THE UNIVERSITY OF MANITOBA

THE EFFECTS OF FUEL COST ON CANADIAN DOMESTIC AIR PASSENGER TRANSPORTATION

by

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ABSTRACT

The study addresses the effects of energy cost on domestic air transportation in Canada. The research is carried out in two main stages and focuses on the high density corridor along the United States/Canadian border. This market accounted for 32 percent of the total domestic passengers flown in Canada in 1977.

In the first stage, econometric models are derived based on two methods of zoning, using historic data from 1970 to 1977. One method considers the Canadian domestic market as comprising 21 zones each corresponding to a major city. No account is taken of the effects of competition from surface modes; nor is any adjustment made to recognise that the major airports within a given zone (city) in fact serve a population much larger than the zonal population. The results of analyses based on this method of zoning are inconclusive.

To alleviate the problems mentioned above new zones are defined, each including all areas served by the airports within it. Furthermore, only travel between zones separated by more than approximately one day by auto is considered. This approach yields markedly improved results.

Econometric models are derived according to the latter method relating the demand for air travel to socioeconomic factors such as population, mean incomes and air fares. Statistical tests confirm the validity and reliability of these models. By examining the nature of the fit of model to data, it is found

that another variable could be justifiably defined as a community-of-interest measure between area pairs. Its inclusion in the model building process improved the results even further. A number of demand models are then developed to define mathematical relationships between air travel demand and the other variables.

The second stage of the investigation begins with a comparison of demand models. Demand models for the years prior to the "energy crisis" of 1973 are compared with those for the years after, to determine any changes in travel behaviour attributable to the energy shortage. No such changes were reflected in the models.

Further study then reveals that the effects of energy shortages and rising fuel prices have been greatly alleviated by modification of the operating techniques by air transportation suppliers. Mathematical functions are used to quantify the effectiveness of these modifications against a worsening fuel problem. Load factors, aircraft seating arrangement and aircraft efficiency are identified as key areas where effective modifications can yet be made.

According to the statistics, fuel prices have increased 750 percent over the last five years (CBC radio, April, 1979). In March 1979 fuel shortages grounded such major United States airlines as National and Trans World. Given these and other trends the investigation concludes that, beyond the next decade, skyrocketing fuel prices would dwarf any improvements in engine technology and/or in the other areas mentioned above.

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CHAPTER I

INTRODUCTION

The primary purpose of this study is to determine the effects of the energy crisis on Canadian domestic air travel demand. In order to evaluate such effects, it is important to describe the present and past travel patterns, preferably in terms of mathematical models. These models could then be analysed and/or compared to identify revealing differences attributable to known causes.

This study focuses on the backbone of the entire Canadian air network which interlinks all the major Canadian cities and provides access to international air services. Passenger travel in this "mainline" market has maintained a high growth rate over the years, accounting for an ever-increasing proportion of total domestic inter-city air travel. In recent years, however, this pattern appears to be leveling off. Between 1960 and 1970 the mainline market's share of total domestic inter-city passenger trips rose from 23 percent to 31 percent. In 1977 this proportion was 32 percent; so reliable prediction of the response of this mainline travel to a range of circumstances is not only important but an essential requirement when examining future developments of Canadian air transportation.

The modelling is undertaken in two phases. At first, use is made of the methods of Roman A. Manastersky, recorded in a 1974 Master's Thesis (Ref. 1), at the University of Manitoba. The thesis considers the same study area, identifying 21 cities and 69 city pairs of interest. Competition from surface transportation and the effects of strong regional biases are ignored. Figure 1.1 is a map of Canada outlining the 21 cities. In a second phase, a "long-haul market" is defined to include only air travel among large population areas separated by more than one day of automobile driving (i.e. say 800 km). Complications due to competition from surface transportation were thus side-stepped by excluding short-haul links. Figure 1.2 outlines the thirteen study zones considered. Each zone encompasses a major city, or cluster of cities, thereby eliminating those less populous cities where unpredictable exogenous factors may cause future development to be erratic and difficult to predict.

1.1 OBJECTIVES OF THE STUDY

In planning for future air transport developments, detailed forecasts of air travel must be made. This facilitates evaluation of the impacts of various factors on the pattern of air travel demand. The purpose of this study is to build suitable econometric models to explain variation in air travel demand among several area pairs in a given year, in terms of known factors, characteristic of each pair. The models for different years are then compared to identify any changes in

FIGURE 1.1

DOMESTIC AIR TRAVEL MARKET – CITIES

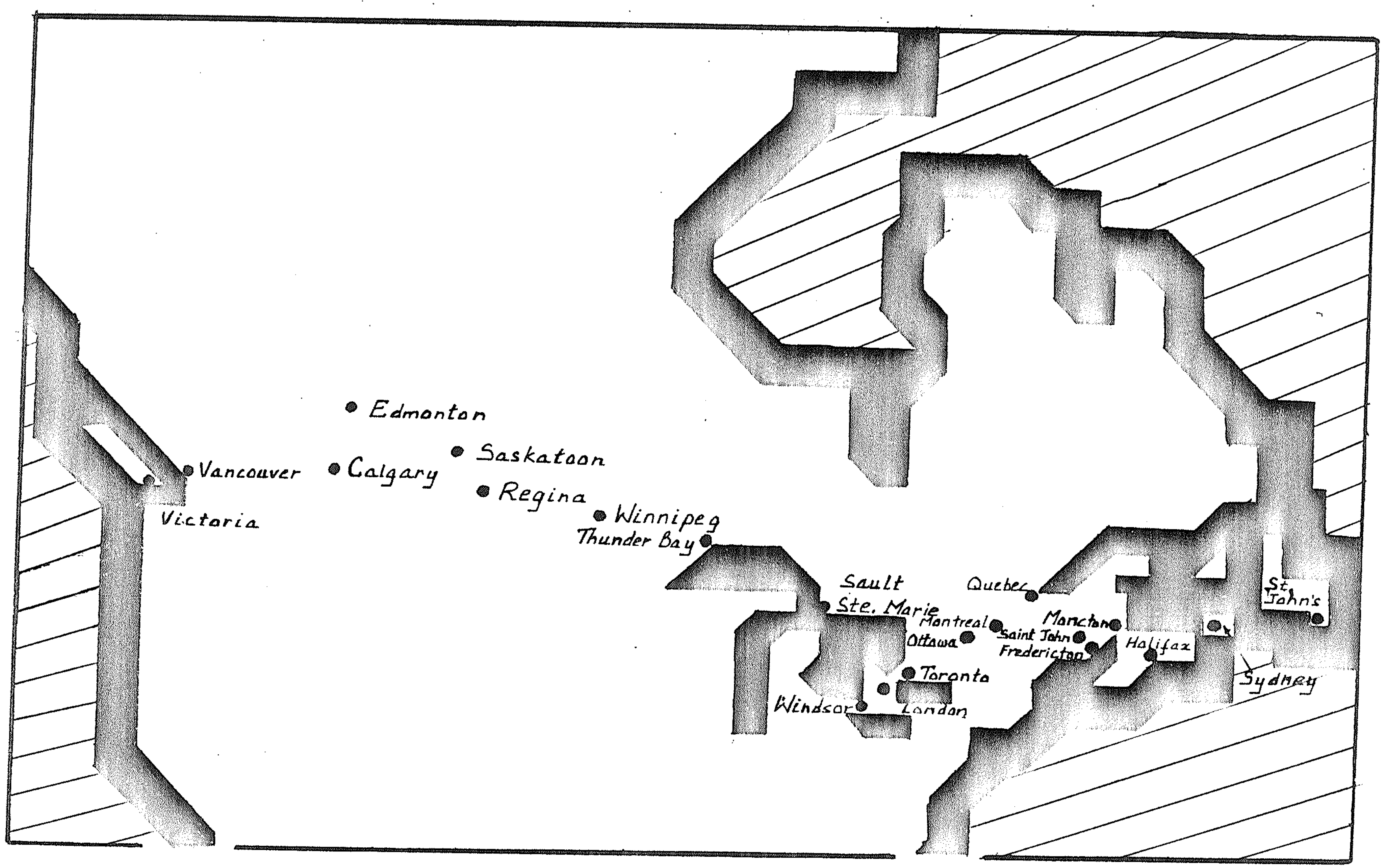
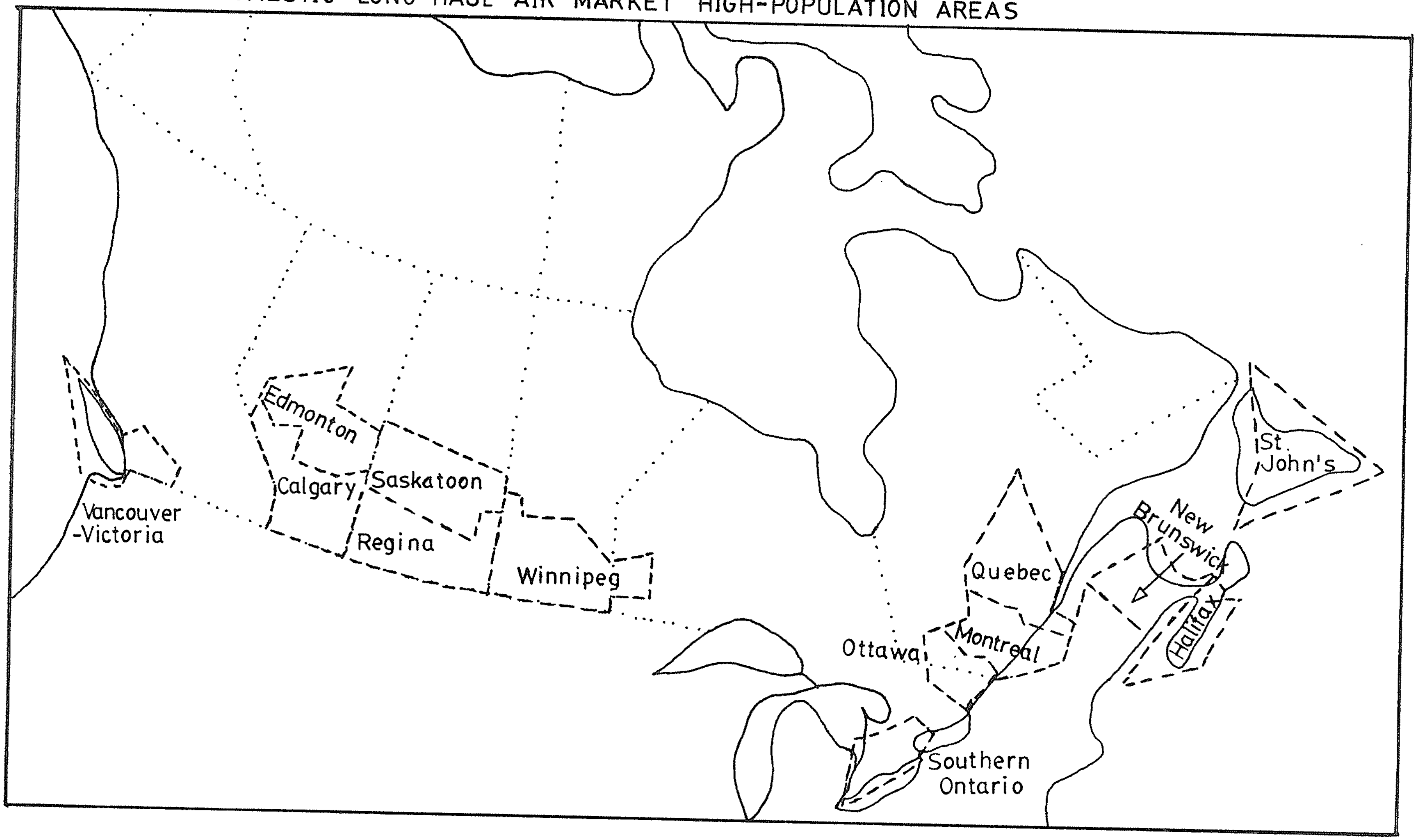


FIGURE 1.2

DOMESTIC LONG-HAUL AIR MARKET HIGH-POPULATION AREAS



SOURCE : REF. 2

pattern which may have resulted from the energy crisis of 1973. Thus, of major concern to the study is the development of suitable demand functions enabling past and present passenger trip profiles to be expressed quantitatively in terms of such variables as populations, indicators of socioeconomic activity and measures of air service.

1.2 METHODS

Either of two approaches is commonly used in demand model building: derivation using time series analyses on demand variation in time, between individual pairs of cities or areas, or alternatively, development of a cross-sectional function based upon differences in volumes among a number of pairs of cities or areas at a single point in time. This study also proposes, where applicable, to make use of combined cross-sectional and time series information in an attempt to improve the quality of the conclusions drawn.

CHAPTER II

THE DEMAND FUNCTION

The econometric model building technique has been widely used in the development of air demand functions. It represents a method of relating a dependent variable with some or all of a number of independent variables.

In order to provide reliable estimates of demand levels or demand patterns, a demand function must fully describe the relationship between demand, the dependent variable, and the causal factors, or independent variables. Causal factors which are independent of each other must be chosen to avoid repeated incorporation of a single "cause" into the demand function. The development of a demand function involves selecting different combinations of variables, testing for independence and assessing which combination estimates known demand levels most satisfactorily. Also, especially if the demand function is to be used in some aspect of prediction, care must be taken to select independent variables whose future values can either be predicted reliably or safely assumed. Lack of sufficient or dependable data often limits the selection of the independent variables and the estimating accuracy and forecasting reliability of the demand function.

The independent variables used in the demand function developed for air travel in the market area were population, *incomes and air fares together with empirically derived community-of-interest or attractivity measures. The inclusion of other factors or indices which might further contribute to the demand relationship was prohibited by the lack of consistent records matching the market areas chosen, since most information of important economic indicators is normally recorded at the provincial level. The basic demand function used in this study is consistent with that found to be most satisfactory in other comparable work (Refs. 1,2). It takes the general form:*

Passenger trips between areas (dependent variable)	*= function of:*	*population, per capita income air fare, community-of-interest measure (independent variables)*

Analysis of variance and regression techniques were applied to historic data and used to assess various combinations of independent variables and to quantify their effects on demand levels.

CHAPTER III

THE DOMESTIC AIR TRAVEL MARKET

This chapter describes the specifications and boundaries of the market areas used in the two phases of modelling mentioned previously. It also deals generally with the basic data and data collection methods.

3.1 THE MARKET AREAS

In the first modelling phase, 21 market areas are defined, (Manastersky, Ref. 1). Each of these areas includes the immediate environs of a major city. No attempt is made to reconcile the extent of these areas with the population directly served by the air facilities they contain. Invariably, therefore, trips are also derived from the populace not directly included in these metropolitan areas, but which resides in nearby zones where there are no facilities for inter-city air travel.

The second phase explicitly treats the problem of rationalizing area boundaries. The model is based on 13 areas, each surrounding a major city or a cluster of cities. These areas were deliberately defined to be quite extensive since they were intended to be catchment areas for the major airport(s) contained within them. The population in each area will make use of these airports and are unlikely to travel by surface transport to another area prior to commencing an outbound flight. This stipulation must be satisfied for any demand function relating passenger trips to variables such as population to be valid. The boundaries must encompass many smaller towns and cities within convenient driving distance of the major airport (including towns possessing their own scheduled connecting services) since substantial numbers of long-haul passengers fly for personal reasons and may minimize the journey cost by avoiding a short connecting flight. Passenger traffic from "feeder" airports in an area is incorporated into the area's total traffic, and airports with scheduled air services contained in each area are listed in Table 3.1. By far the largest portion of origin and destination passenger trips are generated by these airports and generally all the area's long-haul traffic passes through them.

These market areas are identical to the traffic generation zones adopted in the National Planning for Airports Study (Ref. 3). Each area comprises several counties or census divisions as listed in Appendix II.

TABLE 3.1 AIRPORTS WITH SCHEDULED SERVICE CONTAINED IN THE LONG-HAUL MARKET AREAS

AREA	AIRPORTS	AREA	AIRPORTS
St. John's	St. John's Gander	Saskatoon	Saskatoon Prince Albert Yorkton
Halifax	Halifax Yarmouth	Regina	Regina Swift Current
New Brunswick	Saint John Moncton Fredericton Charlo Chatham	Edmonton	Edmonton Int'l Edmonton Ind. Red Deer
Quebec	Quebec Sagueney Charlevoux	Calgary	Calgary Lethbridge Medicine Hat
Montreal	Dorval Trois Rivieres	Vancouver -Victoria	Vancouver Victoria Nanaimo
Ottawa	Ottawa		Port Hardy Alert Bay
Southern Ontario	Toronto Hamilton Windsor London Sarnia		Campbell River Port Alberni Tofino
Winnipeg	Winnipeg Brandon Kenora Dryden Dauphin		

3.2 HISTORIC DATA FOR MARKET AREAS

Historic passenger trip interchanges, fares, populations and per capita incomes for the 21-cities phase are readily available (Ref. 1) for the period 1960-1971. Demand functions for the above phase and period are also contained in the same source. More recent historic data (up to 1975) have also been compiled at the University of Manitoba by various people responsible for up-dating them.

In the case of the thirteen long-haul market areas, only historic passenger trips and demand models (1960-1970) are readily available (Ref. 2). The up-dating of data for both phases was carried out as follows.

Passenger trip interchanges were compiled from Aviation Statistics Centre records of passenger origin and destination trips for domestic city pairs (Ref. 4). City-pair trips are transformed into totals for pairs of areas by summing the trips of all the city-pairs within each area pair. Populations for the study areas were determined from Census data for 1976 (Ref. 5), Statistics Canada County and Census Division estimates for 1970-1975 (Ref. 6), and the Financial Post Survey of Markets (Ref. 7). Personal disposable income estimates were also obtained from the Financial Post Survey of Markets. Air fares between areas are represented by economy fares as supplied by the Winnipeg branch of Air Canada. Fare data for before 1973 were not available at the above offices and time constraints made it virtually impossible to obtain them from *sources such as Air Canada headquarters in Montreal or Canadian Transport Commission in Ottawa. However, the information was compiled from old Air Canada schedules obtained from private sources.*

CHAPTER IV

CALIBRATION AND ANALYSIS OF DEMAND MODELS

The calibration of demand models is carried out in two phases to match the two methods of selecting air traffic zones as outlined previously.

4.1 PHASE I: 21 CITIES/69 CITY-PAIRS

As has been demonstrated in the work by Manastersky (Ref. 1), observations of passenger trips and the independent variables can be arranged from the data file in two ways:

i) by individual city-pair, comprising a time series of 18 sets of observations covering the period 1960-1977 (69 series, one for each city-pair);

ii) by year, comprising a cross-sectional series of 69 city-pairs of observations (18 series, one for each year).

The time series technique minimizes the effects of yearly fluctuations and emphasizes trends for each pair. On the other hand, cross-sectional analysis relates all the variables observed in a given year for all the city-pairs. It therefore highlights yearly demand fluctuations prevailing throughout the study area as a whole.

To be consistent with the findings of previous analyses (Ref. 1), the following demand model was adopted for the period 1972-1977:

$$T_{ijt} = K(P_iP_j)_t^{\alpha} \cdot (I_iI_j)_t^{\beta} \cdot F_{ijt}^{\gamma} \cdot e_{ijt} \qquad (4.1)$$

or in logarithmic form:

$$\log_e T_{ijt} = K_t + \alpha \log_e (P_iP_j)_t + \beta \log_e (I_iI_j)_t$$
$$+ \gamma \log_e F_{ijt} + e'_{ijt}$$

where: T_{ijt} = 2-way passenger origin and destination trips between city i and city j, in year t;

$(P_iP_j)_t$ = populations cross-product, cities i and j, (000,000) in year t;

$(I_iI_j)_t$ = per capita personal disposable income cross-product, cities i and j in year t, (b (based on 1961 constant dollars);

F_{ijt} = one-way economy air fare between cities i and j in year t($1961);

e_{ijt} = error in trips estimated between city i and city j in year t;

e'_{ijt} = error in $\log_e$ trips estimated between city i and city j in year t;

$\alpha, \beta, \gamma, K_t$ = regression coefficients.

The formulation is an "expanded" gravity model in which a per capita income term is included and distance is replaced by air fare.

4.1.1 Procedure

A FORTRAN (WATFIV) programme was employed, through the computer facilities at the University of Manitoba, to calculate cross products and to effect the necessary logarithmic transformations. The multiple regression programme known as BMDP1R, contained in the BMDP statistical package (Ref. 8), was used for the least squares regression analysis. By combining the two programmes a series of cross-sectional models for the years 1972-1977 were developed, in order to derive a set of values for the coefficients α, β, γ and K_t. These coefficients together with some relevant statistics are listed in Table 4.1.

4.1.2 Examination of Results

The use of these models and model-parameters in the study of trends and patterns is conditional on their statistical validity. The accompanying statistics of Table 4.1 show a rather poor fit of model to observations. In particular the coefficient of multiple determination R^2, which is a measure of the amount of variation the model can explain relative to the total observed variation, differs considerably from $R^2 = 1$, its value for the perfect model. For the years after 1972 the highest value of the statistic R^2 is a meagre 0.50 associated with the 1975 cross-sectional model. A plot of residuals against predicted values for the 1975 model is shown in Fig. 4.1. In the ideal situation the residuals should distribute along the zero value showing no dependence on the estimated values. The apparent curvilinearity in Fig. 4.1 suggests an inadequate model (Refs. 9,10,11). Similar unsatisfactory patterns are observed when the residuals are plotted against transformed population and income cross-products.

TABLE 4.1 PHASE I CROSS-SECTIONAL DEMAND FUNCTIONS

$$Ln\ T_{ijt} = K_t + \alpha ln(P_iP_j)_t + \beta ln(I_iI_j)_t + \gamma ln\ F_{ijt}$$

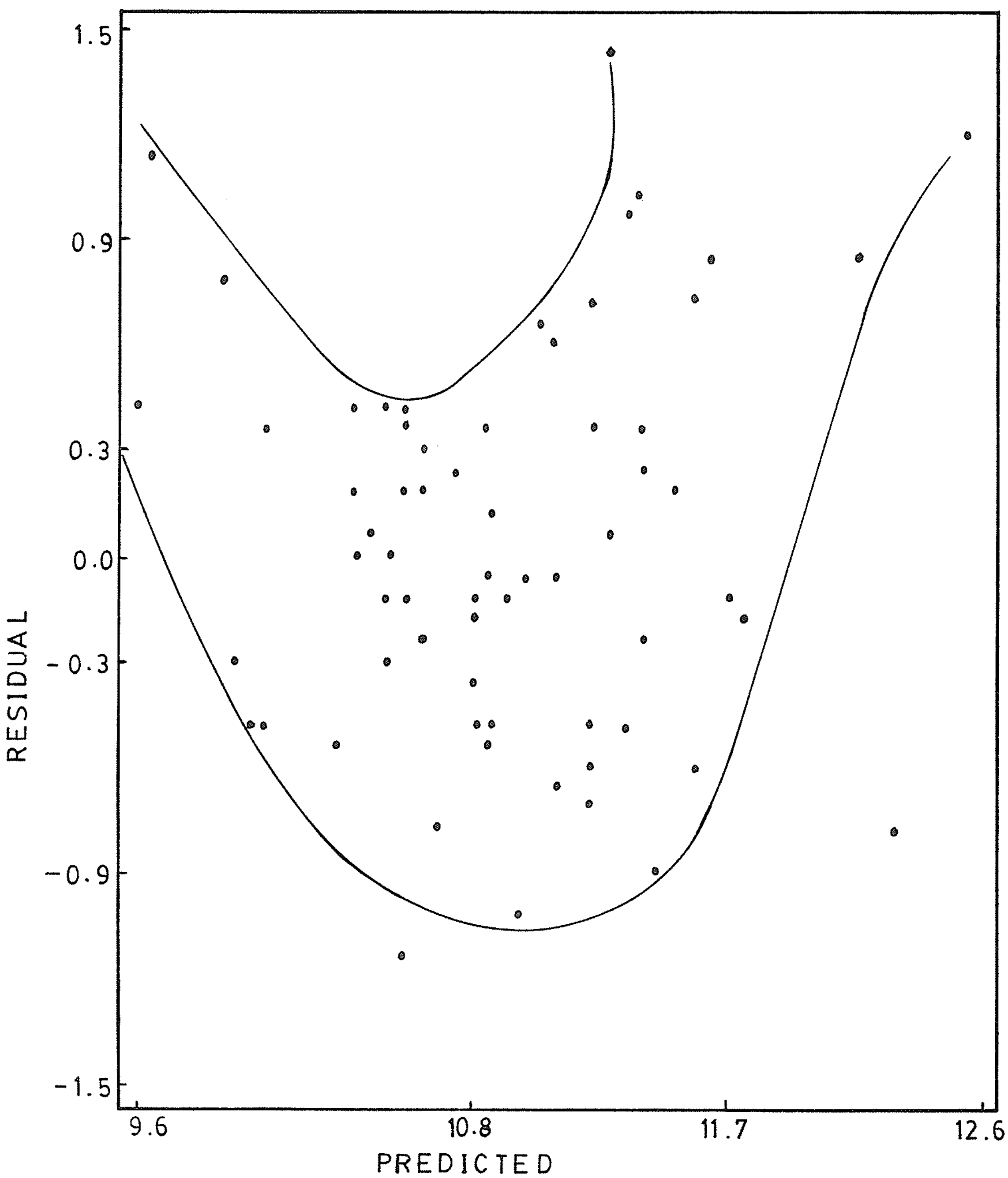
YEAR	K_t	α	β	γ	R^2
1972	-5.456	0.433	0.869	-0.8467	0.191
1973	-10.848	0.424	1.141	-0.403	0.500
1974	-13.840	0.111	1.514	-0.054	0.173
1975	-8.771	0.416	1.009	-0.407	0.501
1976	-10.024	0.397	1.238	-0.241	0.476

In Ref. 1 where this difficulty was encountered an attractivity factor was introduced. The factor is defined for each city-pair simply as the average ratio of predicted to observed demand over the period in question, and attempts to represent some measure of the "attractivity" between cities for any given city-pair.

For the period 1972-1977 the basic "lack of fit" as reflected in the statistics, Table 4.1, and other factors discussed above, was considerable. Hence it was considered unreasonable and undesirable to expect that any attractivity factor should account for so much variation to make the analysis in this phase worthwhile.

FIGURE 4.1

1975 PHASE I MODEL -:
DISTRIBUTION OF RESIDUALS
WITH PREDICTED VALUES



4.2 PHASE II: 13 AREAS/58 AREA-PAIRS

In an effort to consider some of the more fundamental factors which were not dealt with in Phase I, particular attention is paid to zoning and competition from other modes (Refs. 18,19). Thirteen zones or areas are thus deliberately defined to be quite extensive, each describing a logical "catchment area" for the major airport(s) within it. Errors due to modal competition are minimized by considering only those zones separated by more than one day's drive, or say 800 km.

4.2.1 Procedure

The same independent variables as in Phase I are considered. The 1973 cross-sectional observations were regressed in various formulations to determine the most suitable combination of the available independent variables. The model formulation (4.1) again proved most satisfactory and accordingly is restated as:

$$T_{ijt} = K(P_iP_j)_t^{\alpha} \cdot (I_iI_j)_t^{\beta} \cdot F_{ijt}^{\gamma} \cdot e_{ijt} \quad \ldots\ldots\ldots \quad (4.2)$$

T_{ijt} = 2-way passenger origin and destination trips between area i and area j, in year t;

$(P_iP_j)_t$ = Populations cross-product, areas i and j, (x 10^{10})in year t;

$(I_iI_j)_t$ = per capita personal disposable income cross-product,areas i and j, (based on 1968 constant dollars), in year t;

F_{ijt} = economy air fare (one-way) between areas i and j, (\$1968) in year t;

e_{ijt} = error in trips estimated between areas i and j, in year t.

All incomes and fares are expressed in terms of 1968 constant dollars in this phase, to facilitate comparison with similar work undertaken by the Canadian Transport Commission for the period 1960-1969 (Ref. 2).

Once again the data file can be arranged either

i) by individual area pair - for time series analysis

ii) by year - for cross-sectional analysis.

The energy crisis years 1973-1977 do not form a large enough base for deriving time series trends. The larger the base the more reliable the trend, however revealing periodic fluctuations may be smoothened. Hence in this phase whenever time series analysis is used, it is combined with some cross-sectional analysis to maintain perspective.

It is commonly hypothesized that cross-sectional differences can be used to analyze demand trends, since such differences among a series of area-pairs at given points in time are assumed to represent stages of some pattern of development. Although not clearly established as being valid, the hypothesis seems reasonable and is often invoked in the analysis in this phase.

4.2.2 Examination of Phase II Results

Modified versions of the computer programs in Phase I were applied to each set of cross-sectional observations for the period 1970-1977. Table 4.2 lists the various values for the regression coefficients with relevant statistics. A comparison of Tables 4.1 and 4.2 immediately shows an improvement due to the methods of Phase II.

The most significant improvements are seen in the consistently higher R^2 statistics and in the increased statistical significance of the coefficients taken all together (i.e. the F-statistic). On the average, the coefficient R^2 has jumped from 0.37 in the Phase I analysis to a value of 0.81 in Phase II (Tables 4.1,4.2).

Comparing the Phase II cross-sectional models together, the intercept K_t and the coefficient β appear to decrease and increase respectively with time. The values of the other coefficients remain within fairly narrow ranges for most years. The models also compare well with those obtained by the Canadian Transport Commission (Ref. 2) for the period 1960-1969 (Table 4.3).

4.2.3 Examination of Residuals

Although the models in this phase show a marked improvement over those of Phase I, it might still be possible to improve them even further.

Fitting a regression model requires several assumptions (Refs. 9,10,11). To estimate the model parameters it is

TABLE 4.2 PHASE II CROSS-SECTIONAL DEMAND FUNCTIONS 1970-1977

$$Ln\ T_{ijt} = K_t + \alpha Ln(P_iP_j)_t + \beta Ln(I_iI_j)_t + \gamma Ln\ F_{ijt} + e'_{ijt}$$

YEAR t	K_t	α (S.E.)	β (S.E.)	γ (S.E.)	R^2 S.E. of Estimate
1970	2.595	1.160 (0.115)	1.561 (0.592)	-1.944 (0.255)	0.8144 (0.8188)
1971	-7.209	0.919 (0.403)	3.157 (0.031)	-1.878 (0.217)	0.8523 (0.6781)
1972	-9.592	1.030 (0.113)	3.346 (0.728)	-1.808 (0.262)	0.8122 (0.7695)
1973	-8.420	0.999 (0.097)	3.302 (0.640)	-1.972 (0.238)	0.8576 (0.6643)
1974	7.177	0.919 (0.097	3.132 (0.623)	-1.919 (0.236)	0.8514 (0.6530)
1975	-6.886	0.892 (0.102)	3.026 (0.655)	-1.835 (0.245)	0.8340 (0.6746)
1976	-3.558	0.964 (0.107)	2.484 (0.732)	-1.940 (0.760)	0.8127 (0.7141)
1977	-2.426	0.972 (0.111)	2.194 (0.728)	-1.790 (0.268)	0.7996 (0.7353)
All Years 1973-1977	4.610	1.045 (0.037)	1.303 (0.132)	-1.946 (0.089)	0.8056 (0.7442)
All Years 1970-1972	-1.027	1.080	2.105 (0.319)	-1.871 (0.142)	0.8156 (0.7601)
All Years 1970-1977	4.511	1.079 (0.037)	1.264 (0.132)	-1.883 (0.189)	0.8093 (0.7442)

S.E. = Standard Error

TABLE 4.3 COEFFICIENTS OF CROSS-SECTIONAL DEMAND FUNCTIONS, 1960-1969

$$\log Trips_{ijt} = K_t + \alpha \log P_{it}P_{jt} + \beta \log I_{it}I_{jt} + \gamma \log F_{ijt} + e'_{ijt}$$

S.E. = Standard Error

Year t	K_t	α (S.E.)	β (S.E.)	γ (S.E.)	R^2 S.E. of Estimate
1960	-.94720	.96579 (.16382)	1.58089 (.48844)	-2.19106 (.26125)	.8058 .8917
1961	4.06445	.66376 (.15236)	2.34294 (.45818)	-2.18140 (.23926)	.8493 .7467
1962	.52878	.88169 (.19410)	1.66765 (.60461)	-2.18233 (.32970)	.7345 1.0510
1963	-2.38735	1.06798 (.12155)	.75092 (.39067)	-2.06686 (.22446)	.8461 .7133
1964	-.72444	.97740 (.15399)	1.45707 (.51471)	-2.27939 (.25718)	.8297 .8176
1965	-1.53037	1.02269 (.14736)	1.08380 (.52046)	-2.19725 (.27721)	.8275 .8776
1966	-2.22848	1.04593 (.14736)	1.10942 (.52046)	-2.14342 (.27721)	.7971 .8776
1967	-1.30304	.97919 (.12192)	1.26210 (.46866)	-2.08611 (.21974)	.8557 .7001
1968	-1.47158	.98955 (.14568)	1.00173 (.48054)	-2.05413 (.25643)	.8120 .8206
1969	-.82398	.95394 (.14318)	1.06404 (.49341)	-2.02509 (.25866)	.8073 .8162
All Years	-1.00991	.97858 (.04294)	1.22849 (.11032)	-2.14513 (.07980)	.8173 .8147

Source: Ref. 2

usually assumed that the errors [e.g., e_{ij}'s in model (4.2)] are uncorrelated random variables with mean zero and constant variance. Tests of hypotheses related to the significance of the fitted model further require that these errors are normally distributed. Direct examination of residuals helps in checking these assumptions.

A residual is the difference between the fitted or calculated value and the actual observed value. In regression analysis, residuals are conceived as measures of the error component. The average size of residuals is used as a basis for a number of summary statistics such as R^2 and the standard error of estimate. Such summary statistics are useful in deciding whether the fit of the regression equation is "good" or "bad", whether the proportion of explained variation is adequate, and so forth.

4.2.4 Implications of Residual Analysis

The reliability of cross-sectional demand equations developed in Phase II may be greatly improved by reducing the errors associated with individual area-pairs. By the preceding discussion, given a single year's observations, the errors or residuals must be regarded as random variables provided no auto-correlation exists. The availability of eight sets of observations and errors (one set for each of the years 1970-1977) ought to permit consistencies in individual area-pair errors to be identified.

Firstly, a common base is provided by including the entire eight years' observations in a single regression to derive one demand model (Table 4.2). In this model each of the 58 area-pairs has eight values of the error term, one for each year. A close look at them reveals that the eight residual or error values per pair resemble each other not only in magnitude but also in sign. In addition, they sometimes appear to follow definite trends in time.

Noting the above, it became imperative to investigate whether error observations were significantly related to the area-pair and/or the point-in-time to which they belong. The analysis thus becomes a typical Two-way Classification factorial experiment, with one observation per cell, the two factors being area-pair and year. The linear statistical model for the classification may be written as (Ref. 9):

$$e_{kt} = \mu + \tau_k + \beta_t + (\tau\beta)_{kt} + \varepsilon_{kt} \qquad \begin{array}{l} k = 1,2,\ldots,58 \\ t = 1,2,\ldots,8 \end{array} \qquad (4.3)$$

where

e_{kt} = the residual or error associated with the k^{th} area-pair in the year t, is decomposed into:

μ = an overall mean value common to all residuals,

τ_k = the effect of the k^{th} area-pair (that portion of the residual derived solely because it belongs to the k^{th} pair),

β_t = the effect of time (that portion of the residual derived solely because it is associated with the year t),

$(\tau\beta)_{kt}$ = the portion of the residual contributed by the interaction of the two factors pair and year, and

ε_{kt} = the experimental error associated with the linear statistical model (4.3).

In the case of one observation per cell (or pair-year combination) the two-way classification procedure assumes that the two-factor interaction effect is zero (Ref. 9). The model (4.3) thus becomes

$$e_{kt} = \mu + \tau_k + \beta_t + \varepsilon_{kt} \qquad \begin{array}{l} k = 1,2,\ldots,58 \\ t = 1,2,\ldots,8 \end{array} \tag{4.3a}$$

Using the Subprogram ANOVA of the Statistical Package for the Social Sciences (Ref. 12) computer files at the University of Manitoba, the statistical significance of the area-pair and year effects were analyzed. The analysis of variance (ANOVA) table in Table 4.4, confirms that both effects are indeed highly significant even at the 0.1 percent significance level. This means that about 97 percent of what was once regarded as experimental error can now be accounted for in terms of an area-pair effect and effect due to time. Table 4.5 gives estimates of τ_k and β_t for each of the 58 area-pairs and the 8 years as output from the Subprogram ANOVA. As expected, the overall mean μ of the residuals is zero.

It is possible that the area-pair and time effects indicate the existence of some missing independent variable. The constraints of time prevented any investigation in this direc-

TABLE 4.4 ANALYSIS OF VARIANCE TABLE: TWO-WAY CLASSIFICATION OF MODEL RESIDUALS BY FACTORS AREA-PAIR AND YEAR

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
MAIN EFFECTS	239.877	64	3.748	113.154	0.0
PAIR	231.174	57	4.056	122.441	0.0
YEAR	8.703	7	1.243	37.534	0.000
EXPLAINED	239.877	64	3.748	113.154	0.0
RESIDUAL	13.216	399	0.033		
TOTAL	253.093	463	0.547		

464 CASES WERE PROCESSED.
0 CASES (0.0 PCT) WERE MISSING.

TABLE 4.5 MULTIPLE CLASSIFICATION ANALYSIS OF RESIDUALS FROM 1970-1977 MODEL FIT BY AREA PAIR AND YEAR

AREA PAIR	PAIR EFFECT τ_k	AREA PAIR	PAIR EFFECT τ_k
St. John's-Halifax	1.71	Montreal-Winnipeg	-0.66
St. John's-New.Bruns.	0.64	Montreal-Saskatoon	-1.42
St. John's-Quebec City	-1.48	Montreal-Regina	-1.10
St. John's-Montreal	-0.19	Montreal-Calgary	-0.04
St. John's-Ottawa	0.28	Montreal-Edmonton	-0.50
St. John's-S. Ontario	0.56	Montreal-Vancouver	0.30
St. John's-Winnipeg	0.05	Ottawa-Winnipeg	0.17
St. John's-Saskatoon	-0.65	Ottawa-Saskatoon	0.05
St. John's-Regina	-0.26	Ottawa-Regina	0.32
St. John's-Calgary	0.46	Ottawa-Edmonton	0.55
St. John's-Edmonton	0.36	Ottawa-Calgary	0.68
St. John's-Vancouver	0.45	Ottawa-Vancouver	0.95
Halifax-Montreal	-0.68	S. Ontario-Winnipeg	0.16
Halifax-Ottawa	0.09	S. Ontario-Saskatoon	-0.42
Halifax-S. Ontario	0.03	S. Ontario-Regina	-0.15
Halifax-Winnipeg	0.29	S. Ontario-Edmonton	0.25
Halifax-Saskatoon	-0.19	S. Ontario-Calgary	0.58
Halifax-Regina	0.31	S. Ontario-Vancouver	0.58
Halifax-Edmonton	0.72	Winnipeg-Edmonton	0.23
Halifax-Calgary	1.07	Winnipeg-Calgary	0.61
Halifax-Vancouver	0.96	Winnipeg-Vancouver	0.99
New Brunswick-S. Ontario	-0.73	Sask.-Vanc./Victoria	0.28
New Brunswick-Winnipeg	-0.45	Regina-Vanc./Victoria	0.69
New Brunswick-Saskatoon	-0.87	Edmonton-Vanc./Victoria	0.60
New Brunswick-Regina	-0.54		
New Brunswick-Edmonton	-0.11		
New Brunswick-Calgary	0.26		
New Brunswick-Vancouver	0.20		
Quebec C.-Winnipeg	-1.01		
Quebec C.-Saskatoon	-1.72		
Quebec C.-Regina	-1.32		
Quebec C.-Edmonton	-0.85		
Quebec C.-Calgary	-0.79		
Quebec C.-Vancouver	-0.53		

YEAR	YEAR EFFECT β_t
1970	0.10
1971	0.12
1972	0.06
1973	0.02
1974	0.06
1975	0.09
1976	-0.19
1977	-0.27

Multiple R^2 For Classification = 0.948

tion. On the other hand, the area-pair effects may be seen as some sort of community-of-interest or attractivity factor, accounting for a variety of factors difficult to quantify. Hence values for the St. John's area are above average, since air service is perhaps the most attractive way to cross the Gulf of St. Lawrence; low Quebec City-to-the-West values reflect language and cultural aversions; the agriculture-based economy of Saskatchewan no doubt explains the low values for the areas, and so on. The time factor suggests a general decrease in willingness or need to undertake interzonal travel This may be due to the increasing weight placed on time and perhaps more importantly, to the rapid improvements over the years in communications and data bank systems.

4.2.5 An Improved Model:

The high statistical significance of the area-pair and time effects is strong support for incorporating these effects into the demand function. Therefore, a dummy variable intended to represent the combined effects of area-pair and year, i.e. $(\tau_k + \beta_t)$ in model (4.3), was assigned to each area-pair for each year and a modified demand model derived by the least squares multiple regression technique. With the dummy variable the model formulation looks like:

$$T_{ijt} = K(P_iP_j)_t^{\alpha} \cdot (I_iI_j)_t^{\beta} \cdot F_{ijt}^{\gamma} \cdot e^{\delta A_{ijt}} \cdot \varepsilon_{ijt} \qquad (4.4)$$

where

where

A_{ijt} = dummy variable for combined area-pair, time effects,

δ = coefficient.

The results of the introduction of the dummy variable are shown in Table 4.6. It appears that all the cross-sectional models now fit the observations almost perfectly; whether this is in fact significant or not must now be investigated.

4.2.6 Statistical Evidence of Significant Model Improvement

To establish that the model (4.4) provides statistically more reliable results than the model without the dummy variable, the results in Tables 4.2 and 4.6 are compared. Consider the 1975 cross-sectional model as typical and also suitable as a basis for comparing across the two tables. The summary statistics associated with the 1975 models derived from the two fits under consideration, are displayed in Tables 4.7 and 4.8.

Comparing these tables the remarkable improvement in the statistic R^2 can be seen. However, this statistic should be used with caution as it is always possible to make R^2 unity by simply adding enough terms. For meaningful model improvement a superior R^2 value should be matched by a sufficiently reduced error or residual sum of squares, i.e. the variation still unaccounted for by the model. Indeed it is in this respect that the superiority of the model (4.4) stands out. The Tables 4.7 and 4.8 show that the residual sum of squares

TABLE 4.6 CROSS-SECTIONAL DEMAND FUNCTIONS FROM THE FORMULATION (4.4)

$$Ln\ T_{ijt} = K_t + \alpha ln(P_iP_j)_t + \beta ln(I_iI_j)_t + \gamma lnF_{ijt} + \delta A_{ijt} + \varepsilon_{ijt}$$

Year t	K_t	α (S.E.)	β (S.E.)	γ (S.E.)	δ (S.E.)	R^2 (S.E.)
1970	5.875	1.207 (0.019)	0.961 (0.096)	-1.875 (0.410)	1.107 (0.025)	0.995 (0.1305)
1971	4.087	1.075 (0.020)	1.272 (0.127)	-1.794 (0.040)	0.987 (0.025)	0.995 (0.1257)
1972	4.437	1.179 (0.044)	1.159 (0.304)	-1.803 (0.100)	1.064 (0.060)	0.9732 (0.2937)
1973	3.460	1.106 (0.015)	1.425 (0.106)	-1.917 (0.037)	0.968 (0.021)	0.9967 (0.1024)
1974	4.067	1.035 (0.015)	1.358 (0.948)	-1.879 (0.036)	0.948 (0.020)	0.9967 (0.0982)
1975	4.318	1.006 (0.017)	1.300 (0.114)	-1.819 (0.040)	0.968 (0.022)	0.9956 (0.1104)
1976	4.278	1.035 (0.017)	1.335 (0.120)	-1.900 (0.042)	0.986 (0.022)	0.9953 (0.1143)
1977	4.852	1.022 (0.017)	1.178 (0.115)	-1.763 (0.042)	1.012 (0.022)	0.9953 (0.1142)
1973-1977	4.683	1.045 (0.007)	1.246 (0.029)	-1.859 (0.019)	0.983 (0.009)	0.995 (0.1155)
1970-1977	4.523	1.084 (0.008)	1.235 (0.029)	-1.845 (0.020)	1.006 (0.011)	0.9908 (0.1634)

TABLE 4.7 REGRESSION ANOVA TABLE 1975 CROSS-SECTIONAL MODEL - NO DUMMY VARIABLE

MULTIPLE R	0.9132	STD. ERROR OF EST.	0.6746
MULTIPLE R-SQUARE	0.8340		

ANALYSIS OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	P(TAIL)
REGRESSION	123.471	3	41.157	90.446	0.00000
RESIDUAL	24.573	54	0.455		

VARIABLE	COEFFICIENT	STD. ERROR	STD. REG. COEFF.	T	P(2 TAIL)
INTERCEPT	-6.886				
LN(F)	-1.835	0.245	-0.421	-7.496	0.000
LN(XPOP)	0.892	0.102	0.561	8.744	0.000
LN(XIN)	3.026	0.655	0.294	4.621	0.000

TABLE 4.8 REGRESSION ANOVA TABLE 1975 MODEL WITH DUMMY VAR, LNA(I,J)

MULTIPLE	0.9978	STD. ERROR OF EST.	0.1104
MULTIPLE R-SQUARE	0.9956		

ANALYSIS OF VARIANCE	SUM OF SQUARES	DF	MEAN SQUARE	F RATIO	P(TAIL)
REGRESSION	147.398	4	36.849	3023.745	0.00000
RESIDUAL	0.646	53	0.012		

VARIABLE	COEFFICIENT	STD. ERROR	STD. REG. COEFF.	T	P(2 TAIL)
INTERCEPT	4.318				
LN(F)	-1.819	0.040	-0.417	-45.415	0.0
LN(XPOP)	1.006	0.017	0.633	59.563	0.0
LN(XIN)	1.300	0.114	0.126	11.401	0.0
LNA(I,J)	0.968	0.022	0.428	44.310	0.0

have been drastically reduced by model (4.4) from 24.573 to 0.646. As a direct result the error mean square value is also slashed from 0.455 to 0.012 causing the all-important F ratio to leap from 90.446 to 3023.745, to establish the high statistical significance of the model (4.4).

The other statistics such as the standard errors of the regression coefficients and of the estimated regression plane are all greatly reduced to strengthen the virtues of the new model formulation. The standard error of estimate is down to 0.1104 from 0.6746, and the fit is unquestionable.

More generally, the introduction of the dummy variable to account for the area-pair and year effects has increased the values of K_t. *More importantly the elasticities (β's), of the income cross-product are reduced, revealing that the explanatory power of this variable has been cut approximately in half. This fairly large reduction indicates that the dummy variable reflects area-pair affluence to some extent. This interpretation is borne out in the correlation matrix associated with the fit of model (4.4), Table 4.9. The Table (a) shows that of all the other independent variables the dummy variable is highest correlated with the transformed incomes cross-product. Note also that all the independent variables are highly correlated with the dependent variable while their own intercorrelation is quite low. This is very much in keeping with the assumptions of the multiple regression technique (Ref. 9,10,11) and further enhances the adequacy of the model*

TABLE 4.9(a)

CORRELATION MATRIX - FORMULATION (4.4)

		LN(TRIP) 1	LN(F) 2	LN(XPOP) 3	LN(XIN) 4	LNA(I,J) 5
LN(TRIP)	1	1.0000	-			
LN(F)	2	-0.5321	1.0000			
LN(XPOP)	3	0.7718	-0.1576	1.0000		
LN(XIN)	4	0.6015	-0.0773	0.4900	1.0000	
LNA(I,J)	5	0.4882	-0.0122	0.0253	0.3101	1.0000

TABLE 4.9(b)

CORRELATION MATRIX OF REGRESSION COEFFICIENTS - FORMULATION (4.4)

		LN(F) 2	LN(XPOP) 3	LN(XIN) 4	LNA(I,J) 5
LN(F)	2	1.0000			
LN(XPOP)	3	0.1374	1.0000		
LN(XIN)	4	-0.0029	-0.5029	1.0000	
LNA(I,J)	5	0.0088	0.1525	-0.3416	1.0000

(4.4). The Table 4.9(b) verifies that the elasticities of the incomes cross-product and dummy variable are in fact inversely correlated to a large degree, so that as one variable increases in its explanatory power, the other can be expected to lose some of its own importance.

CHAPTER V

THE IMPACT OF ENERGY SHORTAGES

5.1 INTRODUCTION

The oil embargo placed by the OPEC nations in 1973 shocked the western world into the realization that it could have a real energy problem. The awareness of the direct consequences of an energy shortage reached a peak at that time, but, as time went by, the urgency linked with the conceived imminence of depleted energy supplies has apparently faded. In fact, it is now widely believed that any changes in attitudes wrought by the so-called "energy crisis" of 1973 have since been substantially eroded.

5.2 PETROLEUM RESERVES

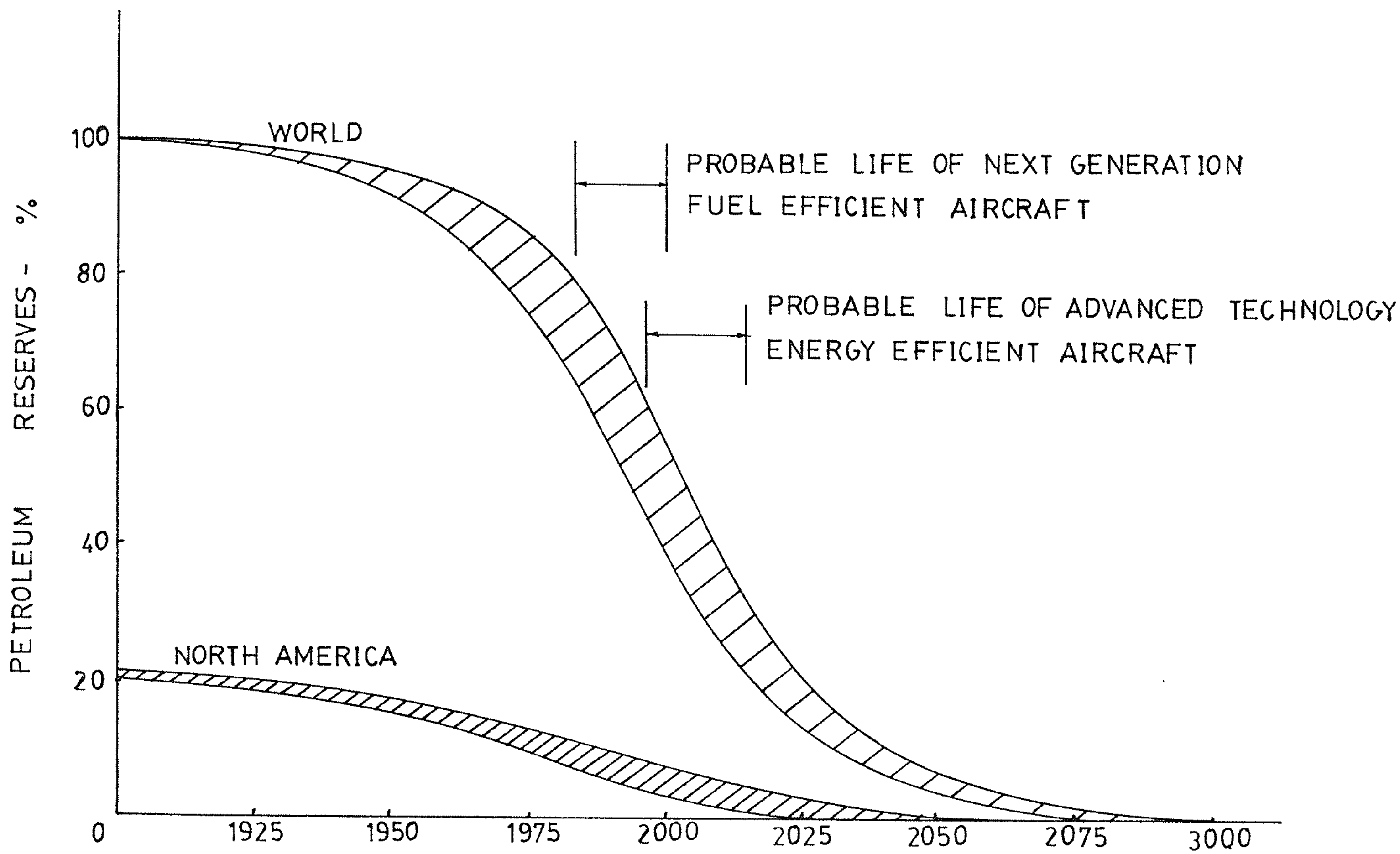
There are as many estimates of total world natural petroleum reserves as there are estimators. Figure 5.1 is regarded as a reasonable average between the most optimistic and pessimistic.

The world is rapidly depleting its natural petroleum reserves and present estimates indicate that we will run out in less than 100 years. The situation in North America is even more acute and estimates of ultimate depletion time range from 50 to 75 years hence.

The per capita reserves in Canada are roughly double those for the U.S. (Ref. 13), and although one may feel that

FIGURE 5.1

ESTIMATE - NATURAL PETROLEUM RESERVES



SOURCE : REF. 13

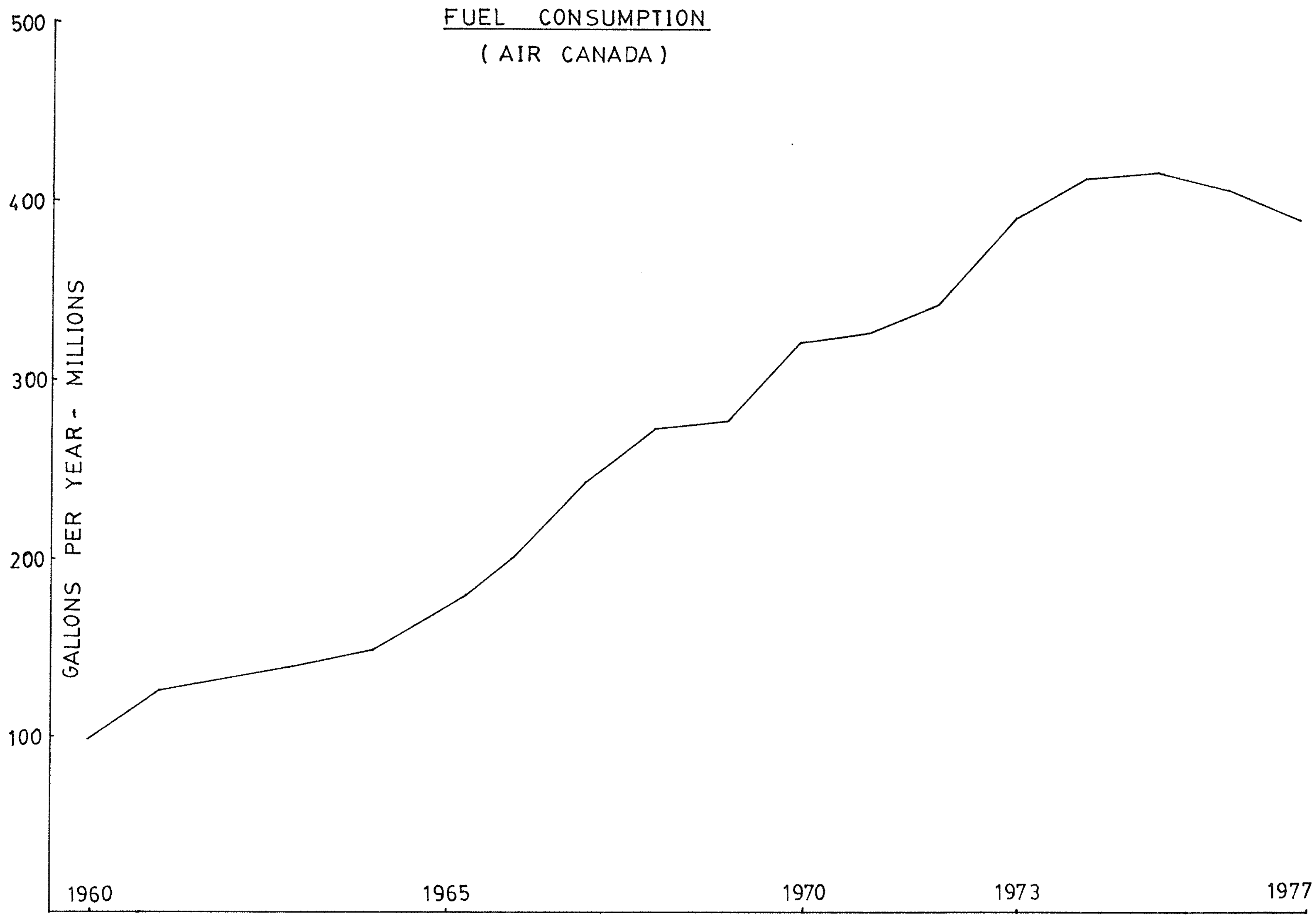
Canada does not have the same problem as does the U.S., it is difficult to imagine a situation where the U.S. has run out of oil and Canada is still sitting on some of its own. For all practical purposes, both countries will run out at the same time, i.e. before the rest of the world.

5.3 THE AVIATION INDUSTRY

The aviation industry in general is not a large consumer of petroleum products, worldwide consumption in 1974 being approximately 5 percent of the total liquid petroleum consumption. In Canada in 1972 the percentage was about 4 percent of the total Canadian consumption, including the military. Although it does not represent a major sector of consumption, the growth rate of aviation fuel consumption is considerably higher than the rates in most other countries (Ref. 14). Figure 5.2 indicates the growth in consumed fuel since 1960, for Air Canada. Over this period, the annual growth rate has averaged about 11 percent per year which means a doubling of consumption every seven years.

It is not reasonable to assume that petroleum production will increase until the day when the world supply comes to an end. As the end approaches, petroleum in its natural form will become a costly commodity and production will have to diminish. It is not realistic to assume that commercial air transportation (which in its present state cannot use other energy forms) will be given priority over other users of

FIGURE 5.2


FUEL CONSUMPTION
(AIR CANADA)
GALLONS PER YEAR - MILLIONS
500
400
300
200
100
1960
1965
1970
1973
1977

petroleum, who would be forced to use more costly energy forms. This assumption becomes an extremely important consideration, as aircraft which are now on the drafting board and more advanced types, will still be in service in the year 2000, a time when the reserves will be sharply declining and natural petroleum prices will be skyrocketing (Ref. 13).

Figure 5.1 also shows the probable life span of the next two generations of entirely new commercial passenger carrying aircraft technology (as distinct from direct derivatives of existing types).

5.4 ENERGY AND CANADIAN DOMESTIC AIR PASSENGER DEMAND

A previously stated hypothesis suggests that the differences in a series of area-pairs compared at various points in time reflect and trace differences in stages of development and prevailing conditions at these various points in time. If this hypothesis is considered to be reasonable, then the effects of energy on domestic air passenger demand may be estimable from variations among the yearly cross-sectional demand models according to the formulation (4.4), Chapter IV, (see Table 4.6). Specifically, the investigation ought to differentiate and then compare the models for those years after 1973 and those for the period up to 1973 when energy supplies were abundant. Additional information on the demand characteristics for the period 1960-1969 may be obtained from comparable studies done by the Canadian Transport Commission (Ref. 2), *from which the cross-sectional models in Table 4.3 have been quoted.*

The cross-sectional demand equations of Table 4.6 show no marked variations across the years. This may be surprising at first because it seems reasonable to expect that the energy situation of 1973 should in some way have affected air passenger demand. The possibility that somehow it really did not affect the demand is further strengthened by the total inter-area-pair trips (Raw Data, Appendix I) for the market area which maintained a steady increase right up to 1976.

What the ten demand equations of Table 4.6 stress is that during the analysis period the making of an air trip between any two area-pairs within the defined market area has continued to be governed by the same factors (i.e. the independent variables in the equations) and to the same extent (i.e. the coefficients α, β, γ, K remain more or less constant). In other words people have not changed their definition of what the need to travel depends on.

But then the energy crisis and the ensuing increase in fuel prices must have caused something. From the model formulation (4.4) it appears that the only factor which could conceivably be directly affected by the energy situation is the fare variable. The indication that travel patterns and demand were not affected by the energy shortages suggests in turn that the fares were not unduly manipulated. Indeed the raw data (Appendix I) supports this suggestion. But how could fares not be "affected" in the face of the fierce fuel price increases experienced after 1973?

Some light is thrown on this most confusing situation in the next chapter where an attempt is made to evaluate the various factors which contribute to, or help in, the determining of fare levels.

CHAPTER VI

THE CONTRIBUTION OF FUEL TO AIR FARE LEVEL

6.1 INTRODUCTION

By far the largest carrier serving the Canadian domestic air travel market is Air Canada. In 1977 the Corporation accounted for approximately 55 percent of the total number of revenue passenger miles (RPM's) flown in Canada (Ref. 15). To simplify the analysis therefore, without losing perspective or accuracy it can reasonably be assumed that the effect of fuel shortages on Air Canada operations is a reflection of a more general effect of energy shortages on domestic air travel demand in Canada.

The price of fuel inevitably has a direct bearing on the future health of the aviation industry. As shown in Figure 6.1, the price of aviation fuel has risen from about 13¢ in the mid 1960's to a current price of approximately 60¢ per imperial gallon (Ref. 13,15). In doing so, fuel as a percentage of total operating costs for Air Canada has risen from 9 percent in the mid 1960's to about 19 percent in 1977 (Table 6.1). This relationship is quite significant as it indicates that fuel prices have been rising at a much greater rate than other costs.

In spite of these marked increases, the airline's rates have not mounted accordingly. Recognition of this fact

FIGURE 6.1

FUEL PRICE PER IMPERIAL GALLON AND
FUEL EXPENSE AS A PERCENTAGE OF TOTAL OPERATING COSTS

(AIR CANADA)

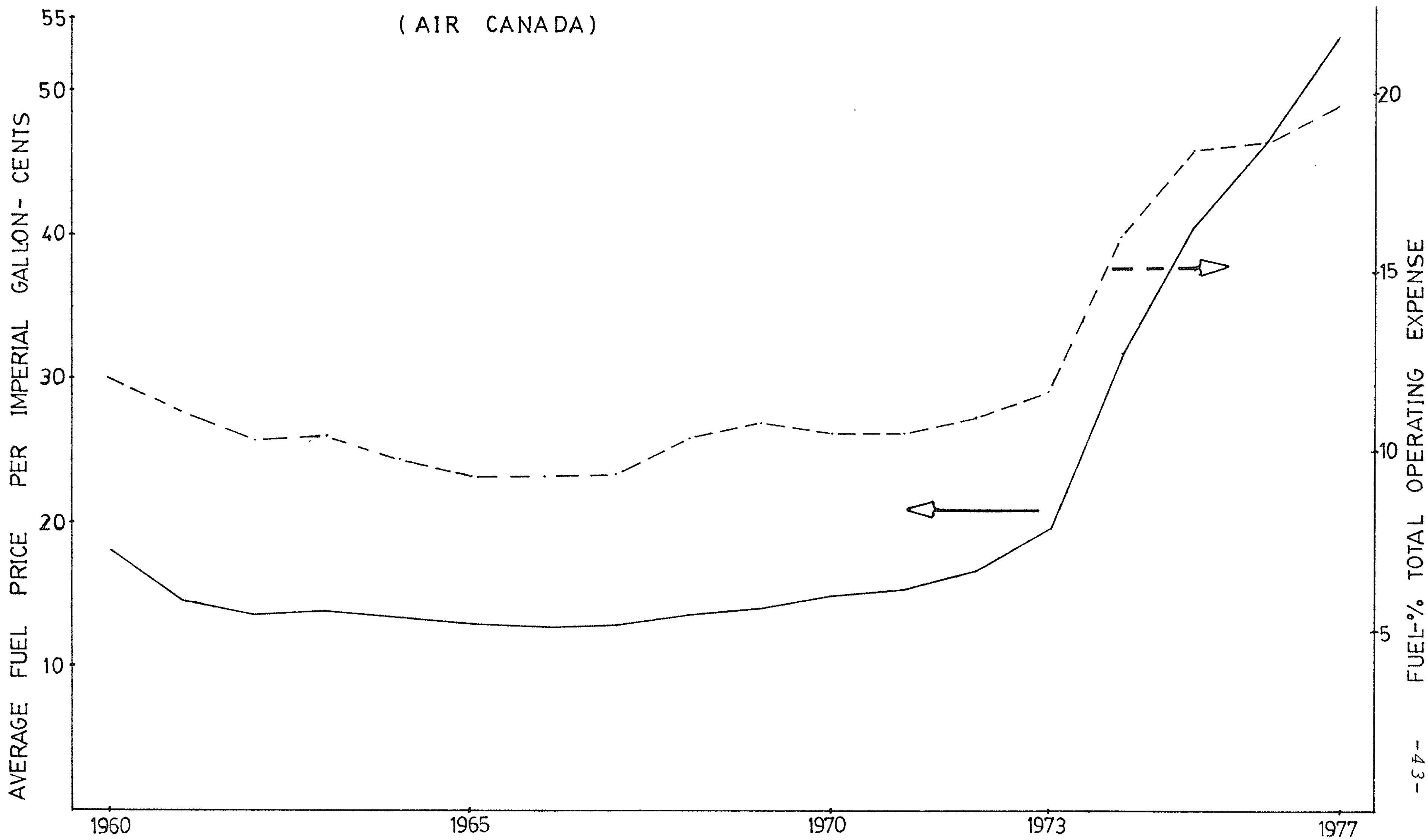


TABLE 6.1 AIR CANADA (HISTORIC) OPERATING STATISTICS

Year	Yield Per Revenue Pass-enger Mile (1968 ¢)	Total Fuel Consumed (M Gal)	Total Fuel Cost ($ M)	Total Operating Expense ($ M)	Total Available Ton Miles (10^2M)	Total Available Seat-Miles (10^2M)	Fuel Price Per Gallon (¢ 1968)	Fuel Exp. as % of Operating Expense (%)	Fuel Exp. per Available Ton Mile (¢ 1968)	Available Ton-Miles Per Gallon	Available Seat-Miles Per Gallon	Passenger Load Factor %	Weight Load Factor %
1960	7.59	98.25	17.80	147.93	4.03	31.00	22.0	12.0	5.37	4.10	31.5	66	58
1961	6.98	124.65	18.18	163.29	5.22	38.57	17.5	11.1	4.18	4.19	30.9	64	53
1962	7.17	133.03	18.13	176.08	5.93	43.80	16.2	10.3	3.63	4.46	32.9	60	51
1963	7.24	141.35	19.50	188.12	6.68	45.82	16.1	10.4	3.40	4.73	32.4	59	50
1964	6.94	148.08	19.66	203.53	7.15	46.42	15.2	9.7	3.15	4.83	31.4	63	52
1965	6.63	170.92	22.09	237.40	8.68	54.58	14.5	9.3	2.85	5.08	31.9	65	51
1966	6.27	201.30	25.70	275.99	10.09	63.87	13.8	9.3	2.75	5.01	31.7	66	53
1967	5.89	242.01	30.94	329.73	12.27	80.55	13.3	9.4	2.62	5.11	33.3	65	53
1968	5.84	273.19	37.23	359.61	15.04	97.17	13.6	10.4	2.48	5.51	35.6	58	49
1969	5.55	277.27	41.69	386.19	16.63	100.58	13.4	10.8	2.40	6.00	36.3	57	47
1970	5.58	320.77	47.84	457.40	20.54	112.07	13.8	10.5	2.16	6.40	34.9	57	46
1971	5.75	326.14	50.22	480.09	21.22	117.06	13.9	10.5	2.13	6.51	35.9	55	45
1972	5.15	343.64	57.64	537.77	22.15	121.69	14.4	10.7	2.29	6.45	35.4	65	52
1973	4.74	390.71	76.08	651.70	25.99	143.99	15.6	11.7	2.34	6.65	36.9	67	52
1974	4.97	412.41	130.63	814.70	28.21	161.27	22.8	16.0	3.33	6.84	39.1	64.	49
1975	5.06	416.93	169.30	917.90	30.75	174.19	26.4	18.4	3.58	7.38	41.8	58	45
1976	4.95	406.31	189.12	1017.72	31.75	176.81	28.1	18.6	3.60	7.82	43.5	61	46
1977	4.94	389.00	208.72	1098.50	30.95	178.72	30.0	19.0	3.77	7.96	45.9	63	49

and some explanation for it can be found in the Air Canada 1977 Annual Report (Ref. 17) which states:

> "Air Canada's role is to provide air transportation both in Canada and internationally at the highest standard of service, safety and efficiency while maintaining financial self-sufficiency. Its fare structure must meet the needs of those who must travel as well as those who do so for pleasure."...
>
> ..."Rising costs forced tariffs up... In March, Canadian fares rose by 7%, the only increase in the year."...
>
> ..."(But) Despite these increases, Canadian fares are still among the lowest in the world. Air Canada's average income per scheduled RPM has risen only half as much as prices for other goods and services. In the past decade, the company's yield has gone from 5.66¢ per RPM to 8.84¢ per RPM, an increase of 56% while Canadian prices, as measured by Statistics Canada's Implicit Price Index, rose by 103%. This has come when fuel cost per gallon has risen by 500% and aircraft prices have more than doubled in cost per seat purchased."

The report goes on to say that fuel continues to present major problems for the airline. It recognises the important fact that Canadian petroleum prices are not yet up to world levels and will continue to rise until they are. In the meantime some remedial action was necessary.

As soon as the (fuel) problem was evident, Air Canada embarked on a major conservation program and that program has continued to make itself felt.

It is this "major conservation program" which gives valuable insight into just how air fares are structured and how the airline industry has been forced to modify its operating practises as the energy situation worsens.

6.2 THE FARE STRUCTURE

If the fare is considered as the revenue to be derived when one unit of available capacity is actually utilized, then it is reasonable to expect that the fare should depend most generally on:

(i) the cost of producing one unit of available capacity, and

(ii) the expected utilization of the units of available capacity.

6.2.1 Cost Per Unit of Capacity

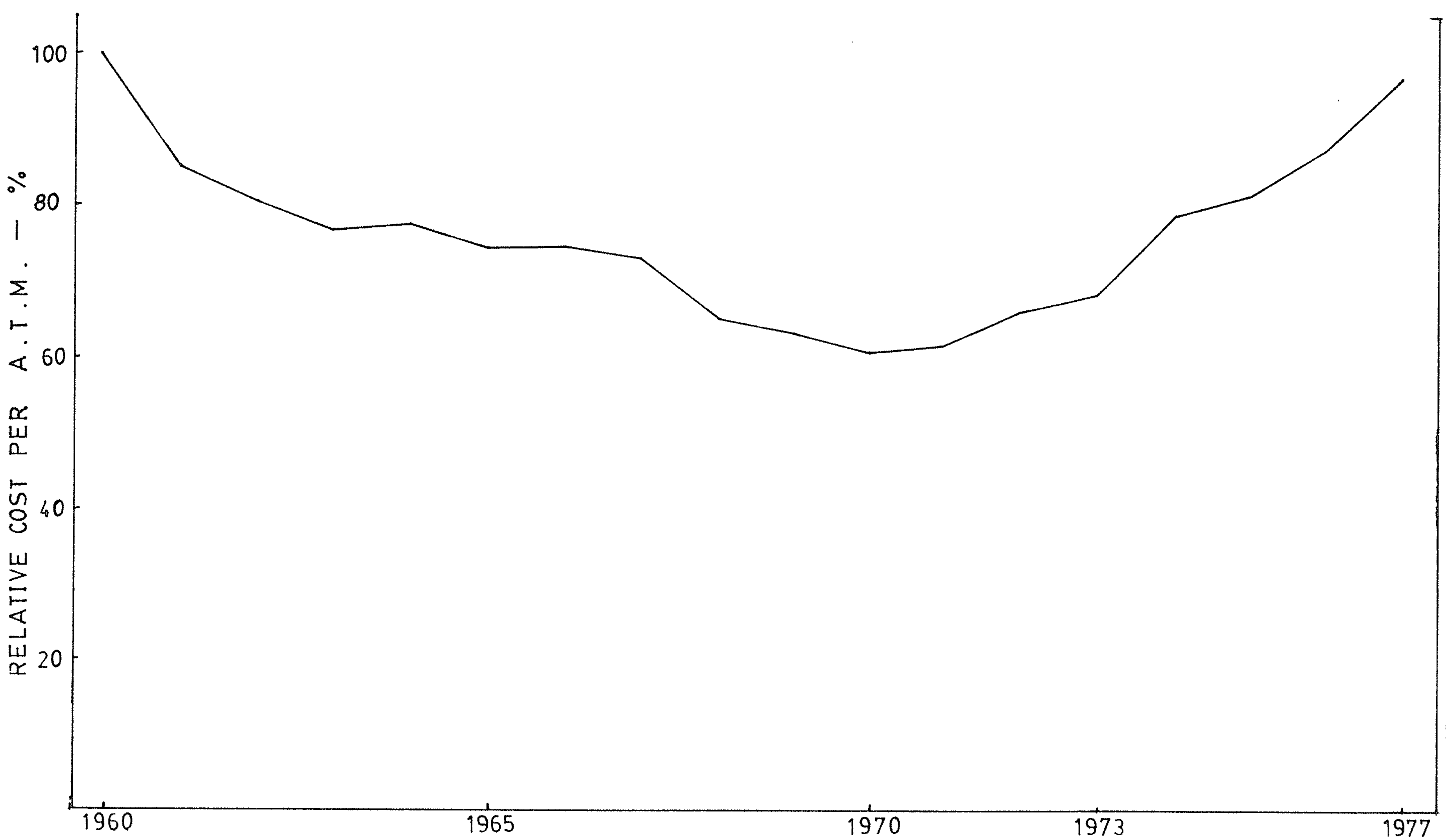
(a) Figure 6.2 shows the variation with time, of Air Canada's costs per available ton mile (ATM) of capacity, since 1960. The costs dropped progressively until 1970 in spite of inflation, and after that time the unit costs started to rise. Part of this increase can be attributed to the change in fuel price. However, had the fuel price stayed at the 1970 level then costs would still have gone up as is discussed later.

(b) The major reduction in cost after 1960 (even in spite of rising fuel prices and inflation) resulted from the introduction of better and better aircraft over the years. First came the standard DC-8, a vast economic improvement over the other aircraft then in operation (Ref. 14). The advent of the DC-9's led to further improvement and the stretched DC-8's between 1968 and 1970 drove costs down further, in spite of inflation.

The 747 has the lowest cost per unit of available capa-

FIGURE 6.2

OPERATING COST PER AVAILABLE TON MILE



city of almost any aircraft flying today, (see Table 6.2). In 1973 came the L-1011, however the introduction of these improved aircraft after 1970 has not been enough to keep operating costs down. The problem is that although the 747 is still the best on the basis of cost per ATM, because of its size, not enough of them can be deployed to keep down the cost of the total fleet mixture.

(c) The efficiency of the aircraft used, therefore, affects the operating costs which in turn affect the fare structure. The effect on fare structure is best observed if aircraft efficiency is viewed in terms of the fuel consumption per ATM.

Accordingly the airline industry is becoming more and more efficient from the point of view of energy consumption. Using Air Canada as an example, in the period 1965-1975 the ATM grew by a factor of about 3½, whereas during that time the fuel consumption has only grown by a factor of 2½. This is illustrated in Figure 6.3. In terms of the number of gallons per ATM there has been substantial annual improvement as shown in Figure 6.3. "This improvement has been the result of a number of factors which includes the introduction of more efficient aircraft and more nonstop flights, that is, longer average stage lengths". (Ref. 13).

6.2.2 Utilization of Available Capacity

When the U.S. was faced with the energy crisis in 1973 they were able to reduce their fuel consumption by 10 percent

TABLE 6.2

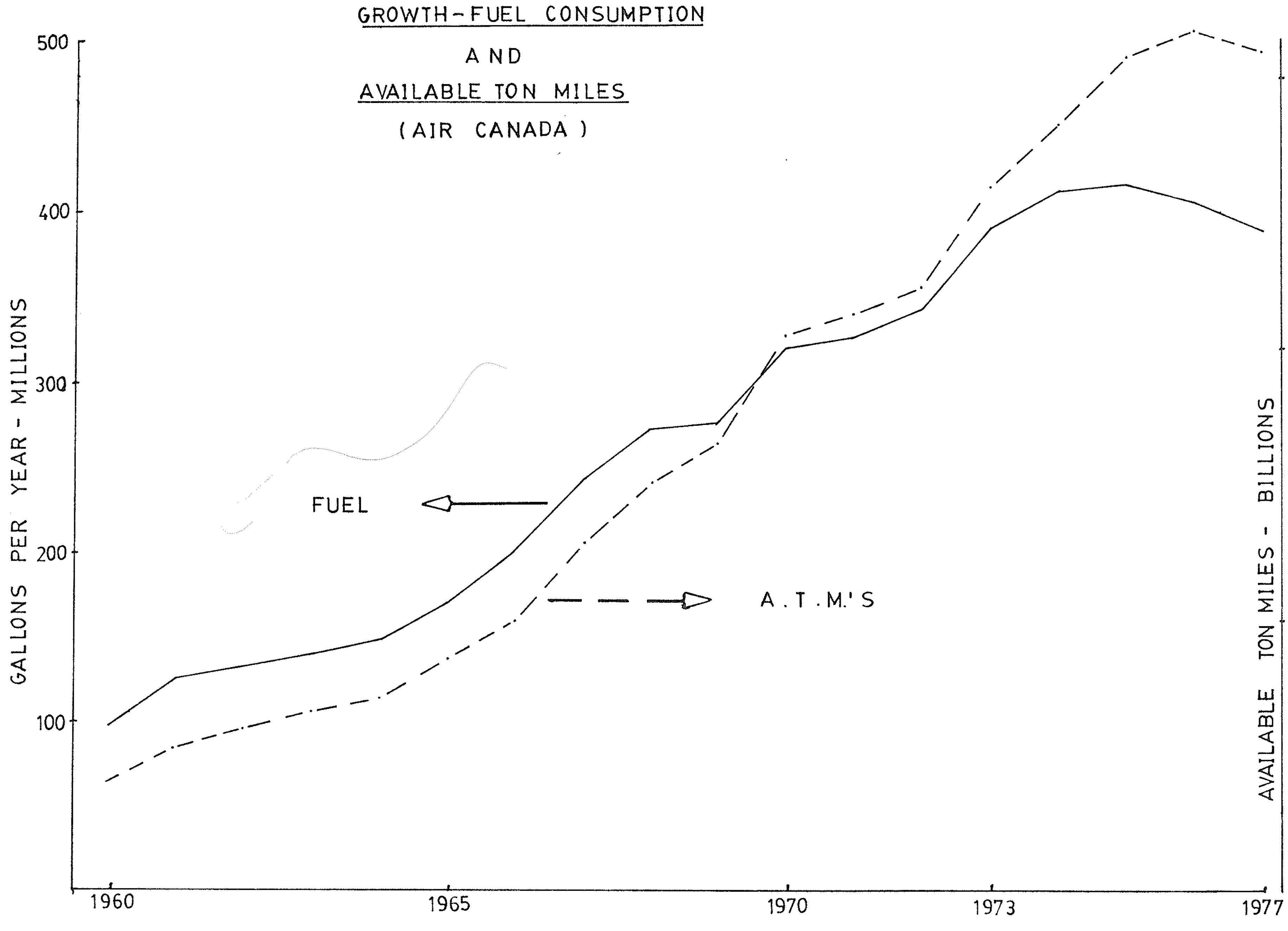
RELATIVE DIRECT OPERATING COSTS

(1000 MILE FLIGHT)

	$ PER A.S.M.	$ PER A.T.M.
747	100	100
DC-8-63	100	135
L-1011	107	152
DC-9	118	173
DC-8 CONWAY	140	210

SOURCE: REF. 14

FIGURE 6.3


GROWTH-FUEL CONSUMPTION
AND
AVAILABLE TON MILES
(AIR CANADA)
GALLONS PER YEAR - MILLIONS
500
400
300
200
100
AVAILABLE TON MILES - BILLIONS
3·0
2·0
1·0
FUEL
A.T.M.'S
1960
1965
1970
1973
1977

and still carry more passengers (their savings were greater than the total cost of the aviation fuel burned in Canada in 1974), (Ref. 13). Most of this increase was due to improved load factors achieved by cutting flights.

In Canadian air transportation the fare structure has doubtless been affected by load factors. Fuel consumption can be made more beneficial if the payload carried per aircraft is maximized. This means more useful production per unit of fuel and hence less operating cost to earn a given amount of income.

6.3 THE FARE STRUCTURE MODEL:

Recognising that there probably is some relationship between the fare level on the one hand and factors representing expenses per unit of available capacity, load factors and aircraft technological efficiency on the other, the next step is to investigate the nature of any such relationship.

First a number of variables are defined, (Table 6.1), each of which is thought to have some direct bearing on the fare level. Observations are made on each of these variables or factors from the most reliable sources available (Refs. 13, 14,15,16,17) as they apply to the Air Canada Corporation. In the Table 6.1 the yield per revenue passenger mile (RPM) is defined by Air Canada as the average income derived per RPM. It is calculated as the ratio of the total revenue attributable to passenger traffic to the total number of RPM's flown. As such it can be used and in fact is used in this investigation as a sort of average fare level per revenue passenger mile.

This fare variable (the dependent variable) is regressed on various combinations of the other (independent) variables shown in the Table 6.1. The multiple regression technique was applied to these combinations assuming first a mathematical relationship involving a linear combination of the variable, and then one involving a multiplicative arrangement of the independent variables.

After careful study of the many regression models which resulted, the following one turned out to be most powerful.

$$\text{Yield/RPM} = 5.3 - 8.2\ (\text{Passenger Load Factor}) + 1.0\ \left(\frac{\text{Fuel Price Per Gallon, 1968¢}}{\text{Available Seat Miles Per Gallon}}\right) + 1.4\ (\text{Expenses Other Than Fuel Expenses Per Available Seat Mile}) \quad \ldots\ldots \quad (6.1)$$

The statistics for this "best" equation are shown in Table 6.3. The $R^2 = 0.98$ is quite high, the standard error of estimate is low and the general fit of the regression plane to the observations (see F-statistic), and the regression coefficients are all highly significant even at the 5 percent level.

It is important to note that the independent variables appearing in the model (6.1) are perhaps the very ones that logically might be expected to dictate the future modus operandi of domestic Canadian air transportation. The "Load Factor" term tells about the effect of level of utilization of the

TABLE 6.3 STATISTICS FOR REGRESSION EQUATION (6.1)

SQUARED MULTIPLE CORRELATION	0.97743
RESIDUAL MEAN SQUARE	0.023657
STANDARD ERROR OF EST.	0.153807
F-STATISTIC	202.13
NUMERATOR DEGREES OF FREEDOM	3
DENOMINATOR DEGREES OF FREEDOM	14
SIGNIFICANCE	0.0000

VARIABLE NAME	REGRESSION COEFFICIENT	STANDARD ERROR	T-STAT.	2TAIL SIG.
INTERCEPT	5.37760	0.619619	8.68	0.000
PASSLF	-8.19252	1.10280	-7.43	0.000
OTHEXASM	1.39677	0.0569562	24.52	0.000
FEXASM	0.966247	0.358881	2.69	0.018

Key:

PASSLF = Passenger Load Factor

OTHEXASM = Expenses other than Fuel Expenses per ASM

FEXASM = Fuel Expense per ASM

$$= \frac{\text{Fuel Price/Gal}}{\text{ASM/Gal}}$$

passenger capacity provided; the "seat-miles per gallon" term shows the effect of providing more passenger capacity per unit of energy consumed. It also reflects the importance of the technological efficiency of the aircraft. The "unit fuel price" term describes the effect of fuel expenses on fare levels. Included among the "expenses other than fuel expenses" are items such as salaries, wages, depreciation, rent, advertising, landing fees, sales commission, and so on.

The model (6.1) is derived as an attempt to describe Air Canada's fare structure. It is not intended for use in the setting of future fares; rather it is merely a mathematical description of how Air Canada's fare levels might have varied historically with certain factors of interest and importance. Such an expression, therefore, is considered to be quite useful in evaluating how fare levels are likely to be affected if these factors were subject to some variation.

The implications of this model in the context of the influence of energy shortages on domestic Canadian air passenger demand, are discussed at length in the following chapter.

CHAPTER VII

IMPLICATIONS AND CONCLUSIONS

7.1 INTRODUCTION

The demand equations of the model (4.4) in Chapter IV, relate domestic air passenger demand to a number of factors, socioeconomic and otherwise. In addition, the fare structure model of equation (6.1) describes fare levels in terms of several variables, some controllable (e.g. passenger load factor) and others not controllable (e.g. unit fuel prices). The ultimate effects on demand of fuel shortages and price variations, and any measures taken to combat such shortages and price variations, can now be investigated by first studying their effects on fare levels.

Because of the nature of the factors involved in the model (6.1) it is necessary to develop some broad overview of just how much room there is for variation in each of these factors. A brief presentation of this is now attempted.

7.2 OVERVIEW OF THE FUEL SITUATION

If Air Canada is assumed to represent a reasonable cross-section of the Canadian airline industry the following points cited by C.H. Glenn, Vice-President, Fleet Planning, Air Canada (Ref. 14) in relation to Air Canada, may also reflect the situation of the Canadian industry at large:

(1) Jet fuel will be available in the future, however further increases in prices are visualized.

(2) The historical improvement in average fuel consumption per Available Ton Mile will probably not continue beyond the next few years.

(3) There is not too much further improvement possible in the conservation of fuel quantity by varying operating techniques such as flying altitude and air speed.

(4) Improvements can still be made in terms of increased payload per aircraft.

(5) As fuel becomes a greater and greater proportion of total operating costs, the planned retirement of uneconomical aircraft may help increase overall fleet fuel efficiency.

7.3 THE IMPLICATIONS

(i) The item (2) above, reflects a widely expressed concern that new aircraft types are not offering substantially better operating economics as they have in the past, to combat escalating labour, material and fuel costs.

Over the past two decades, major improvements have been made in the fuel consumption of jet engines (see Chapter VI). Although there is still room for improvement, additional improvements may be quite costly to attain.

The last generation of high-efficiency jet engines for commercial use cost approximately one-half billion dollars each to develop (Ref. 14). Later engines now in the design stages are assumed to cost more. For the small improvement in fuel consumption it is not thought that the industry can afford it.

(ii) Item (5) presents a short term solution in the light of the above discussion on item (2). It points to improved fuel efficiency by incorporating in the fleet higher proportions of the more efficient aircraft types now available. Before identifying the implications of this option, the efficiency characteristics of the various airplanes should be studied (see Figure 7.1). Available seat miles (ASM) per gallon (like available ton miles per gallon) is a measure of efficiency. It varies with flight distance as shown in the Figure 7.1. From this figure and based on the current aircraft seating layouts the 747's, DC-9's, stretched DC-8's and L-1011's all have approximately the same efficiencies. The poorest is the standard size DC-8 with Rolls-Royce engines now in the process of being retired (Ref. 13).

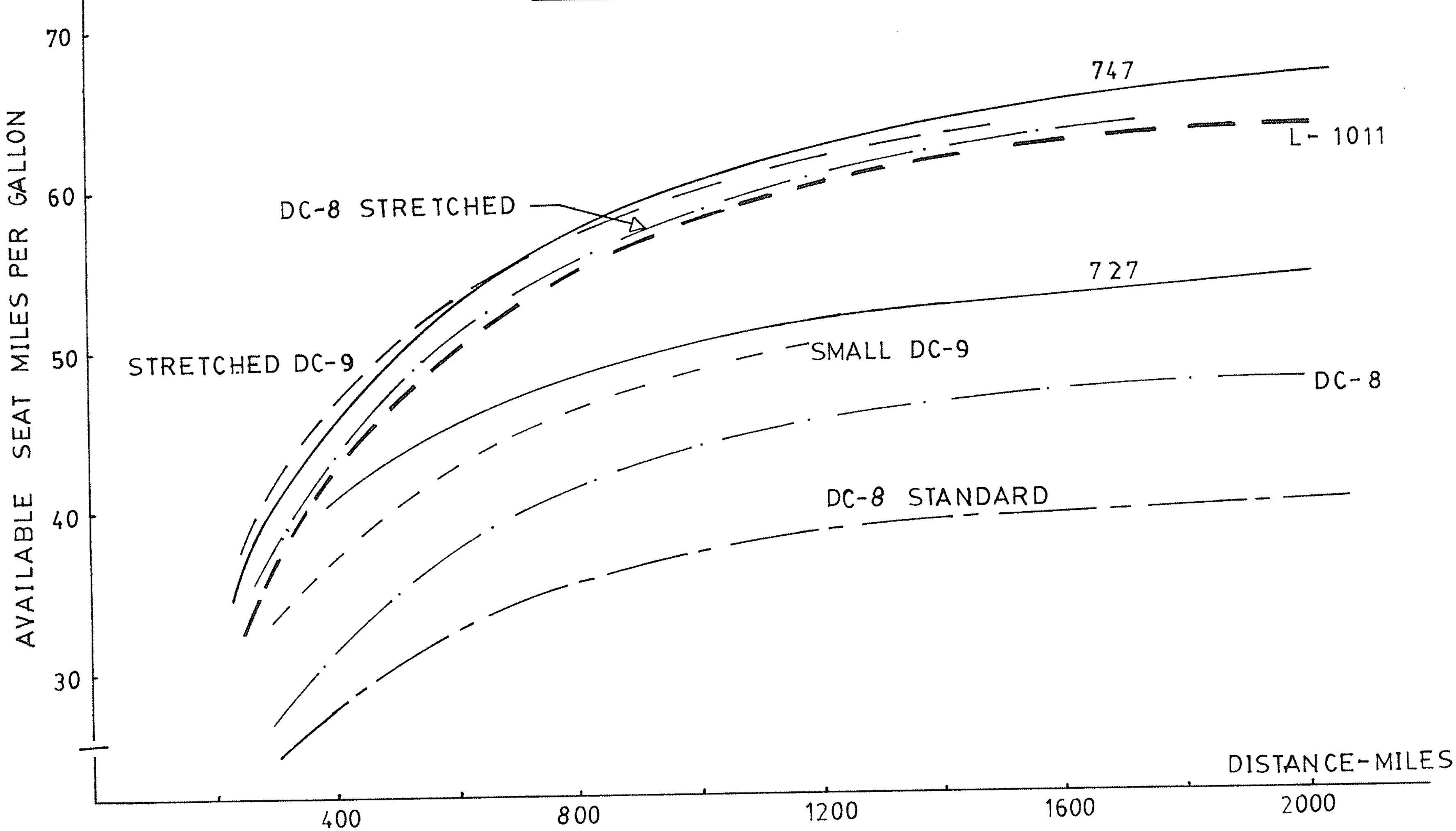
In order to put Figure 7.1 in the correct perspective it is necessary to show the impact of these various aircraft types on the fuel uplifted in Canada. This is shown in Figure 7.2. Note carefully that this figure suggests that over three-quarters of the fuel consumed in Canada is already due to aircraft of high efficiency! As more of the inefficient ones are retired the improvement in efficiency tends to its upper limit which is considered to be in the order of 7.69 to 8.33 Available Ton Miles per gallon. This represents a maximum increase

FIGURE 7.1

AVAILABLE SEAT MILES PER GALLON VS DISTANCE

AIR CANADA'S FLEET MIX - 1975

CLASS CONFIGURATIONS

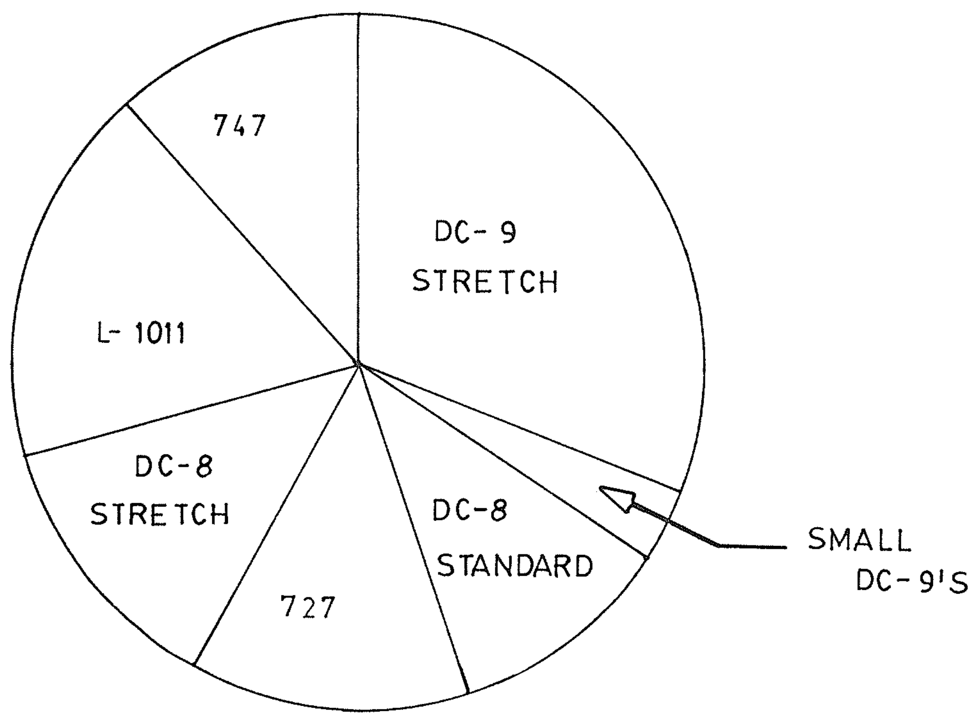


SOURCE : REF. 13

FIGURE 7.2

DOMESTIC FUEL UPLIFT

AIR CANADA



SOURCE : REF. 13

of about 6½ percent over present levels (Ref. 14), by the next three years when the retirement is expected to be complete.

From the equation (6.1) it can be seen that the 6½ percent increase in aircraft efficiency implies a decrease of about 1 percent in the fare levels.

If all other factors remained constant the possible impact of this improved efficiency on travel demand may be studied using the combined time-series cross-sectional regression model encompassing all the years from 1970 to 1977. The equation states that (see Table 4.6):

$$T_{ij} = 92(P_i P_j)^{1.08} (I_i I_j)^{1.24} (F_{ij})^{-1.85} e^{1.01 \, A_{ij}} \quad .. \ (7.2)$$

where all terms have been defined previously, and (7.2) implies that a 2 percent fare decrease by itself is expected to boost demand by approximately 3.7 percent.

(iii) The variation in operating techniques referred to in item (3) is in recognition of the fact that speed and altitude have a marked effect on the amount of fuel consumed. At present however, Air Canada, like most other domestic carriers, have already throttled back towards an optimum speed and altitude, so that in the future no significant improvements from this area are expected.

(iv) Item (4). Among the biggest single items which would improve fuel consumption according to equation (6.1) are those which deal with the provision of passenger capacity

(ASM per gallon) and the utilization of this capacity (passenger load factors).

Over the past years the airline industry in Canada has theoretically been wasting energy when it is considered that weight load factors have been averaging slightly above 50 percent (Table 6.1), so that about one-half of the fuel is consumed in providing wasted "weight" capacity. In the case of the passenger load factor the average has been about 65 percent or one third of the fuel consumed goes into the production of unused capacity.

It is felt that if there is cooperation between airlines, or even legislation, to eliminate wasteful competition in certain markets, average passenger load factors could be increased up to 10 percent. From equations (6.1) and (7.2) such an increase by itself could raise demand by approximately 20 percent.

From the point of view of the efficient provision of passenger capacity substantial improvements can also be derived through reconfiguration of the aircraft. Present configu r ations of wide-body aircraft, for example, devote a large area to first class and spacious economy seating. This arrangement is inefficient in comparison with a high density all-economy aircraft configuration. Air Canada is considering this option and they estimate that the number of Available Seat Miles per gallon for their fleet could be up 15 percent by the early 1980's, Ref. 13. This alone could bring fares down by approximately 2 percent.

(v) Item (1). So far all the factors considered could create reductions in fares of up to about 13 percent of present levels, within about the next ten years. But what about the effect of fuel price increases?

The rate of increase of unit price of fuel may be expected to continue to increase, so that whereas between 1966 and 1976 fuel prices increased over 100 percent in terms of constant 1968 dollars (Table 6.1), it is estimated (Figure 6.1) that at present rates, similar increases could be generated within the next 6 to 8 years. In fact, all it requires is an increase in fuel prices of about 100 percent over the next ten years to erase the possible 13 percent depression of fare levels mentioned above (see Equations 6.1 and 7.1).

7.4 CONCLUSIONS

The investigation shows that over the next five to eight years a number of measures may be adopted by the airline industry in Canada to further offset the adverse effects of increasing fuel prices. These measures include:

(1) The gradual phasing out of inefficient aircraft from the fleet, in an effort to increase overall fuel efficiency.

(2) Continued modification of flying techniques to operate at flying speeds and altitudes known to be optimum in terms of fuel consumption.

(3) Improvements in aircraft configuration to provide more high-density all-economy type seating arrangements, i.e. better utilization of physical aircraft space.

(4) *Passenger load factor improvement to maximize the payload carried per aircraft and yield more useful production per unit of fuel.*

It is anticipated that during this period fuel prices in terms of $1968 = 100 would increase by the 100 percent required to neutralize the 13 percent allowance for fare reduction ($1968 = 100) which could be forged from the above improvements.

Figure 5.1 shows that, beyond the next decade, fuel prices would soar and the full effect of this on fare levels, and hence demand, would be felt. This would be so because by that time fuel price increases would have outstripped whatever favourable effects could yet be derived from the four measures outlined above.

At that time, the models (6.1), (7.1) and (7.2) show that for every one percent increase in the unit price of fuel ($1968 = 100), the fare level would increase 0.13 percent and the demand could fall a corresponding 0.24 percent, all other factors remaining constant.

But by the beginning of the 1990's the end of world reserves for natural petroleum will already be in sight (Figure 5.1) and fuel prices would skyrocket and dwarf any of the "positive" effects described above. By the mid 1990's any new airplane placed on the market then would not be fuelled with present energy forms. Indeed it could be a serious crisis in the year 2000 when petroleum based energy is becoming so scarce that even the most efficient engines of the day are not enough to combat the rising unit costs led by fuel.

Yes, it would seem like new forms of energy must be developed soon if the air transport industry is to survive.

7.4.1 Suggestions for Further Research

In the first part of this study an effort is made to derive improved demand functions for the market area. Further work needs to be done to examine the reliability of these functions. Specifically, their ability to estimate known travel demand for years not included in the present analysis period should be investigated.

Further areas of research arise readily from the energy analysis portion of this study.

1) The fare structure model itself and its usefulness doubtless need some clarification and refinement. Questions such as (i) what other factors should be included in the fare equation and (ii) can such an equation ever be refined enough to become instrumental in the actual setting of future fare levels, ought to be studied.

2) How do the effects of energy shortages on Air Canada differ from those on the smaller, more regional type carriers also operating in the domestic market area?

3) To better understand the changes brought on by the scarcity of energy the study might be broadened to analyze the entire North American experience, comparing the situation in the United States with that found in Canada.

4) Further work might also be done on the effects of the energy situation on the world air travel market, in an effort to place the domestic Canadian experience into a more international perspective.

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APPENDIX I

MARKET AREA RAW DATA

ALL ITEMS CONSUMER PRICE INDEXES

CANADA $1968 = 100

1960	82.3
1961	83.3
1962	84.3
1963	85.8
1964	87.3
1965	89.4
1966	92.8
1967	96.1
1968	100.0
1969	104.5
1970	108.0
1971	111.1
1972	116.4
1973	125.2
1974	138.9
1975	153.8
1976	165.4
1977	178.8

INTER-AREA PASSENGER TRIPS (000)

Pages 71-74

AREA-PAIR	1970	1971	1972	1973	1974	1975	1976	1977
ST. JOHN'S/HALIFAX	37.19	40.56	49.02	57.41	64.98	66.92	72.41	69.73
ST. JOHN'S/NEW BRUNSWICK	12.49	14.25	18.57	18.74	22.97	25.82	23.52	22.12
ST. JOHN'S/QUEBEC CITY	0.89	0.70	1.50	1.35	2.10	1.83	3.19	1.92
ST. JOHN'S/MONTREAL	29.06	29.71	33.70	38.76	42.65	42.92	40.09	38.21
ST. JOHN'S/OTTAWA	8.84	11.95	11.30	16.10	16.77	19.34	18.11	18.91
ST. JOHN'S/SOUTH. ONT.	44.09	50.40	60.31	75.95	91.60	88.97	89.77	85.05
ST. JOHN'S/WINNIPEG	1.61	2.11	1.84	3.20	4.82	4.47	4.73	4.38
ST. JOHN'S/SASKATOON	0.25	0.47	0.38	0.44	0.57	0.66	0.68	0.76
ST. JOHN'S/REGINA	0.39	0.39	0.66	0.70	0.97	1.12	0.81	0.86
ST. JOHN'S/EDMONTON	1.03	1.25	1.97	20.00	2.73	3.59	3.71	4.39
ST. JOHN'S/CALGARY	0.95	1.40	1.62	2.18	2.91	4.34	3.39	3.66
ST. JOHN'S/VANCOUVER	1.89	2.70	2.88	4.53	5.33	5.45	5.01	5.84
HALIFAX/MONTREAL	91.12	86.10	91.50	108.91	119.79	114.22	115.89	105.58
HALIFAX/OTTAWA	32.90	37.40	42.43	57.68	63.83	66.92	65.90	64.04
HALIFAX/SOUTH. ONTARIO	108.57	103.10	126.30	164.75	178.71	188.46	190.75	172.77
HALIFAX/WINNIPEG	7.69	7.71	8.53	10.91	13.29	13.87	13.64	12.58
HALIFAX/SASKATOON	1.11	1.35	1.31	2.06	2.00	3.07	2.81	3.05

AREA-PAIR	1970	1971	1972	1973	1974	1975	1976	1977
HALIFAX/REGINA	1.80	2.07	3.00	3.18	4.26	3.83	3.68	3.70
HALIFAX/EDMONTON	4.17	4.84	7.30	7.70	9.28	11.04	12.07	13.20
HALIFAX/CALGARY	4.88	6.71	7.84	10.20	12.05	14.23	16.03	16.81
HALIFAX/VANCOUVER	8.82	9.24	11.62	18.14	18.66	21.14	21.02	20.63
NEW BRUNSWICK/SOUTH. ONT.	77.23	73.60	91.37	115.48	134.65	140.69	132.95	124.76
NEW BRUNSWICK/WINNIPEG	4.64	5.19	5.56	6.71	10.51	10.58	10.90	10.47
NEW BRUNSWICK/SASKATOON	0.80	1.15	1.08	1.27	1.96	1.99	2.42	2.16
NEW BRUNSWICK/REGINA	1.08	1.32	1.76	1.26	3.29	2.83	2.61	3.33
NEW BRUNSWICK/EDMONTON	2.45	3.01	3.64	4.64	5.95	7.62	7.13	9.22
NEW BRUNSWICK/CALGARY	3.74	3.70	4.56	6.59	8.54	9.46	10.15	9.65
NEW BRUNSWICK/VANCOUVER	5.56	6.29	8.30	11.64	14.00	13.50	12.48	12.88
QUEBEC CITY/WINNIPEG	3.25	3.58	3.57	5.88	7.10	7.78	7.00	7.18
QUEBEC CITY/SASKATOON	0.38	0.67	0.46	1.00	1.11	1.07	1.62	1.02
QUEBEC CITY/REGINA	0.38	0.77	0.92	1.44	1.39	2.07	1.74	1.89
QUEBEC CITY/EDMONTON	1.30	1.94	2.29	3.57	3.73	4.07	5.67	4.44
QUEBEC CITY/CALGARY	1.21	1.82	1.78	2.90	3.80	6.26	4.96	8.51
QUEBEC CITY/VANCOUVER	2.92	3.83	4.11	6.83	9.09	10.01	8.96	8.51

AREA-PAIR	1970	1971	1972	1973	1974	1975	1976	1977
MONTREAL/WINNIPEG	61.52	58.65	64.61	73.04	80.10	76.19	73.91	67.76
MONTREAL/SASKATOON	6.63	7.49	8.19	10.52	11.57	11.68	10.96	10.82
MONTREAL/REGINA	8.49	8.59	10.24	12.47	14.79	14.88	15.92	13.98
MONTREAL/EDMONTON	24.85	25.07	31.08	35.92	38.95	41.04	44.16	47.78
MONTREAL/CALGARY	32.76	34.72	39.34	48.80	58.60	61.24	67.70	70.93
MONTREAL/VANCOUVER	87.29	84.18	93.54	128.37	140.01	129.23	122.75	112.58
OTTAWA/WINNIPEG	40.00	41.22	45.12	55.79	65.98	65.85	64.96	62.93
OTTAWA/SASKATOON	6.87	8.39	9.87	12.59	15.79	17.34	17.35	15.55
OTTAWA/REGINA	8.63	11.40	12.00	17.92	18.39	21.41	21.95	19.89
OTTAWA/EDMONTON	17.74	20.33	25.37	33.73	37.38	39.56	41.04	43.40
OTTAWA/CALGARY	18.97	20.41	24.74	31.17	39.48	41.92	43.64	44.91
OTTAWA/VANCOUVER	40.42	45.92	55.63	70.97	80.32	84.39	79.32	80.96
SOUTH. ONTARIO/WINNIPEG	197.13	163.10	209.35	252.11	281.35	284.20	274.63	275.56
SOUTH. ONTARIO/SASKATOON	27.10	28.90	34.69	46.83	47.66	53.49	56.55	52.93
SOUTH ONTARIO/REGINA	34.89	38.01	46.77	55.13	62.10	69.43	75.26	66.04
SOUTH ONTARIO/EDMONTON	77.73	80.01	97.98	123.81	138.75	154.42	167.77	167.27
SOUTH ONTARIO/CALGARY	94.78	103.37	116.74	148.02	179.21	197.94	209.07	214.29

AREA-PAIR	1970	1971	1972	1973	1974	1975	1976	1977
SOUTH. ONTARIO/ VANCOUVER	206.86	222.01	249.09	330.02	372.50	367.80	354.07	341.15
WINNIPEG/ EDMONTON	45.80	44.12	50.10	61.34	69.89	75.63	78.13	73.97
WINNIPEG/ CALGARY	62.74	59.32	67.87	80.87	91.95	98.64	99.68	95.28
WINNIPEG/ VANCOUVER	100.82	97.15	110.13	140.95	154.20	156.48	147.10	136.73
SASKATOON/ VANC.-VICT.	29.27	33.63	42.11	55.47	69.34	70.47	72.20	58.29
REGINA/ VANC,-VICT.	32.84	40.56	46.40	64.37	73.05	83.52	79.28	62.88
EDMONTON/ VANC.-VICT.	155.17	163.36	194.97	253.34	287.27	302.18	314.19	293.13
TOTAL	1923.80	1961.20	2299.24	2917.65	3314.02	3439.07	3447.39	3296.73
% ALL CANADA	31.20	30.30	31.80	32.20	32.70	33.20	33.20	32.10

INTER-AREA PASSENGER TRIPS (000)

AREA-PAIR AIR FARES - $1968 = 100¢

Pages 76-81

AREA	1970	1971	1972	1973	1974	1975	1976	1977
ST. JOHN'S	397.2	397.6	406.6	418.0	418.3	416.7	423.2	462.5
HALIFAX	483.0	483.3	490.7	518.9	523.1	540.0	542.3	548.6
NEW BRUNSWICK	624.0	634.6	643.0	651.9	661.8	674.9	677.3	686.4
QUEBEC	798.6	796.6	808.5	810.2	812.7	822.3	827.5	835.0
MONTREAL	4241.1	4360.6	4374.3	4400.3	4451.7	4465.8	4468.7	4534.6
OTTAWA	1116.3	1084.0	1106.0	1110.7	1134.2	1150.0	1179.6	1250.3
SOUTHERN ONTARIO	5206.3	5151.7	5229.0	5429.7	5525.0	5617.3	5426.3	5718.2
WINNIPEG	978.1	972.3	973.1	988.8	1000.2	1018.7	1067.7	1031.3
SASKATOON	492.4	484.2	482.8	477.4	476.4	484.5	487.5	494.2
REGINA	425.8	420.2	411.4	406.3	405.4	410.3	412.7	418.5
EDMONTON	784.9	807.4	824.9	832.7	843.1	863.3	899.0	927.6
CALGARY	658.6	671.1	681.3	697.8	714.1	743.0	768.9	798.3
VANCOUVER VICTORIA	1533.7	1537.4	1579.2	1601.3	1641.9	1683.3	1696.7	1711.0
TOTAL	1774.0	1780.1	18010.8	1834.4	1860.8	1889.0	1887.7	1941.7
% ALL CANADA	83.2	82.5	81.6	82.8	82.9	82.8	82.1	83.4

POPULATION (000) BY MARKET AREA

AREA	1970	1971	1972	1973	1974	1975	1976	1977
ST. JOHN'S	1800	2100	2280	2233	2250	2380	2670	2820
HALIFAX	2620	2690	2904	2954	2960	3100	3340	3550
NEW BRUNSWICK	2690	2840	3120	2880	3000	3120	3325	3500
QUEBEC	2300	2350	2510	2480	2560	2730	3180	3400
MONTREAL	2600	2750	2890	2867	2950	3120	3360	3600
OTTAWA	3140	3300	3470	3430	3520	3720	3930	4240
SOUTHERN ONTARIO	2700	3050	3210	3090	3220	3462	3810	4150
WINNIPEG	2820	2760	2980	2954	3010	3180	3580	3880
SASKATOON	2680	2610	2730	2800	2800	3030	3600	3920
REGINA	2790	2720	2850	2922	2920	3150	3615	3930
EDMONTON	2810	2920	3100	3018	3080	3270	3770	4000
CALGARY	2950	3100	3310	3216	3290	3500	3950	4190
VANCOUVER VICTORIA	2590	2880	3050	3000	3090	3300	3600	3950

PER CAPITA DISPOSABLE INCOME BY MARKET AREA

$1968 = 100

AREA-PAIR	1970	1971	1972	1973	1974	1975	1976	1977
ST. JOHN'S/HALIFAX	38	40	39	35	35	38	38	42
ST. JOHN'S/NEW BRUNSWICK	44	45	46	41	40	44	45	47
ST. JOHN'S/QUEBEC	60	62	61	54	51	55	56	61
ST. JOHN'S/MONTREAL	62	63	63	56	53	58	59	63
ST. JOHN'S/OTTAWA	68	68	69	61	57	62	63	68
ST. JOHN'S/SOUTHERN ONTARIO	79	80	80	70	67	73	74	78
ST. JOHN'S/WINNIPEG	122	122	116	100	97	105	105	114
ST. JOHN'S/SASKATOON	147	148	135	116	108	120	127	134
ST. JOHN'S/REGINA	141	143	130	112	104	116	121	129
ST. JOHN'S/EDMONTON	161	161	146	126	124	134	135	146
ST. JOHN'S/CALGARY	161	161	146	126	124	134	135	146
ST. JOHN'S/VANCOUVER	183	183	165	142	140	151	152	164
HALIFAX/MONTREAL	35	37	36	33	33	38	36	40
HALIFAX/OTTAWA	41	41	41	37	37	40	41	44
HALIFAX/SOUTHERN ONTARIO	53	54	54	48	47	50	51	56
HALIFAX/WINNIPEG	95	95	94	82	78	85	85	92
HALIFAX/SASKATOON	122	123	113	98	94	102	103	111

AREA-PAIR	1970	1971	1972	1973	1974	1975	1976	1977
HALIFAX/REGINA	116	118	109	94	90	98	99	106
HALIFAX/EDMONTON	134	134	125	108	105	114	114	124
HALIFAX/CALGARY	134	134	125	108	105	114	114	124
HALIFAX/VANCOUVER	157	157	143	123	122	132	132	143
NEW BRUNSWICK/SOUTH.ONTARIO	49	50	48	43	43	46	50	53
NEW BRUNSWICK/WINNIPEG	88	88	85	77	74	80	83	89
NEW BRUNSWICK/SASKATOON	118	120	111	96	91	88	88	95
NEW BRUNSWICK/REGINA	114	116	107	93	88	83	83	88
NEW BRUNSWICK/EDMONTON	130	131	120	104	101	109	111	121
NEW BRUNSWICK/CALGARY	127	128	118	106	101	109	111	121
NEW BRUNSWICK/VANCOUVER	153	153	138	119	117	126	129	139
QUEBEC CITY/WINNIPEG	77	77	78	68	64	70	70	76
QUEBEC CITY/SKATOON	102	103	96	84	83	85	86	92
QUEBEC CITY/REGINA	96	98	92	80	79	83	84	91
QUEBEC CITY/EDMONTON	117	119	110	95	92	99	100	109
QUEBEC CITY/CALGARY	117	119	110	95	92	99	100	109
QUEBEC CITY/VANCOUVER	138	138	127	110	108	116	117	127

AREA-PAIR	1970	1971	1972	1973	1974	1975	1976	1977
MONTREAL/WINNIPEG	69	69	91	62	58	63	64	69
MONTREAL/SASKATOON	92	93	70	79	76	82	83	89
MONTREAL/REGINA	86	87	86	75	71	77	80	85
MONTREAL/EDMONTON	107	108	104	90	86	94	94	102
MONTREAL/CALGARY	107	108	104	90	86	94	94	102
MONTREAL/VANCOUVER	131	131	121	105	103	111	112	121
OTTAWA/WINNIPEG	65	66	66	58	55	60	60	66
OTTAWA/SASKATOON	88	88	87	76	73	79	79	86
OTTAWA/REGINA	82	83	83	72	68	74	75	81
OTTAWA/EDMONTON	104	104	100	87	84	90	91	99
OTTAWA/CALGARY	104	104	100	87	84	90	91	99
OTTAWA/VANCOUVER	126	126	119	103	100	107	109	118
SOUTHERN ONT./WINNIPEG	59	59	58	54	51	55	56	61
SOUTHERN ONT./SASKATOON	82	84	83	72	68	73	75	81
SOUTHERN ONT./REGINA	77	77	78	68	64	69	70	77
SOUTHERN ONT./EDMONTON	99	99	96	84	80	86	88	94
SOUTHERN ONT./CALGARY	99	99	96	84	80	86	88	94

AREA-PAIR	1970	1971	1972	1973	1974	1975	1976	1977
SOUTHERN ONT./VANCOUVER	120	120	113	98	96	104	105	113
WINNIPEG/EDMONTON	48	50	49	44	43	46	47	51
WINNIPEG/CALGARY	48	50	49	44	43	46	47	51
WINNIPEG/VANCOUVER	70	72	80	64	61	64	66	71
SASKATOON/VANCOUVER-VICTORIA	49	50	55	45	44	47	48	52
REGINA/VANCOUVER-VICTORIA	54	55	61	49	48	51	52	56
EDMONTON/VANCOUVER-VICTORIA	37	37	41	34	34	36	38	40

AREA-PAIR AIR FARES

$1968 = 100¢

A P P E N D I X II

MARKET AREAS COMPOSITION

APPENDIX II

CENTRES CONTAINED IN THE LONG-HAUL MARKET AREAS

MARKET AREA	COUNTIES AND CENSUS DIVISIONS	
ST. JOHN'S	Newfoundland Census Divisions 1,2,3,6,7,8	
HALIFAX	Nova Scotia counties:	
	Annapolis	Kings
	Colchester	Lunenburg
	Digby	Queens
	Halifax	Shelburne
	Hants	Yarmouth
NEW BRUNSWICK	Entire Province	
QUEBEC CITY	Quebec Counties:	
	Charlevoix	Montmorency
	Chicoutimi	Portneuf
	Lac-St-Jean	Quebec
MONTREAL	Quebec Counties:	
	Argenteuil	Huntington
	Arthabaska	Iberville
	Bagot	Joliette
	Beauce and Dorchester	Labelle
	Beauharnois	Laprairie
	Bellechasse and Levis	L'Assomption
	Berthier	Lotbiniere
	Brome	Maskinonge
	Chambly	Megantic
	Champlain	Missisquoi
	Chateauguay	Montcalm
	Compton and Sherbrooke	Montreal (Ile-de Montreal et Ile-Jesus)
	Deux-Montagnes	Napierville
	Drummond	Nicolet
	Frontenac	St-Jean
	Richelieu	St-Maurice
	Richmond	Terrebonne
	Rouville	Vaudreuil
	Shefford	Vercheres
	Soulanges	Wolfe
	Stanstead	Yamaska
	St. Hyacinthe	

OTTAWA	*Ontario counties:* *Carleton, Dundas, Frontenac, Glengarry, Grenville, Lanark, Leeds, Precott, Renfrew, Russel, Stormont, Hull (P.Q.), Papineau (P.Q.), Pontiac (P.Q.*
SOUTHERN ONTARIO:	*Ontario counties:* *Brant, Elgin, Essex, Haldimand, Halton, Huron, Kent, Lambton, Lincoln, Middlesex, Norfolk, Ontario, Oxford, Peel, Perth, Waterloo, Welland, Wentworth, Wellington, York*
WINNIPEG	*Entire Province of Manitoba plus Kenora Co. (Ont.) minus Manitoba Census Div. 16*
SASKATOON	*Saskatchewan Census Divisions 9-17*
REGINA	*Saskatchewan Census Divisions 1-8*
EDMONTON	*Alberta Census Divisions 7,8,10,11,13,14*
CALGARY	*Alberta Census Divisions 1-6, 9*
VANCOUVER AND VICTORIA	*British Columbia Census Divisions 4,5 Alberni-Clayoquot, Capital, Greater Vancouver, Nanaimo, Squamish*