LONG RANGE FORECASTING OF DOMESTIC AND INTERNATIONAL BOARDING PASSENGERS AT CANADIAN AIRPORTS BY MULTIPLE REGRESSION ANALYSIS

by

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ABSTRACT

The purpose of this thesis is to attempt to explain the forces behind the past growth of Canadian air travel and to use the explanation as a basis for forecasting the long-run growth of Canadian air travel. The forecasting attitude adopted in this study is that of the Department of Transport wishing to quantitatively forecast, to 1975, total Canadian domestic and international air passenger boardings independent of other modes, on the basis of average total Canadian data. Accurate forecasts are important to the Department of Transport since new airports cannot be constructed instantaneously, but at the same time, premature construction of airports is undesirable.

There are a great variety of forecasting methods. Due to the problems of inadequate Canadian air passenger travel data, however, the author felt that the only appropriate quantitative method of forecasting air passenger boardings at the major Canadian airports, would be with dynamic and static, multiple regression models. The dynamic model is a new approach at forecasting air passenger boardings, since at the time of this study, not one example of its use in forecasting air passenger boardings could be found. The dynamic model of this thesis expresses the idea that current decisions are influenced by past behavior i.e. habit formation. Also, although there are many examples of the use of a static model for forecasting air passengers, the form of this study's static models is quite unique since it tries to take into account the increasing air travel elasticity of rising per capita incomes.

There are many factors affecting demand but it was not possible to provide explicitely in multiple regression forecasting formulas for

all of them because of the complexities involved and the lack of data with respect to some of them. It was found that one of the major factors affecting future boardings per capita will be fare policy. The long-run fare elasticity was found to be approximately -2.30. In forecasting air passenger boardings, five different assumptions were made with respect to future fare levels.

The growth patterns of each of this thesis's five air passenger boarding forecasts based on the five future fare assumptions had two things in common: (1) all showed a declining rate of growth both in terms of boardings per capita and total Canadian boardings and (2) all showed absolute annual increments which in general increased from year to year throughout the entire forecast period. These two trends are both major characteristics of a growth industry which has not yet matured.

An average annual decrease of 0.1334 current cents in the air passenger yield per passenger-mile seems the most reasonable future fare assumption. If this is so, the growth of total air passenger boardings will progressively decline from a 7.81 percent increase in 1968 to a 6.54 percent increase in 1975 and the growth of boardings per capita will progressively decline from a 5.07 percent increase in 1968 to a 4.35 percent increase in 1975. This forecasted growth is much lower than in the historical period of 1955-1966 when the average percent growth in total boardings was 11.4 percent and in boardings per capita was 8.48 percent.

Of course, national forecasts of total domestic and international air passenger boardings are of little value in comparison to air passenger boarding forecasts of individual Canadian cities. Fortunately, the largest twenty-five air transportation hubs, which have accounted for 89 percent to 93 percent of the total of all Canadian air passenger boardings in the past, have through time each maintained a generally consistent relationship to the national total. Thus, by fitting numerous least-squares trend curves through each community's past percentage of national air passenger boardings and modifying where necessary because of the advice of experienced people in Canadian air travel, forecasted percentages of total Canadian boardings were arrived at for each of the largest twenty-five Canadian air transportation hubs.

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CHAPTER I

INTRODUCTION

A. Scope and Purpose of the Study

The purpose of this study is to explain the forces behind the past growth of Canadian air travel and to use this explanation as a basis for a projection of the future growth rate of Canadian air travel. Of course, accepting normal fluctuations in the Canadian economy but barring any major world catastrophe, growth in air traffic is inevitable as the airlines strengthen their position in the common carriage of passengers. There is the ever-present incentive to travel in any developed country and the airlines represent the most efficient long-range transportation media available.

It is necessary, however, to have more than vague long-range forecasts to be able to plan and construct airports. But accurately forecasting future events is a hazardous undertaking in any industry in this modern era of rapidly increasing incomes and changing technology. One way of reducing the margin of error is to have a short forecasting period. In many quarters, five years is considered to be the longest forecast period, in which any confidence can be put. However, government agencies connected with air transportation require long-range forecasts of from ten to twenty years for conceptual planning.

B. Forecasting Attitude of This Study

There is a wide diversity in forecasting attitudes. The viewpoint of the economist, who defines future trends on the basis of large scale quantitative models, is far removed from the businessman, who is concerned with increasing his clientele or smoothly running his company. There are also further differences in research carried out by those trying to analyze individual behaviour in terms of social class, education received and age, and research carried out by statisticians using average data for the total Canadian population. Furthermore, there is the wide difference in opinion between those who think an overall study should be made first of all modes from which respective shares could be distributed to each mode, and those who assume a high degree of independence between modes and thus calculate each separately.

The problem tackled in this thesis is to forecast quantitatively to 1975, total Canadian domestic and international air transport boardings[1] on the basis of average total Canadian data. This is the problem which faces the Department of Transport. Accurate forecasts are important to the Department of Transport since new airports cannot be constructed instantaneously, but at the same time, premature construction of new airports is undesirable. To build an airport with a 1975 annual capacity of 500,000 boardings where the actual need may only be 100,000 boardings annually, is to deprive more urgent needs of resources. On the other hand, construction of an airport designed to handle 100,000 boardings annually, where 500,000 will be using it, may have consequences which are much more serious than that of economic misallocation alone. The social

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[1] Boarding passengers are defined as those scheduled passengers who originate their trip at the reporting station (Airport) plus those who transfer from other flights of the same carrier with more than normal layover time (generally more than 4 hours). Domestic boarding passengers are those arriving from or departing to Canadian points while international boarding passengers are those arriving from or departing for points abroad (including U.S.).

and political effects arising from traffic congestion do breed conflicts that are not easily resolved.

An attempt is being made to forecast boarding passengers rather than origin and destination passengers[2] since reliable boarding statistics go back as far as 1955, whereas reliable domestic origin and destination statistics only came into being in approximately 1961 and thus do not provide a time series of adequate length for forecasting purposes. It must be emphasized that this study's forecasts represent an initial step, open to later methodological improvements. Although forecasts of future events can never have a completely scientific, analytical basis since human actions are not entirely random and some few individuals exercise an important influence on events, valid analytical observation about relationships among important variables in the system is very useful in improving the quality of forecasts.

C. Forecasting Techniques

As already mentioned, this study's forecasts are to have a quantitative, scientific basis. But a great variety of forecasting methods exist. One group of methods has the common trait that they base future values of a variable only on the past relationship of the variable over time. Within this group are several possible methods. One technique is to draw a freehand trend line through past data and to extrapolate it to yield forecasts. A second technique involves mathematically fitting an

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[2] Origin/destination passengers are defined as those who complete a continuous Canadian Carrier online journey from the boarding station to the passenger's immediate destination.

appropriate least squares trend line to historical data and projecting it forward. An example of the use of this technique can be found in a formula devised by Professor J. Tinbergen of the Rotterdam School of Economics.[3] A third possible technique of determining future values of a variable based on past relationships, is to make judgments regarding future year-to-year changes and iteratively apply these expected changes to obtain the required estimates. An example of the use of this technique is in Mr. Larsson's "A Critical Review of Earlier Forecasting of Air Traffic and a New Approach".[4] However, regardless of which technique is used in this first type of forecasting methods, there is the implicit assumption that those factors which effect air passenger boardings are highly correlated with time and will continue to be in the future; but if past growth is irregular, as Canadian air travel has been, time is inadequate as the sole explanatory variable on which to base a projection.

A better method of forecasting is to explicitly take into account the influence of causal factors. This method, however, is dependent upon the fulfillment of three basic requirements:

(a) It must be mathematically possible to approximate the relationship of the dependent variable to its determinants, and it must be reasonable to assume this quantitative relationship will persist in the future.

(b) It must be possible to relate changes in a particular variable to identifiable causal factors.

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[3] G. Desmas, Methods of Market Research in Air Transport, (Paris: Institut du Transport Aerien, 1964), p. 15.

[4] *Ibid*., p. 13.

(c) Excellent projections of the independent variables can be made or are available.

Provided these conditions are met--and they are in this study--the most appropriate tool in establishing this mathematical causal relationship is multiple correlation and regression analysis.

In its simple linear form, a multiple regression model can be formulated in an equation of this form:

$$Y = a + b_1X_1 + b_2X_2$$

where: Y = variable to be forecast. i.e. dependent variable.

X_1 = causal factor. i.e. independent variable.

X_2 = causal factor. i.e. independent variable.

a = constant.

b_1 = weight or coefficient of variable X_1

b_2 = weight or coefficient of variable X_2

The researcher specifies those variables, such as X_1 and X_2, which he considers to be determinants of Y and then uses historical data to estimate a, b_1 and b_2 by the method of least squares. In other words, minimizing the squared deviations of the observed combinations of Y, X_1 and X_2 from the straight line. Since multiple regression and correlation explicitly takes into account the influence of causal factors, it has a more scientific basis than trend analysis.

Multiple regression analysis has been the most widely used air travel forecasting technique. Some of the more recent studies employing variations of this technique are:

- Boeing Company. Forecast of Free World Airline Traffic 1959-1975. Renton, Washington: Boeing Company, 1961.

- Boeing Company. International Air Traffic Forecast. Renton, Washington: Boeing Company, 1966.
- Boeing Company. Traffic Forecast. Renton, Washington: Boeing Company, 1967.
- Civil Aeronautics Board. Forecast of Airline Passenger Traffic in the United States: 1959-1965. A Report prepared by the Research and Statistics Division of the Bureau of Accounts and Statistics. Washington: Government Printing Office, 1959.
- Civil Aeronautics Board. Forecasts of Passenger Traffic on the Domestic Trunk Air Carriers, Domestic Operations, Scheduled Service 1965-1975. Staff Report Number Five of the Research and Statistics Division of the Bureau of Accounts and Statistics. Washington: Government Printing Office, 1965.
- Clare, Kenneth G. Southern California Regional Airport Study. South Pasadena, California: Southern California Labratories of Stanford Research Institute, 1964.
- Federal Aviation Administration. Aviation Demand and Airport Facility Requirement Forecast for Large Air Transportation Hubs Through 1980. Washington: Government Printing Office, 1967.
- Federal Aviation Administration. Aviation Forecasts--Fiscal Years 1962-1967. A Report Prepared by the Air Commerce Division of the Economics Branch. Washington: Government Printing Office, 1961.
- Federal Aviation Administration. Aviation Forecast--Fiscal Years 1967-1977. A Report Prepared by the Systems Planning Division of the Airport Services Branch. Washington: Government Printing Office, 1967.

- Saginor, Irving. Forecast of Scheduled Domestic Air Passenger Traffic for the Eleven Trunk Carriers 1968-1977. Economic Research Section, Planning, Programming and Research Division, Civil Aeronautics Board. Washington: Government Printing Office, 1967.
- Richmond, Samuel B. "Forecasting Air Passenger Traffic by Multiple Regression Analyses", The Journal of Air Law and Commerce. XXII (Autumn, 1955), pp. 434-449.
- Schary, Philip and Robert M. Williams. "Airline Fare Policy and Public Investment", Transportation Journal, VII (Fall, 1967), pp. 41-49.
- Air Canada. "Air Canada's Econometric Marketing Model". Technical paper for the Second Annual Meeting of the Canadian Transportation Research Forum, Niagara Falls: September 8-9, 1966.

A third procedure of forecasting, the evolution theory method, is based on a thorough study of past history and a detection of some apparent rule of growth which can be assumed to continue in the future. The only widely known study using this approach was by T. F. Comick and W. M. Wallace.[5] After closely scrutinizing the development of the U.S. domestic air traffic, Comick and Wallace concluded that air traffic develops in successive leaps according to technical progress leading to the introduction of new aircraft types. These leaps have been in nine year intervals since 1926 with the rate of growth declining progressively. Unfortunately, this

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[5] T. F. Comick and W. M. Wallace, Forecast of United States Domestic Airline Traffic 1961-1975, Market Research and Planning Division, Boeing Company (Washington: Government Printing Office, 1967).

evolution theory method could not be used in Canada since reliable Canadian domestic and international air passenger boardings only go back as far as 1955.

Along quite similar lines, the Boeing Company just recently forecasted air travel using the concept of a growth industry--growth begins with innovation and it continues as long as technological improvements: (a) upgrade quality and lower unit costs simultaneously; (b) upgrade quality at static unit costs; or (c) lower unit costs at static quality.[6] They have tried to quantify the quality of each element of a total trip experience. The following quality variables were analyzed:

(1) Seat Departures -- This variable reflects the quality of convenience of ample departure frequency, combined with seat availability; it permits the air traveller to fly when he wants, with only short notice for reservations.[7]

(2) Airline Scheduling -- Since the increase of nonstop services leads to greater passenger convenience in terms of fewer transfers and shorter travel time, the quantity variable used was average number of intermediate stops equals average passenger trip divided by average airplane trip.[8]

(3) Schedule Reliability -- Percentage of total nonstop and one-stop flights of domestic trunk carriers that arrive within

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[6] W. M. Wallace and J. G. Moore, Calling the Turns--The Forecasting Problem in the Air Transport Industry, Market Research and Planning Division, The Boeing Company (Renton, Washington: The Boeing Company, 1968), p. 9.

[7] *Ibid.*, p. 15.

[8] *Ibid.*, p. 16.

0 - 15 minutes of scheduled time.[9]

(4) Schedule Cancellation equals seat miles performed divided by seat miles scheduled.[10]

(5) Passenger Service -- Each of the variables of passenger service (food, labour, interrupted trip expense, insurance and all other) were put in terms of constant dollars per passenger to measure service improvement.[11]

(6) Air Time of Average Passenger Trip equals average passenger trip divided by flight time. This variable reflects not only increasing air speed but also a trend toward longer average passenger trips.[12]

(7) Interior Airplane Passenger Perceived Noise in Deubels per Passenger-hour.[13]

(8) Space equals Cubic feet of passenger space per revenue passenger including load factor. This index was calculated by taking each aircraft type and dividing its cabin volume by average installed seats and load factor. This value was weighted with Revenue Passenger Miles flown by a particular aircraft type and a subsequent composite "space" index for all airplanes was computed.[14]

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[9] _Ibid._, p. 17.

[10] _Ibid._, p. 18.

[11] _Ibid._, p. 19.

[12] _Ibid._, p. 20.

[13] _Ibid._, p. 21.

[14] _Ibid._, p. 22.

(9) Ride Comfort equals vertical G's experienced by the airplane due to a unit gust loading. After these values were calculated for each aircraft type, they were weighted by RPM's flown by the aircraft type to obtain a composite index for all aircraft types.[15]

(10) Safety equals 1/ (accidents + 2 x passenger Fatalities).[16]

The relative weighting for each quality variable was calculated by finding the Bayesian weights. The Boeing Company was very fortunate in being able to quantify these quality variables since here in Canada, only a few of these quality variables could be quantified due to a lack of data.

A fifth air travel forecasting method is the market analysis method. With market analysis forecasting techniques, the composition of the air travel market is determined as to age, industry, family income, education, etc., for several years, and then compared for these same years to a breakdown of the national population by the same characteristics. This shows how people with various social, economic and demographic characteristics demonstrate distinct and predictable air travel behaviour. Assuming this hypothesis to be true, the composition and size of the future air travel market will be determined principally by the future size of each of the corresponding elements of the population as a whole, measured in terms of (at least) occupation, age, industry, income and education, and the distinct growth rate of air travel frequency per thousand people in each

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[15] Ibid., p. 23.

[16] Ibid., p. 24.

population group. The Port of New York Authority has made the most comprehensive use of the market analysis forecasting technique.[17] The Douglas Aircraft Corporation conducted a superficial study using this technique.[18]

A sixth air travel forecasting method is the traffic model approach, Traffic models estimate, through equations, travel by each major travel mode on each origin-destination segment for each of several trip types. Traffic models are very sensitive to changes in the travel time, cost and convenience of travel by each available travel mode, as well as to socio-economic changes as they affect travel. So far travel models have been used mainly for urban transportation purposes, but some air traffic models have been developed for inter-city travel. Probably the most extensive application is by Wesley H. Long.[19]

Unfortunately, statistical information on air travel in Canada is less complete than in the United States and data on other modes of travel such as car and bus trips is even less available. Consequently, traffic and market analysis forecasting techniques could not be experimented with in this study.

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[17] Port of New York Authority, New York's Air Travelers, A Report Prepared by the Forecast and Analysis Division of the Aviation Department (New York: Port of New York Authority, 1955).

[18] Douglas Aircraft Division, Measuring the 70's--An Air Travel Market Analysis, (Long Beach, California: Douglas Aircraft Division, 1966).

[19] Wesley H. Long, "City Characteristics and the Demand for Interurban Air Travel", Land Economics, XLIV (May, 1968), pp. 197-204.

CHAPTER II

THE FORECASTING TECHNIQUE USED IN THIS STUDY

A. Forecasting Using Multiple Regression Models

Due to the problems of inadequate Canadian air passenger travel data, as mentioned in Chapter one, the author felt that the most appropriate method of forecasting air passenger boardings at the major Canadian airports would be with dynamic and static, multiple regression models. The dynamic model is a new approach at forecasting air passenger boardings, since at the time of this study not one example of its use in forecasting air passenger boardings could be found. The major airplane manufacturers (Boeing, Douglas and Lockheed), the Civil Aeronautics Board and the Federal Aviation Agency have made quantitative forecasts of U.S. air passenger boarding using only static multiple regression forecasting models. The dynamic model of this study expresses the idea that current decisions are influenced by past behaviour i.e. habit formation. Also, although there are many examples of the use of a static model for forecasting boardings using variables similar to those used in this study, the form of this study's static models is unique since it tries to take into account the increasing air travel elasticity of rising per capita incomes.

Throughout this study, it must be remembered that high correlation coefficients with time-series are commonplace, so that this in itself is little reason for self-congratulation. More important in many respects is the statistical significance of the regression coefficients. The statistical significance or reliability of regression coefficients is usually measured in terms of the standard errors of the regression coefficients. Given the assumption of a normal distribution, 99 percent of all the individual observations will fall within three standard errors of the regression coefficient, 95 percent will fall within two standard errors and 68 percent within one standard error. Thus, one can tell how well a regression coefficient represents the data on which it is based by examining the size of the standard error of the regression coefficient; the smaller the standard error, the smaller the scatter in the data and the better the regression represents that particular data. In this study, any model which has a regression coefficient with a standard error larger than the regression coefficient has been rejected.

Multiple regression need not be carried out only on a linear basis but can be fitted to any mathematical curve. In the present state of the forecasting art, the mathematical form of the forecasting model cannot be specified a priori. Although there is quite wide agreement on the adoption of a mathematical growth curve describing first of all a rapid development, tending after a certain stage to a degree of stabilization; there are wide differences of opinion as to the exact stage of development reached in Canada.[1] Thus several different forms, especially those involving logarithmic transformation of one or more of the variables will be tried.

It is possible, given a sufficient number of parameters and a small number of observations, to adjust any curve to a mathematical expression. The adjustment, however, is only of practical value when it retains but three or four easily measurable variables and expresses a simple, easily

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[1] G. Desmas, Methods of Market Research in Air Transport, (Paris: Institut du Transport Aerien, 1964), p. 49.

interpreted relationship. Since the computer is being used in this study, many large models involving many variables could easily be built. The limits of the computer's capabilities, however, extend well beyond the limits of their usefulness in model building. Using the high order of computation capabilities of computers, complex mathematical models have been developed in other transportation fields (especially urban transportation) to purportedly show scientifically the exact relationships between large numbers of variables depicting the many characteristics of travellers. But in developing these seemingly precise mathematical models, the important fact seems to have been overlooked, that there are few, if any, fully validated and generally accepted behavioral models, and few realistic measurable inputs for the computers to digest. Complex mathematical models founded on a series of assumptions as to human behavior rather than on factual data, have created an aura of mathematical precision that is very misleading.

Mathematical forecasting models used with a relatively few meaningful variables, however, are much better than verbal models. First of all, a forecast based on intuition is hard to define. It is difficult to explain exactly what is and what is not taken into account and to what extent. Secondly it is difficult to choose among several verbal models since their accuracy is hard to test. On the other hand, a mathematical model leads to completeness. The mathematical framework allows one to see where gaps exist so that important areas or essential relationships are less likely to be omitted. Thirdly by setting up formal definitions of relationships, the vagueness and inaccuracy present in many verbal theories is precluded. For example, multiple regression and correlation techniques may show that it is impossible to accept, as is so often done in verbal forecasts, the simplifying assumption of all other things remaining constant. A fourth advantage of mathematical models is that their framework permits the use of actual figures. Furthermore, with predictions in actual figures, it is easily possible to test prediction results so that if errors occur, the model can be easily corrected. Of course, it should be emphasized that the results of a mathematical model can be no better than the assumptions and the series of specific judgments that go into the model.

A mathematical framework does not have to be complete in every detail. The forecaster must use judgment and make logical assumptions in forming the framework. The forecaster can test the effect of opposing ideas to see if they would make significant differences in the predicted results. A logically more valid forecasting model would introduce variables which would be difficult to measure and project, and the whole structure would be much more complex. The best plan of attack is to first deduce what are the immediate causes suggested by theory, and then to subject them to practical considerations of manageability and availability of statistical observations. In most cases, a relatively small number of variables will suffice since, although there may, in fact, be many other variables relating to the situation, they may either tend to balance each other out or be of minor importance quantitatively.

Of course, significant differences between the estimated levels of the predictor factors used in the multiple regression forecasting models developed in this study and the levels actually realized during each of the next nine years would necessitate revising the forecasts. Even if the independent variables do approximate their estimated values, actual air passenger boardings will probably not correspond exactly with the forecasts because they are based on a study of average relationships. But if the values of the independent variables turn out as forecast, it is unlikely that the number of Canadian air passenger boardings will differ significantly from the levels indicated by statistically valid and logically correct multiple regression forecasting models.

The art of forecasting has been developing during the last few decades, and will no doubt be considerably refined as time goes on. Such refinement will come about mainly as a result of improvements in the collecting and processing of important statistics and an improved understanding of economic relationships and human behavior. Today, man cannot rely on the crystal ball or patterns of tea-leaves to tell the future, but he must know the future subject to unpredictable events--and mathematical forecasts should not be measured by a non-valid yardstick borrowed from the greener pastures of the experimental scientists.

B. Choice of Independent or Predictor Variables

There is a wide variety of possible predictor or independent variables which could appear in a regression equation. An appraisal of the various factors affecting air travel can never be complete, but some of the most important are the following:

(1) General Economic Health Measures

(a) Gross National Product--Since this variable measures the total value of goods and services produced by the Canadian economy, it demonstrates the process by which these goods and services were produced and incomes were generated. Like any other industry, the air transportation industry is dependent on the economy within which it exists. However, the total air transportation industry (and each segment of the industry) will expand at rates differing from that of the total economy, so that one cannot forecast commercial air travel just on the basis of Gross National Product since one does not know the position of the industry on the Gross National Product growth curve. In other words, we cannot simply relate air travel to Gross National Product functionally for long periods since one cannot allow for the "youth" of air transport. For example, one cannot assume a stability of psychological factors and fare levels. Furthermore, it is generally assumed that the rate of growth of commercial air traffic exceeds that of the total economy because of the changing composition of consumer demands as personal income rises. In other words, with the rise in personal income, the purchase of services, including air transportation, tends to command an increasing percentage of the consumer dollar. Reliable estimates of potential Gross National Product to 1975 have been made by the Economic Council of Canada.

(b) Retail Sales--As evidenced by continued increases in the volume of Canadian Retail Sales, Canadian consumers are spending their larger incomes. However, as retail sales have not increased as fast as discretionary income, people have an increasing capability to buy goods and services, such as air travel, which are not essential for maintaining a basic standard of living.

(2) Population Trends

(a) Total Size--Since consumption and production, not only of the products of aviation but of all other goods and services, depend first on population size, this is a very important variable. The rate of growth in Canadian population has been declining since the Canadian birth rate began to fall and since net immigration began to level off. Although this might at first glance appear to have an adverse effect on the air travel market, it may not since with "family planning" there will be a reduction in family size. With smaller families, less is spent on the minimum living necessities of food, clothing and housing, leaving more for discretionary spending on air travel.

(b) Age Distribution--With the passage of time, the proportion of experienced air travellers and those who have been born and reared during the age when air transportation became a primary mode of common carrier travel will increase as oldsters who have never taken an air trip represent a smaller proportion of the population. There is still uncertainty as to the effect of this rise in travel experience on the volume of air traffic since at present we do not know whether experienced air travellers will continue to be more likely to employ this mode than other people, other factors remaining constant.[2]

(c) Education--Educated people usually have both the desire and the means to travel, and their occupations commonly call for a considerable amount of air travel.

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[2] J. B. Lansing, The Travel Market: 1958, 1959-1960, 1961-1962. (Ann Arbor, Michigan: Survey Research Center, 1963), p. 51.

Education has both an indirect and a direct effect on air travel. The direct effect is a result of travelling by air for the purpose of "going to and from school." In the future, international educational travel for purposes of study, teaching and research should increase since international educational exchange is becoming an important feature of international relations.

The indirect impact of education which is indicated by the fact that professional, technical, managerial and administrative people tend to travel by air more frequently than persons in other occupations, is far more important than the direct impact of education. This has been brought out in several United States air passenger surveys by John B. Lansing.[3] Air Canada also found this out in a Vancouver air travel survey.[4] Surveys by John B. Lansing have also found that the proportion of persons with college degrees or some college training is significantly higher among air passengers than among the general population.[5]

In the future these direct and indirect impacts of education will exert considerable influence on the future volume of air travel. School enrollments and especially university enrolments, are increasing faster than population.

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[3] Ibid., p. 70.

[4] Air Canada, The Vancouver Market Experiment, A report Prepared by the Market Analysis Division (Montreal: Air Canada, 1967), p. 109.

[5] Lansing, op. cit., p. 76.

(d) Leisure and Recreation Time--The average work week has steadily declined over the past 50 years and is expected to decline gradually during the forthcoming decade. Consequently leisure and recreational time will have increasingly significant economic and social ramifications. Furthermore longer block-time leisure should increase in the future, as more and longer vacations and holidays, early retirement and possibly longer weekends become a reality.

The true significance of increased leisure periods can be realized when we also take into account changes in the age, income and education of Canadians. By 1975, the over 65 age group should have increased by 20 to 30 percent and this group will have the greatest amount of leisure time. Also those in the higher income brackets normally devote more daily time to their work and therefore value leisure time more highly. As a result much of their leisure time will be devoted to changing their environment, and to rest and relaxation. The non-business portion of air travel (about one-third of domestic and three-fourths of overseas passengers carried by United States' scheduled airlines)[6] is a larger potential air travel market than business air travel. So far the airlines have not been too successful in capturing a large share of the domestic non-business travel market.

In the calculations reported in this study, most variables are expressed in

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[6] Air Transportation 1975 and Beyond: A Systems Approach, A Report of the Transportation Workshop 1967 (Cambridge, Massachusetts: Massachusetts Institute of Technology Press, 1968), p. 173.

per capita terms so that forecasts of traffic per head are multiplied by forecasted population levels to get total boardings. It is desirable to use per capita terms partly because the underlying theory of consumer choice refers primarily to individuals, and partly because per capita relationships are likely to be more meaningful and stable than relationships between aggregates. Furthermore, it is felt that it is illogical to use combinations of variables such as Gross National Product (related to population mass) and consumer price index and airline passenger yield per passenger-mile (related to persons). However, the use of per capita figures raises the difficulty of not being strictly correct in giving all persons equal weight irrespective of age and sex. As is well known, in principle one should use a scale of weights; but due to the limited data available on the characteristics of air travellers, the use of such a scale is not possible.

(3) Income Changes

(a) Discretionary Income--This is a general measure of the funds available for non-essential consumer spending and as such gives an indication of how much Canadians can spend on air travel. Perhaps, in the future, larger portions of discretionary income will be spent on air travel as Canadians become more affluent and have greater leisure periods in which to spend their incomes. Air transportation is in an attractive position for continued rapid growth if it can compete with other services and goods available to the consumer. In 1965, for instance, the total passenger service sales of all Canadian scheduled airlines amounted to approximately $282 million.[7] Yet in 1965, personal consumption expenditures for services amounted to more than $12,625 million.[8]

Unfortunately, reliable published forecasts of discretionary income could not be found.

(b) Household Distribution of Income--The total amount of discretionary income available for air travel gains added significance when it is seen that the portion of families with an income of $10,000 or over has increased greatly since 1955. Traditionally, airlines have drawn most of their customers from the middle and upper income brackets. The Lansing Reports found that, of those who travelled by air, income level is obviously a decisive factor since 59 percent of those with incomes of $10,000 and over are experienced air travellers.[9]

(4) Urbanization Factors--Generally speaking, urban dwellers have higher incomes, have more recreation and travel time, and are less conservative in their outlook with respect to exploring new horizons.[10] Since 1955, total Canadian urbanization has increased.

Increasing urbanization also affects the length of time spent in getting to an airport to start a flight since new airports are being

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[7] Dominion Bureau of Statistics, Civil Aviation; 1965 (Ottawa: Queen's Printer, 1965), p. 24.

[8] Dominion Bureau of Statistics, National Accounts-Income and Expenditure; 1965 (Ottawa: Queen's Printer, 1965), p. 50.

[9] Lansing, op. cit., p. 1

[10] The Douglas Aircraft Corp., Effect of Selected Demographic Characteristics on U.S. Citizen Travel Abroad (Los Angeles: The Douglas Aircraft Corporation, 1967), p. 1.

forced further out into the country to avoid residential areas because of its requirement for long clear approaches and of the noise generated along these lanes. Thus, with the increasing speed of planes, the amount of time spent getting to an airport to start a flight as a percentage of total time from origin to destination tends to increase. The effort to plan and locate the airport so that it is isolated from the city has clearly failed in some areas and it is quite likely to fail in others for two reasons; (a) the airport in itself is not a passive element but a force that attracts development in its direction, and (b) most cities are growing so fast as to make their boundaries short-lived.

(5) Technology--Although there is a wide divergence in opinion, it appears that technical progress may have had just as great an influence on air travel growth as has economic expansion. Technical progress has allowed the vertical component of growth to increase.

As mentioned earlier the Boeing Company in a study entitled "Forecast of U.S. Domestic Airline Traffic 1961-1975", found that air traffic develops in successive leaps according to technical progress leading to the introduction of new aircraft types. These leaps have been of nine year intervals since 1926, and the growth rate of each new cycle was about one-half that of the preceding cycle.[11] Also mentioned earlier, the Boeing Company has forecast air travel, using the concept of a growth industry--growth begins with innovation and it continues as long as technological improvements: (a) upgrade quality and lower unit costs simultaneously; (b) upgrade quality at static unit costs;

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[11] T. F. Comick and W. M. Wallace, Forecast of United States Domestic Airline Traffic 1961-1975, Market Research and Planning Division, The Boeing Company (Renton, Washington: The Boeing Company, 1961), p. 6.

or (c) lower unit costs at static quality.[12]

(6) Fares--Although it is generally recognized as desirable to introduce a fares factor in any equation referring to the growth of air travel, this is considered a delicate if not impossible operation. However, it is essential to allow for the influence of price changes in any forecasting model. Many forecasting models give price an implicit role, assuming that rates will adapt themselves to market conditions and will not impede development. Other models assume fares to be stable or that they will develop at a given rate. As of yet, there have been few good studies of the elasticity of demand as applied to airline fare reductions due to the problems associated with holding constant such items as changes in the general price level, alternations in consumer's attitudes, technological advances and variations in competitive mode prices. Perhaps the best study so far is the one by Brown and Watkins of the Civil Aeronautics Board.[13] At present, the Department of Transport is conducting a market survey of air passengers which should give an indication of the attitudes of existing or potential customers to price levels and different fare combinations.

Fully realizing the complexity of the rates question, the fare factor chosen in this study is average air passenger yield per passenger-mile

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[12] W. M. Wallace and J. G. Moore, Calling the Turns--The Forecasting Problem in the Air Transport Industry, Market Research and Planning Division, The Boeing Company (Renton, Washington: The Boeing Company, 1968), p. 9.

[13] S. L. Brown and W. S. Watkins, "The Demand for Air Travel: A Regression Study of Time-Series and Cross-Sectional Data in the U.S. Domestic Market" (Washington: Government Printing Office, 1968).

for Canadian scheduled carriers i.e. total air passenger revenue divided by total air passenger-miles. This is a general average of all fares paid by the public, reflecting the effects of the growing proportion of economy traffic and discount fares, as well as changing prices in air as well as other modes of travel. It would have been much better to use a measure of fare structure since the price is far more important to the individual farepayer than the overall average yield; since no one pays the average yield. A fare structure measure would give appropriate consideration to the cost and value of service differences between classes of service and between long, medium and short-haul fares to the individual farepayer. However, due to a lack of adequate data on fare structures, the average yield had to be used in this study.

In the past, there have been substantial price changes depending on the length of haul and these are reflected in the average air passenger yield. In 1958, there was a substantial reduction, principally in economy fares. From 1958 onward there was an upward drift in fares until 1961, when fares were increased for short and medium haul trips, but long-haul economy fares were substantially reduced. However, in 1962, financial problems forced an upward revision in fare levels in nearly all categories. No further major changes were made to fares until 1968 when most domestic fares were on the average increased by ten percent with a $2 minimum increase.

To make forecasts of total Canadian air passenger boardings, it is necessary to have forecasts of the various predictor variables used in the forecasting model. Fortunately, forecasts of some predictor variables have been made by reliable external groups. Forecasts of potential Canadian

Gross National Product and population made by the Economic Council of Canada are shown in Table I. The forecasts of potential GNP in current dollars assume a two percent GNP price deflator.[14] Forecasts of the other socio-economic variables can be made from historical data using trend projection in conjunction with the exponential smoothing method of finding the trend level, but necessarily these will be much cruder long-range forecasts due to the elementary projection technique employed. Air Canada has used this method, adding an annual 1 percent and 2 percent to/from the exponentially smoothed curve to give five forecasts of predictor variables.[15] Since this method is crude, it was felt that it would be far better not to make any internal forecast of socio-economic variables, but rather to rely on reliable external forecasts where available. It is even more difficult to forecast air passenger yield per passenger-mile since this depends so much on airline company policies, and the efficiency of the next generation of airplanes.

It does not look as if there will be substantial reductions in unit capacity costs due to larger future passenger volumes since the effective impact of economies of scale on total costs are uncertain. However, technical improvements in aircraft, flight support equipment, reservation systems, luggage handling and ticketing could substantially reduce unit capacity costs and passenger costs in the future. But declining unit

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[14] The Economic Council of Canada, Fourth Annual Review--The Canadian Economy from the 1960's to the 1970's, September 1967, p. 110.

[15] Kates, Peat, Marwick and Co., "Study of Air Travel Forecasting Techniques", (Toronto: Kates, Peat, Marwick and Company, 1967), p. 56.

TABLE I

FORECASTS OF POTENTIAL GROSS NATIONAL PRODUCT AND POPULATION

Year	Gross National Product '000,000		Population Based on Medium Immigration and Fertility '000
	In Constant Dollars	In Current Dollars	
1967	60,625	61,779	20,251.8
1968	63,656	66,103	20,596.3
1969	66,839	70,730	20,943.7
1970	70,181	75,681	21,294.0
1971	73,515	80,600	21,647.7
1972	77,007	85,839	22,008.1
1973	80,665	91,419	22,374.9
1974	84,496	97,361	22,747.9
1975	88,510	103,689	23,126.5
1976			23,509.9
1977			23,900.3
1978			24,297.7
1979			24,701.2
1980			25,110.0

Sources: The Economic Council of Canada, Fourth Annual Review--The Canadian Economy from the 1960's to the 1970's, September 1967, p. 89.

Wolfgang Illing, Population, Family, Household and Labour Force Growth to 1980 (Ottawa: Economic Council of Canada, 1967), p. 40-41.

capacity cost does not necessarily mean falling fares. There is the danger that airline overcapacity will develop, and air carriers will propose raising passenger-mile yields relative to passenger-mile costs in an attempt to improve profits. However, so far, studies have found that "fare increases have little effect on revenues but can substantially affect traffic growth."[16] As a result, fare increases would probably cause the traffic levels to be substantially below forecast levels and be ineffective in improving the profit situation.

Consequently the future air passenger yield per passenger-mile is very dependent on the future capacity of the Canadian scheduled airline industry. This study does not attempt to forecast capacity but rather gives five alternative forecasts of air passenger yield per passenger-mile and shows how they affect the future size of air passenger boardings. Forecast A is based on the assumption that fares will decline 0.1334 current cents annually--the average annual decrease from 1955 to 1966. Forecast B is based on the assumption that fares will decline more annually in the future, that is they will decline 0.20 current cents annually. A third fare assumption of an average annual decline in fares of only 0.05 current cents gives Forecast C. Forecast D is based on the assumption that fares will remain constant in current cents at the 1966 level in the future. The fifth fare assumption of an annual increase of 0.05 current cents gives Forecast E.

It might be appropriate at this point, to comment on the quality of the data used. Since for most variables they are the only figures

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[16] Forecasts of Passenger Traffic of the Domestic Trunk Carriers, Domestic Operations, Scheduled Service, 1965-1975, Research and Statistics Division, Bureau of Accounts and Statistics, Civil Aeronautics Board (Washington: Government Printing Office, 1965), p. 11.

available, there is no basis for commenting on their accuracy without a great deal of additional research. However, it is an accepted fact that total Canadian domestic and international boardings can be out by as much as five percent a year. One is always tempted to attribute unsatisfactory regression results to defects in the data but it is equally conceivable that crude data will give higher correlations.

CHAPTER III

MAJOR PROBLEMS AND ASSUMPTIONS

A. Major Problems

The determination of a relation between the past and the future encounters major difficulties in economic time series projections. Some of the major problems have already been mentioned, but further elaboration on them and others is necessary.

First of all, it is possible, guided by purely empirical criteria of goodness of fit, to fit a great variety of curves to describe past data fairly adequately, but each curve yields different projection levels for the future. The crux of the problem lies in the fact that, in the absence of effective theory or even of working hypotheses, a great wealth and variety of data is needed to differentiate amongst the many models that can describe major characteristics of change. However, no such variety of data is available at present. With the limited information now available on air passenger characteristics in Canada, it is extremely difficult to choose even among the simple models used to describe underlying secular trends in air passenger boardings. The development of superior air travel forecasting models requires a detailed data base providing travel demand by origin-destination segment, trip purpose, socio-economic type of traveller, party size and other market identification features; at present, however, such data are lacking.

Although an attempt may be made to determine individual behavior, which differs greatly depending on whether an economic or social viewpoint is taken, no data are available to know correctly what percentage of air travel is business and what percentage is pleasure. Knowledge of the split between business and pleasure travel is important in policy decisions, owing to the very different demands placed on airport facilities by, for example, large families with many pieces of luggage and a business traveller with only a briefcase. With an adequate data base, a market analysis forecasting model could be used.

Projections into the future will differ significantly depending on the model used as can easily be demonstrated by fitting three curves, such as an exponential, double-logarithmic and linear curve to past data on boardings and then projecting values into the future. This projecting problem is made even more difficult by the fact that at present, there are only eleven years of historical boarding data from which to derive relationships for ten year forecasts. With such a short period, it is quite easy to calculate trends which may simply be "optical illusions" or may only partly account for the facts. In order to pick out long-term trends, quite long periods of data are needed in which certain factors are stable and specific general conditions are maintained. Irregular and fast growth lends itself much less readily to forecasting.

In conjunction with the difficulty of choosing between many theoretical models, there are several other problems that arise when time-series data are used in multiple regression models. These problems are autocorrelation, multicollinearity, and lagged variables.

If all observations of variables are completely random drawings from a bivariate or multivariate normal universe (i.e. successive observations are drawn independently of previous values), all the simple, and multiple correlation coefficients, the simple and multiple regression coefficients and the standard error of estimate, calculated from the observations are true estimates of corresponding parameters of that universe. However, in time-series analysis, this quite often is not true since auto-correlation coefficients (the correlation between each item of a series and the item of the same series next following it in time)[1] differ significantly from zero, meaning that the basic simple sampling conditions have probably not been met.

If the simple method of least squares is applied in a situation in which the random errors are autocorrelated, the sampling errors underestimate the true sampling errors of the estimates.[2] The regression coefficients will be unbiased but the downward bias in the standard errors will tend to distort the tests of significance, and make the results look significant in cases where they are not. Thus the serious effect of autocorrelation in the random errors is that supposedly significant results could be insignificant in cases, where, if we had the correct standard errors, the estimates clearly would not be significant.

There are two commonly used tests for the presence of significant autocorrelation in residuals: (a) a coefficient of autocorrelation and (b) the ratio of "mean-square successive difference" to the variance (i.e. Von Neumann's ratio). If the residual derived from mathematically fitted regression is Z, then the coefficient of autocorrelation is calculated as follows:

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[1] Mordecai Ezekiel and Karl A. Fox, Methods of Correlation and Regression Analysis (New York: John Wiley, 1963), p. 327.

[2] James J. Thomas, Notes on the Theory of Multiple Regression Analysis (Athens, Greece: Center of Economic Research, 1964), p. 96.

$$r_a = \frac{\sum_{t=1}^{m} Z_t \, Z_{t-1}}{\sum_{t=1}^{m} Z_t{}^2}$$

Where n is the sample size and Z again is a residual, the formula for calculating Von Neumann's ratio is:

$$\frac{\delta^2}{s_Z^2} = \frac{\dfrac{\sum_{t=2}^{m} (Z_{t-1} - Z_t)^2}{n - 1}}{\sum_{t=1}^{m-1} \dfrac{Z_t^2}{n}}$$

Von Neumann's ratio gives a better indication of autocorrelation since it is based upon somewhat less restrictive assumptions and since 1950 has been generally used in the analysis of economic time series.[3] At the given level of significance and the appropriate sample size (N), there is positive autocorrelation if Von Naumann's ratio falls below the following critical value of K, or negative autocorrelation if it exceeds the following critical value of K'; if it falls between the two critical values, no evidence of autocorrelation is present.

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[3] Ezekiel, <u>op. cit.</u>, p. 337.

TABLE II

Five and One Percent Significance Points
for the Ratio of the Mean-Square Successive
Difference to the Variance[4]

N	Values of K		Values of K'	
	P = .01	P = .05	P = .05	P = .01
10	.8353	1.1803	3.2642	3.6091
11	.8706	1.2062	3.1938	3.5294
12	.9033	1.2301	3.1335	3.4603

If there is autocorrelation, an estimating procedure must be used which explicitly takes this dependence into account. The methods used, yield estimates of the regression coefficients in two stages. First, the parameters of the assumed first-order autoregressive process are computed to generate the error terms:

$$u_t = pu_{t-1} + v_t$$

Second, the resulting estimate of p, $\hat{p}$, are used to transform the original variables as follows:

$$\begin{aligned} Y_t' &= Y_t - \hat{p}Y_{t-1} \\ X_{it}' &= X_{it} - \hat{p}X_{it-1} \end{aligned} \qquad (2)$$

Note that if $\hat{p} = 1.$, then this process amounts to taking first differences and if $p > 0$, the transformed variables are weighted sums (rather than differences) of the original variables.[5] There are two common methods of

[4] Ibid., p. 341.

[5] For formal justification of the procedure, see J. Edward Kane, Economic Statistics and Econometrics (New York: Harper and Row, 1968), p. 371.

estimating p.

One method of estimating p is to assume $e_t = pe_{t-1} + v_t$ (suppress the intercept) where e_t is the ordinary least-squares error term. Of course, if the v_t turn out to be autocorrelated, they can themselves be used as input data and another try made. However, each iteration throws away a valuable degree of freedom.[6]

A second method produces estimates of p with nice asymptotic properties and ones more efficient for samples of all sizes.[7] Taking the two variables case (Y is dependent and X is independent), one regresses Y_t on the three variables Y_{t-1}, X_t, X_{t-1} and estimate the parameter of the relation:

$$Y_t = a + pY_{t-1} + B_1X_t + B_2X_{t-1} + v'_t$$

Then as before, one employs the resulting estimate of p in equations (2) to generate the corrected variables Y' and X'.

Not only does one have autocorrelation problems in time series regression analysis but also multicollinearity problems. Multicollinearity is the "general problem which arises when some or all of the explanatory variables in a relation are so highly correlated one with another that it becomes very difficult, if not impossible, to disentangle their separate influences and obtain a reasonably precise estimate of their relative effects."[8] Least squares allocate the sum of explained variation among

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[6] Kane, op. cit., p. 371.

[7] J. Durbin, "Estimation of Parameters in Time-Series Regression Models", Journal of the Royal Statistical Society, Vol. 22, series B (1960), pp. 139-153.

[8] J. Johnston, Econometric Methods (Toronto: McGraw-Hill, 1963), p. 201.

the individual explanatory variables more arbitrarily and unreliably as the degree of multicollinearity increases. Consequently, multicollinearity results in parameter estimates that are: (a) possessed of inordinately high standard errors and (b) discomfortingly sensitive to changes both in the precise data set employed and in the precise model specification. As a result, when multicollinearity is particularly severe, no regression coefficient will prove sufficiently large relative to its standard error to achieve statistical significance, while at the same time the equation as a whole registers a very high R^2.

Conventional methods of testing are not very precise and are exceedingly tedious to administer since when the number of variables is three or greater, it is no longer adequate to just look at pairwise relations among first-order correlation coefficients. Multicollinearity can be quite subtle, involving the interaction of the various rows and columns of the moment matrix.[9] However, if two or more time series are intercorrelated as the result of trends, the use of first differences (in a time series of n original values, X_t, there will be n-1 first differences, $X_{t+1} - X_t$) will typically reduce intercorrelation and thus increase the probability that the regression coefficients obtained will represent meaningful relationships.[10]

If theory leads to the formulation of a relationship in which lagged values of the dependent variable appear on the right-hand side of a least squares regression equation, we run into another problem. In applying

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[9] Kane, <u>op. cit</u>., p. 278.

[10] Ezekiel, <u>op. cit</u>., p. 342

least-squares regression we assume that the error terms are independent of future values of variables on the right hand side of the equation, as well as current and past values. However in a model with lagged values of the dependent variable on the right-hand side of an equation, the error term is not independent of future values of the explanatory variables. The consequences of using least-squares estimators when this assumption of independence between disturbance term and explanatory variable is violated, is that the least squares estimates will be biased, though if the disturbance term has a normal distribution, they will tend to have the desirable asymptotic properties of consistency and efficiency.[11]

But let us assume that the major difficulty of selecting the proper pattern of systematic change to describe the past has been solved and that accurate standard errors, confidence intervals and significance levels have been calculated for the regression coefficients. At this point, one faces the problem of determining whether this pattern can be projected into the future.[12] This difficulty must be examined in view of two considerations. First of all, will the future contain some elements that did not exist in the past? If, at the time of the forecast, there are indications or portents of impending changes, fully taking these into account will enable one to deal more precisely with the translation from the past to the future. But foreknowledge of such portents, no matter how good, is never ample. For example, will the new generation of "jumbo jets" and vertical takeoff

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[11] Johnston, op. cit., p. 212.

[12] Simon Kuznets, "Concepts and Assumptions in Long-Term Projections of National Product", Studies in Income and Wealth, Vol. XVI, 1954, p. 14.

planes lower the cost, expand the market coverage, increase the safety, comfort and convenience of flying and decrease the travel time as much as past innovations such as the introduction of the jet? Obviously, a technical innovation like the supersonic transport (SST) may materially alter future travel patterns, in the same way as the development of short-haul aircraft will influence the structure of the market for trips of between 500 and 1,000 miles. In the past, each new generation of planes has increased air travel but this is no guarantee for the future. It is necessary to ascertain whether the "new" changes are analogous to those that affected the pattern of past change which one is projecting, or whether they are so new as to come outside the range of past changes.

This really introduces the second question of what was the range of changing situations under which the persistent pattern of long-term movement was found in the past.[13] If great changes occurred in possibly relevant conditions during the period in which one empirically establishes a long-term trend, then this pattern has more significance than one calculated for a period in which the potentially relevant conditions changed but little. Unless it is assumed that the future will be free of changes in relative conditions, projecting a pattern which has not been tested for a diversity of conditions is a risky endeavor.

Thus, whether the past can be projected into the future depends on whether possible future changes, insofar as they can be foreseen at present, can be compared with the range of relevant changes in the past within which the systematic pattern persisted. This requires: (1) knowledge of the

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[13] Ibid., p. 15.

conditions and factors that are relevant to the projection; (2) skill to appraise the magnitude of future changes in relevant factors and (3) skill to estimate the magnitude of past changes in relevant factors.

B. Major Assumptions

From the discussion of the previous section on major problems, it can be concluded that any economic projection such as the present one, carries with it a multitude of assumptions.

A first group of assumptions is concerned with the continuity of physical nature.[14] It is assumed that the laws governing the physical universe, as observed by empirical science in the past, will continue. The laws relate to inanimate nature, biological species and the psyche of man.

A second group of assumptions pertains to forces or factors "that may be outside and not affected by the social system but which may affect it much more specifically than the borrowed assumptions" under the first group.[15] The first group of assumptions only allows one to expect that society will continue to function on the same broad physical foundation, but not to limit or specify any particular magnitudes for the performance of human society. An assumption included in the group is that there will be no major breakthrough in present modes of travel--however, improvements in the quality of air service will gradually occur in the future, as in the past. Furthermore it is assumed that technological development and innovation will result in greater output per man-hour and the length of the work week will decline gradually as it has in the past.

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[14] _Ibid._, p. 16.

[15] _Ibid._, p. 17.

A third group of assumptions is concerned with social continuity.[16] Such continuity is more doubtful than that of the physical universe. Assumptions of continuity are essentially judgments of the effects of possible changes in the future, foreshadowed at present. Since the raison d'être for a projection is to indicate acceptable possibilities, one must put limits on future events. One cannot simply say that the projection will be accurate if the future changes are like those in the past since projections cannot assume wartime conditions or long periods of semi-mobilization of sufficient magnitude to result in continued inflationary pressure. Although the economy will probably experience ups and downs, it is assumed that the Canadian government will be at least partially effective in its countercyclical measures to prevent deflations and unemployment of the magnitude of the depression of the 1930's. It is also assumed that society will adapt itself, belatedly or with difficulty, to new tastes and habits.

The fourth and final group of assumptions may be regarded as "specifying conditions".[17] The purpose of some specifying conditions is to bring to the attention of the readers certain future contingencies, not necessarily revealed in the past but which quite probably will occur in the future while others set out future range limits of past changes. The specifying conditions for the basic variables used are:

(1) The Canadian population and Gross National Product will increase according to the estimates of the Economic Council of Canada.

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[16] *Ibid.*, p. 19.

[17] *Ibid.*, p. 20.

(2) The split in air travel between business and pleasure trips and between professional and family travel, will remain much the same in the future as in the past. Any change in the composition of the yet unknown clientele split would bring about changes in the attitude towards the choice between air and surface transport.

(3) The ratio of domestic to international travel will be much similar in the future as in the past.

(4) In the future, the effect of competition from surface modes of transport will be roughly the same as in the past. The possible introduction of much higher speed inter-city ground transportation systems will not significantly induce short-haul passengers to shift to surface transportation on a Canada wide basis. Implied in this assumption is that the problem of providing adequate airports and airport-access can be solved. Thus it is assumed that air travel will continue to gain traffic from the railways and will divert some traffic from the private car so air travel will continue to grow as in the past provided the economy grows as predicted and that fares are competitive with respect to other modes.

(5) Although there may be a question of possible competition for business travel from other modern means of communication such as telephones with attached closed circuit television screens, this study maintains that each has a different role to play and thus such development will not greatly affect air travel. In 1960, the University of Michigan Survey Research Center found that most business travelers either meet with a group of people

or have several appointments. Few trips are made to talk to just one person. Consequently the purposes of a business trip could not be served by a system of communication designed for conversations between only two persons, one in each location. It was also found that the time spent at appointments on business trips was quite long (usually over 12 hours). Consequently a new means of communication would have to be suitable for long periods of use. Therefore new methods of communication might complement but should not supplement business travel.[18]

(6) There will be no major interruptions of the productive process (including airline industry) through labour disputes.

(7) No specific provisions have been made for the future introduction of new types of aircraft such as "stretched" versions of the present subsonic jets, the C-5A, or the supersonic transport. The "stretched" versions of the present subsonics are affecting at present and will affect in the future, passenger demand through their effect on passenger fares, but the C-5A or the SST will have very little impact on demand during the forecast period. It is hard to determine how the larger aircraft will affect fares. The larger planes have lower direct operating cost per seat-mile but if their introduction cycle coincides with a future recession in general business, fares would probably be increased. Fares would probably be increased as a result of

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[18] Air Transportation 1975 and Beyond: A Systems Approach, A Report of the Transportation Workshop 1967 (Cambridge, Massachusetts: Massachusetts Institute of Technology Press, 1968), p. 90.

the pressure of slower traffic growth and reduced profits at a time when cash flow needs are highest. At the most recent International Air Transport Association meeting in January of 1969, it was decided that fares on Jumbo Jets such as the Boeing 747 would not be reduced.[19] Although the bigger planes have lower operating costs per seat-mile, there is conflict between the airlines that plan to use the Jumbos (and who of course want the lowest possible prices) and the others who will be without Jumbos (and who naturally do not want to be under-priced by the "Jumbojetters").

(8) The Canadian scheduled airline passenger yield per passenger-mile will, in the future, go in one of five directions: it will decrease 0.1334 current cents annually (Forecast A); it will decrease 0.20 current cents annually (Forecast B); it will decrease 0.05 current cents annually (Forecast C); it will remain constant at the 1966 level (Forecast D); or it will increase 0.05 current cents annually (Forecast E). The reader may choose whichever projection he believes will occur. In an article published in July 1968,[20] the International Civil Aviation Organization forecast an average annual reduction in world average fares per passenger-kilometre of two percent with a maximum of four percent and a minimum of no reduction.

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[19] Ramsay Milne, "Jumbos Won't Reduce Fares", The Province, January 29, 1969, p. 15.

[20] International Civil Aviation Organization, A Review of the Economic Situation of Air Transport 1957-1967 (Montreal: International Civil Aviation Organization, 1968), p. 26.

This assumes that the airlines will not abandon their low-fare policy as a result of poor profit margins due to the accelerated rise in air transport wages and salaries. It is believed that rising personnel costs should be offset by increased aircraft productivity. It also assumes, of course, that airlines will continue to stimulate growth of traffic and to maintain passenger load factors by offering promotional off-peak fares.

CHAPTER IV

STATIC FORECASTING MODELS

A. Introduction

Although one forecasting model may be statistically correct, it was thought necessary to use a combination of models since a single model could yield misleading results due to the short historical data period, as discussed in chapter three. Thus it was decided to use a combination of the two basic forms of multiple regression forecasting models, static (i.e. has no lagged variables) and dynamic (i.e. has lagged variables) and to discuss each one separately in this and the following chapter respectively.

From the discussion in chapters one, two and three, it is seen that a static model can have many mathematical forms. The relationship can be linear or curvilinear. Various combination of dependent and independent variables can be used.

To determine which variables to use, simple linear, exponential and double logarithmic correlations among the many possible independent and dependent variables were first calculated. However, two major problems were encountered. Although many variables such as Gross National Product per capita and personal disposable income per capita individually correlated highly with boardings per capita (i.e. $R^2 > 0.90$), there was significant autocorrelation amongst the residuals. There was significant autocorrelation not only when using total boardings but also when using total boardings minus Vancouver and Victoria boardings.[1]

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[1] The reason for subtracting Vancouver and Victoria boardings was that they have been quite erratic since the introduction in 1958 of the efficient Government of British Columbia ferry system.

As a result, some forecasts of Canadian total annual boarding passengers by the Department of Transport, may be inaccurate since these forecasts are based on a simple linear regression with GNP.[2]

An attempt was made to reduce the autocorrelation, by transforming the variables as follows:

$$Y_t' = Y_t - pY_{t-1}$$

$$X_t' = X_t - pX_{t-1}$$

Where p is computed by either of the two methods shown in chapter three.[3] Although both these methods eliminated any significant autocorrelation amongst the residuals, they also eliminated in most instances any significant correlation between the two dependent variables and the various independent variables since the boarding statistics were too unreliable for such a sensitive method of correlation.

In addition to the problem of autocorrelation, there was the second difficulty of significant intercorrelation amongst many of the independent variables. Since multicollinearity in multiple regression equations often leads to illogical results, this meant that the number of socio-economic variables could be reduced down to one or at most two.

B. Structures of the Static Equations

Since simple regression models proved unsuccessful due to autocorrelation problems and since intercorrelation amongst many of the

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[2] Department of Transport, Air Transportation--Statistics and Forecasts, A Report Prepared by the Transportation Policy and Research Branch (Ottawa: Queen's Printer, 1968), p. gen. 7.

[3] See page 33.

independent variables reduced the number of independent variables needed, this study experimented with logically valid multiple regression models using combinations of three or four of the following variables for the 1955-1966 time period.

B - boardings per capita (dependent variable)

BL - natural logarithm of boardings per capita (dependent variable)

BLO - common logarithm of boardings per capita (dependent variable)

GC - GNP per capita in current dollars

GCT - GNP per capita in current dollars multiplied by trend factor t

GCLT - natural logarithm of the GNP per capita in current dollars multiplied by trend factor t

GCLOT - common logarithm of GNP per capita in current dollars multiplied by trend factor t

GCTL - GNP per capita in current dollars multiplied by the natural logarithm of the trend factor t

GCTLO - GNP per capita in current dollars multiplied by the common logarithm of the trend factor t

GCLTL - natural logarithm of GNP per capita in current dollars multiplied by the natural logarithm of the trend factor t

GCLOTLO - common logarithm of GNP per capita in current dollars multiplied by the common logarithm of the trend factor t

GCL - natural logarithm of GNP per capita in current dollars

GCLO - common logarithm of GNP per capita in current dollars

T - trend factor t (i.e. 1955 = 1)

TL - natural logarithm of trend factor t

TLO - common logarithm of trend factor t

GP - GNP per capita in constant 1949 dollars

GPT - GNP per capita in constant 1949 dollars multiplied by trend factor t

GPTL - GNP per capita in constant 1949 dollars multiplied by natural logarithm of trend factor t

GPTLO - GNP per capita in constant 1949 dollars multiplied by common logarithm of trend factor t

GPLT - natural logarithm of GNP per capita in constant 1949 dollars multiplied by the trend factor t

GPLOT - common logarithm of GNP per capita in constant 1949 dollars multiplied by the trend factor t

GPLTL - natural logarithm of GNP per capita in constant 1949 dollars multiplied by the natural logarithm of the trend factor t

GPLOTLO - common logarithm of GNP per capita in constant 1949 dollars multiplied by the common logarithm of the trend factor t

GPL - natural logarithm of GNP per capita in constant 1949 dollars

YC - average air passenger yield (in current dollars) per passenger mile for Canadian scheduled carriers

YCL - natural logarithm of average air passenger yield (in current dollars) per passenger mile for Canadian scheduled carriers

YCLO - common logarithm of average air passenger yield (in current dollars) per passenger mile for Canadian scheduled carriers

YP - average air passenger yield (in constant 1949 dollars) per passenger mile for Canadian scheduled carriers

YPLO - common logarithm of average air passenger yield (in constant 1949 dollars) per passenger mile for Canadian scheduled carriers

Deflated versions of GNP per capita and average air passenger yield per passenger mile of scheduled Canadian carriers were experimented with to try to adjust for changes in the purchasing power of money. The Consumer Price Index was used as a deflator since it reflects the average prices paid by consumers for most goods and services. However, this procedure is not completely precise since no perfect index has yet been constructed.[4]

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[4] M. H. Spencer, C. G. Clark and P. W. Haguet, Business and Economic Forecasting - An Econometric Approach, (Homewood, Illinois: Richard D. Irwin, 1961), p. 73.

Also a trend factor t has been included as a catchall for the many factors known to change over time, such as tastes, quality and technology, but for which data was unavailable or which, singly, would be expected to have a small effect on the dependent variable. The Civil Aeronautics Board has used a trend factor, along with average air passenger yield per passenger mile and real disposable income per capita, in their air travel multiple regression forecasting models, the most recent use being in 1967.[5]

Furthermore, the reason for including multiplicative combinations of the time factor t and GNP per capita as independent variables, was to experiment with static equations of the type:

$$B_t = a + (c + dt) \times GNP_t - eY_t \quad \text{(Eq. 4:1)}$$

Equation 4:1 takes into account the influence of gradually rising per capita income on changes in the income elasticity of per capita air travel. In other words, it was assumed that the income coefficient and thus income elasticity increases gradually as incomes rise over time i.e. as incomes rise over time, the slope of the relationship between boardings and income will become steeper. Theoretically, a better variable than GNP would have been real disposable income per capita but GNP per capita was used since it was highly correlated with personal disposable income per capita and because reliable potential estimates of GNP have been made by the Economic Council of Canada whereas no such forecasts were available for personal disposable income.

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[5] Irving Saginor, Forecast of Scheduled Domestic Air Passenger Traffic for the Eleven Trunk Carriers 1968-1977, Economic Research Section, Planning, Programming and Research Division, Civil Aeronautics Board (Washington: Government Printing Office, 1967), p. 14.

By testing relationships in which the dependent variable and the independent variables are expressed in either natural or common logarithmic* form, a multiplicative relationship was assumed. In other words, proportional or percentage changes of fares and/or GNP per capita, for example, are assumed to be related to proportional or percentage changes of traffic. This relationship is expressed by this simple single equation:

$$B = A \; (\; FARE^{a} \;) \; (\; GNP^{b} \;) \; U$$

For each year, traffic is the product of a constant A and of fare and GNP per capita, each to a certain constant power. And of course, there is an error term U to represent the proportional residual between actual and calculated traffic. Fare and GNP per capita are considered as exogenous variables; they affect boardings but boardings do not affect fare or GNP per capita in the same time period.

The multiplicative relationship shown on the last page can be transformed to a simple linear form by taking logarithms of all the variables:

$$\text{Log } B = \log A + a \log FARE + b \log GNP + \log U$$

This mathematical model has several important implications. The relationships of elasticities of traffic to fares and GNP per capita are deemed to be constant over the historical data period and the forecast period(i.e. 1967 - 1975). The assumption of persistence over the period of forecast provides the basis for forecasting boardings from projections of its independent variables. Elasticities could possibly not remain constant so the forecasting equations should be periodically tested, updated and recomputed. As already mentioned, by including an independent variable which is a multiplicative combination of a time factor and GNP per capita, as well as an independent variable of GNP per capita, this study has tested

*Although there exists a constant relationship between common logarithms and natural logarithms, both logarithms were experimented with due to possible roundoff errors.

the assumption that the elasticity of traffic to GNP per capita does not remain constant.

C. Results of Trying Various Static Estimating Equations

Using the various variables given in the previous section, logically valid multiple regression models involving no more than three independent variables were computed. Of the approximately 100 models tested, only the following one proved statistically significant (i.e. high R^2, no significant autocorrelation and statistically significant regression coefficients) and proved logically valid. (i.e. correct signs)

$$B = .2392 + \underset{(.00002609)}{.00003331GC} + \underset{(.00000567)}{.00001435GCTL} + \underset{(.0093)}{.0234YC} \qquad \text{(Eq. 4:2)}$$

$$R^2 = .9758 \qquad \text{Von Neumann Ratio} = 1.989$$

Let equation 4:2 be static model number one.

This model takes into account the influence of gradually rising per capita income on changes in the income elasticity of per capita air travel since it includes the term GCTL (GNP per capita in current dollars multiplied by the natural logarithm of the trend factor t). However, the increase in elasticity is not as great as it would have been had the variable GCT (GNP per capita in current dollars multiplied by trend factor t) been used. Since t is in logarithmic form, there is a relative increase as t becomes larger, but a decreasing absolute increase. As a result, in the future the term GCTL increases relatively but each increase decrease absolutely.

Table III shows how the estimated boardings of this model approximated quite closely the actual boardings. However, it was felt that this model could give misleading forecasts due to the intercorrelation amongst the independent variables. As discussed in chapter three, intercorrelation

TABLE III

COMPARISON BETWEEN ACTUAL AND ESTIMATED BOARDINGS

USING STATIC MODEL ONE

Year	Actual First Difference	Estimated First Difference	Residual	Actual Boardings Per Capita	Estimated Boardings Per Capita	Residual
1955				.13110	.12976	.00134
1956	.01831	.02360	-.00529	.14941	.15470	-.00529
1957	.01579	.01817	-.00238	.16520	.16758	-.00238
1958	.01110	.01358	-.00248	.17630	.17878	-.00248
1959	.02511	.01216	.01295	.20141	.18846	.01295
1960	.01577	.00837	.00740	.21718	.20978	.00740
1961	.01139	.00759	.00380	.22857	.22477	.00380
1962	.00410	.00400	.00010	.23267	.23257	.00010
1963	-.00062	.00829	-.00891	.23205	.24096	-.00891
1964	.01087	.02636	-.01549	.24292	.25841	-.01549
1965	.03402	.03673	-.00271	.27604	.27965	-.00271
1966	.03661	.02493	.01168	.31355	.30187	.01168

amongst the independent variables can result in regression coefficients representing meaningless relationships. Thus it was decided to also experiment with models using first differences of those variables given in the previous section since the use of first differences will typically reduce intercorrelation among the independent variables. Regression models using first differences give the year to year changes in boardings not the levels.

With respect to those variables in logarithmic form, two sets of first differences were tried. One set was expressed in terms of annual first differences of the logarithms of the variables

$$\text{i.e.} \quad \Delta \log X' = \log X_{t+1} - \log X_t \qquad \text{(Eq. 4:3)}$$

$$\Delta \log X' = \log \frac{X_{t+1}}{X_t} \qquad \text{(Eq. 4:4)}$$

Applying elementary logarithmic and percentage definitions to eq. 4:4 gives

$$[(\text{ antilog } \frac{X_{t+1}}{X_t}) - 1.] \times 100 - \text{percentage change in x}$$

from t to t+1. The second set of first differences was expressed in terms of logarithms of the annual first differences of the variables

$$\text{i.e.} \quad \nabla \log X' = \log (X_{t+1} - X_t)$$

Furthermore, if certain logically valid models showed significant autocorrelation amongst the residuals, the original first differences were transformed as follows:

$$Y_t' = Y_t - pY_{t-1}$$

$$X'_{it} = X_{it} - pX_{it-1}$$

Estimates of p were derived as shown in chapter three.

Of the approximately 500 models tested, very few were statistically significant (i.e. $R^2 > 0.40$, significant regression coefficients and no significant autocorrelation) and logically valid (i.e. correct signs). The most likely reason for the poor results being that this is rather a stringent test for boardings which can quite easily err up to five percent annually. None of the models using Δ natural log X', ∇ natural log X', or ∇ common log X' were statistically significant. However the following models using Δ common log X' and original first differences were statistically significant.

$$\Delta B = -.0008139 + \underset{(.00004795}{.00006953\Delta GC} + \underset{(.00002282)}{.00002579\Delta GCTLO} - \underset{(.0120)}{.0229\Delta YC} \quad \text{(Eq. 4:5)}$$

$$R^2 = .4256 \qquad \text{Von Neumann's ratio} = 1.677$$

$$\Delta B = .002792 + \underset{(.00004412)}{.00008987\Delta GC} - \underset{(.0124)}{.0218\Delta YC} + \underset{(.0141}{.0171\Delta TL} \quad \text{(Eq. 4:6)}$$

$$R^2 = .4027 \qquad \text{Von Neumann's ratio} = 1.814$$

Let equations 4:5 and 4:6 be static models two and three respectively. Tables IV and V show how the estimated boarding of these two equations differed from the actual boardings.

Notice that model two is of the same basic form as model one except that the variables are in terms of first differences and the common logarithm rather than the natural logarithm is used. This model again expresses the idea that gradually rising per capita income positively changes the income elasticity of per capita air travel since it includes the term ΔGCTLO (GNP per capita in current dollars multiplied by the common logarithm of the trend factor t). Also, since the time factor is in logarithmic form, the term Δ GCTLO will be positive but will decrease absolutely in the future.

TABLE IV

COMPARISON BETWEEN ACTUAL AND ESTIMATED BOARDINGS

USING STATIC MODEL TWO

Year	Actual First Difference	Estimated First Difference	Residual	Actual Boardings Per Capita	Estimated Boardings Per Capita	Residual
1955				.13110		
1956	.01831	.02646	-.00815	.14941	.15756	-.00815
1957	.01579	.01028	.00551	.16520	.16784	-.00264
1958	.01110	.00869	.00241	.17630	.17653	-.00023
1959	.02511	.00977	.01534	.20141	.18630	.01511
1960	.01577	.01994	-.00417	.21718	.20624	.01094
1961	.01139	.01366	-.00227	.22857	.21990	.00867
1962	.00410	.01016	-.00606	.23267	.23006	.00261
1963	-.00062	.01004	-.01066	.23205	.24010	-.00805
1964	.01087	.02051	-.00964	.24292	.26061	-.01769
1965	.03402	.02534	.00868	.27694	.28595	-.00901
1966	.03661	.02760	.00901	.31355	.31355	.00000

TABLE V

COMPARISON BETWEEN ACTUAL AND ESTIMATED BOARDINGS

USING STATIC MODEL THREE

Year	Actual First Difference	Estimated First Difference	Residual	Actual Boardings Per Capita	Estimated Boardings Per Capita	Residual
1955				.13110		
1956	.01831	.02409	-.00578	.14941	.15519	-.00578
1957	.01579	.00838	.00741	.16520	.16357	.00163
1958	.01110	.00812	.00298	.17630	.17169	.00461
1959	.02511	.01042	.01469	.20141	.18211	.01930
1960	.02577	.02017	-.00440	.21718	.20228	.01490
1961	.01139	.01445	-.00306	.22857	.21673	.01184
1962	.00411	.01151	-.00741	.23267	.22824	.00443
1963	-.00062	.01129	-.01191	.23205	.23953	-.00748
1964	.01087	.02116	-.01029	.24292	.26069	-.01777
1965	.03402	.02553	.00849	.27694	.28622	-.00928
1966	.03661	.02733	.00928	.31355	.31355	.00000

Model three is of a different basic form since it includes a trend factor and does not show an increasing income elasticity of per capita air travel. Notice that since the trend factor is in logarithmic form, Δ TL (natural logarithm of trend factor t) gives a decreasing annual increase in the future. In all three models, both GNP and air passenger yield per passenger-mile are in current dollars rather than constant 1949 dollars. This seems to hint that air passengers do not take into account the decreasing purchasing power of money when travelling. If this is not so, then perhaps some deflator other than the GNP price delfator should have been used.

D. Accuracy of the Three Static Estimating Equations

How well do the estimated boardings derived from the static models approximate actual boardings? A visual answer to the above question is given in charts 1 and 2. Two series of quantitative tests can also be used to test the accuracy of the three models. One involves the direct comparison of the estimated with the actual boardings. However in the present analysis, this test is not sufficient due to the high serial correlation between estimated and actual boardings i.e. correlation of both E_t and A_t (expected and actual boardings, respectively, in period t) with A_{t-1}. Although E_t and A_t may both be of the same general magnitude, with fairly high correlation, the direction of change may be missed altogether because of this serial correlation. Therefore, it is necessary to also use a second test of accuracy--compare the estimated and actual rates of change rather than the actual levels.

First of all, the accuracy will be tested for all three equations by comparing the actual with the estimated boarding levels. A quantitative

Chart 1 - Comparison Between Actual Boardings Per Capita and Estimated Boardings per Capita Using Static Models One, Two and Three

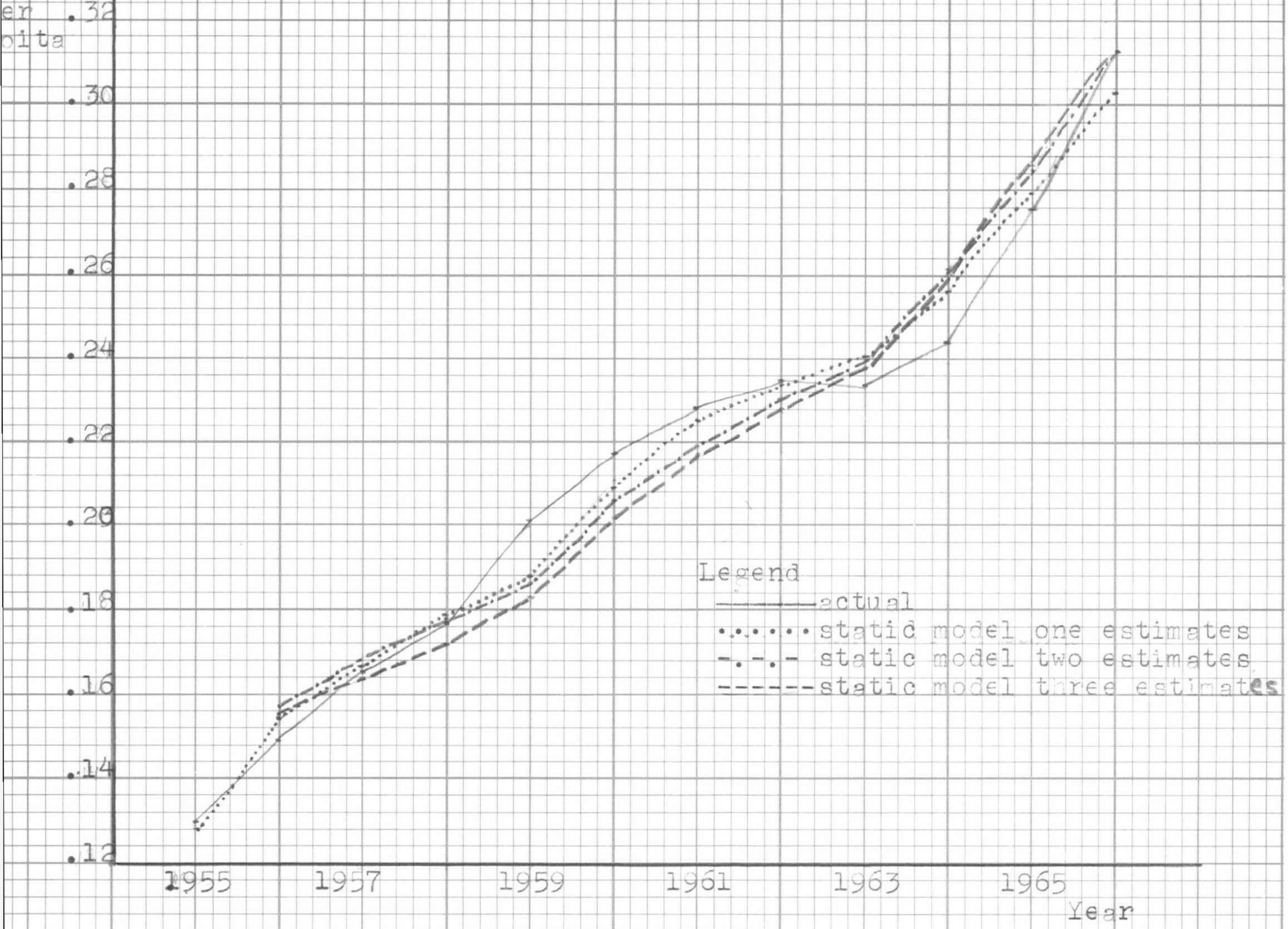

Chart 2 - Percentage Errors of Boardings Per Capita Estimated by Static Models One, Two and Three

analysis of the accuracy of the estimates involves calculating the ratio of expected boardings to actual boardings, a ratio denoted by E_t / A_t. Table VI represents two statistics based on this ratio. Two trends are distinguished in the original values: rising and falling. A simple average of these ratios does not provide a realistic measure of the overall accuracy of the forecasts because of the cancellation of opposing errors. In other words, E / A will be 1.00 for two periods irrespective of whether the individual ratios are 0.80 and 1.20 or .98 and 1.02.

TABLE VI

ACCURACY OF BOARDINGS ESTIMATES, 1955 - 1966

	E / A by Trend of Boardings			Average Absolute Percentage Error		
Model	Rising	Falling	All	Rising	Falling	All
1	.927	1.038	1.000	2.7	3.8	2.8
2	.999	1.034	1.002	3.5	3.4	3.5
3	.987	1.032	.990	4.2	3.2	4.0

Therefore a better measure of the overall accuracy is obtained by computing the average of the absolute relative errors of the forecasts:

$$\text{i.e.} \quad \Sigma \left| E/A - 1. \right| / N$$

and this is the second set of statistics shown in Table VI. Notice that according to this test, all three models estimated boardings that very closely approximated the actual boardings. Model 1 has the lowest overall average absolute percentage error but models 2 and 3 also have very low average absolute percentage errors. As already noted, the correlation of

A_t and E_t is bound to be high, if for no other reason than the serial correlation in the boardings data; this limitation may be removed to some extent by comparing the actual and anticipated rates of change. The coefficients of correlation between E_t / A_{t-1} and A_t / A_{t-1} for the three estimating equations are shown in Table VII.

TABLE VII

COEFFICIENTS OF CORRELATION BETWEEN

E_t / A_{t-1} and A_t / A_{t-1}

FOR THE THREE STATIC ESTIMATING MODELS

Model	R
1	.685
2	.669
3	.630

From these results, it is seen that all three models estimated boardings that quite closely anticipated the rate of change of boardings. Thus these three models provide not only a good idea of the level of boardings but also of the direction of change. This conclusion could not have been arrived at by just comparing the original R^2 of the three static models since, at first glance, models two and three may seem much more inaccurate than model one due to the lower R^2 (.4256 and .4027 vs. .9758)--however, model one uses a different set of data from that of models two and three.

E. <u>Projections</u>

In line with the purpose of this study, projections of international and domestic boardings per capita and for all of Canada till 1975, using static models one, two and three, will now be given. Of course, any forecast of the dependent variable, boardings per capita, depends on the assumptions regarding annual changes or levels in the independent variables. As already mentioned, for the independent variables of population and Gross National Product, this study has used the potential estimates of the Economic Council of Canada. They are as follows:

Year	GNP In Current Dollars Per Capita	Population '000
1967	3061.28	20,251.8
1968	3232.23	20,596.3
1969	3413.35	20,943.7
1970	3605.23	21,294.0
1971	3789.27	21,647.7
1972	3983.40	22,008.1
1973	4188.19	22,374.9
1974	4404.20	22,747.9
1975	4631.91	23,126.5

However with respect to the independent variable of average air passenger yield per passenger-mile of Canadian scheduled carriers, this study has made the five different assumptions regarding its future rate of change as given in chapter two.

Those forecasts (i.e. A, B and C) which assume future annual fare decreases are based on the assumption that the highly efficient aircraft which have begun to come into service and are scheduled for deliveries through the early seventies, will enable fares to be reduced. First of all, the stretched DC-8's and the B-747's can lower seat-mile costs in the longer range markets. Secondly, the whole family of smaller short-range fan-jets--the DC-9, B-727, B-737 and their stretched versions, have seat-mile costs that are lower than the propeller and longer range jets being replaced. There will be more opportunity to fit aircraft to schedules according to length of hop and load than was possible in the past. However the new aircraft are only more efficient than the older if the planes have reasonably high load factors. Thus, this study has included Forecasts D and E based on assumptions that good load-factors are not achieved because of excess seat-mile capacity.

By making five forecasts based on different assumptions regarding future fare levels, this study can point out how sensitive boardings are to fares. All three models are quite fare sensitive since the fare coefficients are -.0234, -.0229 and -.0218 for Models one, two and three respectively.

The results of trying five fare assumptions in the three forecasting models are shown in tables VIII, IX, X, XI, and XII. In model one, the actual levels of the independent variables are used. However since models two and three are first difference models, the independent variables are converted into first differences before being substituted into models two and three. Since models one, two and three give boardings per capita, the total estimated Canadian boardings are obtained by multiplying the boardings per capita by the estimated total population.

Fortunately all three models gave quite similar results. Models two and three gave very similar results (differed no more than one percent) while model one gave forecasts that differed more and more from those of models two and three as the forecast period extended into the future, but still differed no more than 8 percent.

TABLE VIII

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE DECREASES ANNUALLY 0.1334 CURRENT CENTS

		Model 1		Model 2		Model 3	
Year	Average Yield Per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings
1967	5.7346	.31891	6,458,502	.33289	6,741,217	.33310	6,745,875
1968	5.6012	.33658	6,932,303	.35341	7,278,938	.35363	7,283,470
1969	5.4678	.35498	7,434,595	.37488	7,801,374	.37491	7,852,003
1970	5.3344	.37417	7,967,576	.39736	8,461,384	.39699	8,453,505
1971	5.2010	.39289	8,509,165	.41914	9,073,417	.41834	9,056,099
1972	5.0676	.41231	9,074,166	.44181	9,723,399	.44038	9,691,927
1973	4.9342	.43247	9,676,473	.46542	10,413,726	.46315	10,362,935
1974	4.8008	.45342	10,314,353	.49003	11,147,153	.48669	11,071,175
1975	4.6674	.47521	10,989,944	.51570	11,926,336	.51105	11,818,798

TABLE IX

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE DECREASES ANNUALLY 0.2000 CURRENT CENTS

		Model 1		Model 2		Model 3	
Year	Average Yield Per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings
1967	5.668	.32046	6,489,892	.33442	6,772,607	.33448	6,773,822
1968	5.468	.33970	6,996,563	.35642	7,340,933	.35638	7,340,109
1969	5.268	.35966	7,532,611	.37945	7,947,087	.37903	7,938,291
1970	5.068	.38040	8,100,838	.40346	8,591,277	.40248	8,570,409
1971	4.868	.40069	8,674,017	.42677	9,238,589	.42520	9,204,602
1972	4.668	.42166	9,279,935	.45096	9,924,773	.44860	9,872,831
1973	4.468	.44338	9,920,583	.47610	10,652,690	.47273	10,577,286
1974	4.268	.46589	10,598,019	.50223	11,424,678	.49762	12,102,791
1975	4.068	.48924	11,314,409	.52943	12,243,863	.52333	12,102,791

TABLE X

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE DECREASES ANNUALLY 0.0500 CURRENT CENTS

	Average	Model 1		Model 2		Model 3	
Year	Yield Per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings
1967	5.818	.31695	6,418,808	.33098	6,702,941	.33121	6,707,599
1968	5.768	.33268	6,851,977	.34959	7,200,261	.34984	7,205,416
1969	5.718	.34913	7,312,074	.36915	7,731,367	.36922	7,732,833
1970	5.668	.36636	7,801,270	.38972	8.898,698	.38940	8,291,884
1971	5.618	.38314	8,294,100	.40959	8,866,681	.40885	8,850,662
1972	5.568	.40060	8.816,445	.43035	9,471,186	.42898	9,441,035
1973	5.518	.41881	9,370,832	.45211	10,115,916	.44984	10,065,125
1974	5.468	.43781	9,959,258	.47481	10,800,930	.47146	10,724,725
1975	5.418	.45765	10,583,843	.49857	11,530,179	.49390	11,422,178

TABLE XI

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE REMAINS AT THE 1966 LEVEL

	Average	Model 1		Model 2		Model 3	
Year	Yield Per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings
1967	5.686	.31578	6,395,113	.32984	6,679,854	.33012	6,685,524
1968	5.686	.33034	6,863,982	.34730	7,153,095	.34766	7,160,510
1969	5.686	.34562	7,238,562	.36571	7,659,321	.36595	7,664,347
1970	5.686	.36168	7,701,614	.38514	8,201,171	.38504	8,199,042
1971	5.686	.37729	8,167,461	.40387	8,742,857	.40340	8,732,682
1972	5.686	.39358	8,661,948	.42348	9,319,990	.42244	9,297,102
1973	5.686	.41062	9,187,581	.44404	9.935,351	.44221	9.894,405
1974	5.686	.42845	9,746,338	.46559	10,591,195	.46274	10,526,363
1975	5.686	.44712	10,340,321	.48821	11,290,589	.48404	11,195,307

TABLE XII

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE INCREASES ANNUALLY 0.0500 CURRENT CENTS

Year	Average Yield Per Passenger-Mile	Model 1 Boardings Per Capita	Model 1 Total Canadian Boardings	Model 2 Boardings Per Capita	Model 2 Total Canadian Boardings	Model 3 Boardings Per Capita	Model 3 Total Canadian Boardings
1967	5.918	.31461	6,371,419	.32869	6,656,564	.32903	6,663,450
1968	5.968	.32800	6,775,586	.34501	7,105,929	.34548	7,115,610
1969	6.018	.34211	7,165,049	.36228	7,587,484	.36268	7,595,861
1970	6.068	.35700	7,601,958	.38056	8,103,645	.38068	8,106,200
1971	6.118	.37144	8,040,822	.39814	8,618,815	.39795	8,614,702
1972	6.168	.38656	8,507,451	.41461	9,124,778	.41590	9,153,169
1973	6.218	.40243	9,004,331	.43602	9,755,904	.43458	9,723,684
1974	6.268	.41909	9,533,417	.45643	10,382,824	.45402	10,328,002
1975	6.318	.43659	10,095,642	.47790	11,052,154	.47420	10,966,586

As one can see, different fare assumptions have significant effects on estimated boardings. After a nine-year forecast the difference in total Canadian boardings between the extreme opposite fare assumptions of 0.05 current cents annual increase in fares and a 0.20 current cents annual decrease in fares was 1,218,767 boardings for model one, 1,191,709 boardings for model two and 1,136,205 boardings for model three.

CHAPTER V

DYNAMIC FORECASTING MODELS

A. Introduction

A dynamic model expresses the generally accepted idea that current behavior is affected by past behavior: current behavior depends on all past values of the predetermined variables, though more on recent values than on very remote ones. Consequently, it is possible to take into account the effect of habit formation. To make this idea operational, a specific type of relationship between the past the and present must be formulated. The basic form of the estimating equation chosen was:

$$B_t = a_0 + a_1 B_{t-1} + a_2 GNP_t - a_3 Y_t \qquad \text{(Eq. 5:1)}$$

where:

- a_0, a_1, a_2 and a_3 = regression coefficients
- B_t = domestic and international air boardings per capita in period t
- GNP_t = Gross National Product per capita in period t
- Y_t = average air passenger yield of Canadian scheduled carriers per passenger mile in period t

The basic form of equation 5:1 can be modified by using some data that is deflated by the Consumer Price Index and by using some data that is either in common or natural logarithmic* form. As in chapter four, deflated versions of GNP per capita and average air passenger yield per passenger mile of scheduled Canadian carriers were experimented with to try to adjust for changes in the purchasing power of money. By testing

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*Although there exists a constant relationship between common logarithms and natural logarithms, both logarithms were experimented with due to possible roundoff errors.

relationships in which the dependent variable and the independent variables are expressed in either natural or common logarithmic form, a multiplicative relationship amongst the variables was assumed.

As a result, this study experimented with dynamic multiple regression models using logical combinations of these following variables:

- B1 - boardings per capita: 1956-1966 (dependent variable)
- B1L - natural logarithm of boardings per capita; 1956-1966 (dependent variable)
- B1LO - common logarithm of boardings per capita; 1956-1966 (dependent variable)
- B11 - boardings per capita; 1955-1965
- B11L - natural logarithm of boardings per capita; 1955-1965
- B11LO - common logarithm of boardings per capita; 1955-1965
- GC1 - GNP per capita in current dollars; 1956-1966
- GC1L - natural logarithm of GNP per capita in current dollars; 1956-1966
- GC1LO - common logarithm of GNP per capita in current dollars; 1956-1966
- GP1 - GNP per capita in constant 1949 dollars; 1956-1966
- GP1L - natural logarithm of GNP per capita in constant 1949 dollars; 1956-1966
- GP1LO - common logarithm of GNP per capita in constant 1949 dollars; 1956-1966
- YC1 - average air passenger yield (in current dollars) per passenger mile for Canadian scheduled carriers; 1956-1966
- YC1L - natural logarithm of average air passenger Yield (in current dollars) per passenger-mile for Canadian scheduled carriers; 1956-1966
- YC1LO - common logarithm of average air passenger yield (in current dollars) per passenger-mile for Canadian scheduled carriers; 1956-1966
- YP1 - average air passenger yield (in constant 1949 dollars) per passenger-mile for Canadian scheduled carriers; 1956-1966

YP1L - natural logarithm of average air passenger yield (in constant 1949 dollars) per passenger-mile for Canadian scheduled carriers; 1956-1966

YP1LO - common logarithm of average air passenger yield (in constant 1949 dollars) per passenger-mile for Canadian scheduled carriers: 1956-1966.

B. Results of Trying Various Dynamic Estimating Equations

Using the various variables given in the previous section, logically valid multiple regression models involving no more than three independent variables were constructed. First of all, multiple regression models were tried that used absolute levels of the variables, rather than first differences. Of the approximately 60 absolute level models tested, only the following one proved statistically significant (i.e. high R^2, no significant autocorrelation and statistically significant regression coefficients) and logically valid (i.e. in addition to technical statistical tests, a successful model must have coefficients that are consistent with known physical, technological and economic facts).

$$B1 = .2919 + \underset{(.0448)}{.1054B11L} + \underset{(.00001587)}{.00006588GC1} - \underset{(.007000)}{.007232YC1} \qquad \text{(Eq. 5:2)}$$

$$R^2 = .9744 \qquad\qquad \text{Von Neumann's ratio} = 1.455$$

Let equation 5:2 be dynamic model one. This model takes into account the effect of habit formation on annual air boardings since it includes as an independent variable air boardings lagged one year. Notice that the dependent variable B1 is in natural form while the independent variable B11L is in natural logarithmic form (i.e. exponential relationship). This implies that a constant increase in B11L will result in a constant percentage increase in B1, other things being constant.

Table XIII clearly shows that the estimated boardings of this

TABLE XIII

COMPARISON BETWEEN ACTUAL AND ESTIMATED BOARDINGS

USING DYNAMIC MODEL ONE

Year	Actual First Difference	Estimated First Difference	Residual	Actual Boardings Per Capita	Estimated Boardings Per Capita	Residual
1956				.14941	.15159	-.00218
1957	.01579	.01536	.00043	.16520	.16695	-.00175
1958	.01100	.01179	-.00079	.17630	.17874	-.00244
1959	.02511	.01143	.01368	.20141	.19017	.01124
1960	.01577	.02047	-.00470	.21718	.21064	.00654
1961	.01139	.01227	-.00088	.22857	.22291	.00566
1962	.00410	.01270	-.00860	.23267	.23561	-.00294
1963	-.00062	.00837	-.00899	.23205	.23498	-.01193
1964	.01087	.01144	-.00057	.24292	.25542	-.01250
1965	.03404	.01938	.01464	.27694	.27480	.00216
1966	.03659	.03062	.00599	.31355	.30542	.00813

equation closely approximated the actual boardings. However, it once again was felt that a model such as this which used the absolute levels of the variables, could give misleading forecasts due to the intercorrelation amongst the independent variables--intercorrelation amongst the independent variables can result in regression coefficients representing meaningless relationships. Consequently, once again, it was decided that models should be tried that used first differences of those variables given in the previous section since the use of first differences will typically reduce intercorrelation among the independent variables.

Also once again two different sets of first differences were tried for variables in logarithmic (natural or common) form:

(a) $\Delta \log X'_t = \log X_t - \log X_{t-1}$

(b) $\nabla \log X'_t - \log (X_t - X_{t-1})$

Furthermore, if certain logically valid models showed significant autocorrelation amongst the residuals, weighted first differences were calculated as shown in chapter three.[1]

Of the 200 or so models tested, only one was statistically significant (i.e. $R^2 > 0.40$, significant regression coefficients and no significant autocorrelation) and logically valid (i.e. correct signs). This statistically and logically correct model is: (Δ represents first differences)

$$\Delta B1 = -.005434 + \underset{(.1645}{.3054\Delta B11L} + \underset{(.0000397)}{.0001054\Delta GC1} - \underset{(.0101)}{.0110\Delta YC1} \qquad \text{(Eq. 5:3)}$$

$R^2 = .6084$ Von Neumann's ratio = 2.352

Let equation 5:3 represent dynamic model 2.

Table XIV shows how the estimated rates of change and levels of

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[1]See page 33.

TABLE XIV

COMPARISON BETWEEN ACTUAL AND ESTIMATED BOARDINGS

USING DYNAMIC MODEL TWO

Year	Actual First Difference	Estimated First Difference	Residual	Actual Boardings Per Capita	Estimated Boardings Per Capita	Residual
1956				.14941		
1957	.01579	.01441	.00138	.16520	.16382	.00138
1958	.01110	.00974	.00136	.17630	.17356	.00274
1959	.02511	.01052	.01459	.20141	.18408	.01733
1960	.01577	.02219	-.00642	.21718	.20627	.00091
1961	.01139	.01126	.00013	.22857	.21753	.00104
1962	.00410	.01316	-.00906	.23267	.23069	.00198
1963	-.00062	.00737	-.00799	.23205	.23805	-.00601
1964	.01087	.01287	-.00200	.24292	.25093	-.00801
1965	.03404	.02382	.01022	.27694	.27475	.00219
1966	.03659	.03878	-.00219	.31355	.31353	.00002

boardings approximated the actual rates of change and levels of boardings.

Dynamic model two is quite similar in form to dynamic model one except that model two uses first differences of the variables rather than absolute levels and B11L is in natural logarithmic form while Δ B11LO is in common logarithmic form. Once again, model two takes into account the idea of habit formation in boarding forecasts.

C. Accuracy of the Two Dynamic Estimating Equations

From Tables XIII and XIV it can be seen that both dynamic models estimated boardings that closely approximated actual boardings. A visual presentation of the accuracy of the two dynamic models is given in Charts 3 and 4. But once again as in chapter four, two tests can be conducted that will test more quantitatively the accuracy of the two models. One quantitive test involves calculating the ratio of expected boardings to actual boardings, a ratio denoted by E_t/A_t. Table XV gives two statistics based on this ratio. The reasons for giving two statistics are the same as in chapter four.

TABLE XV

ACCURACY OF BOARDING ESTIMATES

	E_t/A_t by trend of boardings			Average absolute Percentage Error		
Model	Rising	Falling	All	Rising	Falling	All
1	.995	1.051	1.000	2.4	5.1	2.7
2	.983	1.025	.982	2.9	2.5	2.8

This first test does not sufficiently test the accuracy of the models due to the high serial correlation between the estimated and actual

Chart 3 - Comparison Between Actual Boardings per Capita and Estimated Boardings Per Capita Using Dynamic Models one and Two

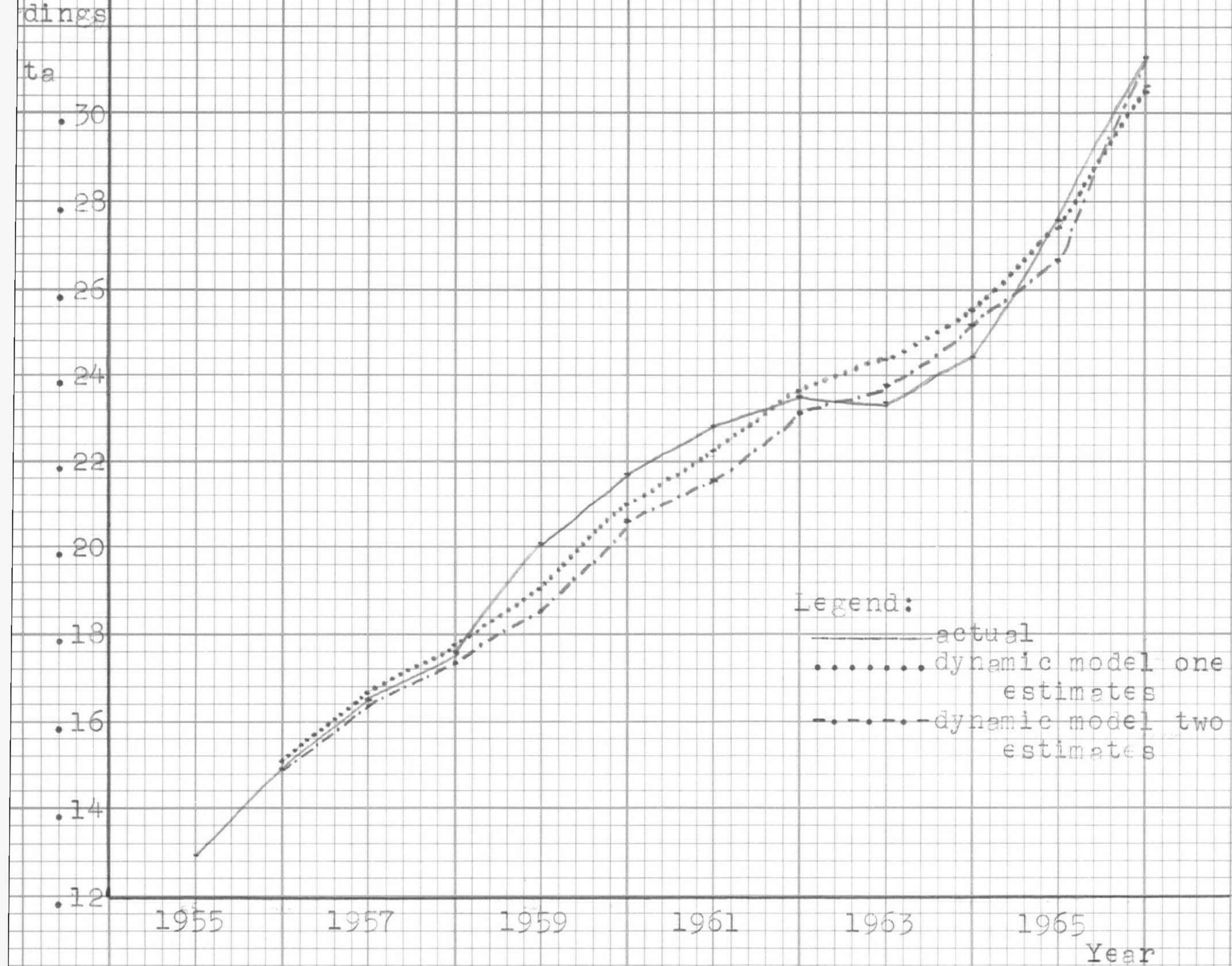
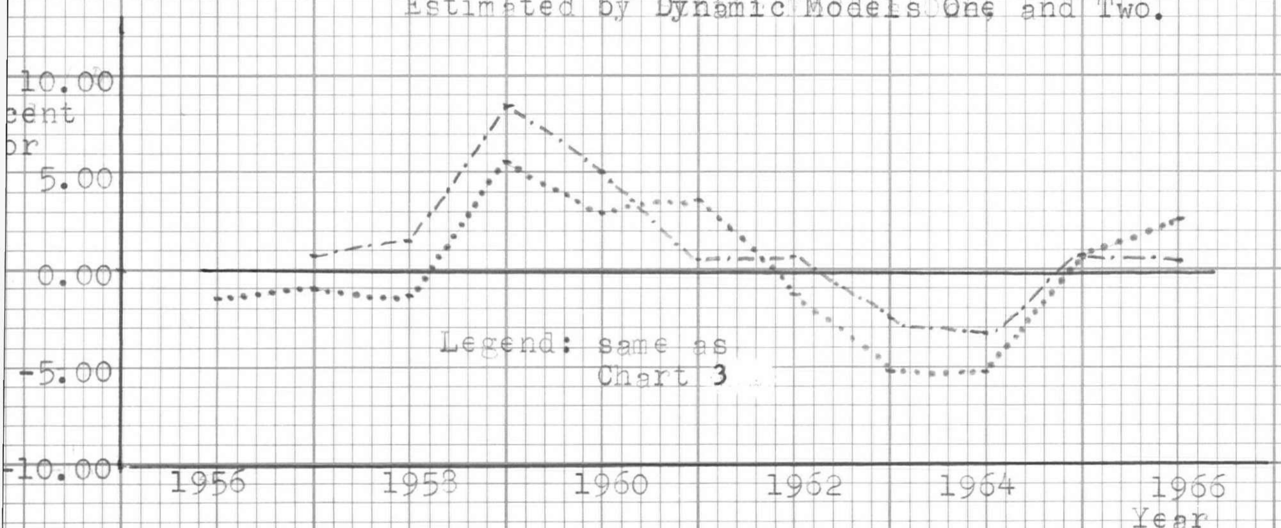


Chart 4 - Percentage Errors of Boardings Per Capita Estimated by Dynamic Models One and Two.



boardings. Although E_t and A_t may both be of the same general magnitude, with fairly high correlation, the direction of change may be missed altogether because of this serial correlation. Therefore, it is necessary to also use a second test of accuracy--compare the actual and anticipated rates of change. The coefficients of correlation between E_t/A_{t-1} and A_t/A_{t-1} for Model one was .647 and for Model two it was .572. Thus both models provide not only a good idea of the level of boardings but also of the direction and magnitude of change.

D. Problems of Estimation and Projection

Although dynamic models one and two seem to be good estimating equations, two problems are encountered in using them for forecasting purposes.

(1) Problem of Error in Boardings for 1966

Projection with a static model is very easy, for the value of the predictors have only to be substituted into the equation. In contrast, the estimating form of the dynamic model is a first difference equation, so the projection must be built up year by year from some initial condition. Alternatively, it is possible to obtain a solution for the difference equation but the solved equation is likely to involve more rounding error.

Since 1966 is the most recent experience in the model, the 1966 values have been used for the initial conditions. There is however, the problem of how to treat the error in 1966. Clearly it should be taken into account, since by ignoring it, valuable information could be lost. The 1966 actual boardings could be forced to lie on the regression line by incorporating the 1966 error into the intercept. Yet, this would give undue weight to the last few years. Furthermore, the error for 1966 was quite small, especially in model two. Therefore, the actual 1966 value of the independent variable was used as an initial condition and the intercept of the estimating equation was not altered.

(2) The Problem of Autocorrelation

Autocorrelation in the error term leads to an under-estimate of δ^2 when the method of least squares is used to estimate the parameters. Similarly, regardless of whether the static or the dynamic model is being used, the classical formula

$$S^2_{1.234...m} = s_1^{\ 2} \ (1 - R_1{}^2{}_{.234...m}),$$ [2]

will underestimate the true projecting variance. In a recent Monte Carlo study of distributed-lag forecasting models, Malinvaud[3] found that the forecasting variance increased sharply upon the introduction of autocorrelation in the error term, with the increase being more marked the longer the forecast interval. Therefore, the presence of autocorrelation not only under-estimates the true forecasting variance, but also increases the variance as well.

Furthermore, autocorrelation in the error term may imply bias in the projection as well as inefficiency because of the

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[2] Modecai Ezekiel and Karl Fox, Methods of Correlation and Regression Analysis (New York: John Wiley and Sons, 1959), p. 191.

[3] E. Malinvaud, "Estimation and Prévision Dans Les Modèles auto-regréssifs," Revue de L' Institute International de Statistique, XXIX (1961), p. 85.

presence of the lagged value of the dependent variable as a predictor. First of all, autocorrelation leads to a biased estimate of the regression coefficient of the lagged value of the dependent variable, which if there are no offsetting biases in the other coefficients, is sufficient to give a biased projection. Secondly, with the effect of errors being spread out over succeeding periods, an error in period t affects the level of the dependent variable in t + 1 directly as well as through the level of the dependent variable in t.

Both models were tested for autocorrelation using Von Neumann's ratio. Von Neumann's ratio showed that there was no significant autocorrelation in the residuals at the five percent significance level.

There remains, however, the problem of adverse effects of autocorrelation in the projections. As already mentioned, the presence of autocorrelation in the error term of a model containing a lagged value of the dependent variable as a predictor leads to an inconsistent estimate of the coefficient of the lagged value. Taylor and Wilson[4] have developed a three-pass estimation procedure to reduce the bias in the estimation of the lagged value of the dependent variable. The use of this method, however, poses a problem when it comes to projecting from the estimated equation: except for the historical period,

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[4]L. D. Taylor and T. A. Wilson, "Three-Pass Least Squares: A Method for Estimating Models with a Lagged Dependent Variable", Review of Economics and Statistics, XLVI (1964).

Z_t (residual) is an unknown quantity. Houthakker and Taylor[5] have carried out Monte Carlo forecasting experiments to test various solutions to this problem. The three main solutions that they experimented with were: (a) assume that Z takes on its historical mean in the projection period; (b) calculate Z year by year in the projection period according to its asymptotic formula; (c) use the least squares equation. A summary of their results is:

(a) The estimating equation is the best form of the model for making projections.

(b) The best means of projecting the Z variable is to use its value computed from the last observation during the historical period for the first forecast and its historical mean thereafter.

(c) While forecasts from the three pass least squares equation are essentially unbiased and the ordinary least squares forecasts are biased downward, the three-pass least squares forecasts are less efficient than those of ordinary least squares.

(d) The forecasting variance in both the three-pass least squares forecasts and the ordinary least squares forecasts increases sharply from the sixth period on.

On the basis of this criteria, the ordinary least squares equations were chosen since it was felt that it was more

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[5] H. S. Houthakker and Lester D. Taylor, Consumer Demand in the U.S. 1929-1970 (Cambridge, Massachusetts: Harvard University Press, 1966), pp. 45-52.

important to have a small variance rather than less biasedness.

E. Projections

The next step is to use dynamic models one and two to give projections of international and domestic boardings per capita and for all of Canada till 1975. Once again, for the independent variables of population and Gross National Product, this study has used the potential estimates of the Economic Council of Canada which were given in chapter four.[6] Also with respect to the independent variable of average air passenger yield per passenger-mile of Canadian scheduled carriers, this study again used the five different assumptions of chapter four.

By once again making five forecasts based on different assumptions regarding future fare levels, this study can point out how sensitive these two dynamic models are to fares. These two dynamic models are not nearly as fare sensitive as the three static models since the fare coefficients are only -0.0072 and -0.0110 for dynamic models one and two respectively.

The results of trying the five fare assumptions in the two dynamic forecasting models are shown in Tables XVI, XVII, XVIII, XIX, and XX. In model one, the actual levels of the independent variables are used while in model two, the independent variables are converted into first differences before being substituted into the model. Since models one and two give boardings per capita, the total estimated Canadian boardings are obtained by multiplying the boardings per capita by the estimated total population.

Fortunately both models gave quite similar results--differed no more than eleven percent. Also notice that boardings are not too fare elastic

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[6] See page 60.

TABLE XVI

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE DECREASES ANNUALLY 0.1334 CURRENT CENTS

		Model 1		Model 2	
Year	Average Yield per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings..	Boardings Per Capita	Total Canadian Boardings
1967	5.7346	.32934	6,669,728	.34159	6,917,812
1968	5.6012	.34595	7,125,290	.36574	7,532,891
1969	5.4678	.36314	7,605,495	.38851	8,136,837
1970	5.3344	.38087	8,110,246	.41120	8,756,093
1971	5.2010	.39799	8,615,568	.43259	9,364,579
1972	5.0676	.41526	9,139,084	.45401	9,991,897
1973	4.9342	.43292	9,686,542	.47600	10,650,452
1974	4.8008	.45106	10,260,668	.49878	11,346,198
1975	4.6674	.46976	10,863,905	.52247	12,082,902

TABLE XVII

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE DECREASES ANNUALLY 0.2000 CURRENT CENTS

		Model 1		Model 2	
Year	Average Yield Per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings
1967	5.668	.32982	6,679449	.34233	6,932,799
1968	5.468	.34706	7,148,152	.36721	7,563,167
1969	5.268	.36492	7,642,775	.39071	8,182,913
1970	5.068	.38330	8,161,990	.41414	8,818,697
1971	4.868	.40107	8,682,243	.43627	9,444,242
1972	4.668	.41895	9,820,293	.45843	10,089,173
1973	4.468	.43720	9,782,306	.48115	10,765,683
1974	4.268	.45593	10,371,450	.50466	10,479,955
1975	4.068	.47521	10,989,944	.52903	12,234,612

TABLE XVIII

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE DECREASES ANNUALLY 0.0500 CURRENT CENTS

		Model 1		Model 2	
Year	Average Yield per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings
1967	5.818	.32874	6,657,577	.34068	6,899,383
1968	5.768	.34455	7,096,455	.36391	7,495,200
1969	5.718	.36091	7,558,791	.38574	8,079,202
1970	5.668	.37762	8,015,299	.40754	8,678,157
1971	5.618	.39415	8,532,441	.42802	9,265,649
1972	5.568	.41063	9,037,186	.44853	9,871,293
1973	5.518	.42753	9,565,941	.46960	10,507,253
1974	5.468	.4494	10,121,451	.49146	11,179,683
1975	5.418	.46291	10,705,488	.51423	11,892,340

TABLE XIX

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE REMAINS AT THE 1966 LEVEL

Year	Average Yield Per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings
1967	5.868	.32838	6,650,286	.34013	6,888,245
1968	5.868	.34372	7,079,360	.36281	7,472,544
1969	5.868	.35958	7,530,936	.38411	8,044,685
1970	5.868	.37599	8,006,331	.40534	8,631,310
1971	5.868	.39184	8,482,435	.42527	9,206,117
1972	5.868	.40785	8,976,004	.44523	9,798,666
1973	5.868	.42429	9,493,446	.46575	10,421,110
1974	5.868	.44125	10,037,511	.48706	11,079,592
1975	5.868	.45880	10,610,438	.50928	11,777,864

TABLE XII

FORECAST OF TOTAL CANADIAN AND PER CAPITA INTERNATIONAL AND DOMESTIC BOARDINGS ASSUMING THAT THE AVERAGE AIR PASSENGER YIELD OF CANADIAN SCHEDULED CARRIERS PER PASSENGER-MILE INCREASES ANNUALLY 0.0500 CURRENT CENTS

Year	Average Yield Per Passenger-Mile	Boardings Per Capita	Total Canadian Boardings	Boardings Per Capita	Total Canadian Boardings
1967	5.918	.32802	6,642,995	.33958	6,877,106
1968	5.968	.34288	7,062,059	.36171	7,449,888
1969	6.018	.35824	7,502,871	.38246	8.010,128
1970	6,068	.37416	7,967,363	.40314	8,584,463
1971	6.118	.38952	8,432,212	.42257	9,146,586
1972	6.168	.40507	8,914,821	.44193	9,726,040
1973	6.218	.42105	9,420,953	.46190	10,334,966
1974	6.268	.43757	9,953,799	.48266	10,979,501
1975	6.318	.45467	10,514,926	.50433	11,663,388

since the difference in boardings per capita is no greater than five percent between the two opposite fare assumptions of a 0.20 current cents annual decrease in fares and a 0.05 current cents annual increase in fares. This is consistent with the theory of habit formation since fares should be expected to exert less of an influence on consumption at high levels of income, because income is a constraining factor.

CHAPTER VI

FARE ELASTICITY AND PROJECTION SUMMARY

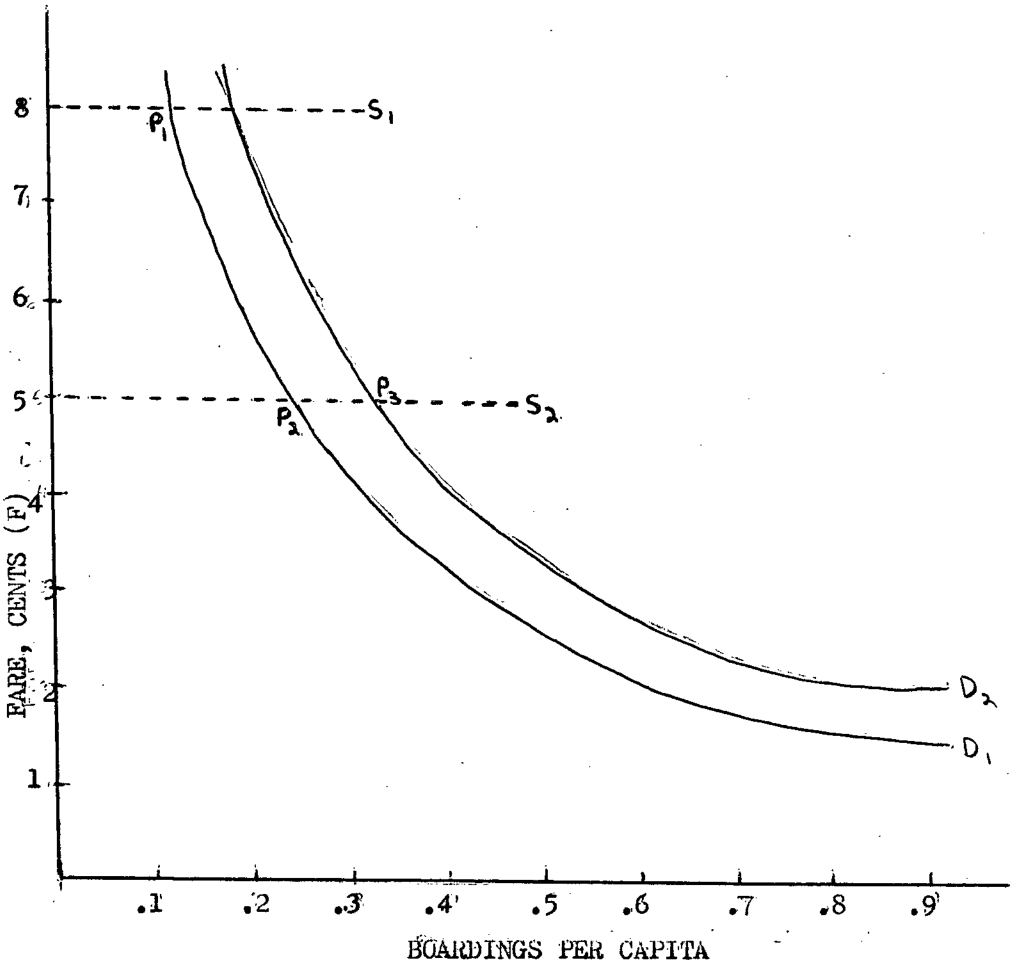
A. Fare Elasticity

It is beneficial to determine how fare changes have affected and will affect the growth of air traffic. In other words, what is the proportionate effect on air passenger demand of a given percentage change in fares, other things equal. The Marshallian law of demand, presumably applies to air travel: people will buy less at higher prices and more at lower prices, if other things are not different or do not change. However, other things such as population, incomes and tastes do change and, therefore, must somehow be held constant in order to gauge the net effect of fares. Chart 5, illustrates the framework of the problem of determining fare elasticity--a demand curve (D_1) having a uniform elasticity is drawn to scales of fares per mile and boarding passengers per capita. The same curve as it would be a year later, is also shown (D_2). It has shifted to the right because of the growth of incomes and because of more favourable taste or preferences of the public for air travel. Two intersecting supply curves (S_1 and S_2) are drawn on the assumption that plenty of seats are available. The past average will show a number of boardings per capita at the fare P_1 and a larger quantity sold a year later at the lower fare P_3. To find the true effect of fares on traffic, one must correct for the shift of the curve, and measure the increase of traffic against the decrease of fares as if both P_1 and P_2 had actually been observed. Fortunately the "weight" or coefficient of the fare variable in a regression analysis

CHART 5

DEMAND FOR AIR TRAVEL $T = aF^b$

ELASTICITY OF DEMAND $\frac{dB}{dF} \cdot \frac{F}{B} = b$



gives the desired estimate of the relationship of boardings to fares, after allowing for, or holding constant, the effects of the other variables.

In this study, the fare elasticities of the static models differ quite significantly from those of the dynamic models. The fare elasticities of the static models are quite similar i.e. -2.34, -2.29 and -2.18. A price elasticity of this general size means that a one percent increase (decrease) in fares would cause boardings per capita to decline (increase) by approximately 2.2 to 2.3 percent. In other words, proportionate changes in fares are accompanied by changes in boardings that are proportionately larger by a factor of approximately 2.2 to 2.3 and in the opposite direction to the fare change. The fare elasticity of static model one is -2.34 with a standard error of 0.93 so that the chances are, therefore, 2 out of 3 that the true elasticity is -2.34 ± 0.93 or between -3.27 and -1.41. For static model two, the fare elasticity is quite similar (i.e. -2.29) but the standard error is higher (i.e. 1.20) so that the chances are 2 out of 3 that the true elasticity is -2.29 ± 1.20 or between -3.49 and -1.09. Although the fare elasticity of static model three (i.e. -2.18) is the lowest of all three static models, it still differs very little from the others. The chances are 2 out of 3 that the trus elasticity is -2.18 ± 1.24 or between -3.42 and -0.94.

For the two dynamic models, the fare elasticities are much lower i.e. -0.72 and -1.10. In other words a price elasticity of this general size means that a one percent increase (decrease) in fares would cause boardings to decline (increase) by approximately 0.70 to 1.10 percent. Not only are the fare elasticities lower but also they are less significant since the ratios of the fare coefficients to their standard errors are lower. For dynamic model one, the fare elasticity is -0.72 with a standard error of 0.70 so that the chances are therefore two out of three that the true elasticity is -0.72± 0.70 or between -0.02 and -1.42. And for dynamic model 2, the fare elasticity is -1.10 with a standard error of 1.01 so that the chances are two out of three that the true elasticity is -1.10± 1.01 or between -0.09 and -2.11. From these results, it appears that the fare elasticities of the static models are a little more significant than those of the dynamic models. In other words, the ratios of the fare coefficients to their standard errors are higher for the static models than the dynamic models.

There is a valid reason for the fare elasticities of the static models to be higher than those of the dynamic models. Since the dynamic model relates boardings per capita from one year to the next, the fare elasticity of the dynamic model may be taken as a short-term elasticity whereas, the fare elasticity of the static model can be looked upon as a long-term elasticity. In the short run, boardings may not be very price elastic since it may be too difficult to quickly change one's means of communicating and travelling but in the long run, it can be changed. The higher long-run fare elasticity is consistent with what generally happens with new goods and services. Although "the demand for a dramatically new commodity may be primarily a matter of considerations other than price, as it is introduced into the population and comes into wider use, the demand for it may become increasingly sensitive to price."[1] Although air transport has on its credit side a rising population, an upward trend in incomes

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[1] John B. Lansing and Dwight M. Blood, The Changing Travel Market (Ann Arbor, Michigan: Survey Research Center, 1964), p. 116.

and an increasing number of experienced travellers, on its debit side, it has the great difficulty of increasing traffic volume more than the amount possible with rising incomes due to the uncertainty with regard to future prices. The increasing level of incomes is still the airlines main asset, but growth in boardings will depend on a fare policy which induces a larger number of people to travel by air. The financial factor greatly affects the choice of mode of travel since those who wish to travel but have limited financial resources, are not likely to choose the most expensive form of travel. The Lansing Report[2] points out how the family situation has an effect on the importance of the cost factor: "single people young or old travel most by air: respectively 13 percent and 15 percent of each of these two groups; only 6 percent of couples without children and 7 percent of couples with children travel by air." Fares, when it means multiplying them by two or more, are a major consideration in air travel.

B. Projected Boardings

Since the main purpose of this study was to forecast total Canadian air passenger boardings, the forecasts of the three static models and the two dynamic models should be combined into one. As mentioned in chapter one, it is much better to use a combination of forecasting models. The three static models and the two dynamic models all estimated the eleven years of historical boarding data extremely well but gave different forecasts--the static models are extremely fare elastic but the dynamic models are not. The crux of the problem lies in the fact that, in the absence of

[2] Ibid., p. 363.

effective theory or even of working hypotheses, a great variety and wealth of data on trip purposes, socio-economic types of traveller, party size and other market identification features are needed to differentiate amongst the many models that can describe major characteristics of change. However, at present there is very little information on air passenger characteristics and so it is extremely difficult to choose amongst the models.

In the end, one wants only one projection and so it is necessary to somehow combine the forecasts of the five models. Ordinarily, choosing a projection value cannot be done in a vacuum. Clearly there is a difference between a good projection equation and a good statistical equation. To assess a projection equation properly, one needs to know how and in what context a forecast is to be used. However, in this study, there appeared to be no basis for accepting one model and rejecting the others. Ordinarily, the forecasts of the five models could be combined using a weighting method that gives a projection with the lowest variance i.e. weight each model's projection according to its standard error of estimate. Unfortunately this method of weighting the forecasts of the five models could not be used since the first difference models had much higher standard errors of estimate than the absolute value models even though their results were just as accurate (based on a comparison of actual and estimated boarding levels) since two distinct types of data were used. As a result this study resorted to combining the five models by just finding the average of the five. Although this method of combining the five models may seem very elementary, it was felt that it was quite adequate for at least two reasons. First of all, the five models gave forecasts for any one period that did not differ too significantly. It seems that despite the fact that the static models were very fare elastic while the dynamic models were not, strong habit formation during the early forecast periods boosted the forecasts of the two dynamic models to approximately the same levels as the static models. Secondly since the coefficients of the two dynamic models were not in general as statistically significant as those of the three static models, more weight is attached to the static model results. The results are shown in Tables XXI, XXII, XXIII, XXIV and XXV.

The growth patterns of these five average forecasts have two things in common: (1) all show a declining rate of growth both in terms of boardings per capita and Total Canadian boardings and (2) all show absolute annual increments which in general increase from year to year throughout the entire forecast period. These two traits are both major characteristics of growth industries. In general, most statistical growth curves, such as the Gompertz or Logistic curve, have an inflection point (i.e. maturation point) where the absolute first differences reach a maximum and thereafter decline. This study's forecasts, however, do not foresee the maturation point of air travel before 1975.

A visual presentation of the five average boardings is given in Charts 6 and 7.

Of the five forecasts, the one based on an average annual decrease of 0.1334 current cents in air passenger yield per passenger-mile seems the most realistic. If this realistic projection does accurately describe the future, the growth of total boardings will progressively decline from a 7.81 percent increase in 1968 to a 6.54 percent increase in 1975 and the growth of boardings per capita will progressively decline from a 5.07 percent increase in 1968 to a 4.35 percent increase in 1975.

CHART 6

AVERAGE FORECASTED BOARDINGS PER CAPITA WITH FIVE ALTERNATIVE FARE ASSUMPTIONS

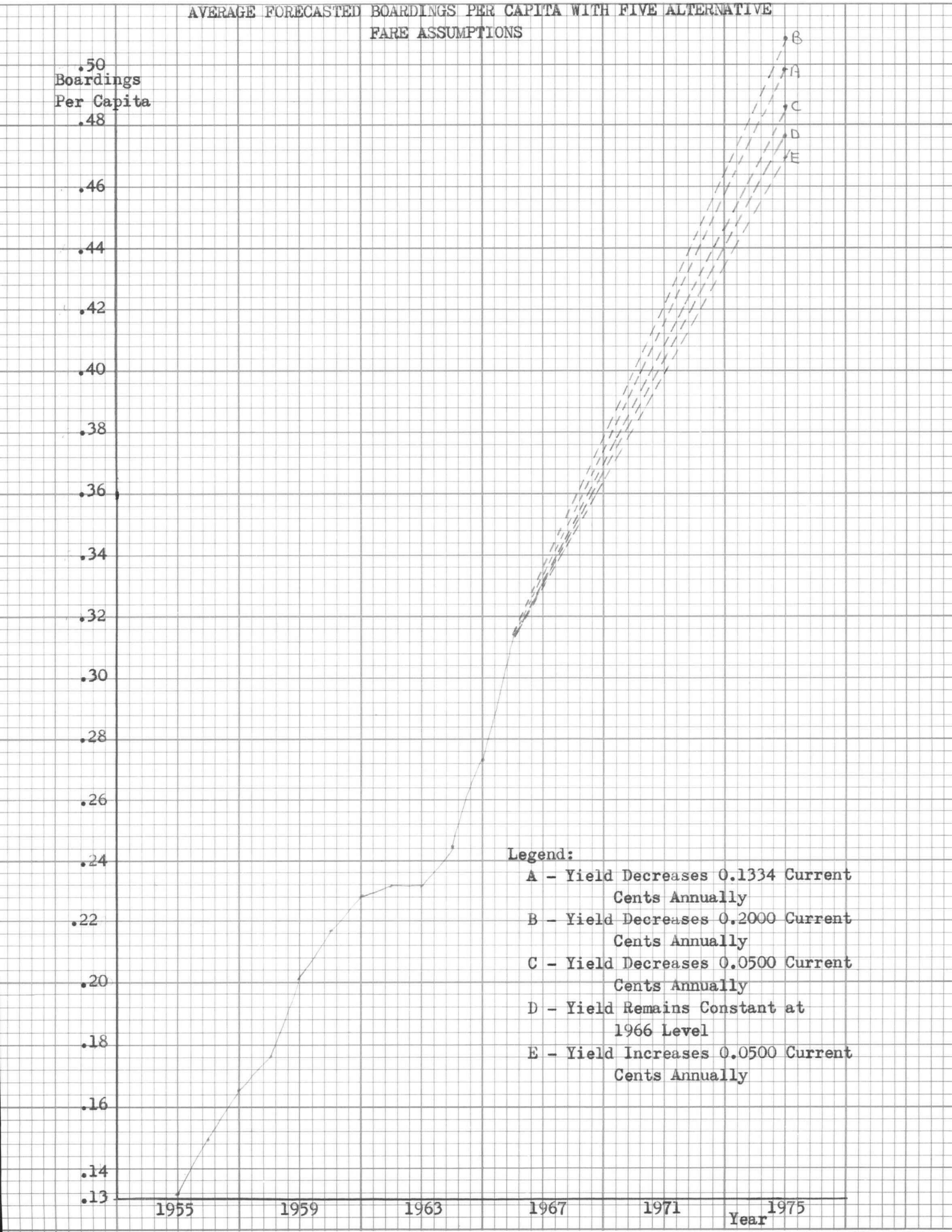

CHART 7

AVERAGE FORECASTED TOTAL BOARDINGS WITH FIVE ALTERNATIVE FARE ASSUMPTIONS

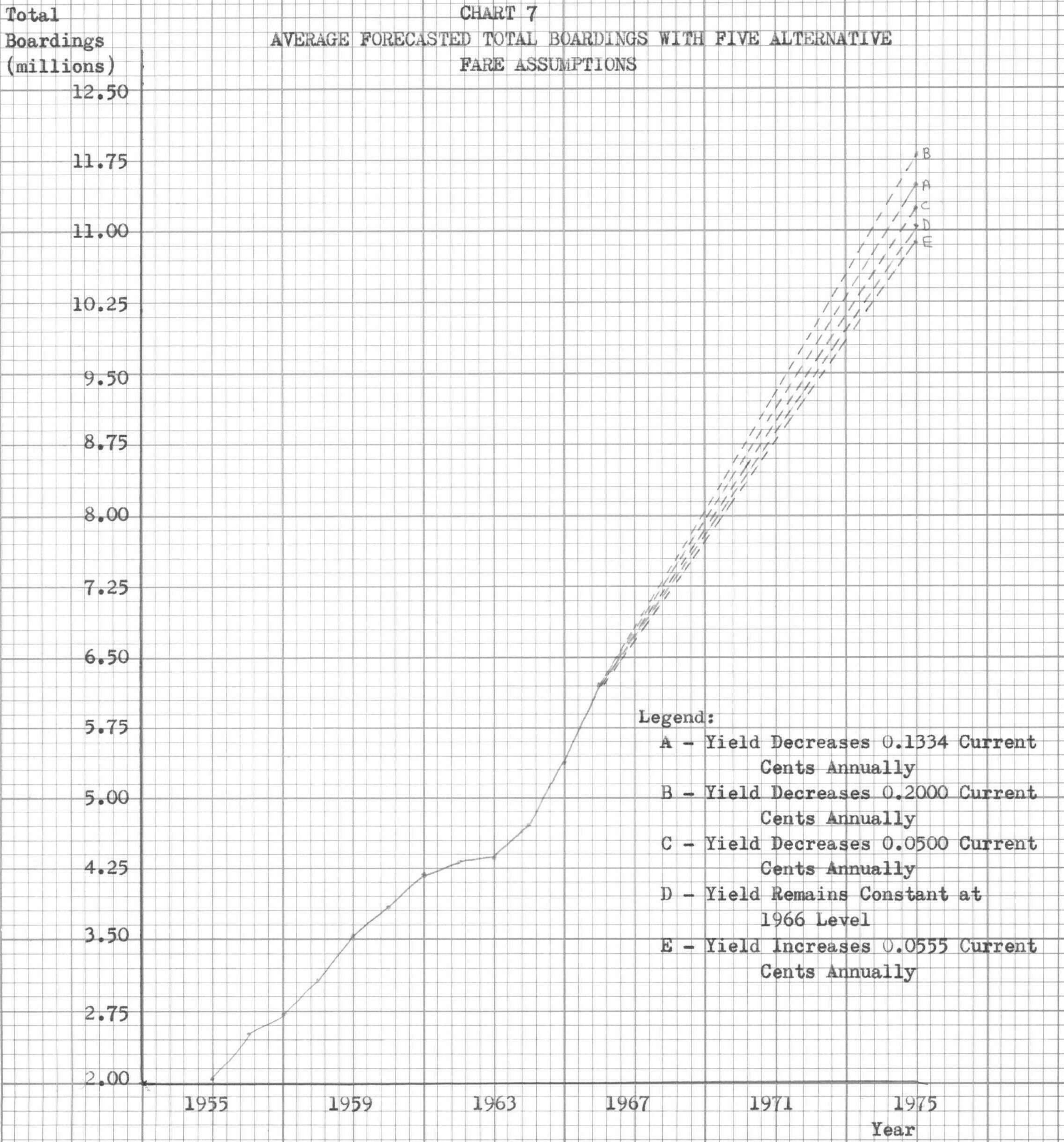

TABLE XXI

AVERAGE PROJECTED TOTAL CANADIAN BOARDINGS AND BOARDINGS PER CAPITA WHEN THE YIELD IS ASSUMED TO DECREASE 0.1334 CURRENT CENTS ANNUALLY

Year	Average Projected Total Canadian Boardings--Percent Increase in Brackets		Average Projected Boardings Per Capita--Percent Increase In Brackets	
1967	6,706,626		.33116	
1968	7,230,578	(7.81)	.35106	(6.01)
1969	7,776,061	(7.54)	.37128	(5.76)
1970	8,349,761	(7.38)	.39212	(5.61)
1971	8,922,965	(6.86)	.41219	(5.12)
1972	9,524,093	(6.74)	.43275	(4.98)
1973	10,158,025	(6.65)	.45399	(4.90)
1974	10,827,909	(6.59)	.47600	(4.84)
1975	11,536,377	(6.54)	.49884	(4.79)

TABLE XXII

AVERAGE PROJECTED TOTAL CANADIAN BOARDINGS AND BOARDINGS PER CAPITA WHEN THE YIELD IS ASSUMED TO DECREASE 0.2000 CURRENT CENTS ANNUALLY

Year	Average Projected Total Canadian Boardings--Percent Increase in Brackets		Average Projected Boardings Per Capita--Percent Increase in Brackets	
1967	6,729,714		.33230	
1968	7,277,785	(8.14)	.35335	(6.34)
1969	7,848,735	(7.85)	.37475	(6.06)
1970	8,448,522	(7.64)	3.9676	(.587)
1971	9,048,738	(7.10)	.41800	(5.35)
1972	9,677,402	(6.94)	.43972	(5.19)
1973	10,339,710	(6.84)	.46211	(5.09)
1974	11,038,782	(6.76)	.48527	(5.01)
1975	11,777,124	(6.68)	.50925	(4.94)

TABLE XXIII

AVERAGE PROJECTED TOTAL CANADIAN BOARDINGS AND BOARDINGS PER CAPITA WHEN THE YIELD IS ASSUMED TO DECREASE 0.0500 CURRENT CENTS ANNUALLY

Year	Average Projected Total Canadian Boardings--Percent Increase in Brackets		Average Projected Boardings Per Capita--Percent Increase in Brackets	
1967	6,677,261		.32971	
1968	7,169,860	(7.38)	.34811	(5.58)
1969	7,682,861	(7.15)	.36683	(5.38)
1970	8,223,061	(7.03)	.38617	(5.27)
1971	8.761,906	(6.55)	.40475	(4.81)
1972	9,327,429	(6.45)	.42382	(4.71)
1973	9.925,013	(6.40)	.44358	(4.66)
1974	10,557,209	(6.36)	.46410	(4.62)
1975	11,226,806	(6.34)	.48545	(4.60)

TABLE XXIV

AVERAGE PROJECTED TOTAL CANADIAN BOARDINGS AND BOARDINGS PER CAPITA WHEN THE YIELD IS ASSUMED TO REMAIN CONSTANT AT THE 1966 LEVEL

Year	Average Projected Total Canadian Boardings--Percent Increase in Brackets		Average Projected Boardings Per Capita--Percent Increase in Brackets	
1967	6,659,804		.32885	
1968	7,133,858	(7.12)	.34637	(5.33)
1969	7,627,570	(6.92)	.36419	(5.15)
1970	8,147,893	(6.82)	.38264	(5.06)
1971	8,666,310	(6.36)	.40033	(4.62)
1972	9,210,742	(6.28)	.41852	(4.34)
1973	9.786,378	(6.25)	.43738	(4.50)
1974	10,396,200	(6.23)	.45702	(4.49)
1975	11,042,904	(6.22)	.47750	(4.48)

TABLE XXV

AVERAGE PROJECTED TOTAL CANADIAN BOARDINGS AND BOARDINGS PER CAPITA WHEN THE YIELD IS ASSUMED TO INCREASE 0.0500 CURRENT CENTS ANNUALLY

Year	Average Projected Total Canadian Boardings--Percent Increase in Brackets		Average Projected Boardings Per Capita--Percent Increase in Brackets	
1967	6,642,307		.32799	
1968	7,097,814	(6.88)	.34462	(5.07)
1969	7,572,278	(6.68)	.36155	(4.91)
1970	8,072,726	(6.61)	.37911	(4.85)
1971	8,570,627	(6.17)	.39591	(4.43)
1972	9,085,252	(6.00)	.41281	(4.26)
1973	9,647,967	(6.19)	.43120	(4.45)
1974	10,235,508	(6.08)	.44995	(4.35)
1975	10,858,539	(6.08)	.46953	(4.35)

This forecasted growth is much lower than in the historical period from 1955 to 1966 when the average percentage growth in total boardings was 11.4 percent and in boardings per capita was 8.48 percent. Although during the last decade or so Canadian airlines have successfully taken from the railroads the major share of the market for common carrier travel, this process is already far advanced and can no longer be expected to give to the airlines a major source of new traffic in the future. Thus it is reasonable to expect that the future demand for air travel will grow as the economy in general expands--this growth will come from the increase in total population and more directly from the increase in number of people in the population in the upper income group. Although it is perhaps just human that people, after a long period of prosperity should look upon high growth of air travel as the normal state of affairs, growth does not assume the role of dependable causal factor.[3] Any future growth rate just based on the past record is no more than a shorthand description of that record, the portion that may be represented by a compound interest curve. It is necessary to understand the causes that operated in the past and will continue to operate with equal effectiveness in the future and all five forecasting models seem to do this.

Of course, there is one other important reason for the forecasted average annual increases in boardings to be lower in the future than in the past. The forecasted average annual increase in potential GNP per capita by the Economic Council of Canada is only 3.60 percent whereas the average annual increase in GNP per capita over the 1955-1966 historical period was 4.91 percent.

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[3] V. Lewis Bassie, Uncertainty in Forecasting and Policy Formation (Austin, Texas: University of Texas, 1959), p. 10.

The forecasts to 1975 based on an average annual decrease of 0.1334 current cents in air passenger yield per passenger-mile seems the most realistic when Chart 8 by the International Civil Aviation Organization is examined.[4] Chart 8 shows how aircraft productivity in terms of tonne-kilometres of available capacity produced per hour has changed between 1951 and 1967 for the scheduled airlines of ICAO members and how the average is likely to move in the future up to 1980. Between 1951 and 1959, even before the introduction of the jets, aircraft productivity was rising fairly fast (i.e. approximately 7.5 percent per year) due to the steady introduction of the larger piston-engined aircraft. From 1960 onwards as the larger and faster jets were introduced, productivity increased steeply for four years (at about 18.5 percent per year) and then settled down to a steady increase of about 9.5 percent per year as the shift to jets continued at a relatively slower pace.[5] In the future, with the known orders for future delivery of new aircraft and the announced programmes of the aircraft manufacturers and the world airlines (including Canadian carriers) for the introduction of further new types in the more distant future, the present steady upward trend of aircraft productivity should continue.

Up to about 1970, the steady upward trend in aircraft productivity will result from the continued introduction of larger versions of the long-range jets and as the present generation of medium and short-range jets continue to take over in their respective sectors.[6] From 1970 to about 1977, the rate of increase of aircraft productivity should rise even

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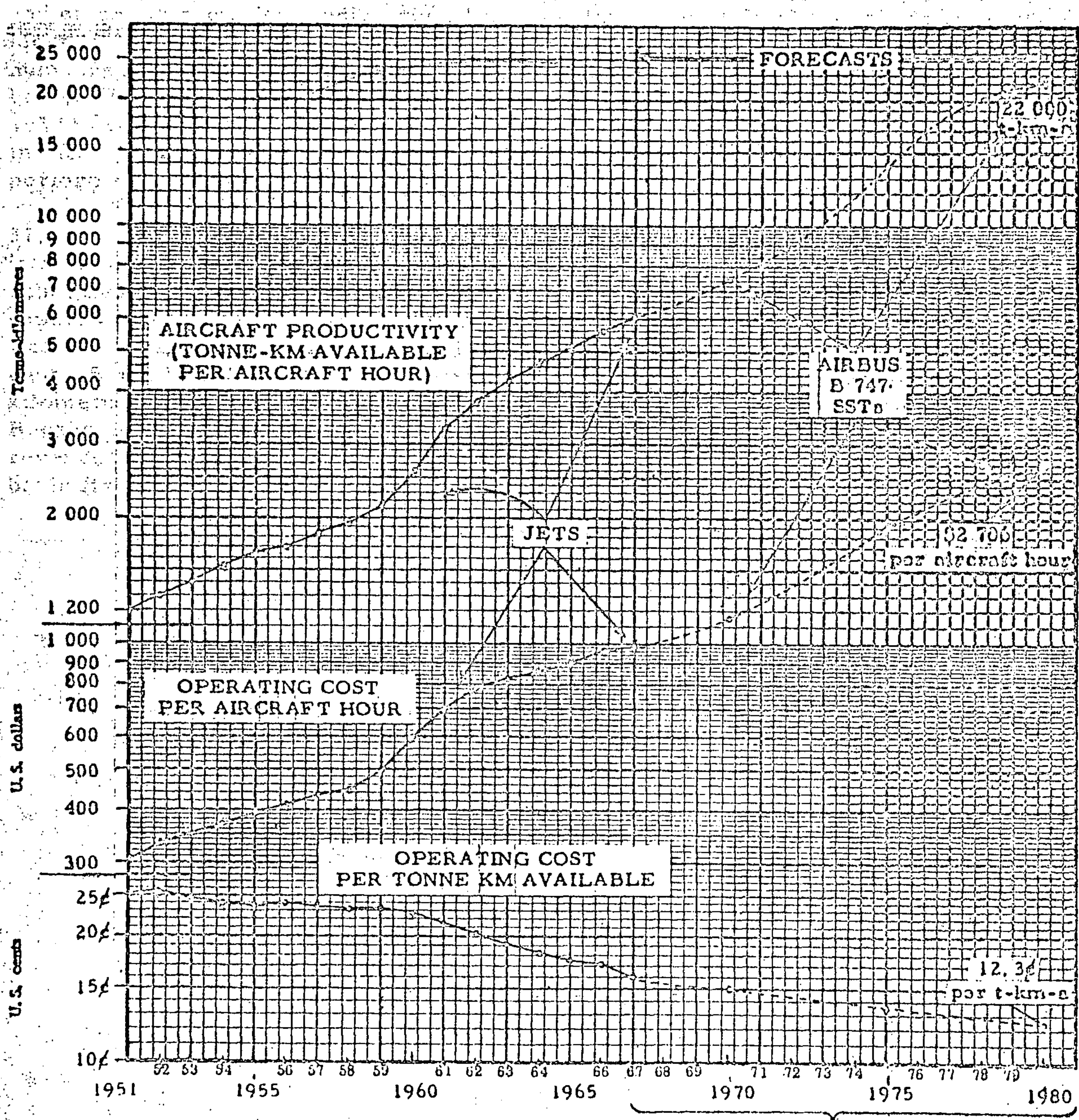
[5] Ibid., p. 23.

[6] Ibid., p. 24.

CHART 8

AIRCRAFT PRODUCTIVITY AND UNIT OPERATING COSTS

(TOTAL OPERATIONS OF THE SCHEDULED AIRLINES)



This diagram is drawn on a logarithmic scale.

further, as it did between 1959 and 1963, when the jets were introduced, due to the increasing introduction of the Boeing 747, various types of "airbus" (200 to 300 seat aircraft for medium and short range) and the SST's. However, although all these aircraft will have considerably higher productivity than their predecessors, the difference in productivity may not be so great as when the long-range jets were first introduced to replace piston-engined aircraft and also the transference will not be so complete and will take place over a longer period, so that the rate of increase in world average aircraft productivity in the 1970's will probably not be so great as it was in the 1960's[7]--a rate of increase of 13 percent between 1970 and 1975 is shown in Chart 8.

Not only does Chart 8 show how aircraft productivity has been steadily increasing, but also how aricraft operating cost per hour has been steadily increasing between 1951 and 1957 and began to increase rapidly as the jets were introduced in the early 1960's. However, as these increases were not as rapid as those in aircraft productivity, the operating costs per tonne-kilometre were forced down as shown in the lower portion of Chart 8. In the future, it seems probable that these two trends will hold the same to the curve of future aircraft productivity. Although the SST's hourly costs are expected to rise more than productivity, particularly in the case of the first generation, this will be more than offset by the effect of the B-747 and the various types of "airbus" whose volume of operations will probably be greater than those of the SST's at least until after 1980.[8] As a consequence, it seems most probable that the world

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[7]Ibid., p. 24.

[8]Ibid., p. 24.

average operating cost per tonne-kilometre will continue to fall till 1980 but at a decreased rate of approximately two percent per year.

As a result of these forecasts of future aircraft productivity and operating cost per tonne-kilometre available, ICAO forecasts that the future reduction in world average fares per passenger-kilometre will be about two percent per year with a maximum of four percent and a minimum of no reduction. Since conditions and airlines in Canada are not that different from world conditions and airlines (e.g. Air Canada ranks ninth in size among the world's airlines), this study's forecasts based on an average annual decrease of 0.1334 current cents in air passenger yield per passenger-mile (implies a reduction ranging from 2.1 percent to 3.0 percent annually) seems the most reasonable.

CHAPTER VII

FORECASTED BOARDINGS FOR THE LARGEST TWENTY-FIVE AIR TRANSPORTATION HUBS

A. Introduction

National forecasts of total domestic and international boardings are of little value in comparison to boarding forecasts for individual Canadian cities. Fortunately, the largest twenty-five air transportation hubs, which have accounted for 89 percent to 93 percent of the total of all Canadian air passenger boardings in the past, have through time each maintained a generally consistent relationship to the national total. Table XXVI shows the consistent relationship through time of a community's percentage of national boarding passengers. Thus a national air passenger boardings forecast may be multiplied by a community's forecasted percentage of national air passenger boardings to obtain a reasonable estimate of that community's air passenger boardings for a forecasted year.

To obtain forecasted percentages of national air passenger boardings for each community, numerous least squares curves have been fitted through past data. This statistical technique is employed by the Federal Aviation Administration in obtaining forecasts of domestic and international boardings for the twenty-one largest United States air transportation hubs.[1]

Recognition of regularity and extrapolation of it is a procedure in which the reader will probably not put too much confidence. The major

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[1]Federal Aviation Administration, Aviation Demand and Airport Facility Requirement Forecasts for Large Air Transportation Hubs Through 1980 (Washington: Federal Aviation Administration, 1967), p. 5.

TABLE XXVI

BOARDING PASSENGER TRAFFIC DISTRIBUTION

PERCENTAGE OF CANADIAN MARKET

CITY	YEAR					
	1955	1956	1957	1958	1959	1960
Baie Comeau	.53	.63	.84	.58	.56	.52
Calgary	3.61	3.50	3.50	3.72	3.86	4.07
Edmonton	3.96	4.30	4.55	4.72	4.35	4.15
Fredericton	.34	.39	.41	.42	.49	.49
Gander	.64	.70	.75	.74	.67	.58
Halifax	2.65	2.63	2.55	2.69	2.64	2.68
Lakehead	.72	.67	.73	.74	.73	.70
London	.87	.74	.81	.95	.99	1.08
Moncton	1.25	1.37	1.38	1.40	1.47	1.48
Montreal	18.60	18.50	18.30	18.00	19.14	19.40
Ottawa	3.25	3.07	3.17	3.62	3.77	3.81
Prince George	.37	.28	.29	.26	.24	.25
Quebec	1.40	1.76	1.83	1.72	1.87	2.04
Regina	1.42	1.50	1.42	1.46	1.53	1.54
Saint John	.74	.67	.68	.71	.68	.77
St. John's	1.10	1.19	1.20	1.25	1.22	1.25
Saskatoon	.81	.78	.72	.87	.99	1.05
Sault Ste. Marie	.38	.36	.37	.34	.40	.39
Sept Iles	.58	.51	.57	.64	1.02	1.20
Sydney	.88	.84	.82	.84	.81	.81
Toronto	18.97	19.33	19.50	20.01	21.02	21.67
Vancouver	13.40	13.21	12.83	12.91	11.47	10.60
Victoria	6.32	5.74	5.45	5.71	4.77	3.50
Windsor	1.50	1.61	1.60	1.59	1.59	1.57
Winnipeg	4.22	4.02	3.90	4.15	4.35	4.46
Others	11.35	11.42	11.65	9.82	9.28	9.94
Total	100.00	100.00	100.00	100.00	100.00	100.00

TABLE XXVI

BOARDING PASSENGER TRAFFIC DISTRIBUTION

PERCENTAGE OF CANADIAN MARKET

CITY	YEAR					
	1961	1962	1963	1964	1965	1966
Baie Comeau	.51	.37	.40	.41	.47	.49
Calgary	4.37	4.32	4.28	4.38	4.56	4.77
Edmonton	4.32	4.09	4.05	4.07	4.32	4.48
Fredericton	.54	.53	.61	.61	.64	.65
Gander	.51	.62	.68	.72	.62	.56
Halifax	2.90	2.82	2.85	2.82	2.74	2.71
Lakehead	.91	.88	.84	.81	.89	.93
London	1.11	1.02	1.01	.91	.89	.84
Moncton	1.49	1.39	1.32	1.45	1.23	1.18
Montreal	19.62	19.94	20.56	20.88	20.48	20.00
Ottawa	4.00	3.91	4.09	3.99	3.93	3.89
Prince George	.22	.30	.35	.44	.52	.59
Quebec	1.99	2.04	2.25	2.03	1.76	1.60
Regina	1.60	1.53	1.49	1.43	1.40	1.46
Saint John	.77	.79	.77	.74	.73	.67
St. John's	1.16	1.35	1.52	1.56	1.43	1.30
Saskatoon	1.14	1.06	1.00	.90	.96	.97
Sault Ste. Marie	.44	.48	.48	.45	.48	.48
Sept. Iles	.91	.65	.58	.56	.50	.58
Sydney	.76	.71	.68	.67	.64	.59
Toronto	23.00	23.27	23.70	24.05	24.12	23.64
Vancouver	9.57	9.86	9.38	9.45	10.13	10.71
Victoria	1.82	1.50	1.27	1.30	1.32	1.23
Windsor	1.58	1.52	1.52	1.40	1.34	1.30
Winnipeg	5.01	5.20	5.24	4.97	5.04	5.05
Others	9.59	9.63	9.00	8.91	8.65	10.55
Total	100.00	100.00	100.00	100.00	100.00	100.00

stumbling block being that the assumption of stability of behavior from past to future is not based on any understanding of the underlying processes. Forecasting by trend analysis is a rather dubious procedure where errors are logically impossible to estimate. Whenever possible, more detailed prediction models should be used. Detailed forecasting models, however, are not always possible in complex situations and the unaided intuition of management is not enough.

Even if it is agreed upon that trend analysis forecasting is probably the most appropriate technique for forecasting a community's air passenger boarding, there is still the major problem of deciding what order of regression to fit. Two orders of regression may represent past history equally well, but could give widely differing results in the future. Although some criteria exist for deciding what order of curve to fit, they are not totally satisfactory. Thus forecasting by trend analysis is valueless (or even harmful) unless applied with judgment and with an understanding of its limitations.

Judgment is necessary in choosing what established forecasting technique should be used. Judgment is needed in deciding how much accuracy is required. The cost of obtaining extra information must be balanced against the gain from better forecasting. Above all, judgment is needed in understanding that mathematical techniques are only useful when allied with experienced intuition. Furthermore, uncertainty increases as the time of forecast moves into the future.

Thus, forecasting by trend analysis is a rather poor substitute for prediction based on a scientific model, but when there is a limited amount of community data, trend analysis forecasting should not be avoided like the plague, especially when it is in the context of an over-all scientific model.

B. Results From Fitting Various Least Squares Curves to Each Community's Percentage of National Air Passenger Boardings

Before fitting various least squares curves to each community's yearly percentage of national air passenger boardings, this data must be assessed according to these various principles:

(1) Ascertain whether the outlets for each community's air passenger boardings have changed remarkably in the past.

(2) Check whether there have been significant changes in inter-modal competition. If so, it is unreasonable to postulate uniform market conditions for trend analysis period so adjustments must be made.

(3) Ascertain whether in the past there has been limited supply so that the community's data does not reflect true demand. Adjustments must be made if there have been any significant restrictions on supply.

Particular attention was paid to Baie Comeau, Edmonton, Gander, Halifax, Sept. Isles, Windsor, London and Quebec City since their irregular trends in percentage of total Canadian air passenger boardings indicated distinct changes in supply, demand or inter-modal competition. Baie Comeau's percentage of total Canadian air passenger boardings hit a peak in the 1956-1959 period when it was a major distribution point for mining and hydro-electric development supplies. Since then its share of air traffic has decreased in line with the slow industrial development of Quebec.

Edmonton's percentage of total Canadian air passenger boardings has had two peaks--one in 1957-1958 and the other in 1966. The drop-off in traffic in the 1961-1963 period can be explained by the withdrawal of scheduled service into Edmonton by Northwest Airlines and Western Airlines. However, by 1966, Edmonton's share of total Canadian air passenger boardings had once again reached a peak with Wardair starting to serve the charter market through Edmonton and Canadian Pacific Airlines inaugurating a polar route to Europe.

Gander's percentage of total Canadian boardings also has fluctuated quite widely. Gander airport was originally built to serve as a refueling depot for Britannias and Super Constellations on transatlantic flights. There was a slight increase in the 1957-1958 period when a new terminal was built but thereafter its percentage of total Canadian boardings began to decrease as the world scheduled airlines started using new long-range jets. However, there was a brief revitalization in the use of the Gander airport during the 1963-1964 period as the charter airlines expanded, using old Britannias and Super Constellations. But this increased use of Gander airport was short-lived since the charter airlines soon started using long-range jets. Furthermore, there are random annual fluctuations in Gander's air traffic depending on weather conditions in the United States Eastern seaboard--Gander is an alternative airport for incoming flights to the Eastern seaboard when weather conditions are unfavourable.

Weather conditions in the United States Eastern seaboard also partially explain Halifax's erratic share of total Canadian air passenger boardings since it also can serve as an alternative airport for incoming Eastern seaboard flights. For the last few years, Halifax's share of total Canadian boardings has been falling in line with the relatively slow growth in the economies of the Maritime provinces. The slow growth in the economies of the Maritime provinces relative to the rest of Canada has slowed down the growth of boardings in all the Maritime airport hubs, except Fredericton. Fredericton's percentage of total Canadian boardings has been increasing over the last few years as it assumes the role of a major regional airport.

The peak in Sept. Isles share of air passenger boardings in 1960, which was nearly double the 1955 or 1966 percentage, can be explained by the development of Northern Quebec and Labrador. Sept. Isles, like Baie Comeau acted as a distribution point for northern hydro-electric and mining developments.

The large decrease in Windsor's share of total Canadian air passenger boardings over the last few years can be explained by the opening in 1964 of Highway 401 to Toronto. On short hauls, such as to Windsor-Toronto, air fares are not competitive with the cost of rapid car or bus travel.

London's recent decrease in its percentage of total Canadian air passenger boardings can also be explained by the opening of the new Highway 401 to Toronto. Highway 401 cut the road travel time to Toronto to less than two hours.

The drastic decrease in Quebec City's percentage of total Canadian air passenger boardings in 1965 and 1966 can be explained by the completion of a new four lane highway to Montreal in 1965.

After taking into account the irregularities in the annual percentages of total Canadian boardings for Baie Comeau, Edmonton, Gander, Halifax, Sept. Isles, Windsor, London and Quebec, several least squares curves were fitted to each of the twenty-five airport hub's percentages of total Canadian boardings. The most commonly used trend curves, and which are used in this study, can be grouped under three headings:

(1) Polynomials

(a) Straight Line: Demand = $a + bt$ where t is time and a and b are constants

The slope of a straight line is constant, implying that demand is increasing by a constant amount each year.

(b) Parabola: Demand = $a + bt + ct^2$ where t is time and a, b, and c are constants

The slope of a parabola changes uniformly with time. For this relationship the effect of an increase in t can be shown to increase demand by $b + 2ct$ (by differentiating the equation with respect to t) times the increase in t. Thus the effect of the increase in t depends on the existing level of t. If c were positive it would mean that the higher to level of t, the more effect any given change in t would have. If c were negative, it would mean that the effect of a further change in t was less the higher the existing level of t.

(2) Exponentials

(a) Simple Exponential: Log (demand) = $a + bt$ where t is time and a and b are constants.

For a simple exponential trend curve, the demand increases by a constant proportion each year. The ratio of the slope of the demand to the demand itself is constant.

(b) Logarithmic Parabola: Log (demand) = $a + bt + ct^2$ where t is time and a, b and c are constants.

Unlike with the simple exponential trend curve where the ratio of the slope of the demand to the demand remains constant, this ratio varies linearly with time for the logarithmic parabola.

(3) Modified Exponentials

A modified exponential trend curve implies the existence of an upper limit to demand which is approached asymptotically.[2]

(a) Simple Modified Exponential: Demand = $a - br^t$ where t is time; a, b, and r are positive constants and r is less than 1.

(b) Gompertz: Log (demand) = $a - br^t$ where t is time; a, b and r are positive constants and r is less than 1.

(c) Logistic: Demand = $\frac{1}{a + br^t}$ where t is time and a, b and r are positive constants and r is less than 1.

Both the Gompertz and logistic trend curves at first increase only slowly, then accelerate; hold the rate of acceleration for a time and then flatten off near some upper limit.

Again, autocorrelation was very important since although some curves gave high correlations with a community's percentage of total national air passenger boardings, the results were misleading due to high autocorrelation. For each potential least-squares forecasting curve, Von Neumann's ratio was calculated and the curve was rejected if there was significant autocorrelation.

Furthermore, although certain curves may be statistically correct and valid, they can not be the only guide of the forecaster since judgment

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[2] J. V. Gregg, C. H. Hossell and J. T. Richardson, Mathematical Trend Curves: An Aid to Forecasting (London: Oliver and Boyd, 1964), p. 12.

must not be forgotten. Thus before accepting the results of some curves, the advice of certain experienced people in Canadian air travel was sought.[3] The forecasted percentages of total Canadian boardings that were finally arrived at for each of the twenty-five hubs are shown in Table XXVII. These percentages are converted into actual forecasted boardings in Table XXVIII.

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[3]Majority of advice from W. C. McNeal and A. L. Saumur of the Air Division of the Transportation Policy and Research Branch of the Department of Transport.

TABLE XXVII

FORECASTED BOARDING PASSENGER TRAFFIC DISTRIBUTION

PERCENTAGE OF CANADIAN MARKET

CITY	YEAR				
	1967	1968	1969	1970	1971
Baie Comeau	.41	.40	.39	.38	.37
Calgary	4.83	4.94	5.06	5.17	5.29
Edmonton	4.55	4.60	4.65	4.70	4.75
Fredericton	.69	.72	.75	.78	.81
Gander	.55	.51	.49	.47	.44
Halifax	2.70	2.73	2.75	2.79	2.81
Lakehead	.95	.98	1.01	1.04	1.07
London	.81	.78	.75	.73	.70
Moncton	1.27	1.21	1.17	1.13	1.10
Montreal	20.76	20.94	21.11	21.28	21.44
Ottawa	4.08	4.11	4.14	4.16	4.19
Prince George	.64	.70	.76	.82	.88
Quebec	1.52	1.50	1.45	1.39	1.32
Regina	1.43	1.41	1.40	1.39	1.38
Saint John	.69	.68	.66	.65	.63
St. John's	1.51	1.55	1.60	1.64	1.69
Saskatoon	.92	.90	.89	.87	.89
Sault Ste. Marie	.51	.52	.53	.54	.56
Sept. Iles	.44	.40	.37	.34	.32
Sydney	.59	.57	.54	.52	.49
Toronto	24.79	25.12	25.42	25.70	25.95
Vancouver	9.49	9.35	9.26	9.19	9.12
Victoria	1.06	.99	.92	.86	.81
Windsor	1.27	1.22	1.17	1.12	1.07
Winnipeg	5.41	5.53	5.65	5.77	5.89
Others	8.13	7.64	7.10	6.57	6.06
Total	100.00	100.00	100.00	100.00	100.00

TABLE XXVII

FORECASTED BOARDING PASSENGER TRAFFIC DISTRIBUTION

PERCENTAGE OF CANADIAN MARKET

CITY	YEAR			
	1972	1973	1974	1975
Baie Comeau	.37	.36	.35	.35
Calgary	5.40	5.51	5.62	5.74
Edmonton	4.80	4.84	4.88	4.91
Fredericton	.84	.86	.89	.92
Gander	.40	.38	.36	.34
Halifax	2.83	2.85	2.87	2.90
Lakehead	1.10	1.13	1.15	1.17
London	.68	.66	.64	.62
Moncton	1.06	1.03	1.00	.97
Montreal	21.59	21.74	21.88	22.02
Ottawa	4.21	4.23	4.26	4.27
Prince George	.95	1.01	1.08	1.14
Quebec	1.27	1.20	1.15	1.10
Regina	1.37	1.36	1.35	1.34
Saint John	.62	.60	.59	.57
St. John's	1.75	1.81	1.87	1.93
Saskatoon	.84	.83	.82	.81
Sault Ste. Marie	.57	.58	.59	.61
Sept Iles	.30	.28	.26	.25
Sydney	.47	.44	.42	.39
Toronto	26.15	26.40	26.59	26.77
Vancouver	9.07	9.02	8.98	8.94
Victoria	.76	.72	.64	.64
Windsor	1.02	.97	.92	.87
Winnipeg	6.01	6.13	6.25	6.37
Others	5.54	5.06	4.59	4.06
Total	100.00	100.00	100.00	100.00

TABLE XXVIII

FORECASTED BOARDINGS FOR CANADA'S TWENTY-FIVE

LARGEST AIR TRANSPORTATION HUBS

CITY	YEAR				
	1967	1968	1969	1970	1971
Baie Comeau	27,497	28,922	30,326	31,729	33,614
Calgary	323,930	357,190	393,468	431,682	472,024
Edmonton	305,151	332,606	361,586	392,438	425,840
Fredericton	40,275	52,060	58,320	65,128	72,276
Gander	36,886	36,875	38,102	39,243	39,261
Halifax	181,078	197,394	214,619	232,958	250,735
Lakehead	63,712	70,859	78,538	86,832	95,475
London	54,323	56,398	58,320	60,953	62,460
Moncton	85,174	87,489	90,979	94,352	98,152
Montreal	1,392,295	1,514,083	1,641,526	1,776,829	1,913,083
Ottawa	273,630	297,176	321,928	347,350	373,872
Prince George	43,927	50,614	59,098	68,468	78,522
Quebec	103,952	108,458	112,752	116,061	117,783
Regina	95,904	101,951	108,860	116,061	123,136
Saint John	46,375	49,167	51,322	54,273	56,214
St. John's	101,270	112,073	124,416	136,936	150,798
Saskatoon	61,700	65,075	69,206	72,642	76,737
Sault Ste Marie	34,203	37,599	41,213	45,088	49,968
Sept Iles	29,509	28,792	28,771	28,389	28,553
Sydney	39,569	41,214	41,990	43,418	43,722
Toronto	1,662,572	1,816,321	1,976,674	2,145,888	2,315,509
Vancouver	634,446	676,057	720,063	767,343	813,770
Victoria	71,090	71,582	71,539	71,807	72,276
Windsor	85,174	88,213	90,979	93,517	95,475
Winnipeg	362,828	399,850	439,347	481,781	525,562
Others	545,248	552,416	558,100	548,579	540,731
Total	6,706,626	7,230,578	7,776,061	8,349,761	8,922,965

TABLE XXVIII

FORECASTED BOARDINGS FOR CANADA'S TWENTY-FIVE

LARGEST AIR TRANSPORTATION HUBS

CITY	YEAR			
	1972	1973	1974	1975
Baie Comeau	35,239	36,568	37,898	40,377
Calgary	514,301	559,707	608,528	662,188
Edmonton	457,156	491,648	528,401	566,436
Fredericton	80,007	87,359	96,368	106,134
Gander	38,096	38,600	38,980	39,223
Halifax	269,531	289,503	310,760	334,554
Lakehead	104,765	114,785	124,520	134,975
London	64,763	67,042	69,298	71,525
Moncton	100,955	104,627	108,279	111,902
Montreal	2,056,251	2,208,354	2,369,146	2,540,310
Ottawa	400,964	429,684	461,268	492,603
Prince George	90,478	102,596	116,941	131,514
Quebec	120,955	121,896	124,520	126,900
Regina	130,480	138,149	146,176	154,987
Saint John	59,049	60,948	63,884	65,757
St. John's	166,671	183,860	202,481	222,602
Saskatoon	80,002	84,311	88,788	93,444
Sault Ste Marie	54,287	58,916	63,884	70,371
Sept Iles	28,572	28,442	28,152	28,840
Sydney	44,763	44,695	45,477	44,991
Toronto	2,493,407	2,681,718	2,879,141	3,088,288
Vancouver	863,835	916,253	972,346	1,031,352
Victoria	72,383	73,137	69,298	73,832
Windsor	97,145	98,532	99,616	100,366
Winnipeg	572,397	622,686	676,744	734,867
Others	527,636	513,996	497,601	468,376
Total	9,524,093	10,158,025	10,827,909	11,536,377

CHAPTER VIII

CONCLUSION

A. Important Results

Efforts have been made in this study to predict the demand for air transportation in Canada up to 1975. Of course, there are many factors that affect demand but it is not possible to provide explicitly in forecast formulas for all of them because of the complexities involved and lack of data with respect to some of them, Nonetheless this study found five statistically correct and logically valid forecasting models. All five models accurately estimated the level and magnitude of change of the historical boarding data. Three of these models were static (i.e. have not lagged variables) and two were dynamic (i.e. have lagged variables). Two of the static models had increasing income elasticities of per capita air travel to take into account the influence of gradually rising per capita income. The third static model contained a trend factor as a catchall for the many factors known to change over time, such as tastes, quality and technology, but for which data was unavailable or which, singly, would be expected to have a small effect on boardings per capita. Both dynamic models expressed the generally accepted idea that current behavior is affected by past behavior: current behavior depends on all past values of the variables, though more on recent values than on very remote ones.

Despite the fact that GNP per capita and air passenger yield per passenger-mile were expressed in constant 1949 dollars as well as current dollars in all models tried, all five successful models used these variables in current dollars. This seems to hint that air passengers do not take into account the decreasing purchasing power of money when travelling. If this is not so, then perhaps some deflator other than the GNP price deflator should have been used.

From these five models, it was found that one of the major factors affecting future boardings per capita will be fare policy. All three static models had a fare elasticity of approximately -2.30. This may be considered as the long-run elasticity and is consistent with what generally happens with new goods and services; for a dramatically new commodity, the demand may be primarily a matter of considerations other than price, but as it comes into wider use, the demand for it may become increasingly sensitive to price. While the static models give one the long-run fare elasticity, the dynamic models give one the short-run fare elasticities since they relate boardings from one year to the next. As one might expect, the short-run elasticities of the two dynamic models are much lower (i.e. -0.72 and -1.10); in the short-run one can not change his usual means of travelling and communicating drastically. This is consistent with the theory of habit formation since fares should be expected to exert less of an influence on consumption at high levels of income, because income is a constraining factor. Thus although the rising level of incomes is still air transport's main asset, growth in air travel will heavily depend on a fare policy allowing a larger number of people to travel by air.

Although each of the five forecasting models was statistically correct and logically valid, each model's forecasts differed primarily because of the short historical data period. It was necessary, however, to combine the forecasts of the five models into one, since only one projection was wanted. After combining the five models by taking the average of the total, five assumptions were made with respect to future fare levels ranging from an annual decrease of 0.20 current cents to an annual increase of 0.05 current cents. The growth patterns of each of these five forecasts had two things in common: (1) all showed a declining rate of growth both in terms of boardings per capita and total Canadian boardings and (2) all showed absolute annual increments which in general increased from year to year throughout the entire forecast period. These two trends are both major characteristics of growth industries. In general most statistical growth curves, such as the Gompertz or Logistic curve, have an inflection point where the absolute first differences reach a maximum and thereafter decline. This study's forecasts, however, do not foresee the maturation point of air travel before 1975.

Of course, the above mentioned growth trends may not have occurred if different forecasts of GNP and population had been used. Rather than making internal forecasts of GNP and population, this study relied on the external potential forecasts of the Economic Council of Canada. In this study the Economic Council of Canada's most plausible population forecasts based on medium immigration and medium fertility were used.[1] If instead, the Economic Council of Canada population forecasts based on low fertility and low immigration had been used,[2] the boardings per capita in 1975, if the air passenger yield per passenger-mile annually decreases 0.1334 current cents, would be 0.51369--this is approximately 2.9 percent above the boardings per capita forecasts based on population forecasts assuming medium

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[1] Wolfgang M. Illing, Population, Family, Household and Labor Force Growth to 1980 (Ottawa; Economic Council of Canada, 1967), p. 40-41.

[2] Ibid., p. 46.

immigration and medium fertility. On the other hand, if the Economic Council of Canada forecasts based on high immigration and high fertility[3] had been used, the boardings per capita in 1975 would be 0.46308--this is approximately 7.2 percent below the boardings per capita forecasts on population forecasts assuming medium immigration and medium fertility. Likewise, forecasts of boardings per capita in 1975 would be lower if the forecasts of GNP were lower. If instead of making the assumption that real GNP will annually increase 5.0 percent to 1970 and 4.5 percent from 1970 to 1975, as the Economic Council of Canada has, the assumption is made that real GNP will only annually increase 3.0 percent to 1970 and 2.5 percent from 1970 to 1975, boardings per capita in 1975 would only be .43384--this is approximately 13.1 percent below the boardings per capita forecast of .49884 given in chapter six.

With respect to the five fare assumptions, the most realistic appears to be that of an annual decrease of 0.1334 current cents in average passenger revenue per passenger-mile. This was the average annual decrease over the historical data period of 1955-1966. Such an annual decrease falls right in line with the estimated decreases of the International Civil Aviation Organization. Naturally each reader is free to pick the fare assumption he likes. And if he likes none of the fare assumptions, he can make his own and, using the five forecasting models, develop his own forecasts. This is one of the main advantages of the analytical and conditional approach to the forecasting problem.

If an average annual decrease of 0.1334 current cents in the air

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[3] Ibid., p. 47.

passenger yield per passenger-mile does accurately describe the future, then the growth of total boardings will progressively decline from a 7.81 percent increase in 1968 to a 6.54 percent increase in 1975 and the growth of boardings per capita will progressively decline from a 5.07 percent increase in 1968 to a 4.35 percent increase in 1975. This forecasted growth is much lower than in the historical period of 1955-1966 when the average percentage growth in total boardings was 11.4 percent and in boardings per capita was 8.48 percent. Nevertheless, this forecasted rate of growth in boardings is still substantially above the expected average growth rate of the national economy i.e. the average annual growth in real GNP per capita for 1967-1975 is expected to be 3.10 percent. Although during the last decade or so Canadian airlines have successfully taken from the railroads the major share of the market for common carrier travel, this process is already far advanced and can no longer be expected to give to the airlines a major source of new traffic in the future. It is perhaps just human that people, after a long period of prosperity should look upon high growth of air travel as the normal state of affairs but past growth itself does not assume the role of a dependable causal factor.

Of course, national forecasts of total domestic and international boardings are of little value in comparison to boarding forecasts for individual Canadian cities. Fortunately, the largest twenty-five air transportation hubs, which have accounted for 89 percent to 93 percent of the total of all Canadian air passenger boardings in the past, have through time each maintained a generally consistent relationship to the national total. Thus by fitting numerous least-squares trend curves through each community's past percentage of national air passenger boardings and modifying where necessary because of the advice of experienced people in Canadian air travel, forecasted percentages of total Canadian boardings were arrived at for each of the largest twenty-five Canadian air transportation hubs. The forecasted percentages for each community were then multiplied by the forecasted total Canadian boardings to obtain boarding forecasts to 1975 for Canada's largest twenty-five air transportation hubs.

B. Suggestions for Improved Forecasts

These are only first step forecasting models that could be improved in the future by the generation of two sets of information: (1) Canadian air passenger characteristics and (2) airport passenger peaking characteristics.

In the future, more complex traffic and market analysis forecasting models should be tried. Traffic models estimate, through equations, travel by each major travel mode on each origin-destination segment for each of several trip types. Traffic models are very sensitive to changes in the travel time, cost and convenience of travel by each available travel mode, as well as the socio-economic changes as they affect travel. With market analysis forecasting techniques, the composition of the air travel market is determined as to age, industry, family income, education, etc., for several years, and then compared for these same years to a breakdown of the national population by the same characteristics. This shows how people with various social, economic and demographic characteristics demonstrate distinct and predictable air travel behavior. Assuming this hypothesis to be true, the composition and size of each of the corresponding elements of the population as a whole, measured in terms of (at least) occupation, age, industry, income, and education, and the distinct growth-rate of air travel frequency per thousand people in each population group.

At present, statistical information on air travel in Canada is less complete than in the United States and data on other modes of travel such as car and bus trips is even less available. Before traffic and market analysis forecasting techniques can be used in Canada, a detailed data base providing travel demand by socio-economic type of traveller, origin-destination segment, trip purpose, party size, and other market identification features, must be developed. With a detailed data base, air travel forecasts would be able to differentiate between market segments and the different demands placed on airports by them and take into account the competitive interactions of all modes of travel as well as socio-economic changes.

In the United States there have been a large number of questionnaire surveys related to passenger travel in general and to air travel in particular. From these surveys, a reasonable profile of the United States air traveler has been obtained. The most striking characteristics of United States air travelers are:

(1) Length of Trip--of course the automobile is the preferred mode of travel for short distances but air travel dominates commercial carrier traffic in terms of passenger miles for all trip distances of over 300 miles. And in 1960, 58.2 percent of the total passenger miles were represented by trips of more than 300 miles.[4]

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[4] Air Transportation 1975 and Beyond: A Systems Approach (A Report of the Transportation Workshop 1967. (Cambridge, Massachusetts: Massachusetts Institute of Technology Press, 1968), p. 66.

(2) Income--In 1962, 85 percent of air travel for all purposes was flown by those people in the \$7,500 and over income bracket, and 60 percent by those in the \$10,000 and above bracket.[5] Thus it is perfectly clear that income is closely related to the propensity and ability to travel by air.

(3) Occupation--In 1962, approximately 28 percent of the professional, technical, managerial and self-employed workers took at least one air trip.[6]

(4) Purpose of Travel--While business travel makes up approximately 30 percent of all trips taken by all modes of travel, it accounts for about 60 percent of all revenue passenger-miles.

These data on U.S. air traveller characteristics are not too useful for forecasting purposes. The U.S. travel surveys carried out during the past ten years have been sporadic, covering in some cases regional travel and employing diverse techniques and sampling theories. Even at present there is no continuing, standardized program of surveys covering the entire industry.

Unfortunately in Canada, no comprehensive overall published data on Canadian travel characteristics could be found. There have been a few local surveys of Canadian air travelers such as the one conducted by Air Canada of Vancouver air travelers in 1967. At present, the Department of Transport is attempting to remedy this situation by financing a study of

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[5] *Ibid.*, p. 66.

[6] *Ibid.*, p. 67.

the travel patterns of a sample of Canadian residents over a twelve month period. The survey conducted by Canada Facts Co. Limited will provide the following information:

(1) Number of trips made

(2) Distribution of trips made by:

(a) Principal mode of transportation (automobile, plane, train, bus, boat, other).

(b) Origin and destination

(c) Date (i.e. month of commencement)

(d) Purpose (business vs. personal)

(e) Duration (days away from home)

(3) Characteristics of travelers:

(a) Demographic (socio-economic level, age, etc.)

(b) High-frequency vs. low frequency vs. non-travelers.

This information will be collected from diaries maintained by a representative set of about 895 Canadian households who will be geographically distributed as shown over the next page. One serious potential distortion stems from the fact that the survey does not include people who are not in families. The most important example being the young single person who has moved out of his or her parents' home. If successful, this system of data gathering could be extended over future years to keep track of trend developments in Canadians' travel patterns.

The other suggested improvement involves airport peaking characteristics. A valuable piece of information to go along with each airport's forecasted boardings would be the probably distribution of traffic in time--in other words, define peak periods and the weekly and seasonal variations. Unfortunately peaking information is not available to the public. If and when it is available, an estimate of each airport's forecasted peak capacity would be a valuable addition to any study concerned with forecasting

GEOGRAPHICAL DISTRIBUTION OF SAMPLE

Atlantic Provinces	150 Households
Quebec	175 Households
Ontario	260 Households
Prairie Provinces	180 Households
British Columbia	130 Households
	895 Households (approximately 3,400 persons over two years of age)

airport requirements.

In order that future studies of this type have the above mentioned improvements, it is suggested that the private airline industry and government co-operate more than in the past. At present the interface between the government and the airline industry is so fragmented that improvements to the overall air transportation system are difficult to implement.

C. Some Restraints on Forecasted Air Passenger Growth

There are at least four distinct factors that may limit the ability of the air transportation system to meet the forecasted demand. First of all, one factor threatening to limit scheduled air passenger growth is the rapid growth of general aviation--the air taxis, fixed-based operators, company and private airplanes. General aviation is growing at such a rapid rate that unless there is an extraordinary expansion of air traffic control and ground-handling facilities, the aircraft of scheduled airlines (Group I and II) will have to vie for air and airport space. The most appropriate means of alleviating this problem would be to provide separate facilities for general aviation aircraft at reliever airports in hub areas. This solution has two advantages. First of all, it takes into account the traditional freedom to fly. Secondly it takes into account the fact that it is not in the public interest for a private airplane with a few people in it to delay a commercial aircraft carrying hundreds of passengers.

A second factor threatening to limit the growth of the air transportation system is the noise and pollution of jet engines. Although the jet engines have made large and efficient aircraft possible, they unfortunately make noise and pollute the air. Fortunately the pollution problem is not too serious at present but as antipollution devices become more common, the proportion of atmospheric pollution contributed by airplanes will increase and attract more public attention. Noise and pollution pressures could force airports to move farther from the cities. The solution to the noise problem does not appear to be in the form of the invention of a quiet jet engine. Rather, compatible land-use plans will evolve to attract industrial rather than residential development to the periphery of airports. Also the imposition of restrictive noise abatement aircraft routing procedures will help.[7] Of course, any solution to the pollution and noise problems must weight equally the considerable economic contribution of a city airport against the relatively small number of citizens who are affected.

A third factor threatening to limit the growth of air passenger boardings is that caused by different political jurisdictions connected with airports. In Canada, major airports are owned and operated by the

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[7] _Ibid._, p. 12.

Federal Government. The Federal Government will build all airport access roads that use Federal property. However, it is the provincial government and to a lesser extent, the municipal government's responsibility to build airport access roads that connect up with Federal Government access roads. The result is jurisdictional problems that cause delay and poor planning. The most recent example being the new Vancouver International Airport where enormous congestion problems resulted from the provincial government's unwillingness to build new adequate access roads.

A fourth constraint on air transportation is that of financing. Federal Government austerity programs are forcing the adoption of a Federal fiscal policy that will require airlines to pay a greater share of the total cost of Federal Government airports and airport facilities. This comes at a time when Canadian airlines are already having financial problems because of purchase committments for new jumbo jets and SST's. Furthermore, a fiscal austerity policy would bring out greater air and ground delays because of inadequate traffic control facilities and access systems. A badly drawn government policy hurts the growth of the air transportation system while on the other hand, a well conceived government policy nurtures growth and provides for an orderly air transportation system that best meets society's needs.

If all these constraints are not alleviated, there could be costly delays and congestion. Up until now, the growth of air travel has been relatively unrestrained by capacity restrictions whether they be airport facilities or access facilities. But some of our hub airports are reaching saturation levels which will bring costly delays--costly in terms of the ill will of inconvenienced air passengers. Furthermore, serious new problems will result at the peak times from the introduction of jumbo jets and SST's since so many more passengers are carried per airplane. And user demand rises or falls depending on whether the service is economical, fast, dependable, comfortable and safe.

D. Future Capacity Problems at Major Canadian Airport Hubs

With many of Canada's largest airports already taxed to capacity during peak hours, it is obvious that the forecast increases at many Canadian airports, cannot possibly be accommodated without major improvements in airport capacity, airport access and air traffic control. It is difficult to predict what will limit the capacity of individual airports since each has its unique problems. But delays at any one major airport will cause system-wide delays as equipment fails to arrive on time.

It is uncertain whether, from the viewpoint of society at large, it would be better to formulate an ambitious investment program or to adopt measures based on price as a rationing device that would contribute to the more efficient use of airport capacity. Using price as a rationing device, one means of improving the efficiency of airport capacity would be to increase the price of airport parking to approximately the same level as downtown parking. At present, parking fees at airports are so low that it costs less to park for three or four days than it does to make the round trip by taxi. With increased parking fees, more would use the airport limousine and as a result congestion on access routes would be reduced, as well as the need for additional parking facilities. A second way of improving the efficiency of airport capacity would be to encourage airlines to make more use of differential fares to reduce the peaks. A device for implementing this would be to charge differential landing fees that airlines would have to pass on to passengers in form of higher fares.

This would greatly improve efficiency since air travel, and in particular business air travel, is highly peaked by hour of day. Furthermore, there should be differential landing fees at different airports, especially the new airports which will probably be less conveniently located so may be under-utilized while congestion continues to grow at the older airports. And finally, the most efficient device for improving efficiency would be to separate commercial and general aviation by the means of differential landing fees.

Thus certain devices could greatly improve the efficiency of airport capacity in the future so that not as large expansions in airport capacities would be needed.

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