence of underlying factors on the continued development will not change greatly over the forecast period, trend projection is undoubtedly a reliable method of traffic forecasting. However, if there is a risk that a continuation of the past trend of traffic development is inconsistent with realistic economic, social or technological developments, it becomes necessary to study the significant factors underlying the development of air traffic. With the latter possibility being applicable to air travel in Canada, the formulation and development of the demand model must be carried out at a detailed level in order that the forecasts resulting from it be a useful component in planning for future air transport development.

Econometric model building is a technique that involves studying the significant factors that account for the past growth of air traffic and quantitatively expressing these factors in the form of a mathematical expression. This technique will be employed in the development of such a mathematical expression, that is, a demand model for air passenger travel in Canada. By utilizing a relatively large data base over a period of twelve years, relationships between air travel demand and certain social and economic factors will be established. A two-pronged approach will be taken in analyzing these relationships, that of time series analysis and of cross-sectional analysis. The results of the two analyses will be compared and time trends of the relationships will be illustrated. Differences between the air travel volumes as calculated by the cross-sectional demand models and the historically observed volumes will be translated into measures of attractiveness between cities. These measures reflect a combination of distinct influences characterizing each city-pair which promote or inhibit in varying degrees the propensity to travel by air. These measures of attractiveness will be incorporated into the resulting demand model as attractiveness factors.

Before proceeding with a description of the methodology used in formulating the resulting demand model, the steps involved in the econometric model building technique will be outlined in Chapter II.

CHAPTER II

THE ECONOMETRIC MODEL BUILDING TECHNIQUE (4)*

2.1 Applicability

Thus far the use of econometric models for air traffic forecasting has generally been confined to developed countries. Partly this is because these countries are often better equipped to carry out these type of forecasts. There is also the contention that existing econometric forecasting techniques basically tend to be more relevant to the air transport situation in highly developed countries.

In most developing countries a great proportion of the air transport market is comprised of foreign users (tourists, expatriates and foreign shippers) while the internal market may consist of relatively few large consumers of air transport services. In such circumstances most existing methods of econometric forecasting relating the social and economic conditions of the country as a whole to air travel would not apply and trend projection or other approaches may be more fruitful. In a developed country such as Canada, the market is made up of a wide spectrum of users of which a large proportion reside in

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* Numbers in paretheses refer to entries in List of References.

in this same country. The economic and social conditions in a developed country are accordingly very pertinent to the development of its air traffic and hence econometric forecasting methods are more applicable.

2.2 Steps Involved in the Econometric Model Building Technique

There are three general steps involved in the formulation of an econometric demand model:

(i) Identification and selection of underlying factors or independent variables* to be taken into account when forecasting the air traffic activity or the dependent variable;

(ii) Determination of the type of functional relationship existing between the dependent variable and the independent variables;

(iii) Empirical testing of the mathematical expression for the relationship between the dependent and independent variables including evaluation of coefficients or exponents.

Basically, these were the steps that were followed in deriving a demand model in this study. In order to avoid confusion later with regards to the methodology outlined in Chapter III, each of these steps will be described now in detail.

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* The term independent variable applies to variables representing factors which affect air traffic development but are themselves unaffected by the traffic variable.

2.2.1 Identification and Selection of Underlying Factors

In identifying and selecting the independent variables to be taken into account in a demand model, the primary criterion is of course that they should be significantly related to the traffic variable. Another important criterion is that they should be measurable and capable of being forecast, and that their magnitude should be on record so that their influence on the traffic can be quantified through statistical analysis.

The variables included in econometric models of air traffic developments reflect different types of influence on the traffic. Some of these types of influence may be: the size and spending ability of the potential market, the cost of using the air transport service, airport accessibility and convenience, the quality of the air service and its competitive situation with respect to alternative surface services, and sociological characteristics of the potential market.

The same type of influence on the air traffic variable may be expressed by a variety of alternative variables. In cases like this only one of the alternative variables should be included in the model. Although a large number of variables representing different types of influence will undoubtedly be significant in any traffic situation, only a few of them will often be expressed in an econometric model. Reasons for exclusion of a variable even if it is assumed to have a significant impact on air traffic may be that its influence is difficult to quantify or that the future development of the variable in question cannot be reliably forecast.

2.2.2 Determination of the Functional Relationship

In determining the type of functional relationship between the dependent traffic variable and the independent variables, one must establish the type of mathematical relationship according to which the market reacts to changes in the independent variables. When the various independent variables represent truly different influences, this relationship is usually multiplicative, that is, the effects of each of the variables on traffic tend to multiply rather than to add. If, however, more than one variable is used to represent one type of influence, the simple multiplicative relationship is not likely to apply.

When the relationship between the dependent traffic variable and the independent variables is multiplicative, the corresponding relationship between the logarithms of the variables will be linear. The practical significance of using the linear form is that the percentage effect on traffic of a certain percentage change of an independent variable remains the same whatever values the other variables assume. For example, the traffic variable

T may be related to two independent variables X and Y by the formula,

$$T = (K)\ (X)^a\ (Y)^b$$

and in natural logarithmic form,

$$\ln T = \ln(K) + (a)\ln X + (b)\ln Y$$

In terms of percentages this formula would read,

$$\%\text{ change of }T = (a)\ (\%\text{ change of }X) + (b)\ (\%\text{ change of }Y)$$

The quantities 'a' and 'b' in the above example are usually termed elasticities. Quantity 'a' is the elasticity of T with respect to X, meaning that a 1 percent change of X would result in an 'a' percent change of T. When 'a' is positive the relationship between X and T is a direct relationship and when 'a' is negative the relationship is an inverse one.

Another important reason for using the transformed logarithmic relationship is that it allows the use of multiple regression analysis to establish the values of the constant and elasticities. Multiple regression analysis is a technique of finding the equation which best fits a body of observed values of the dependent and independent variables provided the relationship is expressed in linear form.

The determination of elasticities in a demand model by multiple regression analysis may be done through a time series or a cross-sectional analysis. Time series analysis determines the effect of changes in the independent variables on the traffic variable through a number of successive years. Cross-sectional analysis measures the same effect of changes in the independent variables on the traffic variable for different markets and travel routes but at specific years. In order that a more complete picture of the development of air passenger travel in Canada be drawn, both methods of analysis were utilized in this study.

When carrying out a time series analysis, a question arises of whether to use current or constant money values to measure monetary quantities. A normal practice is to work with constant money values, that is, to adjust the time series of financial data for simultaneous changes in the purchasing power of the currency, which has been carried out in this study.

2.2.3 Empirical Testing of the Relationship

After assessing the values to be assigned to the constant and coefficients in an econometric model, the model should then be tested to ensure that it is a reliable tool for future predictions of air travel. Even though the constant and coefficients are derived by statistical techniques, the model may be faulty in three ways. One is that the statistical relationship between the dependent and independent variables is too lose on which to base a prediction with an acceptable degree of certainty.

Another cause of concern is that the results arrived at could be due to chance. The last possibility is that even if there is a close statistical relationship between the dependent and the independent variables, this does not necessarily mean that the development of the dependent variable is determined solely by the development of the independent variables. There is the possibility that the development of the dependent and independent variables is affected by some other factor which is not accounted for in the model and hence the independent variables would not in themselves explain the development of the dependent variable.

One way of measuring the strength of the statistical relationship between the variables in a model is by evaluating the coefficient of multiple determination. This coefficient is an index for the closeness of fit of a body of observed values to values estimated by a mathematical model. It indicates how well values of the dependent variable fit to sets of values for the independent variables. The index may take on values ranging between 0 and 1.0 with the latter representing a perfect fit and the former representing the nonexistence of any relationship between the dependent and independent variables.

Another way of evaluating the relationship between the dependent variable and a set of independent variables is by evaluating Thiel's inequality coefficient which is defined in Appendix A. It is an index which represents the magnitude of the deviation between observed and estimated values of the dependent variable. The index may range in values between 0 and infinity where 0 represents no deviation and the latter infinitely large deviation.

Having determined that the relationship between the variables is acceptably close, so-called tests of significance should then be utilized to ensure that this relationship is not due to chance. In this regard the t and F tests are employed. The t test in turn determines whether each independent variable significantly influences the dependent variable at a specified level of confidence. The F test determines whether the variation of the dependent variable explained by the model is significant at a specified level.

The third cause of concern regarding the unreliability of the model involves the possibility of the omission of some other underlying factor(s). In this regard, this study seeks to determine whether in fact such omissions have occurred and, if so, attempts to quantify and include these factors in the model. By examining the differences between the expected and observed values of the dependent traffic variable, some definite trends in these differences may be distinguishable. If such trends are found, these differences may then be used to account for omitted factors and to reconcile these omissions by incorporating these differences in the model. This type of analysis will be carried out in detail in Chapter IV, following the formulation of the demand model which follows.

C H A P T E R III

AN APPLICATION OF ECONOMETRIC MODEL BUILDING TO CANADIAN DOMESTIC INTERCITY AIR PASSENGER TRAVEL

3.1 Initial Formulation and Results

In the initial formulation of the demand model an attempt was made to develop a relationship between the dependent traffic variable; annual number of two-way passengers between two cities, and six independent variables; total annual income, number of taxpayers earning between \$7,000 and \$10,000 annually, number of taxpayers earning more than \$10,000 annually, number of taxpayers earning more than \$7,000 annually, annual value of shipments of goods of own manufacture and total annual scheduled airplane departures.

Total annual income was chosen to express both the size and spending ability of the potential market. The three income distribution variables were included to act as an index for the propensity to travel by air. While all three variables express the same type of influence on the dependent variable, all three were included for initial analysis with the intention of determining which has the strongest relationship with the dependent variable and then eliminating the other two from the model. The value of shipments of goods of own manufacture was intended to serve as a measure of attractiveness between cities. The sixth independent variable, scheduled airplane departures was to express an index for the quality of air service between cities.

To test the reliability of this initial formulation seven city-pairs were selected for preliminary multiple regression analysis. The results of the analysis, however, were not very satisfactory. The only independent variable that was statistically significant was the total income variable and hence this was the only independent variable that could justifiably be included in the model.

With the model being comprised of only one independent variable, it was decided at this point not to pursue any further analysis of this particular formulation. Instead the demand model was reformulated with the introduction of new variables as will be described in the subsequent section.

3.2 Revised Formulation and Data Development

The revised formulation of the demand model incorporated three distinct types of influence on air traffic; the size of the potential market, the spending ability of the potential market and the cost of using the air service as paid for by the consumer. An attempt was also made to include the level of service offered by air services between cities in terms of the number of seats available per unit time. Unfortunately, records that would contain this type of information could not be located and an index for level of service could not be included in the model.

The revised formulation was as follows:

$$T_{ij} = K(P_iP_j)^A \ (I_iI_j)^B \ (F_{ij})^C$$

and in logarithmic form:

$$\ln T_{ij} = K_1 + A\ln\ (P_iP_j) + B\ln\ (I_iI_j) + C\ln F_{ij}$$

where T_{ij} = total annual number of passengers in both directions travelling by air between city i and city j;

P_iP_j = cross-product of the populations of cities i and j (000,000);

I_iI_j = cross-product of the mean disposable incomes of cities i and j ($);

F_{ij} = one-way economy air fare for travel between cities i and j ($).

As before, a preliminary multiple regression analysis was carried out using data for seven city-pairs. This time the results proved to be very promising and suggested that all three independent variables had a significant influence on the traffic variable. It was decided at this point to proceed further with expansion of the data base and with further analysis.

Originally the intention was to collect data representing the three independent variables for all city pairs in Canada with an annual traffic volume exceeding 10,000 outbound plus inbound passenger based on 1971 statistics (7). Preliminary investigation revealed that out of 108 possible city-pairs, 69 city-pairs involving 21 cities could be included for analysis due to data availability constraints. This was still a significant sample since it represents approximately 70% of the passengers carried by the air mode on domestic services in 1971.

A time series data base was established for the years 1960-1971 for each of the 69 city-pairs. Data for the traffic variable was obtained from government publications (1,7). Population figures for the three census years 1961, 1966 and 1971 were obtained from census publications (2,3,8) while population figures for intercensal years were researched from the Financial Post Survey of Markets and Business Year Book (5). Mean disposable income data was also obtained from the Financial Post publication. The mean disposable income of an urban area is calculated by determining the total income of residents in that area after payment of direct taxes and dividing this figure by the population of that area. Data for the fare variable was obtained by researching the relevant Air Canada published schedules. The traffic and fare data is listed by city-pair in Appendix B while the data for the population and income variables is listed by city in Appendix C.

With a time series spanning twelve years involving 69 city-pairs, a data base of 828 samples was established.

For the purpose of time series regression analysis, the two monetary variables, income and fare, were adjusted to be expressed in constant 1961 dollars. The factors used for adjustment were obtained from Statistics Canada and are calculated by using the Consumer Price Indices of the corresponding years. These factors are listed in Appendix D.

A FORTRAN computer program was utilized to adjust the financial data, to calculate all the necessary cross-products and to transform the data into logarithmic form. The transformed data was then ready to be used as input for the multiple regression analysis computer program.

3.3 Model Development and Results

The "Stepwise Multiple Regression" computer program was used to calculate the constant and regression coefficients (that is, the elasticities) of the model. The program is offered in the Statistical Package at the University of Manitoba's computer center. Stepwise multiple regression statistically analyzes the relationship between the dependent variable and a set of independent variables to be included in the regression equation according to their importance. The order of importance is based on the reduction of sums of squares in the variation of the dependent variable (that is, the order of importance increases with increasing reduction). The independent variable most important in a given "step" in the analysis is entered into the regression equation.

For time series analysis, rather than just evaluating the one twelve-year time series model, seven sets or intervals of time series data were evaluated. Starting with a six-year time series, 1960-1965, and increasing this series one year at a time up to a twelve-year time series, 1960-1971, seven sets of constants and elasticities were derived. In this fashion the longer-term changes of the elasticities could be illustrated. The results of these seven regression analyses are illustrated in Table 3.1.

In the case of cross-sectional analysis, twelve regression analyses corresponding to each of the twelve years were carried out. The income and fare variables were not adjusted to constant dollars so that the resulting elasticities would reflect a true indication of the effect that each of the independent variables have on the traffic variable in any particular year. The twelve sets of elasticities are listed in Table 3.2.

The population, income and fare elasticities as determined by the seven time series and twelve cross-sectional models are illustrated in Figures 3.1, 3.2 and 3.3 respectively.

3.4 Empirical Testing

Inspection of the R^2 values in Table 3.1 revealed that in each of the seven time series models at least 78%

TABLE 3.1 REGRESSION ANALYSIS RESULTS OF SEVEN TIME SERIES MODELS

$$\ln T_{ij} = K_1 + A \ln (P_i P_j) + (I_i I_j) + C \ln F_{ij}$$

INTERVAL	K_1	A	B	C	R^2
1960-1965 (6 years)	1.09432	0.50993	0.34550	-0.75815	0.789
1960-1966 (7 years)	-0.44642	0.50100	0.45178	-0.73696	0.784
1960-1967 (8 years)	-2.42222	0.49561	0.58515	-0.71947	0.785
1960-1968 (9 years)	-3.23367	0.48878	0.64181	-0.70482	0.783
1960-1969 (10 years)	-3.63442	0.48722	0.66585	-0.68737	0.784
1960-1970 (11 years)	-4.56205	0.48438	0.72695	-0.67362	0.787
1960-1971 (12 years)	-4.67399	0.47944	0.73479	-0.65861	0.789

TABLE 3.2 REGRESSION ANALYSIS RESULTS OF TWELVE CROSS-SECTIONAL MODELS

$$\ln T_{ij} = K_1 + A \ln (P_i P_j) + B \ln (I_i I_j) + C \ln F_{ij}$$

YEAR	K_1	A	B	C	R^2
1960	2.31248	0.53500	0.27123	-0.90474	0.823
1961	-0.46150	0.50552	0.45208	-0.75094	0.792
1962	1.77521	0.51827	0.29526	-0.75622	0.790
1963	5.37636	0.52378	0.04378	-0.73340	0.784
1964	6.86791	0.50547	-0.04188	-0.72475	0.765
1965	7.31689	0.48937	-0.06542	-0.65305	0.741
1966	3.28655	0.46492	0.20617	-0.57332	0.721
1967	2.84780	0.47916	0.22614	-0.54193	0.731
1968	4.97856	0.45375	0.11783	-0.56488	0.696
1969	0.79654	0.47742	0.35393	-0.50589	0.707
1970	-2.13052	0.46283	0.55502	-0.49485	0.697
1971	-4.99807	0.42197	0.74975	-0.45407	0.676

Figure 3.1 Population Elasticities (Coefficient A) for Seven Time Series Models and Twelve Cross-Sectional Models

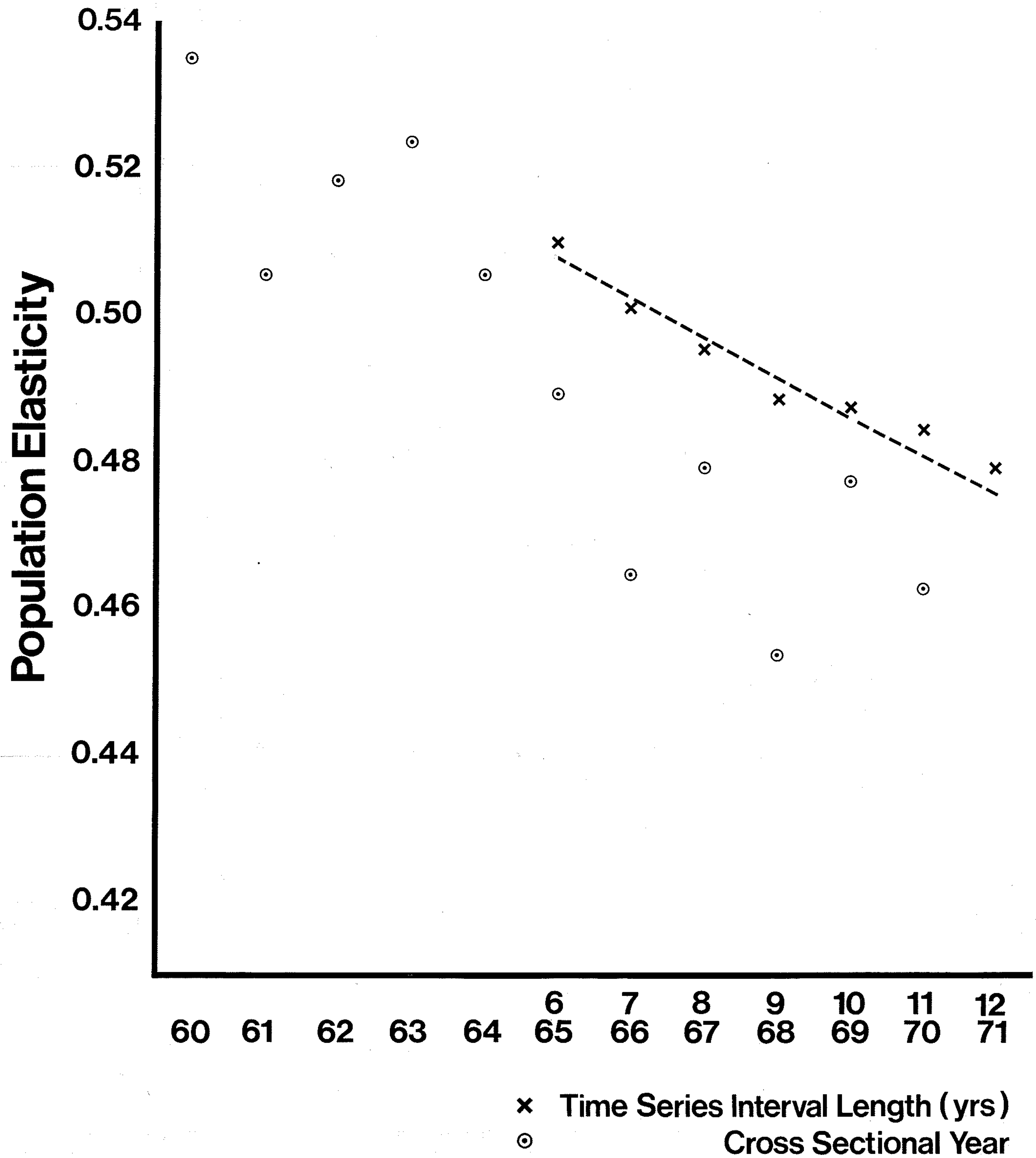


Figure 3.2 Income Elasticities (Coefficient B) for Seven Time Series Models and Twelve Cross-Sectional Models

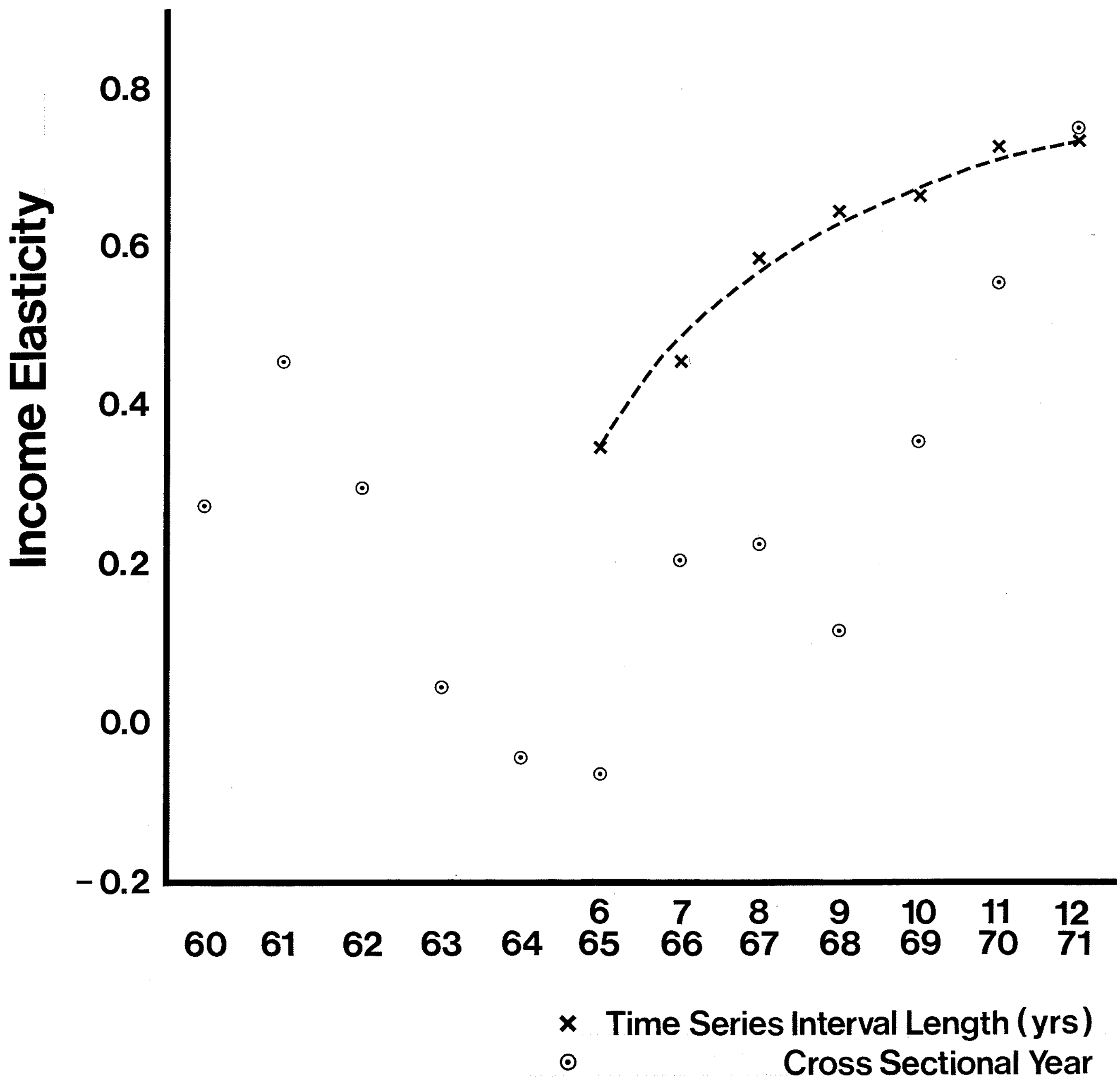
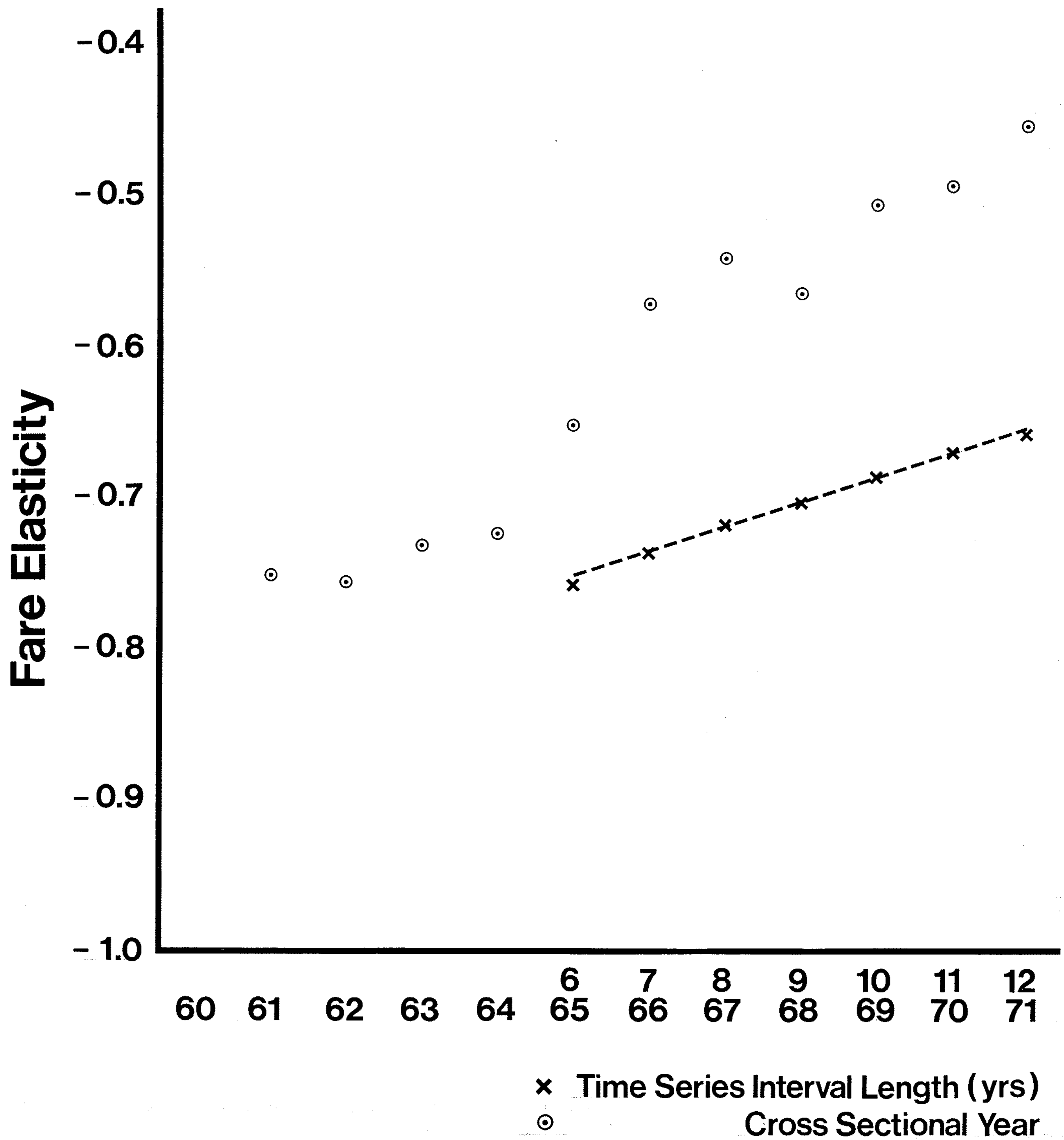


Figure 3.3 Fare Elasticities (Coefficient C) for Seven Time Series Models and Twelve Cross-Sectional Models



of the variation of the dependent variable was explained by the corresponding model. In the case of the cross-sectional models, the R^2 values of Table 3.2 were lower than those for the time series models. This was expected since this is generally the case when comparing time series with cross-sectional results (4). The R^2 values, although somewhat low, were considered to indicate that the relationship between the dependent and independent variables was acceptably close.

Thiel's inequality coefficient, as defined in Appendix A, was also calculated to assess the strength of the relationship between the variables. For the twelve-year time series model the value of this coefficient was 0.4147. The implication of this value will be discussed in Section 3.5.

As was outlined in Chapter II, significance tests are utilized to ensure that the relationship between the dependent variable and the independent variables is not due to chance. In this regard, the t and F tests were applied to each of the time series and cross-sectional models.

The t test compares the calculated t value of each regression coefficient with a tabular value corresponding to a specified level of confidence. For example, consider the calculated t values of the three independent variables for the twelve-year time series model:

population variable; $t = 29,129$

fare variable; $t = -20,069$

income variable; $t = 13,046$

Before determining the corresponding tabular value of t, the number of degrees of freedom, V, must be calculated. For the t test;

$$V = n - k - 1$$

where n = number of observations

k = number of independent variables.

In this case, V = 828 - 3 - 1 = 824 degrees of freedom. From Table A-8 of Neville and Kennedy (6), the correspon- ding t value for a confidence level of 0.1% is approximat- ely 3.350. Since the absolute values of the calculated t values all exceed the tabular value, the null hypothesis that any of the independent variables have no influence on the dependent variable is rejected. The confidence level simply means that in this case there is less than a 0.1% chance of the null hypothesis being correct.

The t test was similarly applied to the other six time series models and in all six cases the calculated t values exceeded the tabulated values at the 0.1% confi- dence level. The t test was also applied to all twelve cross-sectional models. In all twelve models the popu- lation and fare variables passed the t test at the 0.1% confidence level while the income variable did not pass the t test in any of the models, the implication being that in short-run cross-sectional analysis, the income variable does not significantly influence the traffic variable.

The F test is employed to test whether the regression equation as a whole is statistically significant. The F test compares the calculated F ratio,

$$F_{calculated} = \frac{\text{Explained (Regression) Variance}}{\text{Unexplained (Residual) Variance}}$$

with the tabulated value of F corresponding to a specified level of significance.

As an example again consider the twelve year time series model. In this case, $F_{calculated} = 455.417$. Two values for the number of degrees of freedom are utilized in the F test: $V_1 = k = 3$ and $V_2 = n - k - 1 = 824$. From Table A-10 (6), $F = 3.81$ at a 1% confidence level and in this case the null hypothesis that the explained variation is not significant is rejected since the calculated F value exceeds the tabular one.

Applying the F test to the other six time series models and to the twelve cross-sectional models revealed that in every case the explained variation was found to be significant at the 1% confidence level.

3.5 Discussion of Results

In all nineteen of the multiple regression analyses carried out, the population variable entered into the regression equation first, the fare variable second, and the income variable third. This indicated that the order of importance of each of the independent variables in terms of explaining the variation of the traffic variable remained the same in both the time series and cross-sectional models.

Inspection of Figures 3.1, 3.2 and 3.3 reveals that definite trends are distinguishable from the plots of the time series elasticities. The effects of the cross-sectional elasticities in determining these trends is also very evident. Although much more irregular than the time series elasticities, the cross-sectional elasticities generally follow the same trends.

The negative slope of the population elasticities in Figure 3.1 indicates that changes in population have a decreasing effect on the volume of air travel. Figure 3.2 shows that changes in mean disposable income have an increasing effect on the traffic variable. The positive slope of the fare elasticities in Figure 3.3 implies that changes in the air fare have a decreasing effect on the traffic variable (since the fare elasticity is negative, the connotation of a positive slope is opposite to that implied by Figures 3.1 and 3.2). In short, Figures 3.1 3.2 and 3.3 indicate that through the years, the propensity to travel by air becomes more sensitive to changes in the spending ability of the potential market, less sensitive to changes in the size of the potential market and also less sensitive to changes in the cost of using air services.

Simultaneous increases in business travel may be one possible explanation for the decreasing values of the population elasticities. With business travel assuming larger proportions of the travel market, increases in urban population would have a decreasing effect on air traffic.

The increase of the income elasticities over the period of analysis points out an increased responsiveness to air travel resulting from increasing incomes. That is, an increase in income in 1971 would bring about more travel by air than would the same increase in 1968, for example.

It should be pointed out that two abnormal values for the income elasticity were obtained. In the two cross-sectional analyses of 1964 and 1965 the income elasticities were both negative. Although a substantial amount of time was spent in attempting to reconcile these two values no definite cause could be found.

The decrease of the fare elasticity may be a direct result of improved speed and travel comfort. With an increase in the level of service the attractiveness of travel by air would increase as well, thereby offsetting the effect of fare increases in the time series models. The effect of fare increases is apparent in the cross-sectional fare elasticities of 1962 and 1968 where substantial fare increases did occur.

An important unquantifiable factor that would have an impact on all three elasticities would be the growing public acceptance of the air transport mode over the period of study.

The calculated value of Thiel's inequality coefficient listed earlier as 0.4147, cast some doubt on the predictive accuracy of the demand model. A desirable range for this coefficient would be in the order of 0.1 or lower. Larger values would indicate a substantial difference between the observed and estimated values of the dependent variable. This consideration along with the somewhat low values of the coefficients of multiple determination prompted a detailed analysis of the differences between the observed and expected values of the dependent traffic variable.

CHAPTER IV

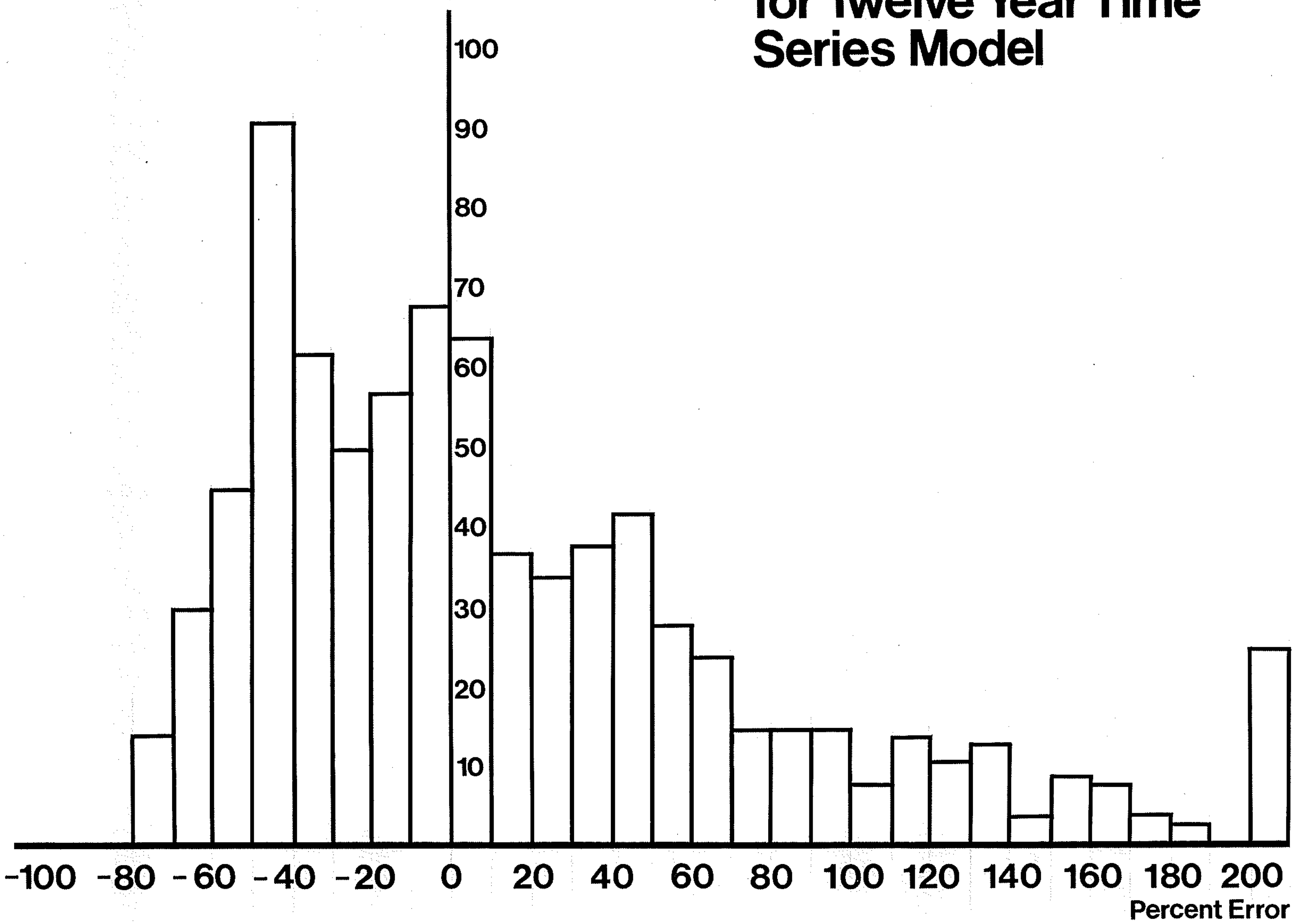
RESIDUAL ANALYSIS AND DEVELOPMENT OF ATTRACTIVENESS FACTORS

4.1 Residual Analysis of Twelve-Year Time Series Demand Model

The twelve-year time series model was selected for analysis of residuals since it encompassed the longest time interval and hence would permit a more complete analysis of the predictive accuracy of the demand model formulation. Since the observed and estimated travel volumes were in logarithmic form, a FORTRAN computer program was used to calculate the antilogarithms of these volumes. The program was also used to calculate the residuals and to express these as fractions of the observed volumes in terms of percent. In this fashion 828 residual and percent error terms were established. A histogram of the resulting percent error terms is illustrated in Figure 4.1.

From Figure 4.1, it is evident that the distribution of errors is not a normal distribution and that a fairly large amount of unexplained variation exists between the observed and estimated volumes. In examining residuals for individual city-pairs through time, however, it was found that in almost every case the error terms varied minimally in magnitude and successively retained the same sign. This suggested that an underlying factor or factors

Figure 4.1 Histrogram of Residuals for Twelve Year Time Series Model



had been omitted from the demand model.

Since the error terms varied considerably among city-pairs both in magnitude and in sign, it was deemed highly unlikely that one or even two factors would be able to account for the residuals of all city-pairs. Rather it was felt that the underlying factors causing the errors changed according to city-pair so that the errors were caused by different combinations of influences for different city-pairs. Some factors might be very significant in affecting air travel for certain city-pairs but meaningless for others. Some of these factors might be: city-pair distance and its effect on the relative advantage of air transport over surface transport, language and cultural similarities or differences between cities, the relative importance of a city as a provincial or federal capital, and the relative importance of a city as a national centre of trade and commerce.

Since all of these factors could not be included in the demand model because of their changing effect for different city-pairs, the error terms instead were used as measures of attractiveness for air travel between cities. These measures would change according to each city-pair reflecting the effect of the various omitted underlying factors in each particular situation.

4.2 Derivation of Attractiveness Factors

For each city-pair an attractiveness factor was derived by calculating the ratio between the observed and estimated air travel volumes. That is,

$$A_{ij} = \frac{\text{Observed } T_{ij}}{\text{Estimated } T_{ij}}$$

These factors were calculated from both the time series and cross-sectional results.

In the time series case, for each city-pair; the six-year model resulted in six factors, the seven year model in seven factors and so forth for all the models. In each case the factors were then averaged so that one factor for each city-pair resulted from each model. With seven sets of attractiveness factors, these were then further averaged to obtain one set of 69 attractiveness factors reflecting a composite of all the time series results. It was noticed that for each city-pair the seven factors from the models were very close in magnitude, in most instances differing only at the third or fourth decimal place. The effects of the omitted factors were thus very consistent through time for each city-pair. The averaged attractiveness factors are listed by city-pair in Appendix E.

A similar type of derivation was also carried out for the cross-sectional analysis results. Sixty-nine attractiveness factors were calculated for each of the twelve models. The factors in each set of twelve representing a city-pair were very close in magnitude and again the effects of the omitted factors appeared to be consistent.

These factors as well were averaged to represent a composite of the cross-sectional results and these averages are also listed in Appendix E.

A comparison between the attractiveness factors derived from the time series results and those from the cross-sectional results revealed that the differences between the two were relatively small. A decision had to be made, however, concerning which of the two sets should be incorporated in a demand model formulation. Since the period 1960-1965 was repeated in each time series model, the relationships existing between the variables during this time period would have a determining effect in each of the time series models. The attractiveness factors would consequently be weighted to reflect influences prior to 1966 more so than influences following 1966.

The cross-sectional attractiveness factors, on the other hand, represent the average effects of unaccounted underlying factors over the twelve-year period with equal weight attached to each year. It was felt that the cross-sectional attractiveness factors more truly represented the average effect of the unaccounted influences over the twelve-year period of study and should therefore be incorporated in the demand model.

4.3 Application of Attractiveness Factors

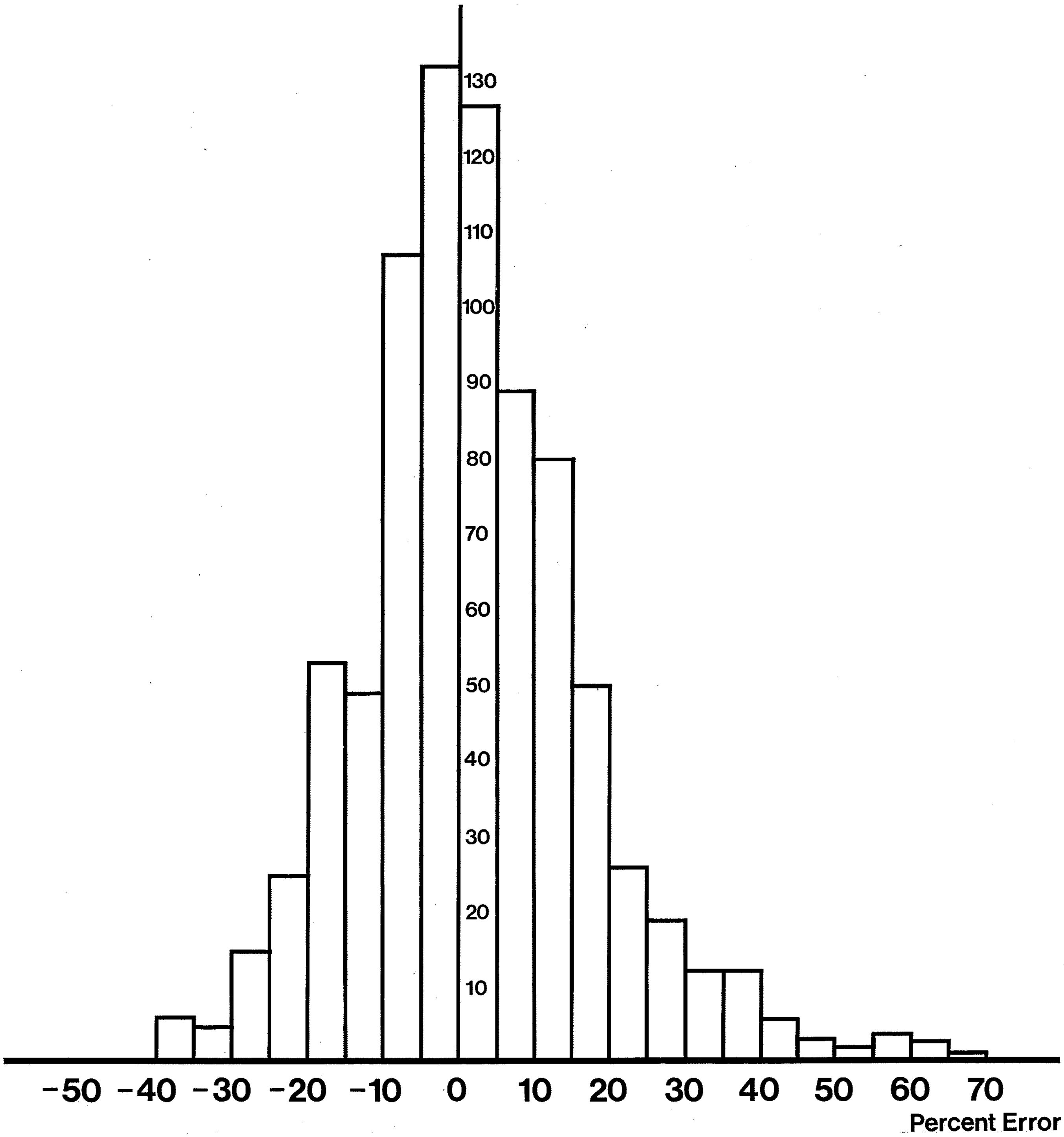
The attractiveness factors derived from the cross-sectional results were incorporated into the twelve-year time series model. This was done to determine the improvement of the predictive accuracy of the demand model resulting from incorporating these factors. The twelve-year model was selected for this purpose since it was the only one that encompassed the entire study time period and thus allowed a comparison to be drawn with the results of section 4.1.

The estimated travel volumes of the twelve-year model were multiplied by the corresponding attractiveness factors. A residual analysis was then carried out on the observed volumes and the modified estimates. A histogram of the residuals was once again constructed and is illustrated in Figure 4.2.

A comparison of Figures 4.1 and 4.2 illustrates the improved predictive accuracy of the demand model using the attractiveness factors. The extremes of the percent errors are reduced markedly and the distribution is very close to a normal one. Examination of individual city-pairs revealed that the consistency in magnitude and sign of the residual terms had been eliminated.

The coefficient of multiple determination and Thiel's inequality coefficient were calculated for the modified estimates. The R^2 value increased very favourably from the previous value of 0.789 to 0.987. Thiel's inequality coefficient decreased from 0.4147 to 0.0707 which is well below the acceptable limit of 0.1. Both of these

Figure 4.2 Histogram of Residuals for Modified Twelve Year Time Series Model Using Attractiveness Factors



values further pointed out the improvement in the predictive accuracy of the models as a direct result of the use of the attractiveness factors.

The attractiveness factors were thus very significant in improving the predictive accuracy of the demand model formulation and their inclusion in the demand model was justified.

CHAPTER V

THE RESULTING DEMAND MODEL AND CONCLUDING REMARKS

5.1 Resulting Demand Model

The final step in the formulation of a demand model involved the selection of either the twelve-year time series model or the 1971 cross-sectional model. Both were logical choices since the twelve-year model spanned the longest time period while the 1971 model was the most up to date.

Selection of a demand model for forecasting purposes is governed by the criterion that the change in the relationships between the dependent and independent variables expressed by the particular model should be minimal over the forecast period. Figures 3.1, 3.2 and 3.3 illustrate that in the cross-sectional case a great deal of year-to-year fluctuations occurred in the three elasticities over the twelve-year period. The use of the 1971 demand model for predictive purposes would, therefore be limited to a short-term forecast period.

The twelve-year time series model, on the other hand, measures the longer-term demand for air travel. The elasticities developed by this model would be more stable over an extended period of time and hence this formulation would be more accurate in forecasting air travel for longer forecast periods than would the cross-sectional model. On this basis the twelve-year time series model was selected as the formulation for use in air travel forecasting.

With the inclusion of the city-pair attractiveness factors, the general form of the demand model is as follows:

$$T_{ij} = (K)\ (P_iP_j)^A\ (I_iI_j)^B\ (F_{ij})^C\ (A_{ij})$$

The constant term, K, and the attractiveness factor, A_{ij}, may be combined to form one so-called attractiveness term, K_{ij}, which would characterize each city-pair. This combination was carried out and the resulting K_{ij} terms are listed according to each city-pair in Table 5.1.

Substitution of the three elasticities of the twelve-year model brings about the resulting demand model for domestic intercity air passenger travel in Canada:

$$T_{ij} = (K_{ij})\ (P_iP_j)^{0.47944}\ (I_iI_j)^{0.73479}\ (F_{ij})^{-0.65861}$$

where T_{ij} = total annual number of passengers in both directions travelling by air between city i and city j;

K_{ij} = term of attractiveness for air travel between cities i and j;

P_iP_j = cross-product of the populations of cities i and j (000,000);

I_iI_j = cross-product of the mean disposable incomes of cities i and j (in constant 1961 dollars);

F_{ij} = one-way economy airfare for travel between cities i and j (in constant 1961 dollars).

TABLE 5.1

K_{ij} TERMS FOR CORRESPONDING CITY-PAIRS

CITY-PAIR	K_{ij}
SYDNEY/HALIFAX	0.01676
SYDNEY/MONTREAL	0.00369
SYDNEY/TORONTO	0.00592
HALIFAX/FREDERICTON	0.01584
HALIFAX/SAINT JOHN	0.01413
HALIFAX/MONCTON	0.08075
HALIFAX/ST. JOHNS	0.26675
HALIFAX/MONTREAL	0.13453
HALIFAX/OTTAWA	0.09580
HALIFAX/TORONTO	0.17593
FREDERICTON/MONTREAL	0.09702
FREDERICTON/OTTAWA	0.06731
FREDERICTON/TORONTO	0.10279
SAINT JOHN/MONTREAL	0.05679
SAINT JOHN/TORONTO	0.05837
MONCTON/MONTREAL	0.08386
MONCTON/TORONTO	0.09498
ST. JOHNS/MONTREAL	0.09371
ST. JOHNS/OTTAWA	0.05567
ST. JOHNS/TORONTO	0.12815
QUEBEC/MONTREAL	0.08447
QUEBEC/OTTAWA	0.03751

CITY-PAIR	K_{ij}
QUEBEC/TORONTO	0.05008
MONTREAL/OTTAWA	0.02521
MONTREAL/TORONTO	0.28943
MONTREAL/LONDON	0.04238
MONTREAL/WINDSOR	0.06384
MONTREAL/WINNIPEG	0.08901
MONTREAL/CALGARY	0.06443
MONTREAL/EDMONTON	0.05199
MONTREAL/VANCOUVER	0.10902
OTTAWA/TORONTO	0.19908
OTTAWA/LONDON	0.04504
OTTAWA/WINDSOR	0.04538
OTTAWA/WINNIPEG	0.08388
OTTAWA/REGINA	0.04899
OTTAWA/CALGARY	0.06040
OTTAWA/EDMONTON	0.06575
OTTAWA/VANCOUVER	0.08111
TORONTO/LONDON	0.01978
TORONTO/WINDSOR	0.12231
TORONTO/SAULT STE. MARIE	0.12867
TORONTO/THUNDERBAY	0.17628
TORONTO/WINNIPEG	0.20469
TORONTO/SASKATOON	0.08167
TORONTO/REGINA	0.09910
TORONTO/CALGARY	0.16201

CITY-PAIR	K_{ij}
TORONTO/EDMONTON	0.12879
TORONTO/VANCOUVER	0.21842
TORONTO/VICTORIA	0.07937
WINDSOR/WINNIPEG	0.03946
THUNDERBAY/WINNIPEG	0.11522
WINNIPEG/SASKATOON	0.13328
WINNIPEG/REGINA	0.20282
WINNIPEG/CALGARY	0.13438
WINNIPEG/EDMONTON	0.10924
WINNIPEG/VANCOUVER	0.17693
SASKATOON/CALGARY	0.09458
SASKATOON/EDMONTON	0.06666
SASKATOON/VANCOUVER	0.08319
REGINA/CALGARY	0.18101
REGINA/EDMONTON	0.09187
REGINA/VANCOUVER	0.10491
CALGARY/EDMONTON	0.30151
CALGARY/VANCOUVER	0.23549
CALGARY/VICTORIA	0.08171
EDMONTON/VANCOUVER	0.20553
EDMONTON/VICTORIA	0.06167
VANCOUVER/VICTORIA	0.10248

5.2 Use of the Demand Model in Air Travel Forecasts

By integrating the results of time series analysis with those of cross-sectional analysis, a demand model for air travel has been developed. A few words of caution and advice should be mentioned regarding the use of such a model to forecast the future development of air travel.

Before an air travel forecast can be carried out, forecasts of the future values of the independent variables must be determined. A forecast of the dependent traffic variable, therefore, can never be more accurate than the forecasts of the independent variables in the demand model. In this respect a substantial amount of work has been done in the area of population and income projections so that reliable forecasts may be obtained for these variables. For the fare variable, the airlines would be in a good position to provide expected future ranges of air fares.

One outstanding feature of an econometric forecast is that it allows study of the sensitivity of air travel development to changing patterns of development of the independent variables. Having established ranges within which the independent variables are likely to develop, it is then possible to calculate the future minimum and maximum expected air travel volumes. When making provisions for future expansion of airport facilities and/or services between cities, the maximum level of traffic is of primary concern. If using the air traffic forecast to estimate traffic revenues for economic planning purposes, the main interest in this case is the lowest expected traffic level.

One last qualification is provided regarding the use of the demand model for forecasting purposes. The assumption that the city-pair attractiveness factors and the relationship between the dependent variable and the independent variable expressed by the model will remain the same over the forecast period is implied when using this model to forecast air traffic. The model should be continually updated with the addition of new data to determine whether any changes do occur in the attractiveness factors or elasticities that would significantly affect the accuracy of the forecasts.

5.3 Concluding Remarks

The unique derivation of attractiveness factors in this study allows the relative magnitudes of the propensity to travel by air between specific cities to be expressed. Incorporation of these factors into an air travel demand model enables the influence of other underlying factors to be taken into account which in previous demand model formulations might have been excluded. As has been illustrated, the predictive accuracy of the demand model formulation is markedly improved as a result of the inclusion of the attractiveness factors.

The establishment of attractiveness factors to express the relative magnitudes of the propensity to travel between different cities may be extended to rail and road passenger transport as well. The factors could be included in the respective demand models in the same fashion. The concept of the attractiveness factor characterizing a city-pair may thus be a powerful predictive tool in forecasting transportation demand.

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APPENDIX A

THIEL'S INEQUALITY COEFFICIENT

$$U = \frac{\sqrt{\frac{1}{h} \sum (\hat{y}_i - y_i)}}{\sqrt{\frac{1}{h} \sum \hat{y}_i^{\,2}} + \sqrt{\frac{1}{h} \sum y_i^{\,2}}}$$

U	**Thiel's Inequality Coefficient**
h	**number of samples**
$\hat{y}_i$	**calculated value of the i^{th} sample**
y_i	**observed value of the i^{th} sample**

A P P E N D I X B

1960-1971 DATA LISTING OF:

1) CORRESPONDING ANNUAL AIR PASSENGER TRIPS,

2) CORRESPONDING ANNUAL ONE-WAY ECONOMY AIR FARE

FOR 69 CITY-PAIRS.

NOTE:

THE FIGURE ON THE LEFT HAND SIDE CORRESPONDING TO EACH YEAR REPRESENTS THE NUMBER OF AIR PASSENGER TRIPS.

THE FIGURE ON THE RIGHT HAND SIDE CORRESPONDING TO EACH YEAR REPRESENTS THE ECONOMY AIR FARE EXPRESSED IN DOLLARS FOR THE PARTICULAR CITY-PAIR.

SYDNEY/HALIFAX

1960	17,150	15	1966	17,880	17
1961	14,870	15	1967	23,560	17
1962	13,855	17	1968	28,675	19
1963	13,260	17	1969	28,230	19
1964	16,690	17	1970	38,300	21
1965	17,920	17	1971	39,075	23

SYDNEY/MONTREAL

1960	6,770	41	1966	8,490	47
1961	6,580	41	1967	10,895	47
1962	6,210	47	1968	9,310	52
1963	5,630	47	1969	10,050	52
1964	5,810	47	1970	12,930	48
1965	8,195	47	1971	13,610	50

SYDNEY/TORONTO

1960	6,530	55	1966	11,160	63
1961	8,280	55	1967	11,640	63
1962	7,745	63	1968	13,290	69
1963	7,790	63	1969	14,950	69
1964	8,380	63	1970	18,050	66
1965	8,745	63	1971	21,085	69

HALIFAX/FREDERICTON

1960	5,870	15	1966	10,905	17
1961	6,600	15	1967	12,310	17
1962	6,325	17	1968	13,100	19
1963	7,170	17	1969	13,580	19
1964	6,970	17	1970	17,555	19
1965	8,340	17	1971	18,060	21

HALIFAX/SAINT JOHN

1960	16,235	10	1966	20,775	12
1961	19,065	10	1967	24,850	12
1962	18,080	12	1968	26,810	14
1963	19,850	12	1969	24,220	14
1964	18,340	12	1970	27,705	15
1965	20,265	12	1971	25,035	18

HALIFAX/MONCTON

1960	12,285	8	1966	10,495	10
1961	10,635	8	1967	13,095	10
1962	10,375	10	1968	14,675	12
1963	8,250	10	1969	12,035	12
1964	9,085	10	1970	14,430	13
1965	9,955	10	1971	13,415	15

HALIFAX/ST. JOHNS

1960	9,720	33	1966	21,680	37
1961	12,985	33	1967	23,730	37
1962	13,510	37	1968	23,910	41
1963	15,105	37	1969	27,650	41
1964	16,520	37	1970	31,555	41
1965	17,765	37	1971	34,550	44

HALIFAX/MONTREAL

1960	31,485	28	1966	52,975	33
1961	37,130	28	1967	75,025	33
1962	36,220	33	1968	69,035	36
1963	35,685	33	1969	80,045	36
1964	40,430	33	1970	89,905	38
1965	48,170	33	1971	86,145	41

HALIFAX/OTTAWA

1960	8,880	35	1966	15,810	42
1961	9,665	35	1967	19,420	42
1962	10,125	42	1968	21,750	46
1963	10,090	42	1969	23,990	46
1964	11,355	42	1970	32,560	44
1965	13,280	42	1971	37,400	46

HALIFAX/TORONTO

1960	25,260	43	1966	54,125	48
1961	33,045	43	1967	63,335	48
1962	36,200	48	1968	70,770	53
1963	37,715	48	1969	84,210	53
1964	40,680	48	1970	98,720	56
1965	47,525	48	1971	103,135	58

FREDERICTON/MONTREAL

1960	7,000	22	1966	18,425	25
1961	8,945	22	1967	24,070	25
1962	10,235	25	1968	20,590	28
1963	10,640	25	1969	22,325	28
1964	12,180	25	1970	26,990	30
1965	15,400	25	1971	28,645	32

FREDERICTON/OTTAWA

1960	1,650	29	1966	5,540	34
1961	2,290	29	1967	5,580	34
1962	2,385	34	1968	7,155	37
1963	3,230	34	1969	6,370	37
1964	3,480	34	1970	8,515	35
1965	3,770	34	1971	10,370	38

FREDERICTON/TORONTO

1960	4,190	34	1966	14,175	40
1961	6,005	34	1967	15,235	40
1962	8,050	40	1968	15,630	44
1963	8,630	40	1969	17,340	44
1964	10,320	40	1970	24,980	48
1965	12,060	40	1971	24,205	50

SAINT JOHN/MONTREAL

1960	10,050	24	1966	18,290	27
1961	11,385	24	1967	26,680	27
1962	12,025	27	1968	21,565	30
1963	12,960	27	1969	21,955	30
1964	15,765	27	1970	26,125	32
1965	17,955	27	1971	24,715	34

SAINT JOHN/TORONTO

1960	7,065	37	1966	13,950	43
1961	8,315	37	1967	15,490	43
1962	9,780	43	1968	18,120	47
1963	10,390	43	1969	17,750	47
1964	10,490	43	1970	20,625	49
1965	11,800	43	1971	22,570	52

MONCTON/MONTREAL

1960	12,940	25	1966	21,720	29
1961	15,095	25	1967	25,955	29
1962	14,920	29	1968	25,505	32
1963	14,360	29	1969	27,950	32
1964	15,755	29	1970	32,755	35
1965	18,905	29	1971	31,580	37

MONCTON/TORONTO

1960	10,860	39	1966	18,425	45
1961	12,775	39	1967	19,250	45
1962	11,410	45	1968	20,785	50
1963	13,330	45	1969	22,705	50
1964	13,230	45	1970	25,505	53
1965	16,270	45	1971	26,845	56

ST. JOHNS/MONTREAL

1960	10,095	55	1966	17,850	60
1961	9,750	55	1967	26,450	60
1962	9,620	60	1968	24,325	66
1963	12,475	60	1969	24,575	66
1964	13,875	60	1970	25,695	67
1965	15,060	60	1971	26,020	70

ST. JOHNS/OTTAWA

1960	2,230	62	1966	5,165	69
1961	2,540	62	1967	5,800	69
1962	2,675	69	1968	5,670	76
1963	2,600	69	1969	6,540	76
1964	3,695	69	1970	7,630	73
1965	4,495	69	1971	10,310	76

ST. JOHNS/TORONTO

1960	8,070	75	1966	22,830	83
1961	9,400	75	1967	24,370	83
1962	10,635	83	1968	25,955	91
1963	13,190	83	1969	30,940	91
1964	10,155	83	1970	35,300	85
1965	18,760	83	1971	40,580	89

QUEBEC/MONTREAL

1960	64,575	11	1966	81,925	13
1961	69,515	11	1967	80,135	13
1962	78,205	13	1968	69,480	15
1963	89,480	13	1969	78,720	15
1964	88,060	13	1970	92,675	16
1965	82,345	13	1971	90,100	19

QUEBEC/OTTAWA

1960	7,580	18	1966	12,170	22
1961	7,305	18	1967	14,450	22
1962	8,400	22	1968	16,035	24
1963	10,105	22	1969	18,320	24
1964	10,010	22	1970	24,495	23
1965	9,530	22	1971	29,940	25

QUEBEC/TORONTO

1960	17,020	31	1966	24,005	36
1961	18,345	31	1967	25,525	36
1962	18,930	36	1968	28,815	40
1963	22,780	36	1969	30,935	40
1964	20,695	36	1970	36,890	36
1965	22,345	36	1971	41,730	38

MONTREAL/OTTAWA

1960	35,215	7	1966	30,595	9
1961	30,275	7	1967	36,975	9
1962	28,510	9	1968	38,265	11
1963	28,770	9	1969	46,565	11
1964	25,425	9	1970	60,460	12
1965	26,965	9	1971	67,710	14

MONTREAL/TORONTO

1960	312,180	20	1966	458,875	23
1961	338,170	20	1967	580,325	23
1962	368,615	23	1968	547,310	25
1963	386,550	23	1969	586,095	25
1964	396,815	23	1970	674,765	28
1965	444,750	23	1971	685,805	30

MONTREAL/LONDON

1960	14,130	27	1966	16,720	32
1961	14,400	27	1967	19,560	32
1962	14,230	32	1968	17,660	35
1963	15,320	32	1969	23,455	35
1964	13,760	32	1970	26,685	33
1965	16,280	32	1971	28,460	35

MONTREAL/WINDSOR

1960	17,250	34	1966	23,670	40
1961	17,080	34	1967	44,495	40
1962	17,390	40	1968	26,100	44
1963	18,275	40	1969	27,530	44
1964	16,625	40	1970	33,870	39
1965	20,200	40	1971	35,635	42

MONTREAL/WINNEPEG

1960	19,185	58	1966	37,040	63
1961	24,355	58	1967	64,520	63
1962	25,400	63	1968	49,335	69
1963	26,980	63	1969	55,500	69
1964	25,510	63	1970	61,175	74
1965	30,625	63	1971	56,680	77

MONTREAL/CALGARY

1960	6,545	90	1966	18,315	100
1961	8,600	90	1967	30,380	100
1962	8,820	100	1968	25,810	110
1963	9,615	100	1969	32,435	110
1964	10,925	100	1970	32,150	116
1965	12,730	100	1971	34,355	120

MONTREAL/EDMONTON

1960	6,285	90	1966	15,095	100
1961	10,055	90	1967	28,080	100
1962	9,615	100	1968	17,125	110
1963	9,295	100	1969	22,390	110
1964	9,740	100	1970	24,750	116
1965	11,675	100	1971	25,065	120

MONTREAL/VANCOUVER

1960	16,655	110	1966	41,165	120
1961	23,105	110	1967	69,825	120
1962	24,730	120	1968	55,680	132
1963	25,150	120	1969	71,470	132
1964	26,150	120	1970	78,045	140
1965	33,095	120	1971	76,885	145

OTTAWA/TORONTO

1960	106,695	16	1966	168,820	19
1961	122,055	16	1967	202,725	19
1962	124,630	19	1968	227,720	21
1963	132,395	19	1969	251,475	21
1964	132,355	19	1970	305,560	23
1965	152,795	19	1971	326,560	25

OTTAWA/LONDON

1960	5,080	23	1966	9,480	28
1961	6,810	23	1967	11,890	28
1962	6,740	28	1968	12,910	31
1963	6,730	28	1969	16,080	31
1964	7,260	28	1970	20,210	28
1965	9,050	28	1971	22,710	30

OTTAWA/WINDSOR

1960	7,120	30	1966	9,160	36
1961	7,370	30	1967	9,060	36
1962	6,290	36	1968	10,010	39
1963	5,610	36	1969	10,530	39
1964	7,000	36	1970	14,170	34
1965	8,100	36	1971	15,060	36

OTTAWA/WINNIPEG

1960	6,645	53	1966	20,020	58
1961	9,890	53	1967	26,905	58
1962	11,405	58	1968	25,615	64
1963	11,290	58	1969	28,595	64
1964	11,430	58	1970	39,545	70
1965	13,725	58	1971	39,780	73

OTTAWA/REGINA

1960	1,740	73	1966	4,650	81
1961	2,640	73	1967	7,405	81
1962	2,600	81	1968	5,355	89
1963	2,910	81	1969	7,050	89
1964	2,765	81	1970	8,630	89
1965	3,490	81	1971	11,390	92

OTTAWA/CALGARY

1960	3,130	86	1966	7,865	96
1961	4,060	86	1967	9,985	96
1962	4,515	96	1968	12,410	106
1963	5,010	96	1969	14,690	106
1964	4,930	96	1970	18,385	112
1965	5,080	96	1971	20,135	116

OTTAWA/EDMONTON

1960	3,885	86	1966	9,470	96
1961	5,765	86	1967	12,000	96
1962	6,195	96	1968	11,610	106
1963	6,000	96	1969	13,735	106
1964	6,560	96	1970	17,640	112
1965	7,370	96	1971	20,330	116

OTTAWA/VANCOUVER

1960	5,330	106	1966	14,735	116
1961	8,950	106	1967	19,160	116
1962	8,595	116	1968	21,510	128
1963	8,895	116	1969	27,245	128
1964	10,210	116	1970	32,215	136
1965	11,720	116	1971	38,345	140

TORONTO/LONDON

1960	21,970	7	1966	14,040	9
1961	21,355	7	1967	16,670	9
1962	15,265	9	1968	17,650	11
1963	15,820	9	1969	19,825	11
1964	14,445	9	1970	23,775	12
1965	13,900	9	1971	21,925	14

TORONTO/WINDSOR

1960	64,800	14	1966	77,165	17
1961	70,435	14	1967	72,180	17
1962	68,785	17	1968	74,330	19
1963	71,955	17	1969	71,935	19
1964	69,870	17	1970	92,975	21
1965	74,110	17	1971	86,160	23

TORONTO/SAULT STE. MARIE

1960	17,840	22	1966	38,380	25
1961	20,430	22	1967	44,945	25
1962	26,300	25	1968	48,620	28
1963	25,830	25	1969	49,080	28
1964	26,630	25	1970	61,085	27
1965	32,990	25	1971	65,965	30

TORONTO/THUNDERBAY

1960	21,030	33	1966	48,275	37
1961	29,510	33	1967	56,680	37
1962	30,680	37	1968	63,040	41
1963	31,115	37	1969	69,955	41
1964	32,345	37	1970	84,500	42
1965	40,500	37	1971	96,530	45

TORONTO/WINNIPEG

1960	46,465	47	1966	95,880	52
1961	62,790	47	1967	109,155	52
1962	65,455	52	1968	125,825	57
1963	70,655	52	1969	146,265	57
1964	69,150	52	1970	170,920	63
1965	79,455	52	1971	163,075	66

TORONTO/SASKATOON

1960	7,115	72	1966	13,255	82
1961	8,935	72	1967	16,740	82
1962	8,935	82	1968	19,190	90
1963	9,295	82	1969	19,685	90
1964	8,620	82	1970	23,915	88
1965	11,805	82	1971	28,875	92

TORONTO/REGINA

1960	9,845	67	1966	19,820	75
1961	12,875	67	1967	21,000	75
1962	12,885	75	1968	25,185	82
1963	13,135	75	1969	28,455	82
1964	13,760	75	1970	31,495	82
1965	16,440	75	1971	34,400	85

TORONTO/CALGARY

1960	19,055	79	1966	44,895	89
1961	28,400	79	1967	52,160	89
1962	27,875	89	1968	64,690	98
1963	27,460	89	1969	75,735	98
1964	31,435	89	1970	82,975	105
1965	38,080	89	1971	86,695	109

TORONTO/EDMONTON

1960	16,985	79	1966	38,755	89
1961	23,440	79	1967	44,520	89
1962	26,455	89	1968	52,170	98
1963	26,135	89	1969	63,395	98
1964	24,885	89	1970	70,055	105
1965	32,885	89	1971	72,800	109

TORONTO/VANCOUVER

1960	34,130	99	1966	87,150	109
1961	48,545	99	1967	97,095	109
1962	51,705	109	1968	117,115	120
1963	56,545	109	1969	142,980	120
1964	59,595	109	1970	163,000	128
1965	73,190	109	1971	182,815	133

TORONTO/VICTORIA

1960	6,395	99	1966	13,705	109
1961	9,260	99	1967	16,155	109
1962	8,150	109	1968	22,750	120
1963	8,530	109	1969	24,195	120
1964	7,650	109	1970	26,475	131
1965	11,085	109	1971	23,850	135

WINDSOR/WINNIPEG

1960	2,580	45	1966	7,440	50
1961	3,560	45	1967	7,525	50
1962	3,550	50	1968	7,760	55
1963	4,985	50	1969	7,650	55
1964	5,060	50	1970	11,125	59
1965	6,070	50	1971	9,080	62

THUNDERBAY/WINNIPEG

1960	9,350	24	1966	19,900	27
1961	12,550	24	1967	23,010	27
1962	12,480	27	1968	24,905	30
1963	12,425	27	1969	25,515	30
1964	12,670	27	1970	28,895	31
1965	16,225	27	1971	29,790	34

WINNIPEG/SASKATOON

1960	11,570	25	1966	21,420	30
1961	13,420	25	1967	26,635	30
1962	12,840	30	1968	30,285	33
1963	12,935	30	1969	32,505	33
1964	13,365	30	1970	39,610	35
1965	15,315	30	1971	39,000	37

WINNIPEG/REGINA

1960	19,060	20	1966	29,525	23
1961	20,010	20	1967	34,585	23
1962	18,610	23	1968	35,630	25
1963	18,345	23	1969	38,245	25
1964	20,775	23	1970	44,105	25
1965	24,820	23	1971	42,785	25

WINNIPEG/CALGARY

1960	12,715	36	1966	27,555	43
1961	17,975	36	1967	33,255	43
1962	16,475	43	1968	42,740	47
1963	18,545	43	1969	50,245	47
1964	19,285	43	1970	60,975	52
1965	23,855	43	1971	57,085	55

WINNIPEG/EDMONTON

1960	15,415	36	1966	24,990	43
1961	18,125	36	1967	29,995	43
1962	18,865	43	1968	28,825	47
1963	18,430	43	1969	32,250	47
1964	16,860	43	1970	45,720	52
1965	20,690	43	1971	43,310	55

WINNIPEG/VANCOUVER

1960	22,140	58	1966	47,295	63
1961	31,680	58	1967	54,050	63
1962	31,825	63	1968	62,825	69
1963	33,545	63	1969	81,765	69
1964	30,205	63	1970	90,320	76
1965	37,225	63	1971	85,050	79

SASKATOON/CALGARY

1960	6,610	23	1966	11,490	26
1961	7,385	23	1967	17,265	26
1962	6,470	26	1968	20,125	28
1963	8,320	26	1969	24,375	28
1964	9,225	26	1970	29,445	28
1965	10,775	26	1971	27,770	31

SASKATOON/EDMONTON

1960	7,990	19	1966	9,385	24
1961	8,065	19	1967	12,585	24
1962	7,180	24	1968	14,725	26
1963	6,560	24	1969	15,985	26
1964	5,965	24	1970	19,350	27
1965	8,370	24	1971	21,000	29

SASKATOON/VANCOUVER

1960	6,755	48	1966	10,400	57
1961	8,250	48	1967	12,600	57
1962	7,895	57	1968	15,380	62
1963	7,055	57	1969	18,010	62
1964	6,230	57	1970	25,370	53
1965	8,025	57	1971	28,945	55

REGINA/CALGARY

1960	14,300	25	1966	27,885	28
1961	15,440	25	1967	32,305	28
1962	16,325	28	1968	33,510	31
1963	20,050	28	1969	36,070	31
1964	20,400	28	1970	41,630	33
1965	25,310	28	1971	40,385	36

REGINA/EDMONTON

1960	7,655	26	1966	13,570	30
1961	10,270	26	1967	17,000	30
1962	9,010	30	1968	18,615	33
1963	9,270	30	1969	20,435	33
1964	9,700	30	1970	23,630	34
1965	11,240	30	1971	22,905	37

REGINA/VANCOUVER

1960	8,715	52	1966	14,160	59
1961	10,155	52	1967	16,665	59
1962	9,860	59	1968	19,515	65
1963	10,250	59	1969	24,675	65
1964	10,030	59	1970	28,795	58
1965	11,940	59	1971	34,925	61

CALGARY/EDMONTON

1960	65,890	11	1966	125,825	13
1961	59,140	11	1967	157,125	13
1962	57,530	13	1968	173,220	15
1963	64,075	13	1969	212,915	15
1964	78,910	13	1970	234,845	17
1965	102,350	13	1971	254,800	20

CALGARY/VANCOUVER

1960	44,115	27	1966	75,930	31
1961	57,320	27	1967	93,415	31
1962	51,105	31	1968	111,175	34
1963	46,835	31	1969	141,910	34
1964	53,150	31	1970	166,035	34
1965	62,555	31	1971	179,370	37

CALGARY/VICTORIA

1960	7,005	34	1966	9,525	39
1961	8,345	34	1967	11,830	39
1962	7,050	39	1968	14,930	43
1963	6,365	39	1969	16,735	43
1964	6,465	39	1970	20,790	37
1965	8,320	39	1971	28,950	39

EDMONTON/VANCOUVER

1960	35,100	29	1966	71,535	33
1961	54,409	29	1967	86,470	33
1962	50,445	33	1968	101,985	36
1963	46,370	33	1969	121,990	36
1964	48,540	33	1970	139,330	39
1965	57,300	33	1971	144,715	41

EDMONTON/VICTORIA

1960	5,245	36	1966	7,490	41
1961	6,450	36	1967	10,525	41
1962	5,680	41	1968	11,720	45
1963	5,255	41	1969	12,285	45
1964	6,495	41	1970	15,420	41
1965	6,560	41	1971	18,510	43

VANCOUVER/VICTORIA

1960	68,860	7	1966	48,060	8
1961	65,765	7	1967	67,775	8
1962	50,675	8	1968	76,060	10
1963	40,485	8	1969	57,695	10
1964	44,490	8	1970	67,340	11
1965	48,275	8	1971	57,690	13

A P P E N D I X   C

1960-1971 DATA LISTING OF:

1) CORRESPONDING ANNUAL POPULATION (000),

2) CORRESPONDING ANNUAL MEAN DISPOSABLE INCOME ($),

FOR 21 CITIES

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	SYDNEY & GLACE BAY	
1960	104.2	1,300
1961	107.2	1,320
1962	108.0	1,375
1963	109.9	1,380
1964	109.9	1,470
1965	110.9	1,590
1966	100.7	1,690
1967	106.1	1,880
1968	105.6	2,070
1969	105.2	2,270
1970	105.0	2,400
1971	104.4	2,550
	HALIFAX & DARTMOUTH	
1960	183.6	1,480
1961	183.9	1,510
1962	188.0	1,570
1963	192.7	1,640
1964	195.1	1,740
1965	189.9	1,870
1966	198.2	1,990
1967	199.7	2,200
1968	203.1	2,410
1969	205.6	2,650
1970	205.3	2,830
1971	222.6	2,990

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	FREDERICTON	
1960	20.4	1,440
1961	19.7	1,480
1962	20.0	1,540
1963	20.2	1,640
1964	20.4	1,760
1965	20.5	1,910
1966	22.5	2,120
1967	22.9	2,310
1968	23.7	2,500
1969	24.2	2,750
1970	24.3	2,970
1971	24.3	3,240
	SAINT JOHN	
1960	93.8	1,170
1961	95.6	1,210
1962	97.5	1,270
1963	99.2	1,380
1964	100.3	1,480
1965	101.7	1,610
1966	101.2	1,770
1967	102.1	1,920
1968	101.6	2,040
1969	102.5	2,220
1970	100.9	2,380
1971	106.7	2,650

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	MONCTON	
1960	56.1	1,525
1961	57.5	1,615
1962	58.4	1,690
1963	59.4	1,600
1964	59.6	1,720
1965	60.7	1,870
1966	55.4	2,070
1967	60.5	2,260
1968	61.2	2,450
1969	61.9	2,690
1970	61.2	2,910
1971	79.8	3,170
	ST. JOHNS	
1960	86.3	1,100
1961	90.8	1,160
1962	93.9	1,240
1963	96.9	1,240
1964	99.2	1,270
1965	96.6	1,390
1966	101.2	1,560
1967	102.9	1,660
1968	104.3	1,630
1969	107.6	1,780
1970	112.1	1,940
1971	131.8	2,340

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	QUEBEC	
1960	338.3	1,240
1961	357.6	1,240
1962	365.4	1,340
1963	373.4	1,500
1964	384.5	1,590
1965	393.0	1,690
1966	413.4	1,800
1967	421.7	1,950
1968	425.3	2,180
1969	429.6	2,340
1970	432.4	2,490
1971	480.5	2,610
	MONTREAL	
1960	1,800.4	1,630
1961	2,109.5	1,630
1962	2,174.6	1,750
1963	2,239.9	1,690
1964	2,265.4	1,790
1965	2,311.7	1,930
1966	2,436.8	2,030
1967	2,485.2	2,210
1968	2,529.6	2,490
1969	2,563.8	2,650
1970	2,570.7	2,810
1971	2,743.2	3,050

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	OTTAWA & HULL	
1960	400.4	1,740
1961	429.8	1,740
1962	442.4	1,800
1963	458.5	2,120
1964	473.1	2,210
1965	483.1	2,390
1966	494.5	2,500
1967	507.7	2,640
1968	519.0	2,990
1969	527.4	3,230
1970	537.2	3,390
1971	602.5	3,670
	TORONTO	
1960	1,559.4	1,870
1961	1,824.5	1,890
1962	1,871.1	1,990
1963	1,921.3	1,990
1964	1,982.3	2,060
1965	2,056.2	2,220
1966	2,158.5	2,320
1967	2,224.5	2,430
1968	2,290.7	2,720
1969	2,329.2	2,870
1970	2,364.5	2,990
1971	2,628.0	3,420

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	LONDON	
1960	168.0	1,750
1961	181.3	1,760
1962	184.9	1,820
1963	189.4	1,850
1964	192.2	1,930
1965	196.6	2,070
1966	207.4	2,170
1967	212.8	2,290
1968	219.9	2,570
1969	224.2	2,740
1970	229.0	2,870
1971	286.0	3,190
	WINDSOR	
1960	193.0	1,820
1961	193.4	1,830
1962	193.4	1,880
1963	192.6	1,860
1964	196.9	1,960
1965	203.3	2,100
1966	211.7	2,210
1967	215.8	2,360
1968	220.4	2,560
1969	222.7	2,730
1970	226.6	2,860
1971	258.6	3,180

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	SAULT STE. MARIE	
1960	40.5	2,020
1961	43.1	2,050
1962	48.3	2,110
1963	45.3	2,170
1964	45.6	2,290
1965	70.9	2,450
1966	74.6	2,580
1967	76.6	2,750
1968	77.6	3,060
1969	77.6	3,340
1970	78.9	3,550
1971	80.3	3,920
	THUNDERBAY	
1960	92.3	1,635
1961	92.5	1,645
1962	94.1	1,740
1963	96.2	1,780
1964	97.0	1,880
1965	98.2	2,010
1966	97.8	2,120
1967	99.3	2,270
1968	100.0	2,510
1969	105.8	2,740
1970	108.0	2,910
1971	112.1	3,220

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	WINNIPEG	
1960	445.1	1,520
1961	476.0	1,530
1962	488.2	1,580
1963	502.0	1,780
1964	491.8	1,850
1965	486.2	1,980
1966	508.8	2,100
1967	509.5	2,330
1968	517.8	2,640
1969	528.6	2,850
1970	539.7	3,050
1971	540.3	3,070
	SASKATOON	
1960	85.6	1,610
1961	95.5	1,670
1962	99.6	1,720
1963	103.5	1,750
1964	107.9	1,820
1965	104.5	1,940
1966	115.9	2,110
1967	118.6	2,260
1968	122.9	2,490
1969	128.1	2,680
1970	130.2	2,890
1971	126.5	2,900

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	REGINA	
1960	102.3	1,800
1961	112.1	1,820
1962	116.1	1,870
1963	119.7	1,820
1964	124.2	1,890
1965	125.9	2,020
1966	131.1	2,190
1967	133.5	2,350
1968	136.5	2,600
1969	139.2	2,790
1970	140.0	3,010
1971	140.7	3,020
	CALGARY	
1960	247.7	1,650
1961	279.1	1,640
1962	293.9	1,700
1963	308.8	1,850
1964	311.4	1,950
1965	318.1	2,130
1966	330.6	2,330
1967	338.7	2,510
1968	358.5	2,710
1969	372.9	3,030
1970	388.7	3,190
1971	403.3	3,450

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	EDMONTON	
1960	311.8	1,580
1961	337.6	1,580
1962	353.2	1,630
1963	368.9	1,760
1964	374.2	1,850
1965	380.6	2,000
1966	401.3	2,200
1967	411.3	2,370
1968	424.2	2,570
1969	437.7	2,880
1970	448.5	3,040
1971	495.7	3,240
	VANCOUVER	
1960	755.4	1,730
1961	790.2	1,720
1962	807.3	1,760
1963	828.5	1,890
1964	829.9	1,990
1965	849.6	2,210
1966	892.3	2,320
1967	920.5	2,420
1968	947.1	2,530
1969	978.1	2,690
1970	1,007.6	2,800
1971	1,082.4	3,210

YEAR	POPULATION	MEAN DISPOSABLE INCOME
	VICTORIA	
1960	140.7	1,710
1961	154.2	1,700
1962	156.7	1,740
1963	160.1	1,760
1964	168.5	1,860
1965	169.4	2,040
1966	173.5	2,160
1967	178.9	2,300
1968	181.1	2,380
1969	185.9	2,610
1970	187.5	2,750
1971	195.8	3,090

A P P E N D I X   D

FACTORS USED TO EXPRESS FINANCIAL DATA IN CONSTANT 1961 DOLLARS

(SOURCE: STATISTICS CANADA)

YEAR	FACTOR
1960	1.01
1961	1.00
1962	0.99
1963	0.97
1964	0.95
1965	0.93
1966	0.90
1967	0.87
1968	0.83
1969	0.80
1970	0.77
1971	0.75

A P P E N D I X E

AVERAGE CITY PAIR ATTRACTIVENESS FACTORS FROM TIME SERIES AND CROSS-SECTIONAL MODELS.

CITY-PAIR	A_{ij} TIME SERIES	A_{ij} CROSS-SECTIONAL
SYDNEY/HALIFAX	1.86013	1.79652
SYDNEY/MONTREAL	0.45508	0.39585
SYDNEY/TORONTO	0.68308	0.63431
HALIFAX/FREDERICTON	1.72597	1.69800
HALIFAX/SAINT JOHN	1.72018	1.51465
HALIFAX/MONCTON	0.92567	0.86550
HALIFAX/ST. JOHNS	3.41375	2.85904
HALIFAX/MONTREAL	1.48040	1.44196
HALIFAX/OTTAWA	0.98028	1.02677
HALIFAX/TORONTO	1.85896	1.88561
FREDERICTON/MONTREAL	1.04996	1.03987
FREDERICTON/OTTAWA	0.68811	0.72141
FREDERICTON/TORONTO	1.08509	1.10167
SAINT JOHN/MONTREAL	0.67901	0.60872
SAINT JOHN/TORONTO	0.67288	0.62558
MONCTON/MONTREAL	0.94020	0.89885
MONCTON/TORONTO	1.05597	1.01799
ST. JOHNS/MONTREAL	1.20825	1.00440
ST. JOHNS/OTTAWA	0.66982	0.59670
ST. JOHNS/TORONTO	1.54470	1.37352
QUEBEC/MONTREAL	1.05545	0.90531
QUEBEC/OTTAWA	0.38570	0.40204
QUEBEC/TORONTO	0.58227	0.53674

CITY-PAIR	A_{ij} TIME SERIES	A_{ij} CROSS-SECTIONAL
MONTREAL/OTTAWA	0.24147	0.27024
MONTREAL/TORONTO	3.05349	3.10211
MONTREAL/LONDON	0.47875	0.45422
MONTREAL/WINDSOR	0.71268	0.68429
MONTREAL/WINNIPEG	0.99799	0.95405
MONTREAL/CALGARY	0.69209	0.69054
MONTREAL/EDMONTON	0.59843	0.55727
MONTREAL/VANCOUVER	1.18141	1.16846
OTTAWA/TORONTO	1.87356	2.13379
OTTAWA/LONDON	0.44048	0.48276
OTTAWA/WINDSOR	0.47877	0.48640
OTTAWA/WINNIPEG	0.83610	0.89903
OTTAWA/REGINA	0.49930	0.52513
OTTAWA/CALGARY	0.60225	0.64740
OTTAWA/EDMONTON	0.70377	0.70470
OTTAWA/VANCOUVER	0.81712	0.86934
TORONTO/LONDON	0.21056	0.21204
TORONTO/WINDSOR	1.33093	1.31090
TORONTO/SAULT STE. MARIE	1.24818	1.37905
TORONTO/THUNDERBAY	1.77766	1.88942
TORONTO/WINNIPEG	2.14357	2.19394
TORONTO/SASKATOON	0.88011	0.87532
TORONTO/REGINA	1.05729	1.06212
TORONTO/CALGARY	1.70294	1.73645

CITY-PAIR	A_{ij} TIME SERIES	A_{ij} CROSS-SECTIONAL
TORONTO/EDMONTON	1.38659	1.38038
TORONTO/VANCOUVER	2.26116	2.34110
TORONTO/VICTORIA	0.84502	0.85068
WINDSOR/WINNIPEG	0.43255	0.42299
THUNDERBAY/WINNIPEG	1.22913	1.23496
WINNIPEG/SASKATOON	1.38149	1.42853
WINNIPEG/REGINA	1.49217	1.52176
WINNIPEG/CALGARY	1.37484	1.44028
WINNIPEG/EDMONTON	1.21269	1.17083
WINNIPEG/VANCOUVER	1.87392	1.89632
SASKATOON/CALGARY	0.93665	1.01373
SASKATOON/EDMONTON	0.70237	0.71452
SASKATOON/VANCOUVER	0.86584	0.89165
REGINA/CALGARY	1.91177	1.94005
REGINA/EDMONTON	0.98947	0.98465
REGINA/VANCOUVER	1.08815	1.12449
CALGARY/EDMONTON	2.75997	3.23165
CALGARY/VANCOUVER	2.31283	2.52399
CALGARY/VICTORIA	0.84489	0.87581
EDMONTON/VANCOUVER	2.09398	2.20288
EDMONTON/VICTORIA	0.66551	0.66101
VANCOUVER/VICTORIA	1.10745	1.09838