ESTIMATING AIR PASSENGER TRAVEL IN THE ATLANTIC REGION

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ABSTRACT

Forecast models developed for air transport have typically focussed on estimating air passenger trips generated at the national or individual route level. Models that estimate demand for regional and local air service are limited because forecasting at this level is considerably more complex since the market characteristics and regional/local air service networks vary greatly from one geographical area to another.

In Atlantic Canada, estimating air passenger demand has remained a challenge as the social and economic variables vary between the provinces of New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland. Forecast models were developed for passenger travel in the region based on published data from 1996. A catchment area generation model and a link estimation model were developed using regression techniques. These models estimate air passenger trips over a ten-year period for major airports located within the Atlantic Provinces. To evaluate the predictive ability and accuracy of the models, historic data from 1991 were inserted into the equations and the resultant air passenger trip values were compared with actual trip totals.

Information determined using these statistical methods are useful to air carriers and other industries affiliated with the air transportation industry in Atlantic Canada. Estimated air passenger demand will enable the air sector to plan accordingly as the market enters a new millennium.

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CHAPTER 1 INTRODUCTION

The process of estimating future demand for a service or product is one which has evolved significantly in the last several decades. The practice known as forecasting has opened new possibilities for businesses and industries as they are able to predict future conditions. Prior to the advent of forecasting, companies relied heavily on past market trends and intuition in order to determine staffing requirements, production needs and market demands. The use of forecasting by industry has reduced the reliance on intuition as companies gained the ability to more accurately estimate the future market of their product. Estimating future conditions has therefore become an important component of the decision-making process of most industries, as organizations seek to optimize their product output with the objective of lowering costs.

One area in which forecasting has become a useful and necessary tool is in the field of transportation. The aviation industry is one mode of transportation that is composed of "large infrastructures in the form of airport and aircraft systems" [1] and relies heavily on technology. In order to introduce change in the industry, it is necessary that long lead-times be incorporated in the network design and operation schedules. Consequently, the need to estimate future conditions is an integral component of daily operations in the air transportation industry.

The airline industry produces estimates on a variety of parameters. Two parameters that are often forecast in the marketplace are aircraft movements and passenger volumes.

Forecasts provided in these areas form the core of airport and airline planning and design processes. Forecasted aircraft movement statistics are used to assess the need for runway, taxiway, and apron space as well as the need for air traffic control systems and capacity. Similarly, forecasts of passenger volume are translated into level of service requirements for an airline and capacity issues associated with aircraft and terminal buildings. With competition in the airline industry being intense and financial viability of airlines tenuous, the field of forecasting has become increasingly important, as has the need for accurate and reliable information.

Regardless of the parameter being estimated, reliable estimates in the air transportation industry are difficult to produce. The estimates depend greatly on historical data and available resources. It is also important to note that forecasting may not be entirely based on the data and mathematical procedures used to produce the final product. An analyst should attempt to incorporate personal intuition into the analytical process based on experience in forecasting and knowledge of the marketplace. By including intuition in the forecasting procedure, the "black box" approach to forecasting is minimized. The black box term is commonly referred to when a model is developed by inserting data directly into a statistical analysis program with little thought given to the real-life applicability of the data. The results of such an approach often lead to less accurate and reliable forecasts.

One area of forecasting that has been historically difficult to estimate is the demand for regional and local air services. Models developed for passenger volume forecasts have typically focussed on estimating air passenger trips generated at the national or individual route level. Models that predict demand for regional and local air service are limited because forecasting at this level is more complex. The major problem in forecasting on a localized level is that the market characteristics and regional/local air service networks vary greatly from one geographical area to another. In Atlantic Canada for example, estimating air passenger demand has remained a challenge as the social and economic variables vary between the provinces of New Brunswick, Nova Scotia, Prince Edward Island and Newfoundland. Another problem is that the demand values tend to be "small" which are volatile and may be subject to significant changes.

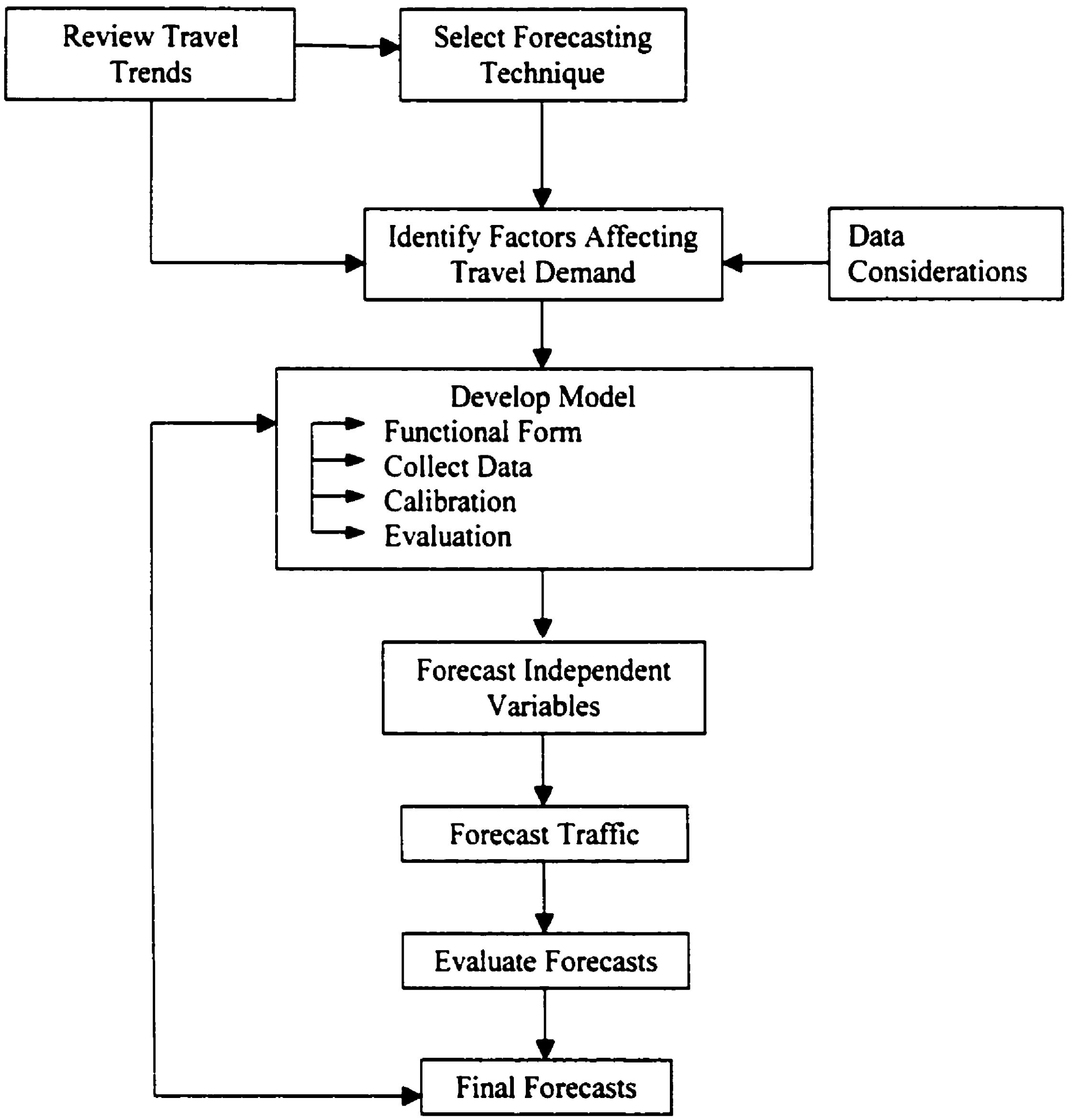
This thesis attempts to forecast regional passenger travel based on published data from 1996. Two different models have been developed using regression techniques to estimate air passenger trips over a ten-year period for major airports located within the Atlantic Provinces. The first model labeled the catchment area generation model, estimates the total number of air passenger trips originating at an airport. Conversely, the link estimation model determines the total one way annual trips generated on links between airports. By adding the volume of passenger traffic on links with the same origin airport, the link model also provides an alternative means of estimating air trips generated from an airport. To evaluate the predictive ability and accuracy of these two models, historic data from 1991 were inserted into the regression equations and the resultant air passenger trip values were compared with actual trip totals.

CHAPTER 2 THE FORECASTING PROCESS

Developing accurate and reliable forecasts is a challenging and time consuming process. A number of steps must be considered when estimating future values of a parameter. Fortunately, while terminology may vary according to the project focus, the stages in the forecasting process typically remain the same. In air passenger modeling, the forecasting procedure can be divided into 6 general steps as illustrated by the flowchart presented as Figure 1. While Figure 1 provides a general overview of the forecasting procedure and the basic steps necessary for traffic estimation, it is important to note that additional steps may be included in the procedure depending on the style of the analyst.

The initial stage of any air passenger estimating procedure is to select a forecasting technique that will assist the analyst with developing a model to estimate future traffic. The most effective means of determining a suitable technique is to review current forecasting practices in the marketplace. This research provides an opportunity to become aware of and better understand the various methods available and identify the techniques most appropriate for different forecasting scenarios.

The next step in the forecasting procedure is to identify the factors that may contribute to the response of air passenger travel. A review of the literature can assist in this process by highlighting the general characteristics that influence the industry. Collecting examples of air passenger models help identify the various parameters that have affected passenger traffic in the past and those variables that will continue to influence travel in the future. An important factor to consider during this step is the quality and availability



Note: Flowchart modified from "Airline Traffic Forecasting", Taneja

Figure 1: Forecasting Procedure for Air Passenger Travel

of the data associated with each travel demand parameter. Specifically, the source of data should be reliable and the information readily accessible. When investigating travel patterns from various time periods, the data should also be consistent. If the data has been collected through a survey, ensure that the methodology has not changed from one time period to the next. Finally, one should consider the predictability of each travel demand variable or the ability to estimate the value of each parameter in the future.

The development of a forecasting model begins with establishing its functional form. This stage involves selecting from the list of influential parameters identified during the preceding step, the variables that are most suitable for investigation. The selection of variables depends on a variety of issues including "theoretical considerations, the purpose of the research, historical traffic trends, empirical data considerations, the time frame of the required forecast, the estimation procedures available, and the simplicity and cost of operation and maintenance." [2]

Once the functional form has been established, data is collected and a model is developed using the forecasting technique selected during the first stage of the procedure. The final step of the model development phase involves evaluating the accuracy of the model. Since regression analysis has been selected as the analytical method for this thesis, it would be necessary to examine the following areas: results of statistical procedure, violation of ordinary least squares assumptions, and comparison with historic data.

Most forecasting techniques produce a range of statistics following the development of a model. Programs used to perform regression analysis typically calculate such parameters as the coefficient of determination, t-statistics, F-statistics and correlation coefficients. Each of these results should be carefully examined prior to proceeding to the next stage of model development. In regression analysis, tests must also be performed on the data in order to verify the adequacy of the ordinary least squares assumptions underlying the analytical method. The final method of evaluating model accuracy is to compare the predicted results with historical data. This can be accomplished by collecting and inserting data from a previous year into the forecasting equation. The resultant values can be compared with actual totals produced for the base year.

To use a model developed to estimate passenger traffic, it is necessary to first estimate future values for each independent variable contained in the equation. Using techniques such as trend projection or sensitivity analysis, the explanatory variables can be projected within a specified time horizon. Once these values have been determined, the response variable can be estimated. The final stage of the forecast procedure requires an evaluation of the estimates. As stated by one author, "erroneous forecasts are usually the result of inaccurate data and compilation, an invalid model, or the incorrect application of a valid model." [3] If the estimates are not acceptable to the analyst, the independent values and assumptions should be reexamined or the various stages of model development should be reevaluated.

CHAPTER 3 LITERATURE REVIEW

The estimation of air passenger demand has received considerable attention by airline organizations for many years. A number of techniques have been developed to predict passenger travel within a country, across neighbouring borders, and internationally. Forecasting methods are typically divided into three main categories: quantitative or scientific, qualitative or judgmental, and a combination of quantitative and qualitative approaches also known as decision analysis [4]. Regardless of the category, each method of forecasting varies according to the desired level of accuracy, the degree of detail, and the time horizon or forecast period. The selection of a technique also depends on several factors including the availability of data, funding, time, computing facilities and individual preference [5].

A brief summary of each of the three main categories is provided along with descriptions of various forecasting methods used to estimate air passenger demand. Examples of forecasting models developed in the industry will be presented where regression analysis was used to predict air passenger travel between cities in the same country and passenger demand between smaller communities in the same region.

Quantitative Methods

Over the years, three categories of forecasting techniques have evolved for use in the estimation of future activities. Quantitative methods, describes those techniques that rely almost entirely on historical data or historical trends to predict future numeric values [6].

Techniques that fall under this category have gained widespread acceptance among the forecasting community for a variety of reasons [7]. In particular, Wheelwright et al identifies three key reasons. Firstly, quantitative methods have developed a record of being accurate. This feature appeals to managers and other professionals who must be confident with the method being used to assist in decision-making alternatives. Secondly, computers have helped overcome obstacles associated with the application of quantitative methods. Specifically, computers have simplified the calculation process involved with quantitative techniques, improved the speed and efficiency of data retrieval, and provided adequate storage for large amounts of data typically associated with these methods. Finally, techniques within this category of forecasting are typically cheaper than other methods available [8].

A number of forecasting techniques currently exist which use historical data to estimate future values. These quantitative methods are typically divided into two classes: time-series models and causal models. As its title suggests, time-series models estimate future values using time as the independent variable [9]. These models assume that a pattern or series of patterns exist within the historical data in which the forecasts are based. If a pattern can be detected and the starting point of the pattern determined, an independent variable can be estimated at any point in the future [10]. It is important to note that time-series models are often useful at producing short-term forecasts such as monthly, weekly, daily or hourly predictions. These methods are not useful however when attempting to predict the impact of a decision on a variable. The value will be predicted for the next period based on a cyclical trend that is unaffected by company decisions [11].

An assortment of methodologies are available to the forecasting community that rely on time-related data to estimate future conditions. Specifically, the following examples of time-series techniques can be applied depending on forecast requirements and personal preference: moving averages, spectral analysis, adaptive filtering, and Box-Jenkins. Also included in this list are two methods that are often used: ratio analysis and trend projection. In the ratio analysis technique, historic local and national data are combined and expressed as a series of ratios. Forecasts are prepared by analyzing trends within the set of ratios and then extrapolating the ratios into the future. Similarly, trend projection is based on "the premise that what has happened in the past has some relevance to the future." [12] Subsequently, a variable can be estimated by extrapolating historic trends into the future. Trend projection is often considered as the oldest and simplest application of time-series analysis.

The second class of quantitative forecasting techniques is known as causal models. Unlike time-series analysis, causal models do not rely on time to estimate future values. Furthermore, time-series models attempt to answer when a particular event will occur while causal methods focus on determining why an event will transpire [13]. The basic premise behind causal models is that a relationship is assumed to exist between variables whereby the forecasted or dependent variable can be expressed as a function of one or more independent parameters. "The aim of these models is to link the variable being forecast to the causes that historically have influenced it and to use their established relationship to forecast in the future." [14]

One of the strengths associated with using causal models is that a range of values can be forecasted which correspond to a range of independent values. However, causal models require extensive data for both independent and dependent variables. Furthermore, it is necessary that the independent variable(s) be known at the time in which the forecast is being prepared [15].

The causal group consists of various techniques which can be used to develop models for forecasting purposes. Among the most common methods are econometrics, regression, simulation, Bayesian analysis, and spatial equilibrium. Spatial equilibrium models for example, postulate that "some basic relationship exists for the movement of traffic between any two points or regions." [16] The relationship typically expresses traffic movement as a function of population and distance. Specifically, the movement of traffic between two points is directly proportional to the size of each region and indirectly proportional to the distance between them. A common spatial equilibrium model used in transportation planning is the gravity model.

Qualitative Methods

The availability of data is a key component of quantitative forecasting. If relevant data cannot be collected or data is not applicable to the project, these methodologies can be ineffective. In such circumstances, qualitative methods can be more appropriate. The aim of qualitative forecasting is "to forecast changes in a basic pattern as well as the pattern itself." [17] For example, a company may use qualitative techniques to estimate the period of time when consumer interest in a product is greatest as well as the duration of peak popularity. Predicting conditions such as those presented in this example require judgement, intuition, and experience by "experts" or key people in the industry. Unfortunately, qualitative techniques are often difficult to apply and quite costly. Subsequently, forecasts of this nature are "generally applied only to long-term conditions (two years or more) and to those of major importance to the firm." [18]

Given the subjectivity involved with estimating future values using qualitative techniques, less research has been invested in developing these methodologies compared to the quantitative group. Furthermore, fewer techniques in this group are available to the forecasting community. Specifically, only three qualitative methods of forecasting are typically applied: judgement, Delphi, and technological forecasting [19]. The latter method is particularly applicable to air transportation as it attempts to "generate new information about future systems and performance, or to simulate the outcome of anticipated events." [20] Technological forecasting helps broaden an analyst knowledge and opinion of future events.

Decision Analysis

A style of forecasting which has grown in acceptance recently combines attributes found in qualitative and quantitative techniques. Decision analysis uses judgement, based on probability, as well as statistical or mathematical terms to forecast future conditions. The technique can easily be incorporated into an organization's decision making approach and the method is most appropriate when "uncertainty is involved in a forecast and when a manager is in a position to supply his judgement of the likelihood of different outcomes." [21]

The market analysis method is a decision analysis technique that "relates travel patterns of a segment of population to its demographic and economic characteristics." [22] Information is typically collected from a survey and for the airline industry, this method has become a reliable tool for estimating potential customers and identifying the population base generating most of the air activity. Unfortunately, this method ignores service characteristics such as trip time and airfare. Other decision analysis techniques include system dynamics, heuristic methods, and probabilistic forecasting.

Based on a review of literature, it is apparent that a variety of techniques are available to provide estimates of future air traffic and/or other events. However, it is important that the research objectives and requirements of the project are closely examined before a suitable forecasting method is selected.

The purpose of this thesis is to estimate air passenger travel between urban centres in the Atlantic Provinces using one or more independent parameters. Models will be developed based on historical data and a 10-year forecast horizon has been selected. Considering this project description, the list of forecasting methods can be narrowed to the causal class of quantitative techniques. Within this category, regression analysis seems to be a suitable choice for research purposes given its acceptance as a reasonably accurate and reliable tool for forecasting as well as its applicability to many problems.

One challenging aspect of causal modeling is determining which independent parameters are suitable for explaining or predicting the forecasted variable. Regression analysis can help in identifying, at a certain level of significance, the parameter that can assist in estimating the dependent variable. It is however important to recognize that a list of relevant independent variables must be selected before any modeling can occur. A review of the literature is an effective means of identifying variables used for similar tasks by the industry.

Examples of air transportation forecasts are available from various academic, research, and industry publications. Estimates of domestic, transborder, and international air passenger travel are most common. These predictions have been prepared based on numerous forecasting models of which several are described in the preceding paragraphs. However, examples of forecasts at a regional level or the demand between communities within a smaller area of the country are more difficult to obtain. Trip estimates at this level are a source of interest as the research outlined in this thesis focuses on passenger travel in a regional context. A literature search was conducted to compile examples that used regression analysis to estimate air passenger travel. An emphasis was placed on collecting examples that addressed air travel between cities in the same country as well as demand between smaller communities in the same region.

Stepwise multiple linear regression analysis was used by Rengaraju and Arasan [23] to develop a demand model that would estimate air travel between cities in India. The average weekly travel in September 1986 was modeled between 40 city pairs. A variety of supply and demand variables were considered as possible predictors of air travel. The supply variables investigated in the analysis included distance between city pairs and the availability of flights or service frequency. Airfare was omitted from the study as it was highly correlated with trip distance. "Logical content and availability of predictable data" [24] dictated the selection of demand variables in the investigation. In total, 6 socioeconomic factors were chosen including population, number of households, the percentage of literacy, migrants, employees, and university degreeholders. To formulate the demand variables between cities *i* and *j*, each socioeconomic variable was combined and represented in four different functional forms: (1) $X_i + X_j$; (2) X_iX_j; (3) X_i/X_j; and (4) $1/x_i + 1/x_j$. The form chosen for further analysis was the "functional form that produced maximum correlation with the dependent variable." [25]

Two additional independent variables were included in the analysis. The first variable, a travel-time ratio, compared the time incurred travelling by rail versus the time expended using air transportation. The second variable, known as the big-city proximity factor, isolated communities with large urban centres nearby using a series of dummy variables.

According to regression statistics, population (t=10.039), the big-city proximity factor (t=4.511), frequency of service (t=4.506), percentage of employees (t=3.851), distance (t=10.039), percentage of university degreeholders (t=2.801), and the travel-time ratio (t=2.073) explained 95.2% (R^2 = 0.952) of the variation in air travel demand. Using these parameters, it was estimated that air travel demand in 2001 would be 2.83 times greater than the total air travel in 1986 assuming the frequency of airline service was increased by 50% between the 40 city pairs used in the study.

Another example of air trip forecasting between city-pairs was performed by Ghobrial and Kanafani [26]. In this research, regression analysis was used to estimate air passenger demand between various city pairs in the United States. A model was developed that related the origin and destination demand between city pairs to city-specific socioeconomic characteristics and transport supply variables. Population and per-capita income were selected to represent the socioeconomic characteristics of passengers while the supply variables included airfare, travel time, city-specific variables, and level of service parameters including aircraft size and the number of flights. City-specific variables were included in the analysis to "represent those unspecified attributes of some markets that affect the demand for air travel." [27] A tourist-market dummy variable was used for example, to account for those centres which were resort areas such as Orlando, Florida and Las Vegas, Nevada. The attractiveness of these cities were considered to increase the demand for travel. Conversely, a congested-hub variable was used to account for lost traffic at capacity-constrained airports such as La Guardia and O'Hare, due to the inconvenience of travelling from these airports.

Regression analysis was performed on a series of variables and statistics were calculated including the coefficient of least squares and coefficient t-statistics. Although the model explained only 50% of the variation in data (R^2 = 0.50), results suggested that air passenger demand was highly dependent on the frequency of flights, travel time and airfare. Furthermore, passengers preferred larger jet aircraft because travel time was reduced.

Estimating scheduled passenger service in small communities (population < 200,000) was the focus of research developed by Kaemmerle [28]. In the research described in this paper, social, economic, and geographical data were collected for 260 small communities across the United States in 1985. Specifically, the following parameters were included in the analysis: population, income, labor force characteristics, economic base, geographic location, departures, air fare per mile, driving distance to an alternative airport, air service characteristics, and the attractiveness of driving to an alternative airport.

Two models were developed using multiple regression analysis in order to estimate passenger enplanements. The first model included only community characteristics and subsequently described 46% of the variation in the data. Conversely, 80% of the variation was explained by the second model which considered community and air service characteristics in the analysis. The variables that were determined to be significant in the second model included income (t=17.76), attractiveness of driving to an alternative airport (t=4.32), number of weekly flights (t=14.17), size of aircraft (t=12.44), and a measure indicating whether the community airport was a hub (t=3.88). This model was used to estimate air passenger travel in 2000 between 52 airport links in the state of Texas.

The majority of forecasting examples collected during the review of literature focussed on air travel in an assortment of countries. Although these samples have provided invaluable information on the subject matter, examples that consider passenger travel in Canada would be beneficial. Unfortunately, the search was unable to find many models of such description. Transport Canada and Statistics Canada have produced forecasts on a national level but research in local travel is limited.

In 1969, the Atlantic Provinces Air Transportation Study was conducted for the Department of Transportation of the Canadian Federal Government [29]. The study investigated the interaction and competition of air passenger travel in the Atlantic Region as compared to passenger travel by other means. A component of the research involved collecting data over a one-year period in order to develop models for forecasting purposes. Following model calibration, air passenger trips were estimated for the years 1975, 1980, 1985 and 1990.

Using multiple regression techniques, a linear model was produced that estimated total air trips originating at 32 different airports throughout the Atlantic Provinces. The explanatory portion of the trip generation model consisted of three variables: population ($t=3.726$), disposable income ($t=5.395$), and a dummy variable to compensate for the variation in trip generation rates between airports ($t=4.156$). These variables were able to explain 99.6% ($R^2 = 0.996$) of the data variation.

An exponential model was also developed as part of the APATS study to estimate total one way annual trips generated on links between the airports. In this model, demographic, economic, and other social characteristics of cities were included in the analysis. Specifically, node population (t=4.115 for node *i*; t=21.135 for node *j*), disposable income (t=2.857), out of pocket trip costs for air travel (t=5.693), and incremental costs of an automobile trip between airports *i* and *j* (t=13.381) were determined to be statistically significant following the regression of data. The multiple correlation coefficient (R^2) of the exponential model was calculated as 0.868 or 86.8%

The process of selecting appropriate variables for modeling purposes is a difficult task. A literature review is often an effective means of identifying variables that are relevant to professionals in the industry. Based on the examples identified in this literature search, a variety of independent variables have been statistically proven to influence the number of air passenger trips generated at an airport. In fact, it appears that approximately 5 key independent variables provide a starting point for most air trip models. Specifically, the following parameters will be used, in the research for this thesis, for the purposes of estimating passenger traffic in the Atlantic Provinces: population, income, employment, airfare and various levels of service measures.

CHAPTER 4 REGRESSION ANALYSIS THEORY

In laboratory experiments, it is possible to measure the response of one variable by altering another. However, the ability to analyze variable interaction in a controlled setting is often difficult or impractical for many projects. In such circumstances, statistics can be applied to estimate the response or dependent variable based on the knowledge of a set of variables that are considered independent from one another. Models that relate a dependent variable "y" to a series of independent variables "x_1, x_2,...,x_k," are known as regression models. [30]

To understand the process in which a model is developed using regression analysis, consider the following scatter diagram:

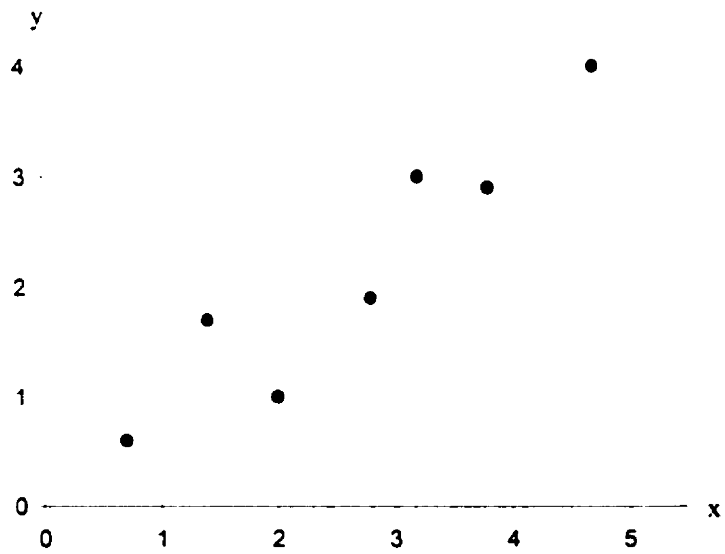


Figure 2: Scatter Diagram of Points

Under ideal conditions, a simple linear relationship between a dependent and an independent variable can be established if the value of y increases at the same rate as the x variable. However, such conditions are somewhat unrealistic in every day life. Most relationships are not perfectly linear and when plotted, the points often resemble the graph illustrated in Figure 2. A straight line however, can be drawn through the data in Figure 2 yet some of the points will deviate from the line (Figure 3). Furthermore, the deviation between line and points will vary depending on the orientation of the line.

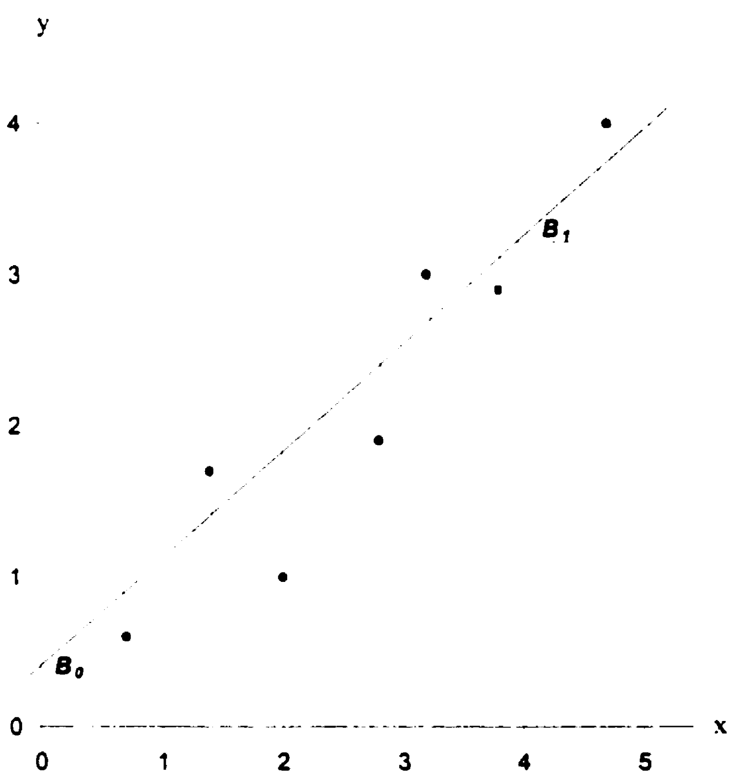


Figure 3: Deviation of Points About a Line

The key to determining the most suitable or "best-fitting" line through a set of data relies on minimizing the sum of the vertical deviation or error about the line. Regression analysis determines the best-fit line using a method of least squares adjustment. As the title suggests, a least squares analysis mathematically determines the line in which the sum of the deviations is a minimum. The intercept (β_0) and slope (β_1) that minimize the sum of squares of the deviations or sum of squares for error are known as the least squares estimates. The equation,

$$E(y) = \beta_0 + \beta_1 x + \varepsilon$$

Eqn. 1

resulting from least squares analysis is often referred as the line of means, least squares line, or regression equation.

To this point, discussion of regression analysis has focussed on establishing a relationship between a response variable and a single independent variable. However, the least squares procedure can also be applied to a set of data that includes multiple independent variables. Specifically, multiple regression fits an equation that "predicts one variable (the dependent variable, Y) from two or more independent (X) variables" [31] as illustrated by the following equation:

$$E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k + \varepsilon$$

Eqn. 2

The most common form of multiple regression is multiple linear regression; however, some relationships between X and Y variables may be nonlinear. In these circumstances, a transformation of one or more X variables may be required or the data could be better described using a higher order model rather than the typical first-order model.

As discussed earlier, estimates of the unknown parameters β_0 and β_1 are required in order to fit a simple linear regression model to a set of data. However, the ability to produce valid least squares estimates rely on the distribution of points or random error about the line of means. The random error component must obey a series of assumptions. Specifically, the following ordinary least squares (OLS) assumptions form the foundation to regression analysis theory.

1. For all forms of independent variables, the variance of E is constant (termed *homoscedasticity*).
2. The probability distribution of points about the line of means is normal (*normality*).
3. Outliers do not exist in the dataset.
4. The random errors are independent or not serially correlated (*nonautocorrelation*).

(Source: Statistics for Engineering and the Sciences, 1992)

It is important that each assumption be carefully examined once a regression model has been developed. Certain tests can be performed to determine if the model violates any of the regression assumptions. If violation does occur, the data can sometimes be transformed by various means. The appropriate tests for OLS assumptions and the transformation methods to satisfy these assumptions will be discussed later in this thesis.

CHAPTER 5 STUDY AREA AND VARIABLE SELECTION

5.1 Study Area

The process of defining a study area is an important step during the preliminary stages of model development. In fact, defining a boundary in which the research will focus should occur before suitable variables are selected for modeling. Establishing a study area is often difficult to perform and the procedure requires a well-developed understanding of the research objectives. A factor to consider when defining a boundary is the characteristics of the target population residing within the study area. Specifically, the study area should include a population which has common or homogeneous characteristics throughout.

For the purpose of this thesis, the study area encompassed the four Atlantic Provinces of Canada. The provinces of New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland and Labrador were further sub-divided into zones to facilitate the collection and analysis of data required in this study. These zones were established based on the geographical areas serviced by airports in the region. The population living within each geographical area is considered to be the user of the facility and the area influenced by the airport is commonly referred as an airport catchment area. Unfortunately, an airport catchment area is often difficult to define and somewhat subjective in nature. These areas are typically best determined by surveying passengers and discussing travel trends with air transportation officials. In the interest of time, the catchment areas presented in this thesis were based on extensive research of Atlantic Canada airport catchment areas conducted in the 1969 APATS study (32). Slight modifications to the APATS zones were performed for this thesis as air passenger travel has changed over the past 30 years. These changes were derived based on discussions with transportation experts.

In Atlantic Canada, a number of airports exist that provide air passenger service within the province, the Atlantic Region, and markets across the country. Given the number of airports in the region and the difficulty involved with estimating passenger travel at small airports, only certain airports were selected for study. Specifically, airports that recorded serving more than 50,000 passengers (origin + destination) in 1996 were used in this thesis. The following nine airports were selected as the service point of each catchment area defined in the study: St. John's, Deer Lake/Stephenville, and Gander in Newfoundland; Sydney and Halifax in Nova Scotia; Moncton, Saint John, and Fredericton in New Brunswick; and Charlottetown in Prince Edward Island. It is important to note that Deer Lake and Stephenville airports were combined as they are geographically located quite close to one another and both provide air service to the population living in Western Newfoundland.

The nine airports selected for analysis are graphically displayed in Figures 4a and 4b together with their corresponding catchment areas. Table 1 lists the study airports and the names of the census divisions included in each catchment area. As one can see in Figure 4, the perimeters of most catchment areas follow the boundaries that divide each province into county divisions. It is important to recognize however that some catchment

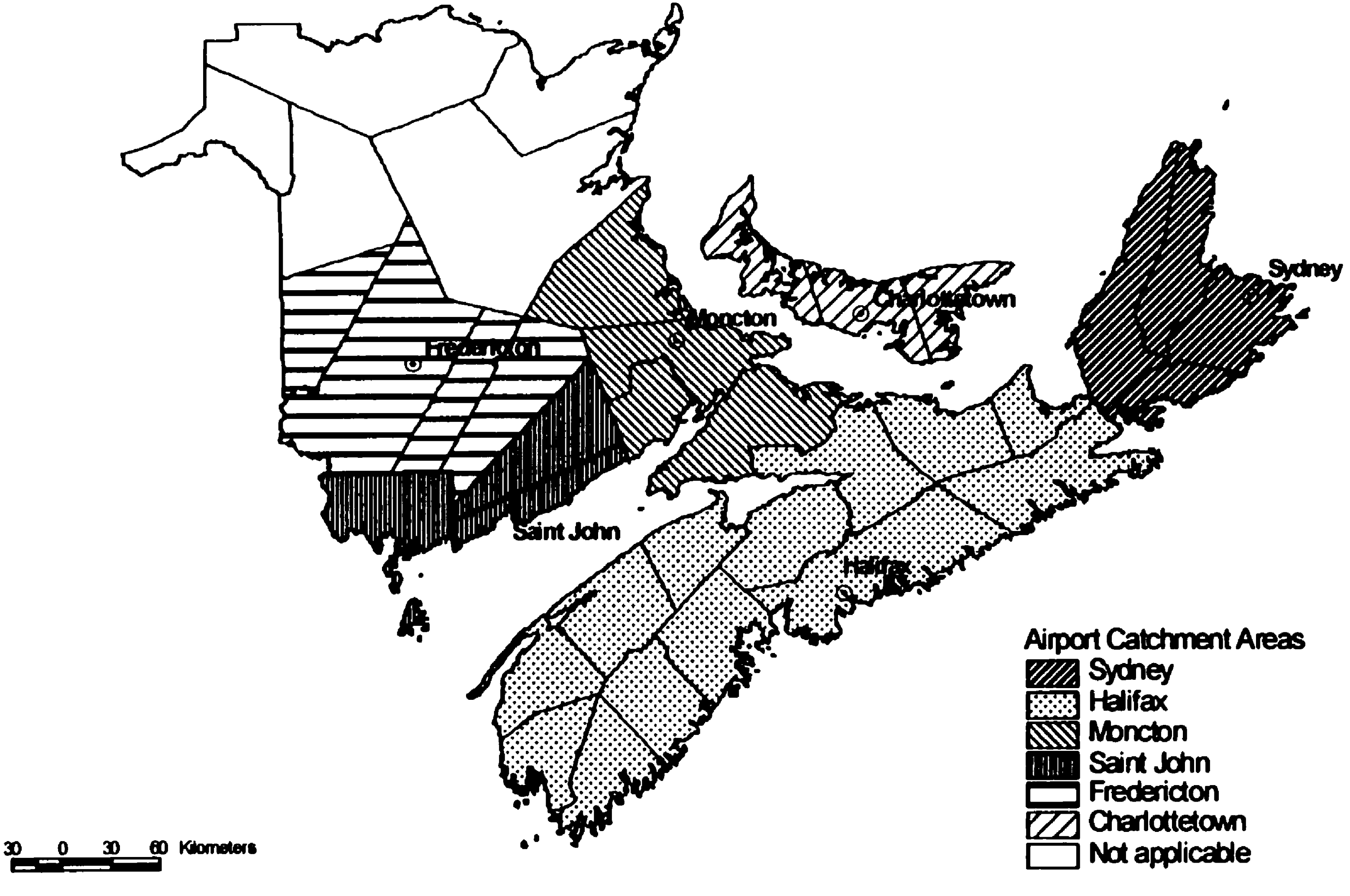


Figure 4a: Airport Catchment Areas for the Maritime Provinces

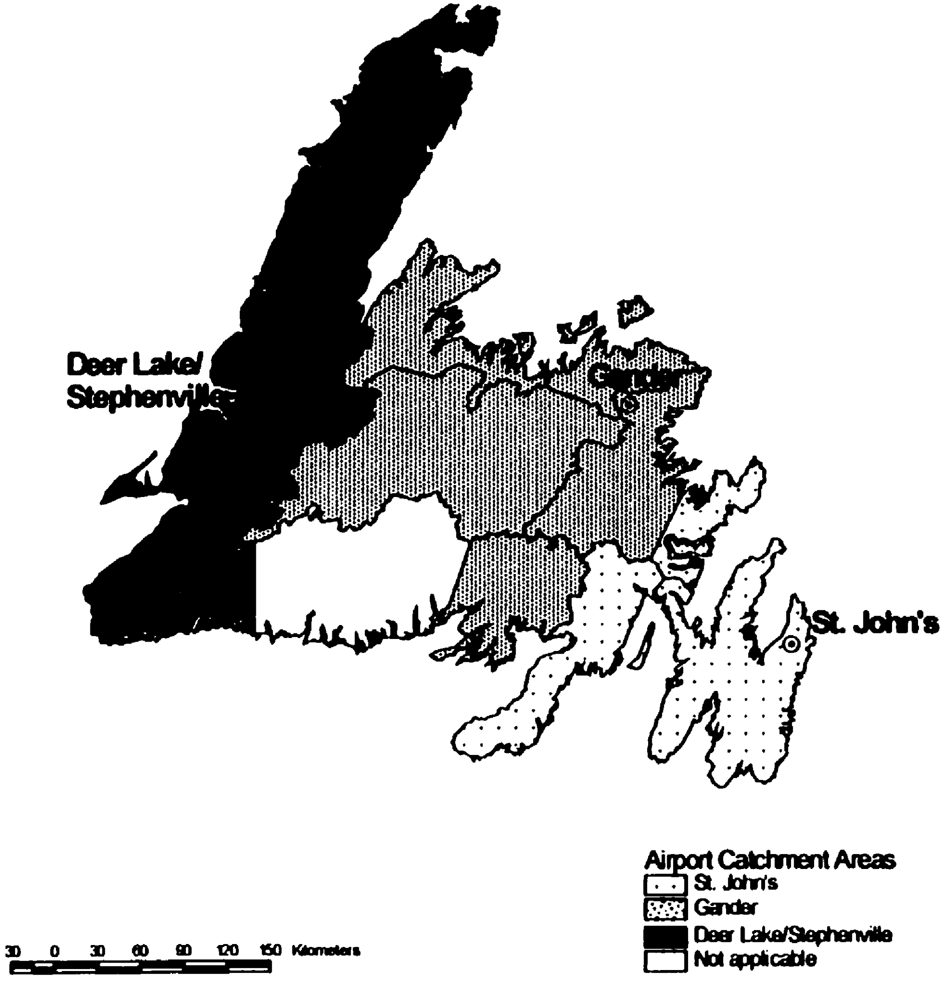


Figure 4b: Airport Catchment Areas for Newfoundland

boundaries deviate from county lines. The Deer Lake/Stephenville and Gander catchment areas include only a portion of Division 3 while St. John's catchment includes a component of Division 7. These Newfoundland counties have been divided into sections based on the availability and orientation of access roads to airports. In areas where counties have been divided, socioeconomic data has been collected according to census subdivision (CSD).

Table 1: Airport Catchment Areas Investigated in the Research

Airport	Census Divisions Included in Airport Catchment Area
St. John's	Division 1, Division 2, Division 7 (CSDs: Subd M, Subd K, Clarenville, Trinity Bay, Port Rexton, Little Catalina, Elliston, Catalina, Bonavista, Subd G, Keels, Duntara, King's Cove, Subd F, Musgravetown, Port Blandford)
Gander	Division 6, Division 8, Division 7 (All communites except for those included in St. John's catchment area), Division 3 (CSDs: St. Jacques, Belleoram, Pools Cove, Harbour Breton, Seal Cove, Hermitage, Milltown, St. Alban's)
Deer Lake/Stephenville	Division 4, Division 5, Division 9, Division 3 (CSDs: Burgeo, Subd H, Isle Aux Morts, Burnt Islands, Port Aux Basque, Subd J, Rose Blanche), Division 6 (CSD: Buchans)
Sydney	Inverness, Richmond, Cape Breton, Victoria
Halifax	Shelburne, Yarmouth, Digby, Queens, Annapolis, Lunenburg, Kings, Hants, Halifax, Colchester, Pictou, Guysborough, Antigonish
Moncton	Albert, Westmorland, Kent, Cumberland
Saint John	Saint John, Charlotte, Kings
Fredericton	Sunbury, Queens, York, Carleton
Charlottetown	Kings, Queens, Prince

To model air passenger travel within the Atlantic Region, it is necessary to include data from specific airport catchment areas outside the study area. Based on statistics and flight information for regional and national air carriers, it was determined that passengers originating in the Atlantic Provinces primarily travel outside the study area to the domestic destinations of Montreal (Dorval Airport only), Ottawa, and Toronto (Pearson Airport only). Since it is difficult to define the catchment areas of these three large airports in terms of counties/census sub-divisions, socioeconomic data were collected based on census metropolitan areas. It is important to note that information pertaining to these airports will only be incorporated in the development of the link estimation model.

5.2 Evaluation of Independent Variables Used in Literature

The process of selecting appropriate variables for modeling purposes is a difficult task. In any forecasting effort, it seems that an endless list of variables could be collected for analysis. A review of the literature is often an effective means of focussing the variable selection procedure and providing a starting point for an inexperienced analyst. More importantly, the search helps identify variables, for example, that are considered relevant to professionals in the industry. However, it is important that the project focus is clearly defined prior to beginning the literature search. Furthermore, the analyst should have a reasonable understanding of the marketplace under investigation. A clearly defined scope and knowledge of the industry will simplify and speed up the variable selection procedure.

A literature review identified a broad spectrum of variables that were proven to be statistically significant at predicting air passenger trips. Over 20 different independent variables, for example, influenced the outcome of the response variable in the models described in Chapter 3. Each parameter observed during the search was evaluated in order to determine its suitability for the research undertaken in preparing this thesis. A series of variables were selected for analysis based on their applicability to the thesis and whether the variable was appropriate given the conditions of the marketplace in Atlantic Canada. In total, 6 variables were chosen for further analysis including population, disposable income, employment, airfare, level of service, and the distance between origin and destination. Additional variables from the review were considered, however, they were deemed irrelevant and removed from the study. Table 2 lists the variables collected during the literature review which were omitted from the research. The table also explains why the parameter was removed.

Table 2: Variables Omitted from the Selection Procedure and Reasons for Removal.

Omitted Variable	Reason for Removal
Car Ownership	Not practical since vehicle ownership data is not available by Census divisions.
Airport Located in Tourist Area	The entire Atlantic Region is considered a tourist market.
Number of Households	Information can be captured by using population.
Charter Flights	Very few charter flights available in Atlantic Canada at time of data collection.

5.3 Independent Variables Selected for Further Analysis

Following an evaluation of numerous parameters and the elimination of some, six variables were chosen for consideration for model development in this research. These included population, disposable income, employment, airfare, level of service, and distance. These variables should provide a reasonable foundation for analysis. However, the search for independent variables should not only be limited to a review of previous research. While a literature search is a necessary step in model development, additional variables should be included in the analysis. That is, the selection procedure should take into consideration variables that are relevant to the market in which the forecast model is being designed.

In Atlantic Canada, transportation to and from the island of Newfoundland is somewhat problematic. If passenger travel to/from a neighbouring province is necessary, transportation is only available using air or combined road/marine modes. Since ferry travel tends to be time consuming and somewhat inconvenient, air travel receives greater attention. Conversely, air transportation to nearby provinces on the mainland does not receive the same amount of attention because other methods of travel are available such as automobile, bus, or limited train service. As a result, an isolation factor or a dummy variable of 1 will be assigned to each airport located on the island of Newfoundland. A factor of 0 will be assigned to the remaining airports investigated in the research.

One of the interesting conditions of the air passenger market presented in this research is the varying size of airports located within the study area. Airports located in Halifax and St. John's for example are considerably larger in physical size than the remaining Atlantic airports, and as a result these facilities can accommodate greater volumes of passengers. A dummy variable will therefore be used in the research to account for airports that receive high levels of origin passenger trips per capita. Specifically, a dummy variable of 1 will be assigned to those airports that experience traffic volumes greater than the average number of origin trips per capita calculated for the study area.

Conversely, airports that receive traffic levels less than the average will be assigned a dummy variable of 0.

Airline service to airports located within the study area provide access to regional and domestic destinations. International flights are also available at Halifax and St. John's airports, and on a limited basis at Gander airport. These airports therefore receive passenger traffic above the levels experienced by the remaining study airports because of the availability of service abroad. A dummy variable will be used in the analysis to separate the three airports that offer scheduled international service in Atlantic Canada. The same approach will be used for Montreal, Ottawa and Toronto airports.

Canada's airline route network is based on a hub and spoke system where passengers are collected along local routes or spokes and carried to larger airports called hubs. A variety of aircraft feed into hub airports offering passengers an endless selection of destinations. In Atlantic Canada, some inter and intra provincial traffic travels through Halifax International Airport. As a result, the flow of passengers at Halifax is higher than other Atlantic airports. To account for passenger traffic levels at hub airports, a dummy variable will be incorporated in the research. A value of 1 will be assigned to Halifax airport, as well as Montreal and Toronto, as they are considered hubs. The remaining spoke airports will receive a value of 0.

An analyst should tailor the variable selection process to the region in which the forecasting is being performed by including site specific variables. Once a list of independent parameters has been established that satisfies the research objectives and the interests of the analyst, data collection can begin.

CHAPTER 6 DATA COLLECTION

For forecasting purposes, data can be collected in a variety of ways. The two most widely used techniques are through surveys or compiling information from publications. The method by which the information is compiled largely depends on such factors as the variables selected, the resources of the analyst, and the amount of time available. Although the parameters selected for analysis in this research were easily defined, time and financial resources were limited. Therefore, the data pertaining to the response and explanatory variables were collected from publications.

The following sub section examines the dependent and independent variables that form the foundation of the forecasting research presented in this thesis. The response or independent variable, air passenger trips, will first be defined and the source from which these data were collected will be described. Each of the following explanatory variables selected from the review of literature will then be discussed: population, disposable income, sector employment, level of service, airfare, and distance.

6.1 Response Variable

Statistics Canada produces a number of publications that summarize passenger travel within the air transportation sector. Since the research presented in this thesis focused on estimating passenger flow originating from an airport, one source in particular, "Air Passenger Origin and Destination, Domestic Report", provided data suitable for forecasting purposes. (35) The publication also lists passenger volumes on catchment and link levels. Data presented in this fashion simplified the data collection process because only one data source was required in order to develop databases for the catchment area and link models. It is important to note that Statistics Canada also produces enplaned and deplaned (E/D) passenger statistics. While E/D data includes those passengers beginning their journey at an airport, passengers transferring through an airport from one aircraft to another, are also counted in the statistic. The E/D data is therefore not appropriate for research purposes because transit passenger traffic is not a source of interest in this thesis.

The annual publication "Air Passenger Origin and Destination, Domestic Report" displays origin and destination (O/D) data based on a 10% sample of coupons having a serial number ending in '0'. Statistics Canada collects the coupons from airlines providing scheduled service to airports during the survey year. The flight information listed on the coupons and each airline route is processed and separated according to its directional origin and destination. For example, a round trip ticket between Moncton and Toronto would be separated into 2 directional origin and destinations. The computer program processing the ticket would classify Moncton as the origin and Toronto as the destination for the flight from Moncton to Toronto. Conversely, Toronto would be considered as the origin and Moncton the destination for the return flight.

It is important to note that the research focused only on air passenger flights provided by scheduled services. Travel by charter airlines was omitted from the study because charter service is limited in the Atlantic Provinces. Furthermore, the process of forecasting air passenger travel by charter service is unique and should therefore be treated separately from estimates of travel by scheduled airlines. (34)

Passenger data from the 1996 O/D publication were collected for the catchment area generation model. Specifically, total origin passengers or the total number of outbound passengers departing from an airport were recorded. Appendix A lists the total passenger trips generated from each airport catchment area investigated in the research.

While the catchment area model focused on the generation of trips from an airport, the link estimation model investigated the distribution of trips from an airport along a series of links. A link is commonly defined as a route bounded by an origin and destination node. Air service between Fredericton and Halifax for example, would be considered one link where Fredericton is the origin and Halifax is the destination. In total, 124 links were established for modeling purposes which included routes between the 9 Atlantic airports illustrated in Figures 4a and 4b as well as links connecting the Atlantic airports to Montreal, Ottawa and Toronto airports. Passenger flow along each of the links listed in Table 3 were collected from the O/D report and the link flows are presented in Appendix A.

Unfortunately, two weaknesses exist with the origin and destination survey that could influence forecasting accuracy. Firstly, the data contained in this publication are not exact estimates of air passenger trips along links. As described earlier, the origin and

Table 3: Airport Links Established for the Link Estimation Model

Origin Airport	Destination Airport	Origin Airport	Destination Airport
St. John's	Gander	Saint John	St. John's
	Deer Lake/Stephenville		Gander
	Sydney		Deer Lake/Stephenville
	Halifax		Sydney
	Moncton		Halifax
	Saint John		Charlottetown
	Fredericton		Montreal
	Charlottetown		Ottawa
	Montreal		Toronto
	Ottawa	Fredericton	St. John's
	Toronto		Gander
Gander	St. John's		Deer Lake/Stephenville
	Deer Lake/Stephenville		Sydney
	Sydney		Halifax
	Halifax		Charlottetown
	Moncton		Montreal
	Saint John		Ottawa
	Fredericton		Toronto
	Charlottetown	Charlottetown	St. John's
	Montreal		Gander
	Ottawa		Deer Lake/Stephenville
	Toronto		Sydney
Deer Lake/ Stephenville	St. John's		Halifax
	Gander		Saint John
	Sydney		Fredericton
	Halifax		Montreal
	Moncton		Ottawa
	Saint John		Toronto
	Fredericton	Montreal	St. John's
	Charlottetown		Gander
	Montreal		Deer Lake/Stephenville
	Ottawa		Sydney
	Toronto		Halifax
Sydney	St. John's		Moncton
	Gander		Saint John
	Deer Lake/Stephenville		Fredericton
	Halifax		Charlottetown

	Moncton		Ottawa
	Saint John		Toronto
Sydney	Fredericton	Ottawa	St. John's
	Charlottetown		Gander
	Montreal		Deer Lake/Stephenville
	Ottawa		Sydney
	Toronto		Halifax
Halifax	St. John's		Moncton
	Gander		Saint John
	Deer Lake/Stephenville		Fredericton
	Sydney		Charlottetown
	Moncton		Montreal
	Saint John		Toronto
	Fredericton	Toronto	St. John's
	Charlottetown		Gander
	Montreal		Deer Lake/Stephenville
	Ottawa		Sydney
	Toronto		Halifax
Moncton	St. John's		Moncton
	Gander		Saint John
	Deer Lake/Stephenville		Fredericton
	Sydney		Charlottetown
	Halifax		Montreal
	Montreal		Ottawa
	Ottawa		
	Toronto		

destination numbers are a series of estimates based on a random sample of airline tickets. Though many of the estimates are reliable for links with high traffic volumes (> 100,000 passengers), the accuracy decreases as the volume along the link decreases. Since traffic flow is low to moderate along most routes in Atlantic Canada, the reliability of these estimates should be considered.

The second weakness of the origin and destination data is that the values contained in the document are based on a survey where the response is not mandatory. In Newfoundland for example, Air Labrador provides service to many regions along the coast. This carrier has decided not to participate in the survey conducted by Statistics Canada and as a result, a portion of air passenger trips within Newfoundland is missing from the publication. Such an issue is important to consider when evaluating model accuracy however, in this case passenger volumes carried by the non-participatory carriers are low and catchment/link flows would only be marginally affected if these passengers were included in the analysis.

6.2 Explanatory Variables

Most air passenger forecast models developed by/for the industry attempt to relate the response variable to a series of explanatory variables. Each independent variable can be typically categorized as a demographic characteristic or a transport supply variable. In this research, the following variables were selected as demographic characteristics of the study area: population, disposable income, and employment. Conversely, level of service, airfare, and distance were chosen as transport supply variables or parameters that influence the demand for air transportation. Each variable is examined more closely in the following section including a description of each data source.

6.2.1 Demographic Characteristics

In order to collect demographic data, a study area is often used to define a target population. In chapter 5, the Atlantic Region was identified as the overall region on which this thesis would focus. The chapter also introduced another level of study known as airport catchment areas which were composed of counties and census sub divisions.

Establishing airport catchment areas was somewhat subjective, however the process provided a means of identifying a homogeneous group of people interested in using the facility. In Figure 4a for example, it was determined that the Saint John airport catchment area would be extended to include the populations residing in Charlotte, Saint John and Kings counties. The catchment area boundary was therefore drawn around the county lines of these three counties. Demographic data for Saint John catchment area was determined by adding demographic totals from these three counties together. Counties and sub divisions were selected as the level of aggregation for research purposes because demographic data was easier to collect and more readily available at this level compared to more detailed aggregation levels such as census tracts or communities.

It is important to note that the catchment areas for Montreal. Ottawa and Toronto airports were not represented in terms of counties or subdivisions. These catchment areas were difficult to approximate at the county/subdivision level therefore metropolitan census areas were used. The population data for Quebec and Ontario as well as Atlantic catchment areas are presented in Appendix B of this thesis. The appendix also displays disposable income and sector employment data.

6.2.1.1 Population

To collect population data for the design year. Census Canada was consulted. The federal government conducts a census in Canada every five years to collect social, demographic and economic data. Two different surveys are distributed to citizens across the country: the "short form" and the "long form". The short form is sent to 100% of the population living in Canada and the purpose of this document is to collect general information such as population and age. The long form is randomly distributed to 20% of the population. As its title suggests, the long form is more detailed than the short form as recipients of the document are asked a series of questions (employment status, income, etc.) beyond the information contained in the short form. Once the data from the long form is collected, the value of each parameter is expanded to represent 100% of the population. The results of both surveys are presented for the census year in a series of documents.

Population data was collected for each county and census subdivision listed in Table 1. Once the information was compiled, the total population of each airport catchment area was determined by adding the population of each county and sub division included in the catchment.

6.2.1.2 Disposable Income

Disposable Income is the net income or the amount of income available for spending after taxes have been removed from the gross salary. Although the definition of this term is somewhat straight forward, disposable income data is challenging to collect because of the difficulty in determining the amount of free or disposable money available for spending. Specifically, each person within a study area may pay different taxes and allocate money towards different investments. As a result, no publication currently exists that expresses disposable income as a single value. A proxy or substitute value for disposable income must therefore be determined.

Each year, Revenue Canada produces a publication that presents income statistics based on the total income taxes filed for that year. (36) The information collected from the income taxes is displayed on a national and provincial level as well as county and census subdivision levels. To determine the amount of disposable income available for each catchment area, data on two parameters were collected for each census division: total income assessed and total taxes paid. To calculate disposable income, the amount of taxes paid by a county was subtracted from the income assessed. To determine the amount of money available in each airport catchment area, individual census division disposable incomes were combined within a catchment area.

In the previous paragraphs of this section, the complexity of defining disposable income and the challenges involved with collecting suitable data were discussed. A component of disposable income that was not addressed which added to the challenge of analyzing this response variable was inflation. Specifically, changes in inflation influence income levels. To adjust or minimize for the affects of inflation, income is typically divided by the Consumer Price Index (CPI). For the purposes of this research, consumer indices (1986=100) were collected from Statistics Canada for the Atlantic Provinces as well as Ontario and Quebec (37). Table 4 lists the provincial consumer price indices used in these calculations. Each disposable income value was adjusted and presented in 1986 dollars by dividing the catchment area value by the CPI for the province in which it was located.

Table 4: Consumer Price Indices for Select Provinces (1986=100)

Province	Consumer Price Index (1986=100)	
	1991	1996
Newfoundland	120.8	129.5
Prince Edward Island	125.9	133.5
Nova Scotia	124.7	132.5
New Brunswick	124.2	131.2
Quebec	126.4	133.1
Ontario	127.6	136.6

The disposable income parameter is an important variable to understand in relation to the airline industry as it provides a sense of the amount of money people have to spend on airline tickets. If an individual has a large amount of disposable income for example, this person would likely have a high propensity to travel because an airline ticket could be more easily purchased. Conversely, airline travel would be difficult for someone with a small amount of disposable income because of the cost involved with purchasing a ticket and the other demands placed on this smaller amount of dollars. Analyzing this issue at a more general level, a linear relationship should therefore exist between the number of air passenger trips generated from a region and the amount of disposable income of the community.

6.2.1.3 Sector Employment

One of the many sections published in the census data is employment. This parameter is based on a 20% sample size that is expanded to represent 100% of the population. The employment section of the census is divided into employment divisions and occupations.

The employment divisions category is composed of 18 different broad classifications that describe the types of industry that a region produces. The industries range from fishing and manufacturing to business and government. The occupation section of employment is more detailed as it lists 47 common occupational classifications found in Canada. Both employment sections provide important information for modeling purposes; however the occupational categories listed in 1996 are different than those in 1991. Since the forecasting models reported in this thesis will be designed using 1996 data and the accuracy of each model will be tested against 1991 data, it is crucial that the data from both years be collected and displayed in a uniform manner. Employment division data were therefore collected as the information was presented in the same fashion between the design and test years.

The airline industry relies heavily on the number of passengers that fly for business purposes. Business organizations are typically willing to pay a higher price for an airline ticket in exchange for flight frequency and efficient service. A passenger flying for personal reasons in contrast, will usually wait until fares are reduced and personal money can be saved. The number of individuals employed in certain industries is therefore an important parameter to determine for airline traffic forecasting. The difficulty in collecting employment data is determining which industries would likely depend on air service for business purposes. To isolate the industry divisions with a high propensity to fly, it was necessary to determine the combination of industries which greatly influenced the number of air passenger trips generated. Data for each employment industry was collected for all counties and expressed in different combinations. Regression analysis was then applied to the different industry totals to determine which combination produced the strongest causal relationship with air passenger trips. Not surprisingly, the analysis determined that business, government, and educational industries most strongly influenced the response of passenger trips. The sector employment variable was therefore defined in this thesis as the total number of people in a catchment area employed in business, government and educational industries.

6.2.2 Transport Supply Variables

The generation of air passenger trips can also be strongly influenced by transport supply variables. Similar to the demographic characteristics, numerous supply variables exist that may affect the response of the dependent variable. For the purposes of this study, three parameters were selected for analysis: level of service, airfare and distance. Fortunately, the data collection process for these variables was not nearly as time consuming as the demographic variables because it was not necessary to compile supply variable data according to census divisions. Furthermore, the transport supply variables were only incorporated in the link estimation model while the demographic characteristics were used in both forecasting models. Level of service, airfare, and distance data for each link investigated in the research are presented in Appendix C.

6.2.2.1 Level of Service

The term, level of service, is a phrase often used to describe the quality or efficiency of a service. In traffic engineering for example, the service level of an intersection indicates how efficient the facility is operating. In the aviation industry, the term can be used in association with the various functions provided by airlines and airports. Unfortunately, when describing the level of service of airlines, this variable is quite complex and difficult to define because of the numerous factors associated with airline travel. In fact, there appears to be no one widely accepted quantifiable means of estimating airline service levels in the industry. The inability to define this variable becomes problematic in airline forecasting because the level of service offered at an airport greatly influences the generation of trips. That is, a passenger's decision to fly will be largely dependent upon factors such as airline frequency, time of departure, and number of stops. To account for the effects of level of service on the generation of airline traffic, many analysts insert dummy variables each representing various service factors. Although this approach is a simple means of accounting for this variable, it does not appear to capture the general sense of level of service. To do this, it is necessary to create a single variable that combines the effects of various service level indicators.

Level of service data was collected from the Official Airline Guide (OAG), an organization which maintains flight schedule information on most airlines around the world. Following numerous discussions with OAG concerning the data required and the markets investigated in the research, service level data were provided by OAG for each flight offered by those carriers serving each of the links listed in Table 3. Specifically, data on the following level of service parameters were compiled: time of departure, number of operations per week. number of stops, aircraft type, and aircraft size measured by the number of available seats on the aircraft. Due to the volume of information available as well as limited resources, data could only be collected for a one-week period in 1991 and 1996. The OAG recommended using the second week in September to represent average service conditions experienced in the industry over the course of the year. September is considered a shoulder season month where airline activity falls between low and high volume seasons.

Once the OAG data for each link was compiled and organized in spreadsheet format, a single level of service variable was calculated. To do this, a service value was calculated for each flight along a link. As discussed in the previous paragraph, 5 fields of data were collected from OAG. To evaluate the level of service for each flight, a numerical measure or rating was assigned to the values contained in the 5 fields. Table 5 lists the rating system used in the research and the corresponding values contained in each field.

As displayed in Table 5, departure time was the first service parameter to be analyzed. Rather than assigning a specific number to each departure time, a single rating was associated with a range of timings. The range of times which were considered more convenient or had greater influence on travel demand (i.e. 5:45 to 9:00 am or 15:30 to 19:30 pm), received a high rating. Conversely, less popular departure times (i.e. 9:00 am to 15:25 pm) were assigned a low value measure.

Table 5: Rating System for LOS Parameters

LOS Parameter	Value	Rating
Departure Time	05:45 to 09:00 09:01 to 15:29 15:30 to 18:30 18:31 to 20:00	2.0 1.0 2.0 1.5
Number of Operations per Week	1 to 2 3 to 5 6 to 7	0.5 1.0 2.0
Number of Stops	0 1 ≥2	2.0 1.5 1.0
Aircraft Type	Turbo Propeller Jet	1.0 2.0
Aircraft Size (Available Seats)	0 to 54 55 to 130 ≥131	1.0 1.5 2.0

The process by which departure times were rated or converted to a numerical measure was repeated for the remaining service level parameters. A single level of service value for each flight was determined by adding together the ratings assigned to departure time, number of operations per week, number of stops, aircraft type and aircraft size. Since multiple flights can occur between origin and destination over a one-week period, the level of service value for each link was calculated by adding the individual flight totals together.

As discussed earlier, the Official Airline Guide provided level of service data based on the 124 links listed in Table 3. It is important to note, however, that OAG only supplied flight information for links which were served by direct flights. Service data between Gander and Moncton, for example, were not included in the OAG file because direct flights were not available during the design year. A link without OAG data indicated that a change of aircraft was required at some point in the itinerary between origin and destination. In total, direct flights were unavailable for 22 links in 1991 and 36 links in 1996. Although data was not available for these itineraries, level of service could be approximated by combining the link service levels calculated before and after the change in aircraft.

One of the difficulties experienced during the procedure outlined in the aforementioned paragraph involved selecting the correct airport where the change in aircraft occurred. Based on airline timetables published by Air Nova and Inter-Canadian, it was assumed that all connecting traffic would occur at Halifax airport for the purpose of this research. The level of service offered between Gander and Moncton, for example, would be determined by combining the service levels calculated for Gander-Halifax and Halifax-Moncton. Since the level of service for connecting flights is less favourable to passengers than direct flights, it was important during research that the service levels for each connecting link was adjusted or penalized. A change in aircraft was considered to be the same as a flight where 2 stops were required along a direct route. According to the rating system outlined in Table 5, such a flight would receive a numerical value of 1. However, it is believed that a change in aircraft should receive greater penalty than a direct flight with 2 stops due to the degree of inconvenience involved with changing aircraft. As such, each flight that required a transfer through Halifax received a rating of 0.5. If a connection plus additional stops were required, the route was also assigned a value of 0.5. The process was repeated for all connecting links in 1996 and 1991.

6.2.2.2 Airfare

Another important variable influencing the flow of passenger traffic along different routes is the cost of air travel. As discussed previously, the issue of ticket cost is important for those travelling for leisure purposes. In some cases, the ticket price is the only factor that influences the decision to fly. Airfare therefore becomes a critical variable when attempting to predict future travel.

Unfortunately, collecting airfare data is somewhat challenging for two reasons. Firstly, it is important that airfare data is obtained from all carriers providing service along a link. Fortunately, only two carriers, Air Canada and Canadian, provided service along most links analyzed during the survey period used in this research.

The other factor that complicates the collection of data on airfares are the numerous fares available for service on a link. Between Moncton and Halifax, for example, Air Canada offers over a year, 50 different fares for one flight ranging from economy to business classes. Canadian Airlines will offer a similar number of airfares for this link. The net result are hundreds of fares for numerous flights which are each difficult to analyze because hidden restrictions and clauses pertaining to when the fare can be offered and who can purchase the ticket are attached.

One-way airfare data was collected from a database maintained by the Canadian Transportation Agency (CTA). The database contains one-way fares offered by each carrier providing airline service in Canada. To reduce the volume of airfare data available and tailor the data collection to the needs of this research, a number of steps were taken. First, it was determined that an average fare value was required for each link. Since an average value is difficult to obtain because of the broad range of fares available, it was recommended by ATAC that a 'Y' fare be used. This class of airfare is considered the standard economy fare that is approximately half way between fares listed in a discount or seat sale and the business class fare. The 'Y' fare does not contain any restrictions and as a result, it is easier to analyze.

The second stage of the data collection phase involved determining an appropriate time of year to collect the fares. Unfortunately, airfares range in price depending on the time of year. During the low volume or dead season (December to February), for example, the cost of airline travel is low while travel in the peak season (June to August) is high. Furthermore, 'Y' fare data could not be collected for each day of the year due to time and resource restrictions. As a result, airfare data was collected over a one-day period four times in 1996. Based on the experience and advice of CTA, 'Y' fares were collected on the third Wednesday during the months of December, April, July and September. The data was compiled according to the carrier providing service on a link.

Once all the data were collected, an average airfare value was determined for each link. This was accomplished by computing the average 'Y' fare for the year based on the data presented in the four seasons. This step was repeated for each airline serving the link and a final airfare value was determined by calculating the average fare between carriers.

6.2.2.3 Distance

The distance between origin and destination is an important variable to consider when travelling. It is a variable that strongly influences the method of travel. In short haul trips (200-300 km) for example, a traveller is more likely to use land transportation, such as automobile or bus, as the primary method of travel. Air travel in these circumstances is not practical given the costs of a ticket compared to the costs incurred with ground transportation. However, for long haul trips (> 300 km), a traveller may not automatically choose the automobile for transportation. Therefore, as the distance between origin and destination increases, a traveller will more likely choose air service as the primary means of transportation due to the convenience of air travel and the time saved. As such, distance is an important variable to include in air passenger forecasting because it serves as an indicator of competition.

The distances between each origin and destination investigated in this thesis were collected and the values are presented in Appendix C. It is important to note that the figures listed in the appendix are not straight-line distances. Rather, the values listed in Appendix C are called Great Circle distances and these values are considered the shortest earth surface distance between airports. In the interests of time, each distance was determined using a computer program available on the internet. (38)

CHAPTER 7 MODEL DEVELOPMENT

7.1 Analysis of Independent Variables

Prior to performing regression analysis on the data, a series of scatter plots were produced where each demographic and transport supply variable were plotted against air passenger trips. The graphical analysis of variables is an important step in model development, particularly when using regression analysis, because it helps identify relationships that may not be evident by examining the data in tabular form. The tabular data for example, may, suggest a linear relationship between the response and explanatory variable. However, when the two parameters are plotted against one another, it may be determined that the relationship is quadratic. If the relationship was not identified and regression analysis was performed on the original data, unfavourable statistics may have resulted when in fact a significant relationship may have existed if the independent parameter was transformed.

The demographic data for the catchment area generation model were first individually plotted against air passenger trips. All 3 graphs were approximately linear and no apparent data transformation was required.

The demographic data for the link estimation model were then tested against air passenger trips. The origin/destination population was the first variable tested. According to Figures 5a and 5b, a linear relationship was not observed between the independent values and the response parameter. Rather, the origin and destination

Figure 5a: Scatter Plot of Air Passenger Trips versus Origin Population

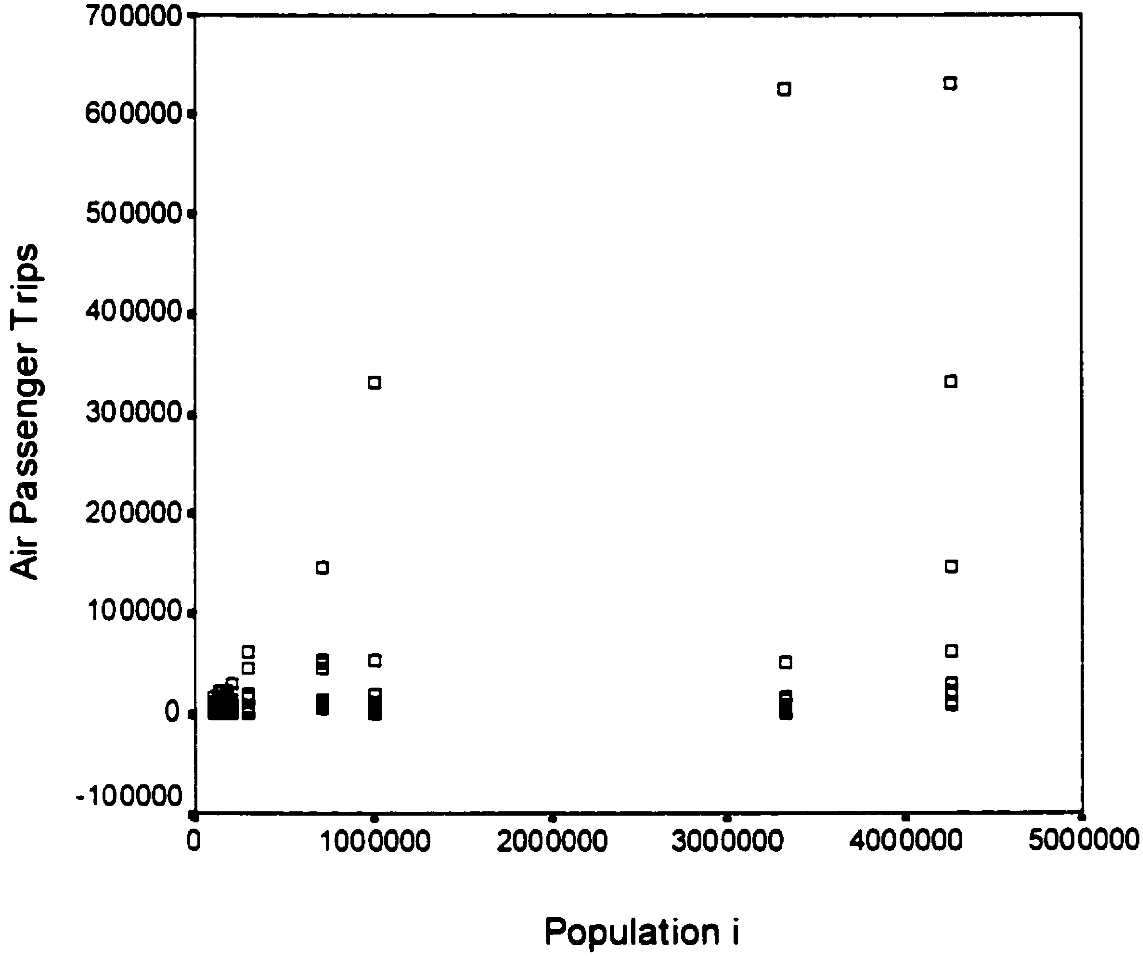
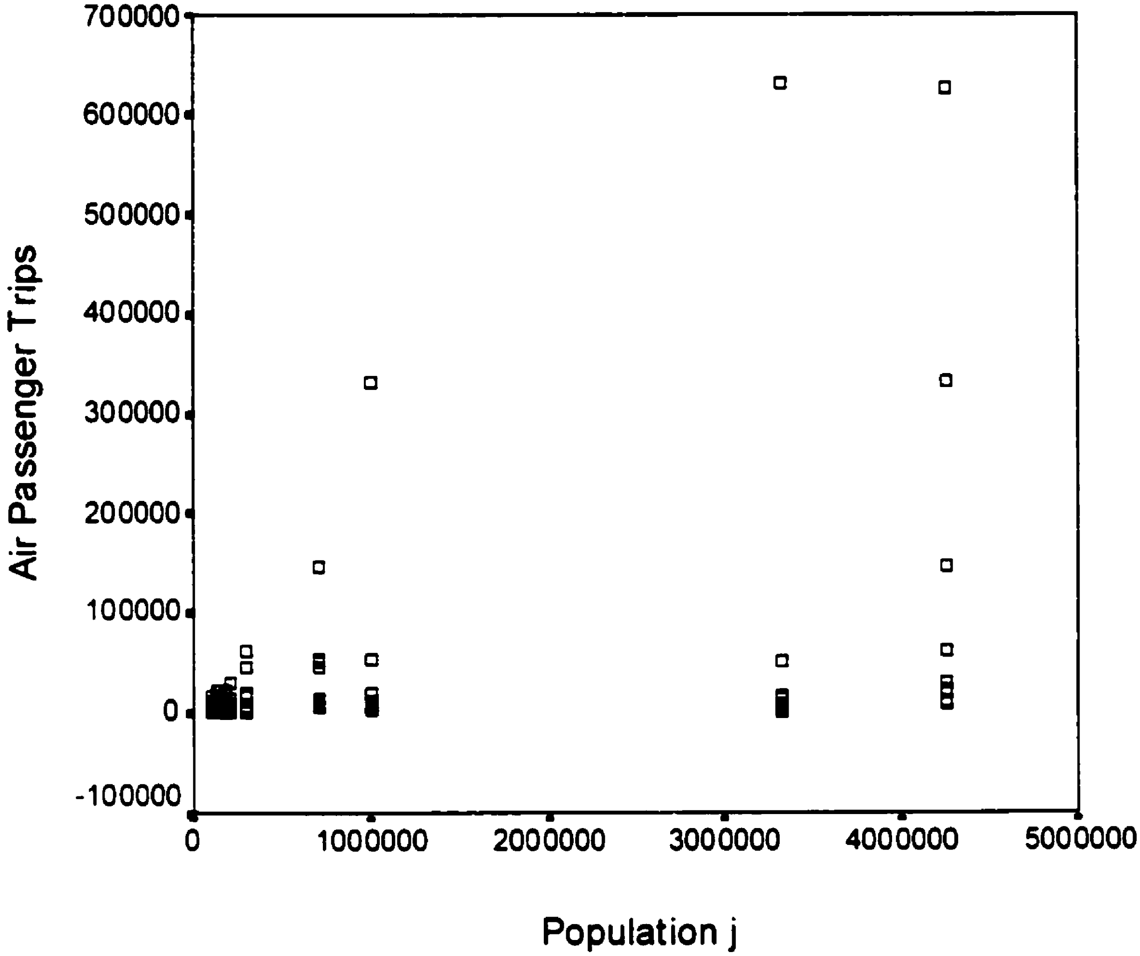


Figure 5b: Scatter Plot of Air Passenger Trips versus Destination Population



population each produced a wedge-shaped fan pattern indicating that the variance in y increased as x increased. (39) A relationship of this nature suggests that a logarithmic transformation of the independent parameter is useful. The x and y variables were therefore transformed and displayed in graphical form. As indicated by Figures 6a and 6b, the points did not form a perfectly straight line however; a positive sloping cluster of points was visible and a linear regression line could be fitted.

The disposable income and sector employment variables for the origin and destination catchment area were then tested. A wedge pattern was observed in the graphs similar to Figures 5a and 5b. The variables were therefore logarithmically transformed and a linear relationship resulted. For modeling purposes, air passenger trips, origin population, destination population, origin disposable income, destination disposable income, origin sector employment, and destination sector employment were all presented in logarithmic form.

The transport supply variables were the last set of parameters to be analyzed graphically. Since it was determined that air passenger trip data would be presented logarithmically in the link estimation model, each supply variable was plotted against the natural logarithm of air passenger trips. The graphs revealed no apparent relationship. That is, it was difficult to determine if the distance variable in Figure 7 for example, required a transformation. As a result, the distance, airfare and level of service variables were left unchanged for modeling purposes. However, based on the initial literature review conducted for this thesis, it was observed that most variables presented in link estimation

Figure 6a: Scatter Plot of ln(Air Passenger Trips) versus ln(Origin Population)

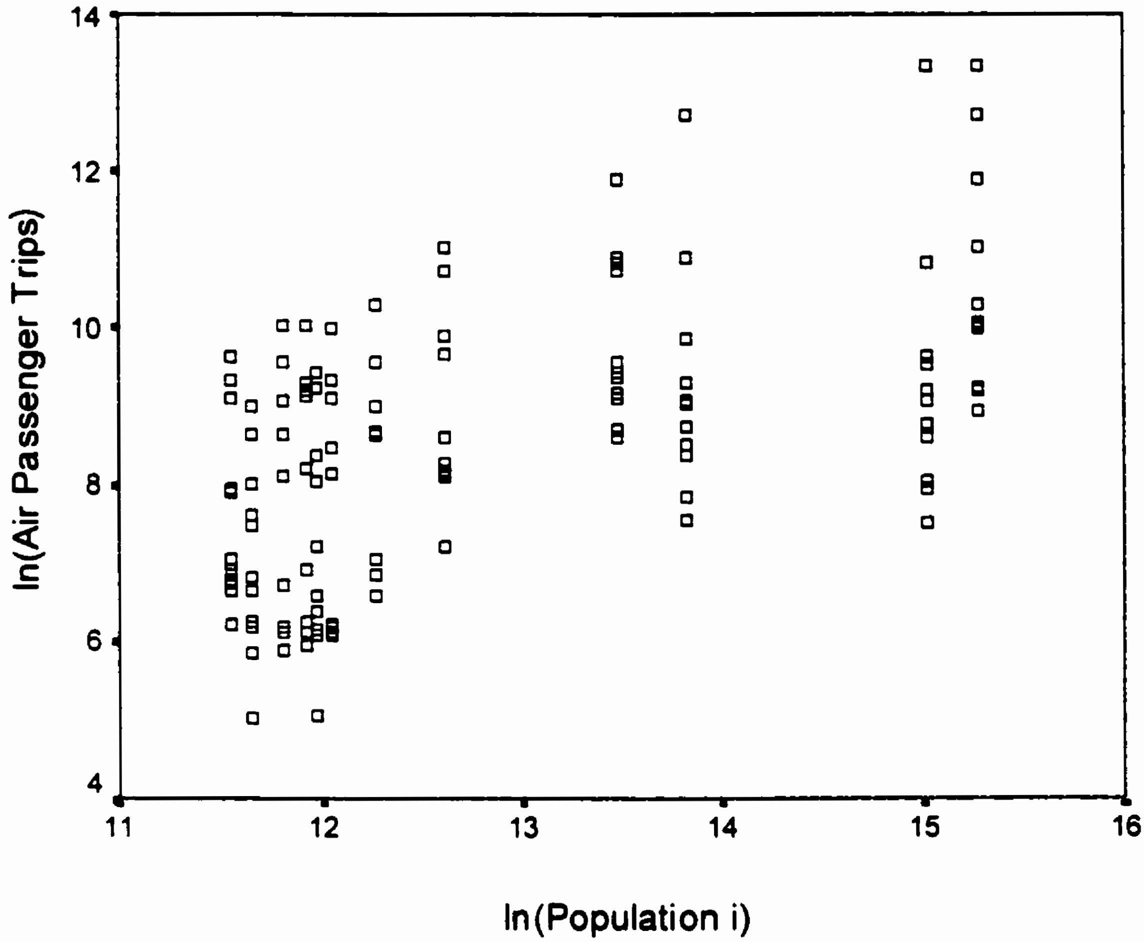


Figure 6b: Scatter Plot of ln(Air Passenger Trips) versus ln(Destination Population)

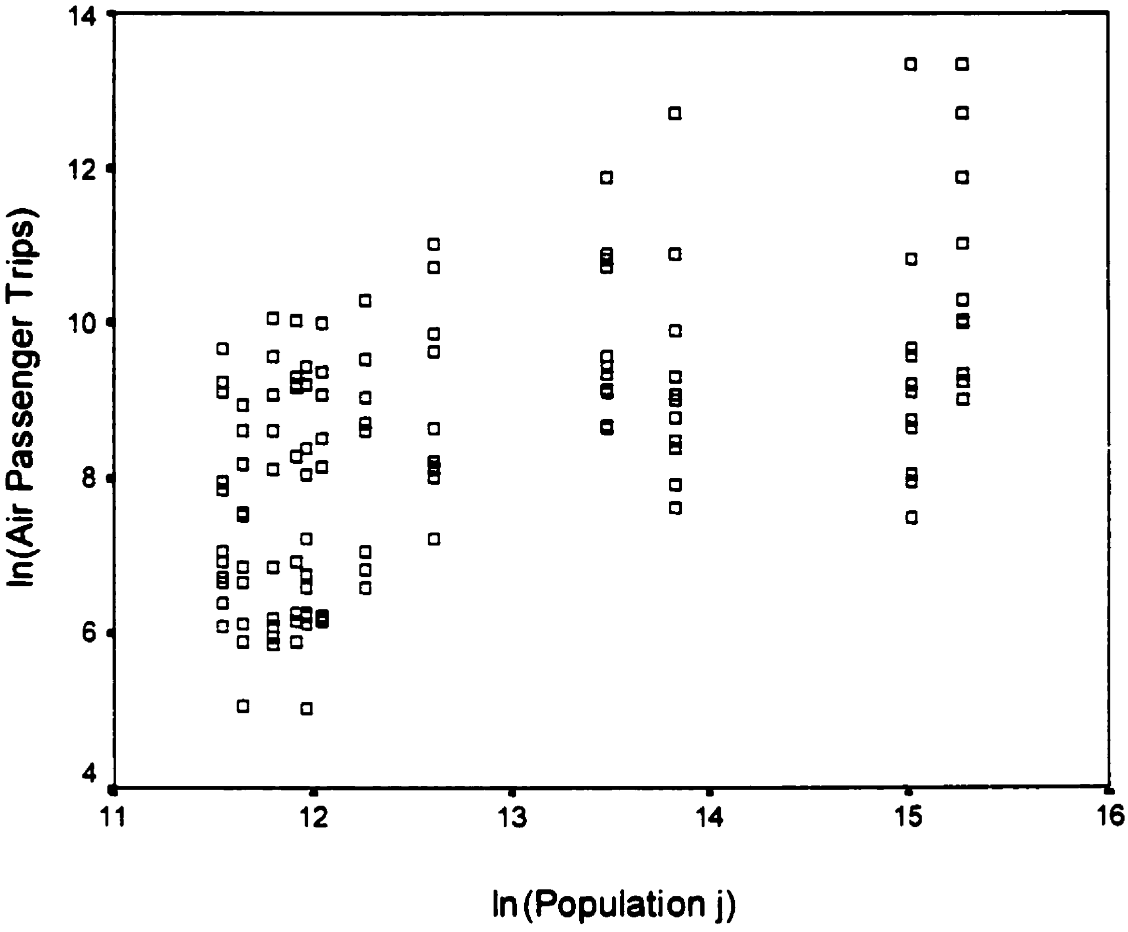
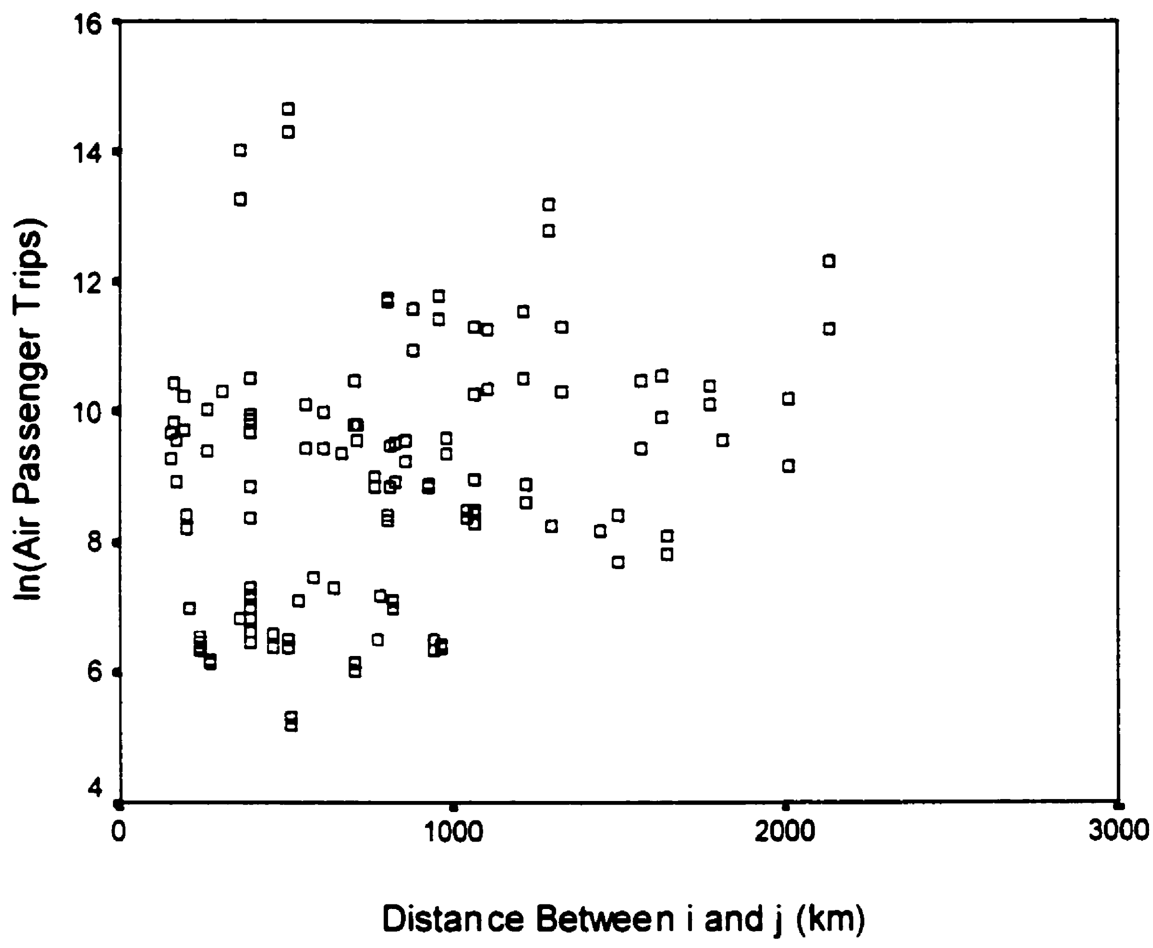


Figure 7: Scatter Plot of ln(Air Passenger Trips) versus Distance



models required a logarithmic transformation. Therefore, regression analysis was also conducted on the data in logarithmic form to determine if the respecified data would improve the regression.

7.2 Functional Relationship between Variables

The graphical analysis of the independent variables revealed a number of interesting trends that assisted in defining the functional relationships required for developing forecast models in this thesis. The following sub-sections discuss the relationships between variables established for the catchment area generation and link estimation models.

7.2.1 Catchment Area Generation Model

As indicated, the focus of this research was to develop two mathematical models, using data from 1996, to estimate air passenger flows in 2001 and 2006. The models developed using 1996 base year data were tested against 1991 data for calibration purposes. As discussed in Chapter 7.1, graphical analysis determined that linear relationships existed between air passenger trips and each demographic variable tested for the catchment area generation model. As a result, the following functional relationship was established for the generation of air passenger trips at an airport catchment area level:

$$AT_i = \beta_0 + \beta_1 POP_i + \beta_2 DI_i + \beta_3 EMP_i + K \qquad \text{Eqn. 3}$$

where: AT_i = Total Air Passenger Trips Originating from Catchment Area i
POP_i = Population of Catchment Area i
DI_i = Disposable Income of Catchment Area i
EMP_i = Sector Employment of Catchment Area I
K = Calibration Constant

The coefficients of the explanatory variables in equation [3] were determined by regression analysis. Regression analysis was also required to determine if all 3 variables are significant at influencing the response variable. It is possible that not all explanatory parameters in equation 3 would be included in the final forecast model. Furthermore, a variety of dummy variables will be incorporated in the analysis of air passenger trips. However, these variables were not included in the functional form of the catchment area generation model.

A calibration constant has also been added to the functional form of the catchment area model illustrated in equation [3] in order to calibrate or adjust the design year model to account for unexplained error. The constant will be determined during the model evaluation phase of the research using actual data from 1996.

7.2.2 Link Estimation Model

The link estimation model was developed to estimate the flow of passenger traffic between airports. Similar to the catchment area generation model, statistical software was used to determine the final forecast model based on 1996 data. It was originally assumed that a linear relationship existed between the independent and dependent variables. However, following a graphical analysis of the explanatory parameters, it was determined that a logarithmic relationship was more suitable. The following functional form was established for the link estimation model:

$$AT_{ij} = e^{\beta 0}(POP_i)^{\beta 1}(POP_j)^{\beta 2}(DI_i)^{\beta 3}(DI_j)^{\beta 4}(EMP_i)^{\beta 5}(EMP_j)^{\beta 6}(LOSij)^{\beta 7}(AF_{ij})^{\beta 8}(DIST_{ij})^{\beta 9}(K_{ij})$$

Eqn. 4

where: AT_{ij} = Total Air Passenger Trips Along Link
POP_i = Origin Node Population
DI_i = Origin Node Disposable Income
EMP_i = Origin Node Sector Employment
POP_j = Destination Node Population
DI_j = Destination Node Disposable Income
EMP_j = Destination Node Sector Employment
LOS_{ij} = Level of Service Along Link
AF_{ij} = Cost of Airfare Along Link
$DIST_{ij}$ = Distance between Origin and Destination
K_{ij} = Link Calibration Constant
3_0 = Model Constant

Similar to the linear function illustrated in equation [3], the intercept and variable coefficients in equation [4] will be estimated using regression analysis. Furthermore, a link calibration constant has been added to the model to account for unexplained error. The hyperbolic form expressed in equation [4] was ultimately selected for modeling purposes because it could be easily transformed into a linear expression for regression analysis. On a theoretical basis, the form satisfies the concept that "many of the factors associated with passenger travel have a multiplicative rather than an additive effect." (40)

7.3 Computer Programs

An assortment of computer software programs were used to produce the final results displayed in this thesis. Firstly, the compilation and manipulation of data was performed on spreadsheets in Microsoft Excel. Two tables were produced each listing the data required for the catchment area generation and link estimation models. These tables were then transferred into the statistical software package SPSS to perform the appropriate analysis. Specifically, all regression statistics, graphs, and residual data displayed in this document were produced in SPSS. To verify some of the results produced in SPSS, the data was entered into the statistical software program SAS and regression analysis was again performed.

7.4 Method of Determining Significant Variables

The next step in model development involves determining the "best" set of independent variables. It is important to note however that the term "best" is somewhat misleading because no single set of parameters perfectly describe the variation in the response variable. The process of selecting a set of significant variables greatly depends on the purpose in which the model is being developed. Furthermore, the mathematical technique used by an analyst to determine the "best set" of parameters will affect the final appearance of the model.

The technique known as "stepwise" regression has been incorporated in research activity for many years and is widely accepted as a reliable method of independent variable assessment. Stepwise regression begins by entering variables into the model one at a time. In SPSS, the first variable to be selected is the parameter which exhibits the strongest correlation with the dependent variable. Each time a new parameter is considered for entry, the program simultaneously tests the variables in the model for removal. The t statistic is used to test the hypothesis that the coefficient of the variable is 0. If the significance of adding a variable to an equation is less than or equal to 0.05, then the variable is included in the model. However, a parameter will be removed if its significance level exceeds 0.10. The stepping procedure ends when the "prediction of the dependent variable Y does not significantly improve." (41)

The SPSS regression procedure also includes a forward and backward approach to variable selection. The forward technique is similar to the stepwise method except that once a variable has been added to a model, it cannot be removed in a later step. Conversely, variables are removed from the equation in the backward elimination procedure but cannot be added. As a result, different models would likely occur if these two methods were applied to a dataset. To ensure that all possible combinations of variables were tested, the stepwise procedure was used in this thesis.

7.5 Regression Statistics: Description of Terms

A variety of statistics are produced in SPSS when regression analysis is performed. To better understand these statistics and their importance in modeling, the following section provides a brief definition of various terms analyzed during model development.

Coefficient of Determination (R^2)

The coefficient of determination is a measure of the adequacy of the regression equation. More simply, the term describes how well the model fits the data. An R^2 value near 0 indicates that a relationship does not exist between the response and explanatory variables. Conversely, an R^2 value near 1 (or −1) would imply a strong relationship between y and x.

The R^2 statistic is determined by comparing the explained variation of the model to the total variation. In mathematical terms, the variable can be expressed as follows:

$$R^2 = 1 - \frac{\sum (y_i - \hat{y}_i)^2}{\sum (y_i - \bar{y})^2}$$

where: y_i = observed value
$\hat{y}_i$ = predicted value
$\bar{y}$ = sample mean

The coefficient of determination is biased because its value increases as the number of independent variables in the model increase.

Adjusted Coefficient of Determination (R^2)

The adjusted coefficient of determination is used to correct for the bias nature of R^2 by adjusting for degrees of freedom. As a result, this variable provides a more reliable measure of model adequacy.

Standard Error of Estimate (SEE)

The standard error of estimate (SEE) is the "standard deviation of the distribution of residuals" or error. (42) This term therefore provides an indication of the typical size of error. If the SEE is small then the accuracy of the model is high. Conversely, a large SEE indicates that the model is inaccurate.

F Statistic

The F statistic provides an alternative method of evaluating the goodness of fit or the overall significance of the regression equation. It is a test for "the hypothesis that all the regression coefficients in the equation are zero." (43) Therefore, the coefficients are less likely to be zero as the F value increases. The variable is determined by comparing the explained variance to the unexplained variance and is calculated using the following equation:

$$F = \frac{\left(\frac{R^2}{k}\right)}{\left[\frac{1-R^2}{(n-(k+1))}\right]}$$

where: R^2 = Coefficient of Determination
n = Number of Cases
k = Degrees of Freedom

t Statistic

The t statistic is used to test the null hypothesis that the OLS coefficient does not contribute information to the prediction of y. Typically, any t value greater than 2 can be considered significant and therefore, the null hypothesis can be rejected and the corresponding independent variable may remain in the model.

Correlation Coefficient (r)

The coefficient of correlation typically denoted by r, measures the degree to which two variables are related or connected to one another. The coefficient varies from +1, which indicates that the two parameters are positively correlated, to –1, indicating that a negative relationship exists. A coefficient of 0 suggests that the variables are unrelated (44).

Variance Inflation Factor (VIF)

The Variance Inflation Factor (VIF) is a measure of multicollinearity. Generally, a VIF of 1 indicates that the independent variables do not contain redundant information. If the variables are collinear, a VIF greater than 1 will result. As a rule of thumb, redundant information will be contained in the model if a VIF greater than 10 is calculated. (45)

7.6 Selection of Initial Models

The following sub-sections specifically address the two models selected to estimate air passenger travel in the future.

7.6.1 Catchment Area Generation Model

The regression analysis of data at the catchment level yielded a variety of models that related independent variables to air passenger trips. To select a suitable model for air trip estimation, regression statistics were closely examined. Specifically, the following parameters were analyzed: R^2 values, F statistic, t statistic and standard error. Table 6 presents the catchment area generation model selected for forecasting purposes as well as the statistics corresponding to the model.

Table 6: Catchment Area Generation Model and Regression Statistics

Model Summary
Number of Cases = 9
R^2 = 0.964
Adjusted R^2 = 0.958
Standard Error of the Estimate = 29,213.84

Coefficients

Variables in Equation	Regression Coefficient	T Statistic (95% Confidence)	Standard Error of Coefficient	Correlation with Dependent Var
$POP_i/10$	7.388	13.614	0.537	0.982
Constant	-107,792			

ANOVA

Degrees of Freedom	Sum of Squares	Mean Square	F Statistic (95% Confidence)
8	1.642E+11	2.052E+10	185.342

Final Model:

$AT_i = -107{,}792 + 7.388(POP_i/10) + 62{,}749K$

where: AT_i = Total Air Passenger Trips Originating from Catchment Area i
POP_i = Population of Catchment Area i
K = Calibration Constant

In most modeling efforts, it is difficult to account for all factors influencing the response of the dependent variable. As a result, the error associated with the base year "tends to vary considerably between area-pairs both in magnitude and sign". (49) A calibration constant was therefore incorporated in the catchment area generation model to account for the 'unexplained' error. The catchment area model presented in this thesis was calibrated by dividing the number of actual base year trips generated from a catchment area by the model base year trips for the same catchment. The calibration constant permits a perfect fit between the response and explanatory variables. (50) The calibration constants for each catchment area are presented in Appendix D along with the actual and estimated values for the design year.

Although acceptable estimates of air passenger trips can be produced using the model presented in Table 6, it is rather interesting that only one independent variable, population, was incorporated in the final equation. All forecast models analyzed during the literature review of this thesis contained at least two socioeconomic variables that were significant at predicting air passenger trips. However, when regression analysis was performed on the catchment area generation dataset containing population, disposable income, and employment, stepwise regression would always return a single significant variable. Yet, each of these parameters were determined significant when analyzed individually with air passenger trips.

The instability observed in the results may be attributed to issues inherent in the data as well as assumptions made to develop the forecast models. The purpose of this thesis is to estimate air passenger travel generated from 9 airports in the Atlantic Region. As a result, only 9 data points exist for analytical purposes. A general rule of thumb used in regression is "to have the number of data points be at least 6 times, and ideally at least 10 times the number of x variables." (46) One should therefore expect a minimum of 18 data points for the development of the generation model since 3 independent variables are being analyzed. Since only 9 points are available, it is difficult to determine "how well the fitted equation matches the data." (47)

The data point issue is complicated by the independent variables selected for analysis. Specifically, multicollinearity exists between the demographic parameters investigated for the catchment area generation model. A large variance inflation factor for example, was determined between population and disposable income. A VIF of high magnitude indicates that these two variables are contributing redundant or overlapping information.

Multicollinearity influences the results produced by regression analysis and unrealistic models are often produced. Typically, redefining the functional form of one of these variables can minimize this correlation problem. It was determined that disposable income would be the simplest variable to change. As a result, regression was performed on disposable income per capita and a new variable, discretionary income, was also considered. However, neither variable appeared in the final model with population or employment. Furthermore, income was no longer significant at predicting the dependent variable when analyzed individually. Caution must be exercised however when interpreting these results because of the lack of data points used for the catchment area generation model.

One other test was conducted in order to include more variables in the final forecast model. The procedure involved 'forcing' the disposable income variable into the equation with population using regression analysis without the stepwise function. The process was also repeated for employment and population, disposable income and employment, then all three variables. In each test, the number of variables entered initially were the number of parameters which remained following regression analysis. However, none of these models could be rejected given two problems encountered during the analysis of regression statistics. Firstly, the t statistics associated with the OLS coefficients for each test were no longer significant at the 5% or 10% level. As a result, the null hypothesis could no longer be accepted therefore implying that the OLS coefficients were not contributing information to the prediction of air passenger trips. Secondly, regression analysis yielded negative OLS coefficients for each model tested.

During the analysis of population and disposable income for example, the least squares coefficient associated with the income parameter was negative. This result is considered counter intuitive as it implies that an individual with greater disposable income will have less propensity to fly. It is likely that the negative coefficients and non-significant t statistics were a combined result of multicollinearity affects between variables and too few data points.

Another issue that may be influencing the aforementioned tests and the final form of the generation model is the source of air passenger data. Specifically, it is difficult to determine from the origin data, the number of trips generated from an airport by those people residing in the catchment area versus the number of passengers on a return trip. Based on approximate calculations, a 0-100% split was assumed using origin/destination data pertaining to each study airport. This ratio indicates that all origin trips generated from each airport were produced by people residing in the catchment area surrounding the airport. This split corresponds with the demographic data compiled for the catchment area generation model because the explanatory data represents 100% of the population living within the catchment area. However, the percent split is only an assumption and there is a possibility that the actual ratio may be different. If the air trip split was 10-90% for example, then 90% of the total passenger traffic originating from an airport would be generated by those people residing in the catchment area. The change in split may influence the results because 90% of the air passenger data would now be tested against the demographic data which is based on 100% of the population in the catchment area. That is, 10% of the trips would no longer be affiliated with the demographic characteristics of the catchment area. Such a complication could influence the precision of the forecast model.

Although the final form of the catchment area generation model was not anticipated, regression statistics in Table 6 indicate that the final model is the most suitable forecasting model from the list of equations initially developed from the dataset. One of the benefits associated with the selected model is that multicollinearity is minimized because only one independent variable is present. Given the range of problems that may be influencing the results, the simple model also offers a more conservative approach to forecasting air passenger travel. It is generally believed by most forecasting experts that the "object of selecting explanatory variables is to find the minimum number of independent variables which maximizes the prediction and control of the dependent variable." (48)

7.6.2 Link Estimation Model

Unlike the generation model, the link estimation model was derived based on various data points. Furthermore, it was determined by graphical techniques that each demographic and supply variable required a logarithmic transformation. The benefit of redefining parameters in this manner is that multicollinearity is reduced. It is therefore not surprising that the final form of the link estimation model was anticipated, and the final model was similar to most models found in literature. The equation presented in Table 7 was selected based on the same statistical parameters investigated during the development of the catchment area generation model.

It is important to recognize that the regression statistics presented in Table 7 are adequate when analyzing the data in a logarithmic transformed state. However, transforming the data influences the degree of error about the regression line or the amount of variation in the dependent variable. As a result, the statistics in Table 7 are distorted when considering the data in standard form.

To produce model statistics in standard form, the data were entered into a nonlinear regression routine in SPSS. Similar to linear regression, the nonlinear function estimates coefficients by minimizing the sum of squared residuals. The difference between regression types is that the nonlinear function requires initial coefficient values to produce the desired statistics. As a result, the least squares coefficients presented in Table 7 were entered into SPSS. Statistics indicated that the independent variables selected for analysis described a large portion of unexplained error when considering the data in standard form ($R^2 = 0.98$). It is important to recognize that the correction factor, K, was not included when performing nonlinear regression. As discussed earlier in the thesis, the correction factor adjusts for the amount of error in the model after the data has been transformed. The K variable would therefore influence statistics during nonlinear regression.

The link model in standard form produced a high R^2 value without the correction factor. This result suggests that the K value is not crucial for the development or validation of the link model. However, the variable remains an important component of the transformed model and regression statistics are improved with the inclusion of K. The correction factor will therefore remain in the link estimation model and the equation presented in Table 7 will provide the foundation for air trip forecasts. All K values for the link estimation model are presented with the catchment constants in Appendix D. The actual and estimated link passenger volumes used to calculate the constants are also included in Appendix D.

Table 7: Link Estimation Model and Regression Statistics

Model Summary
Number of Cases = 124
R^2 = 0.860
Adjusted R^2 = 0.852
Standard Error of the Estimate = 0.672

Coefficients

Variables in Equation	Regression Coefficient	t Statistic (95% Conf)	Standard Error of Coefficient	Correlation with Dep Var
$lnPOP_I$	0.746	11.173	0.067	0.566
$lnPOP_j$	0.724	10.061	0.072	0.572
$lnDICAP_I$	2.261	4.896	0.463	-0.122
$lnDICAP_j$	2.133	4.663	0.458	-0.123
$lnLOS_{ij}$	0.506	7.112	0.071	0.689
$lnAFPKM_{ij}$	-0.616	-3.742	0.165	-0.433
Constant	-52.417			

ANOVA

Degrees of Freedom	Sum of Squares	Mean Square	F Statistic (95% Confidence)
123	375.848	3.056	119.333

Final Model:

$$AT_{ij} = e^{-52.417}(POP_i)^{0.746}(POP_j)^{0.724}(DICAP_i)^{2.261}(DICAP_j)^{2.133}(LOS_{ij})^{0.506}(AFPKM_{ij})^{-0.616}(K_{ij})$$

where: AT_{ij} = Total Air Passenger Trips Along Link
POP_i = Origin Node Population
POP_j = Destination Node Population
$DICAP_i$ = Origin Node Disposable Income per Capita
$DICAP_j$ = Destination Node Disposable Income per Capita
LOS_{ij} = Level of Service Along Link
$AFPKM_{ij}$ = Cost of Airfare per Kilometre Along Link
K_{ij} = Link Calibration Constant (K = 0.998, therefore used value of 1)

As illustrated in Table 7, two demographic variables, population and disposable income per capita, were found to be significant relative to estimating air passenger trips. It is important to note that stepwise regression was performed using disposable income. However, only one demographic variable remained in the model due to multicollinearity effects. The demographic variable was therefore redefined as disposable income per capita to reduce the degree of multicollinearity with population.

Regression analysis also determined that the impedance variables, level of service and airfare per kilometre, both influenced the response of the dependent variable. Originally, it was anticipated that three impedance variables, level of service, airfare, and distance, would influence the response of the dependent variable. However, regression software detected a high degree of correlation between the natural logarithms of airfare and distance ($r = 0.9$). To reduce the level of correlation, these two variables were combined to produce airfare per kilometre. Regression analysis was performed once again on the transformed variable as well as the other parameters to produce the final link estimation model displayed in Table 7.

According to stepwise regression, it was determined that the employment variable was not significant at estimating air passenger trips. This result was rather surprising considering the relationship between business travel and the generation of air trips. One possible explanation could be attributed to the employment data collected from Census Canada. As discussed previously, the industry divisions: business, government and education, were proven statistically significant at estimating air travel when combined. These divisions provided a reasonable proxy for sector employment however expressing employment at a greater level of aggregation would likely improve model efficiency. An attempt was made to further classify sector employment using occupational categories from Census Canada rather than the broader industry divisions. However, as discussed in chapter 6.2.1.3, occupations varied between census years thereby complicating the data collection process. Other sources of employment data may exist in literature but due to time limitations, industry divisions were considered a suitable measure.

CHAPTER 8 MODEL EVALUATION

8.1 Introduction

Prior to forecasting future trends or values, it is necessary to evaluate the effectiveness or accuracy of the selected model. Typically, two measures are used to provide an indication as to whether the forecast model will be useful at estimating future traffic levels. In chapter 4, the theory of regression analysis was introduced. It was stated that a line was fitted to a set of data using a technique known as ordinary least squares. To produce valid least square estimates, four general assumptions must be made. Each assumption can be evaluated using a test. The following section discusses the ordinary least squares tests underlying the OLS assumptions and the forecast models selected in this thesis will be evaluated using those tests.

The second method of evaluating the accuracy of a model involves comparing historical data with values predicted by the model. Specifically, actual air passenger trips from 1991 were compared against the estimates produced by the catchment area generation and link estimation models for that year. To perform this comparison, data from 1991 was collected for each variable determined statistically significant for the purpose of predicting air passenger trips. Data from 1991 was therefore compiled for population, disposable income per capita, level of service, and airfare per kilometre. The data pertaining to each variable are presented in Appendices B and C along with 1996 data. Chapter 8.3 summarizes the results of the air passenger trip comparison.

8.2 Residual Analysis

8.2.1 Tests for Ordinary Least Squares Assumptions

Assumption #1: Detecting Unequal Variance

The first assumption associated with OLS analysis focuses on the variance of data. Specifically, the OLS estimates will be invalid if the variance in the data is heteroscedastic or not constant. The most effective means of examining this assumption involves producing a residual plot. A residual, R_{ij}, is defined as the difference between the observed and estimated value of a dependent variable. (51) The residual of an air passenger trip can therefore be expressed as:

$$R_{ij} = AT_{ij}\text{ (observed)} - AT_{ij}\text{ (estimated)}$$

To produce a residual plot, residuals are graphically displayed against each estimated value. If the variances are equal, no pattern should exist in the distribution of points. Rather, the plot should suggest a cluster of points oriented across the graph.

Assumption #2: Detecting Nonnormality

The presence of normality is another assumption that must be satisfied in order to produce valid least squares estimates. As its title suggests, normality involves the normal distribution of points about a line with a mean 0. A relative frequency histogram of residuals is a simple means of detecting normality. If the distribution of residuals is bell shaped and not badly skewed about the mean 0, the assumption is considered not to have been violated. (52)

Assumption #3: Detecting Outliers

The presence of outliers in a dataset can influence the orientation of the fitted equation by producing anomalous least squares coefficients. If a residual is larger than 3 standard deviations (3s) of the mean, the value is considered an outlier. To detect outliers, the residual plot produced in the first OLS assumption can be consulted. Any residual located a distance of 3s above or below 0 is considered an outlier.

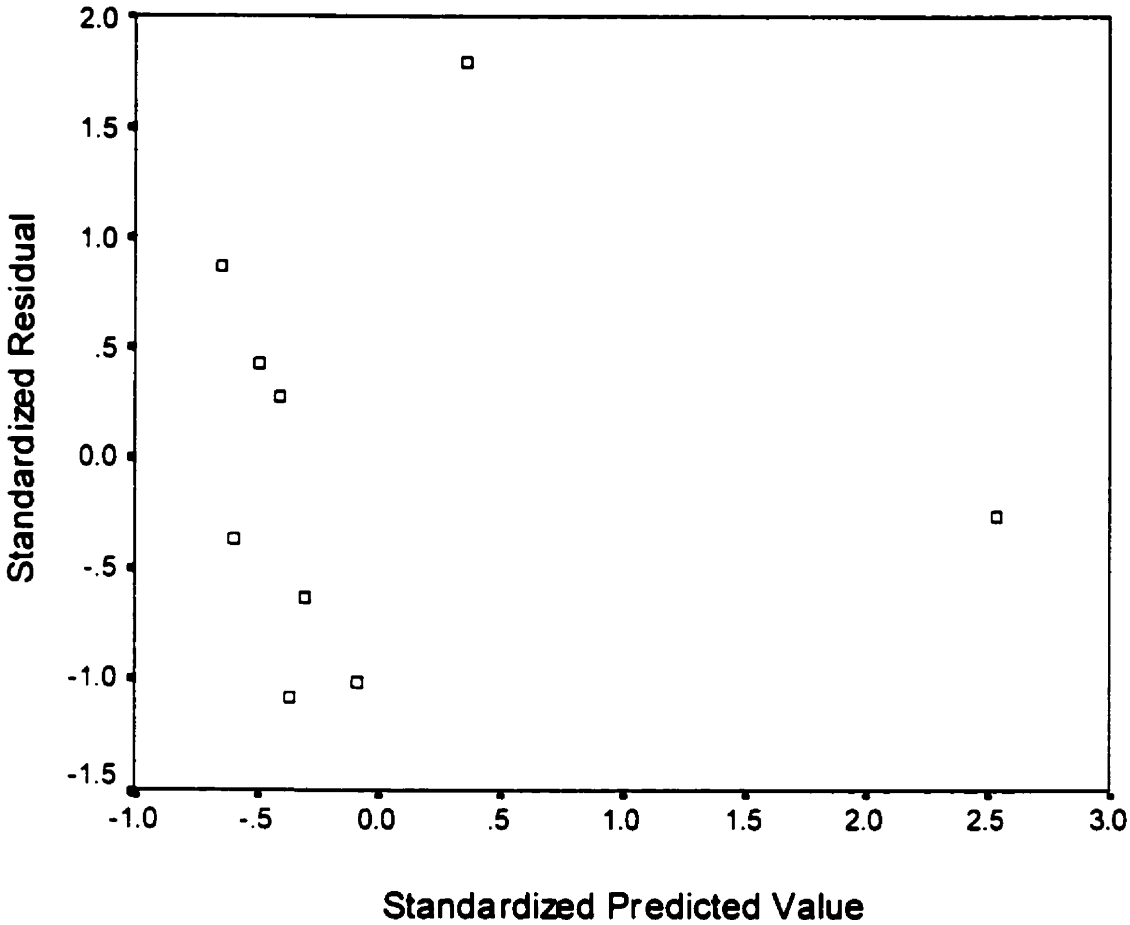
Assumption #4: Detecting Correlated Errors

Ordinary least squares analysis also assumes that residual correlation is not an issue. That is, if trends of positive and negative residuals are detected, then the errors are autocorrelated and the fourth assumption is violated. The Durbin-Watson (D-W) test is a technique for determining autocorrelation in which a statistic is calculated. If autocorrelation is not present in the data, a D-W statistic close to 2 will result. A value significantly smaller than 2 indicates positively correlated residuals while negative correlation exists if a statistic larger than 2 is determined.

8.2.2 Results from the Residual Analysis of the Catchment Area Generation Model

To examine the ordinary least squares assumptions for the catchment area generation model, a residual plot was first produced. Figure 8a graphically presents the residuals produced by the catchment area model. The plot illustrates a cluster of points within +/- 1.0 standard deviations from 0 as well as a single point corresponding to a much larger predicted value. Halifax airport experiences high volumes of air passenger traffic compared to the remaining airports in the Atlantic Provinces. Subsequently, its estimated

Figure 8a: Residual Plot of Catchment Generation Model



Note:

Standardized Residual = Residual Value/Standard Deviation of the Residuals

Standardized Predicted Value = $\frac{\text{(Predicted Value – Mean Predicted Value)}}{\text{Standard Deviation of the Predicted Values}}$

value is quite high yet very important to the accuracy of the model. Except for the unique orientation of points in Figure 8a, the plot does not suggest a trend or pattern within the dataset. As a result, the catchment area generation model satisfies the unequal variance assumption. It is also apparent in Figure 8a that outliers do not exist in the model. Specifically, all residual points lie within a horizontal band located 3 standard deviations from the mean 0.

A frequency histogram was also produced to evaluate the distribution of residuals associated with the catchment area generation model. The bell shaped pattern illustrated in Figure 8b indicates that the residuals are approximately distributed normally. The plot of frequencies is also centered about a mean of 0. Since the histogram is approximately distributed normally and no skewness occurs about the mean, the generation model satisfies assumption #2.

To accept the least squares estimates determined for the catchment area model, the data must be tested for autocorrelation. A Durbin-Watson statistic of 1.7 was calculated. The value is slightly lower than 2.0 but any correlation effects present in the data are minimal.

8.2.3 Results from the Residual Analysis of the Link Estimation Model

A residual plot of the link estimation model was prepared and the results are presented in Figure 9a. The plot immediately illustrates that outliers do not exist in the dataset. The cluster of residuals fall within 3 standard deviations of the mean 0. The spread of points also suggest that the variance of residuals are equal since it is difficult to identify a trend

Figure 8b: Frequency Histogram of Generation Model Residuals

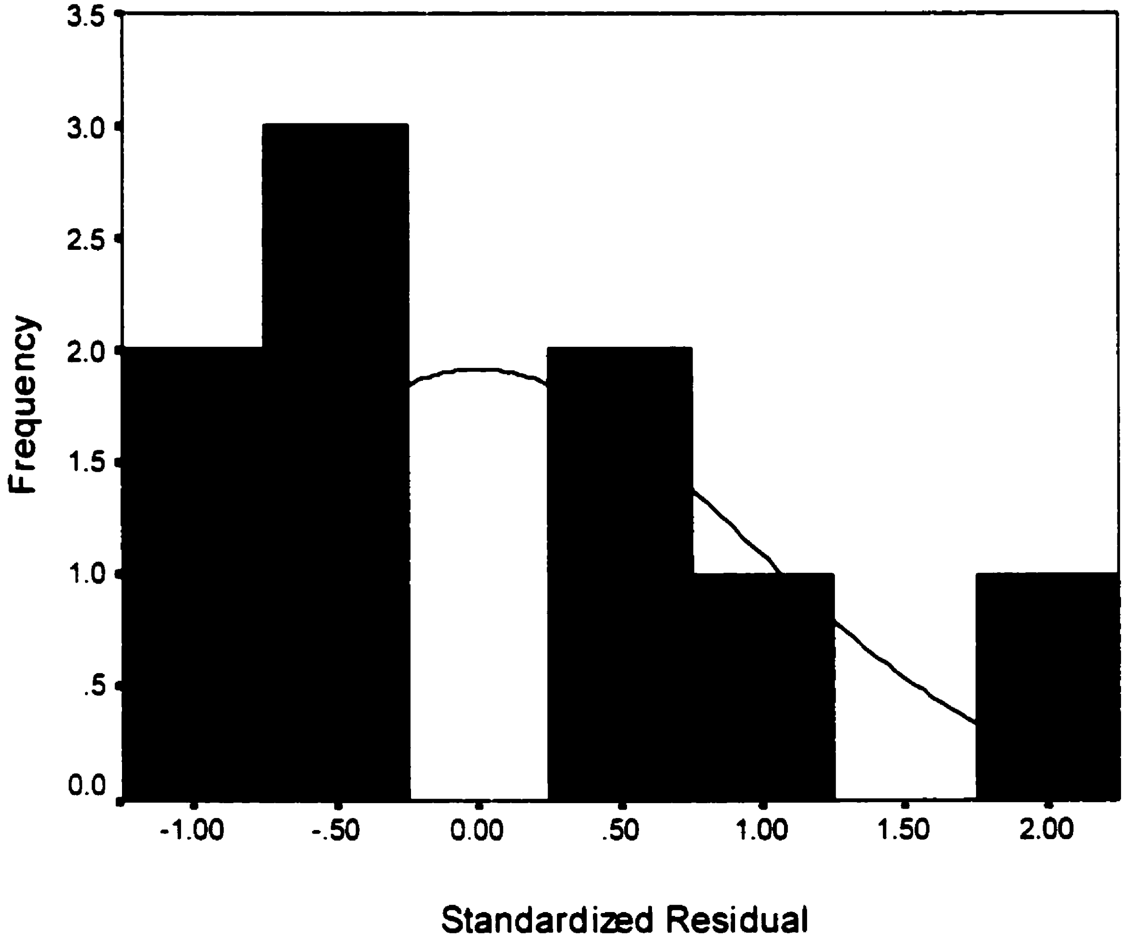
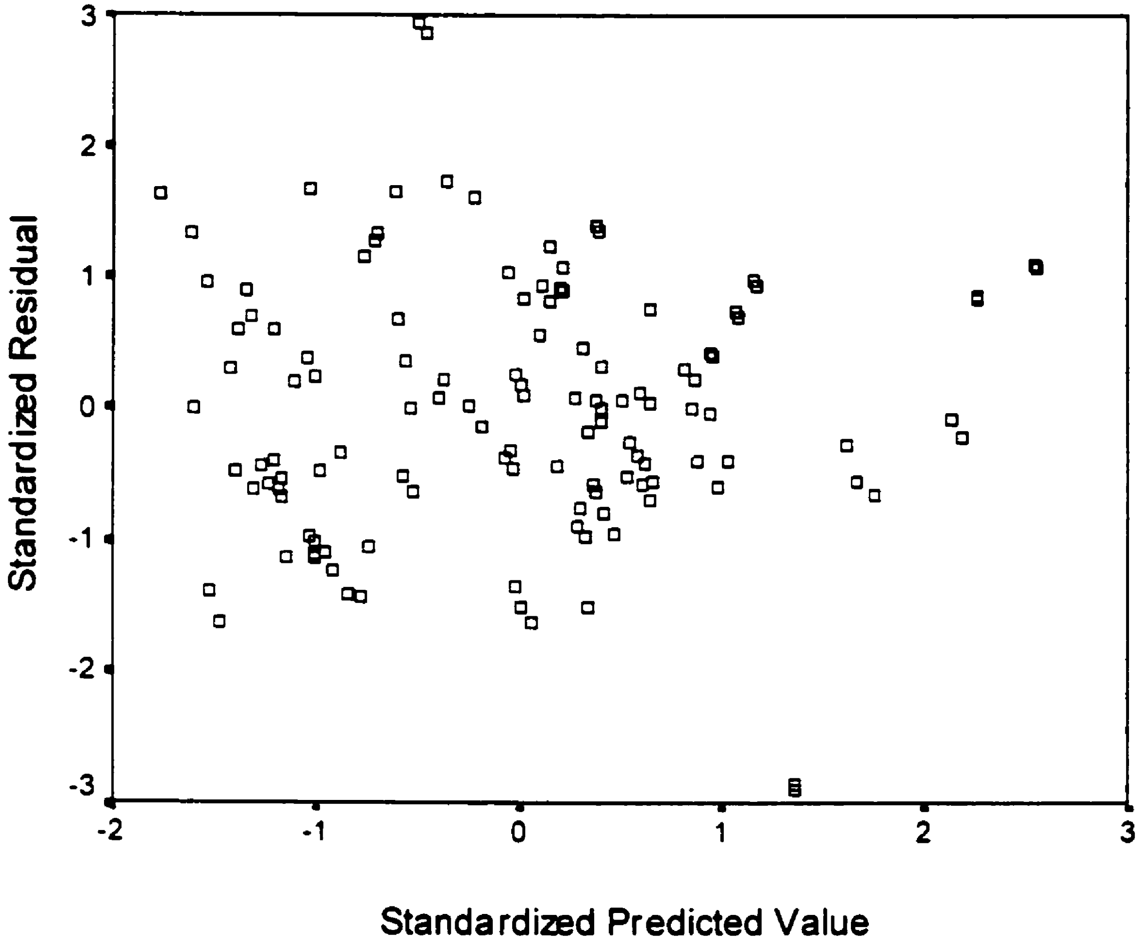


Figure 9a: Residual Plot of Link Estimation Model



Note:

Standardized Residual =	Residual Value/Standard Deviation of the Residuals
Standardized Predicted Value =	$\frac{\text{(Predicted Value – Mean Predicted Value)}}{\text{Standard Deviation of the Predicted Values}}$

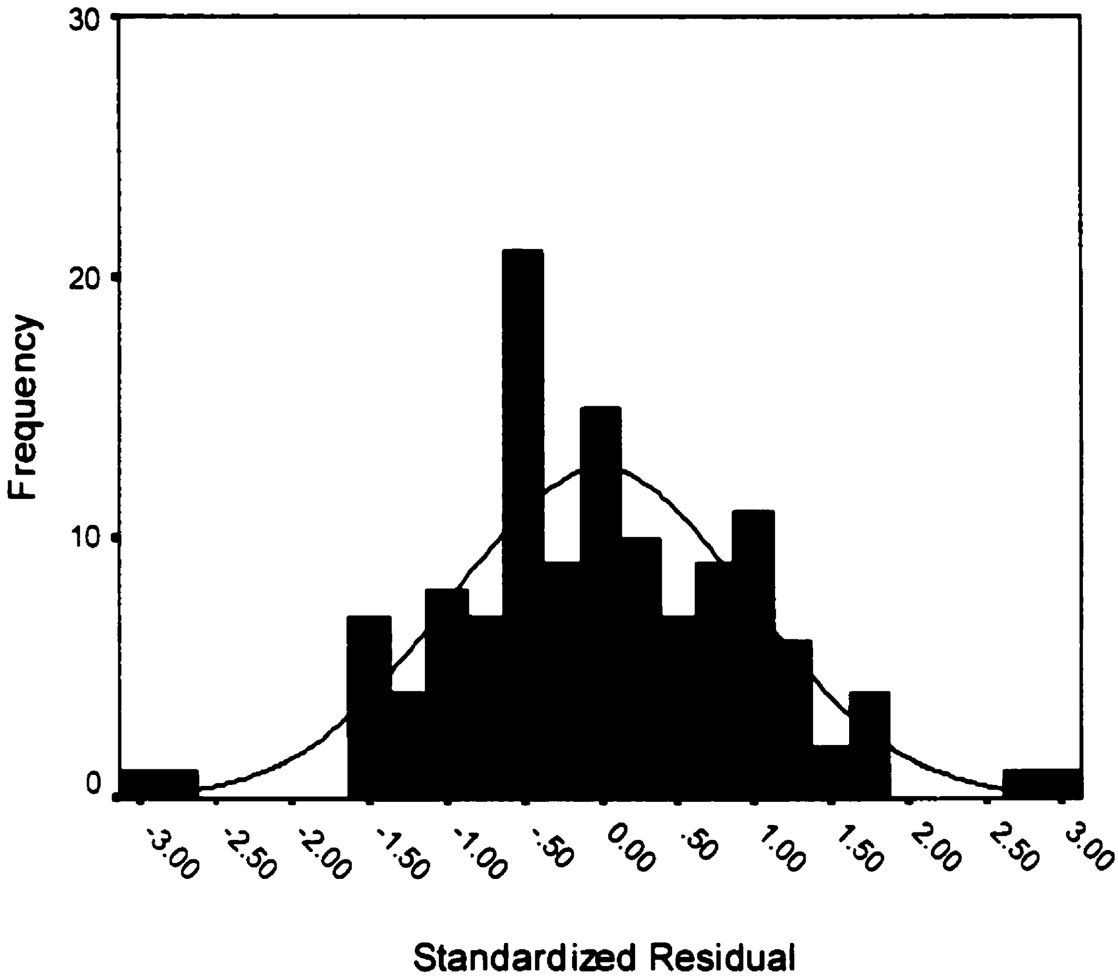
or pattern in the data. The residual analysis presented in Figure 9a therefore indicates that assumptions 1 and 3 are satisfied in the link estimation model. To examine the normality assumption, a frequency histogram of residuals was produced. An examination of the graph displayed in Figure 9b indicates that the residuals associated with the link estimation model are closely distributed about a mean of 0. Furthermore, the residual frequencies produce a bell shape similar to the normal probability curve. Some frequency bars fall above and below the normal curve however, the general shape indicates that the residuals are distributed normally.

Finally, it was determined that autocorrelation was not a concern for the link estimation model. A D-W statistic of 1.9 was calculated for the link estimation model indicating that the effects of correlation in the model are minimal.

8.3 Comparison of Model Estimates and Historical Data

The second method used to evaluate the reliability and accuracy of the models involves comparing historical data with the estimated values calculated using the models. The data sources consulted for the base year, 1996, were also used to compile data for the comparison year, 1991. A spreadsheet of data was prepared for the catchment area and link models according to the catchment areas identified in Figures 4a and 4b. The information was then inserted into the forecast equations to estimate air passenger trips for 1991. The results of the calculations are presented in Table 8a for the catchment area generation model. A sample of link estimates are illustrated in Table 8b while the

Figure 9b: Frequency Histogram of Link Model Residuals



remainder of the calculations are displayed in Appendix E. The actual air passenger trips recorded for 1991 are also included in these tables together with the percent differences.

Table 8a: Comparison of Actual and Estimated Air Passenger Trips (1991) – Catchment Area Generation Model

Origin Airport	Actual Trips	Estimated Trips	% Difference
St. John's	239,180	197,224	-17.5
Gander	35,950	29,300	-18.5
Deer Lake/Stephenville	57,000	82,243	44.3
Sydney	60,550	47,605	-21.4
Halifax	474,770	474,060	-0.1
Moncton	90,060	91,039	1.1
Saint John	70,690	66,757	-5.6
Fredericton	75,590	69,159	-8.5
Charlottetown	70,140	64,459	-8.1

Table 8b: Sample Comparison of Actual and Estimated Air Passenger Trips (1991) – Link Distribution Model

Origin Airport	Destination Airport	Actual Trips	Estimated Trips	% Difference
Halifax	St. John's	49,740	48,993	-1.5
	Gander	5,270	5,169	-1.9
	Deer Lake/Stephenville	8,790	10,008	13.9
	Sydney	19,670	16,033	-18.5
	Moncton	6,460	5,812	-10.0
	Saint John	12,330	13,917	12.9
	Fredericton	10,500	9,692	-7.7
	Charlottetown	13,000	11,961	-8.0
	Montreal	57,570	57,943	0.6
	Ottawa	56,510	42,257	-25.2
	Toronto	147,600	132,930	-9.9

The catchment area generation model produced a range of air passenger trip estimates above and below the actual volumes experienced in 1991. Air trips generated from St. John's, Gander, Sydney, Saint John, Fredericton, and Charlottetown airports were 5 to 21% less than actual volumes. Conversely, predicted trips from Deer Lake/Stephenville and Moncton airports were overestimated by 44 and 1% respectively. The difference between actual and estimated air trip values for Halifax airport was negligeable. Notwithstanding the range of predictions illustrated in Table 8a for individual airports, the total trips forecasted for the region varied from actual trips by only 4% .

The link estimation model also produced a range of air passenger trips above and below the actual data. Specifically, the link model underestimated 81 of the 124 link volumes recorded in 1991. Along select routes, the percent difference between actual and predicted data exceeded 100%. However, an overall error of -8% was calculated for the link estimation model.

As stated earlier, the purpose of comparing model estimates with actual data was to determine the predictive ability of both models developed in this thesis. It is evident from the data presented in Tables 8a and 8b as well as Appendix E that both models lacked full explanatory power. Despite the inclusion of calibration constants, the independent variables included in both forecast models were unable to account for the change in air travel over a five-year period. Such a statement implies that certain causal parameters may be missing from the analysis. However, it is difficult to determine the exact combination of independent variables that would fully explain the response of the dependent variable. Furthermore, only a finite number of causal parameters were tested in the research due to time limitations. If more time had been available, other explanatory variables may have been found significant at predicting air trips. It is believed however, that the independent variables used in both models represented a large portion of the explanatory power as indicated by high R^2 values (catchment area model: 0.96; link model: 0.85). The accuracy evaluation also suggested that the forecasting models provided suitable estimates when compared with historical data. As such, the catchment area generation and link estimation models presented in Chapter 7 are considered to be acceptable in order to produce future levels of air passenger trips.

CHAPTER 9 FORECASTS OF AIR PASSENGER TRAVEL

9.1 Introduction

The model development and evaluation phases of this research produced two models which related air passenger trips with a series of explanatory or independent variables. On a catchment level, it was determined that population was useful for modelling air travel in Atlantic Canada. Population, disposable income per capita, level of service, and airfare per kilometre could be used to estimate passenger flows at the link level.

The final step prior to producing estimates of air travel in 2001 and 2006, involved forecasting future values for each of the independent variables used in the models. Different forecasting techniques were employed to produce low, medium, and high estimates. A range of forecasts provides the analyst with greater flexibility when considering factors that may influence the response of the parameter in the future.

Chapter 9.2 describes the methods used to produce estimates of each independent variable. Also included in this section are the results of the forecasts, the estimated values selected for further analysis, and the assumptions made during the modelling process.

9.2 Forecasts of Independent Variables

9.2.1 Demographic Characteristics

As outlined in the literature search section of this thesis, a variety of techniques are available to estimate air passenger travel. Given the availability and range of historical demographic data as well as the ability to collect the information, it was determined that time series forecasting techniques could be implemented for this research project. The Atlantic Provinces Air Transportation Study (APATS), a project which estimated air passenger travel in the same context as the research presented in this thesis, estimated demographic conditions using time series data. The APATS study produced low, medium and high estimates using three different forecasting relationships: linear regression, triple exponential smoothing, and log transformed exponential relationship. Given the similarities in focus and scope between the air transportation study and this research, it was determined that the three APATS forecasting relationships should provide a suitable foundation to which demographic data could be estimated. Furthermore, the results produced by these techniques are consistent with the accuracy requirements established for this research.

Linear regression was the first technique used to forecast population and disposable income per capita based on historical time series data. As discussed in chapter 4, the linear regression method produces a line that best describes the general trend or shape of a series of data points. The best-fit line is determined using a method of least squares adjustment. The linear regression technique was selected for APATS as well as this thesis because it was anticipated that this method would produce average or medium range estimates compared to the exponential or logarithmic techniques.

To estimate high range demographic values, the quadratic or triple exponential smoothing was incorporated. This method of forecasting is typically applied to a dataset that contains a quadratic trend. Since a quadratic trend can be misleading and is often difficult to analyze, triple exponential smoothing is applied to remove the trend by averaging "past values of a time series in a decreasing (exponential) manner." (53) That is, a weighing system is applied to the data whereby the most recent observations in a dataset receive the heaviest weight while decreasing weights are applied to past observations. Exponential smoothing is relatively simple to apply and relies on few data points to produce future estimates (54). Furthermore, this method, as well as log transformation, is appropriate for data that has a slow rate of growth such as the demographic variables used in this research. It is important to note however that quadratic smoothing "can overreact to random fluctuations in the data" (55). This issue may come into play when producing disposable income estimates since this parameter historically fluctuates due to influential direct, indirect and random factors. Nonetheless, triple exponential smoothing is suitable for analytical purposes given the needs established in this thesis.

To remove quadratic trends, a set of data must first be smoothed using the following model:

$$S_t = \alpha X_t + (1 - \alpha)S_{t-1}$$

Eqn. 5

where: S_t = single exponential smoothed value
α = smoothing constant
X_t = observation from current period
S_{t-1} = single exponential smoothed value from previous period

The smoothing constant, α, which ranges from 0.1 to 0.9, is the weight that is applied to each observation in order to stabilize quadratic trends in the data. To determine the most effective weight, one must smooth the dataset using different values of alpha. The constant that produces the least amount of error should be selected. To measure the accuracy of the smoothing model, the mean square error equation (MSE) is often used. If a small MSE is calculated when the alpha value contained in Equation 5 is close to 1.0, seasonality trends may be present in the data and exponential smoothing may not be the best approach to use.

The next two steps of the exponential forecasting process involve smoothing the data in the same manner described in the preceding paragraph. Future estimates of a variable can be predicted once the original dataset has been smoothed a total of three times. All three sets of processed data are used to produce the final form of the forecasting model presented in Equation 9 where "Equation 6 determines the current value of the data, Equation 7 determines the linear trend, and Equation 8 determines the quadratic trend." (56)

$At = 3S_t' - 3S_t'' + S_{t-1}'''$ Eqn. 6

$b_t = (\alpha/(2(1-\alpha)^2)\,[(6-5\alpha)\,S_t' - (10-8\alpha)\,S_t'' + (4-3\alpha)\,S_{t-1}''']$ Eqn. 7

$c_t = (\alpha/(1-\alpha)^2))\,(S_t' - 2S_t'' + S_{t-1}''')$ Eqn. 8

$F_{t+m} = a_t + b_t x + 1/2 c_t x^2$ Eqn. 9

where: S_t' = single exponentially smoothed value
S_t'' = double exponentially smoothed value
S_{t-1}''' = triple exponentially smoothed value
α = smoothing constant
F_{t+m} = forecasted value

The final method of estimating future demographic values involves logarithmically transforming an exponential curve. Following the derivation of least squares estimates, noted by values a and b, the time series data that has grown exponentially over time can be forecasted using Equation 10.

$$F_{(t+m)} = e^{a+bt}$$

Eqn. 10

where: $F_{(t+m)}$ = forecasted value
a, b = least square estimates

Log transformed exponential growth models are appropriate for long term forecasts. As in the case of both APATS and this research, estimates of air passenger trips were required a number of years in the future. Since this method involves logarithmically transforming data, it was anticipated that this model would produce suitable low range estimates for research purposes.

9.2.1.1 Population

To estimate population levels for each airport catchment area analyzed, historical data were collected from the national census. In addition to the population levels compiled for model calibration and evaluation, three years of data were recorded. Based on the catchment data for the years 1976, 1981, 1986, 1991 and 1996, low, medium and high estimates of population were produced for 2001 and 2006. Table 1 in Appendix F (Table F1) summarizes the estimates produced by linear regression, logarithmic transformation, and exponential smoothing.

The process of selecting reasonable population estimates for each catchment area began by graphically displaying the historic and estimated data together for each catchment area. The purpose of visually displaying the data was twofold. First, the graphs provided an opportunity to check for errors in the historical data that may have occurred during data entry. The second reason for displaying the data visually was to identify any forecasting method that produced unrealistic results. If for example, decreasing population forecasts were estimated by the log transformation method despite a constant increase in population since 1976, the method and its results for the catchment area would not be considered for further analysis. In general, graphical representation of the data assisted in the selection of realistic forecasts.

Another component of the selection procedure involved collecting information on variables that could influence future population levels. In 1998, the forecast division of Transport Canada performed a comprehensive analysis of population growth in Canada, and identified a variety of factors on a provincial level that would likely influence population trends over the next 10 years (57). The following issues were recorded:

Newfoundland

Newfoundland's population continues to age however, population levels may rise as offshore oil activity increases. The net result is a weak increase in population.

Prince Edward Island

PEI will continue to grow as a tourist destination. As a result, employment opportunities will improve encouraging young people to remain on the island. The net result is an increase in population.

Nova Scotia

It is predicted that there will be an interprovincial outflow as young people leave for employment opportunities. The outflow of citizens will likely continue as employment opportunities in the Cape Breton coal industry become limited. Yet, this trend will be offset by a rise in international inflow. The net result is a gradual increase in population.

New Brunswick

Similar to Nova Scotia, employment prospects for young people are poor resulting in an interprovincial outflow. This issue combined with an aging population, will likely result in a slight increase in population growth over time.

Influencing factors, such as those considered in Transport Canada's report, provided a foundation to which population forecasts were selected in this research. It is important to recognize, however, that these issues served only as a guide as it was difficult to incorporate the impact of these issues on population predictions in a quantifiable manner. Nonetheless, it was determined that population estimates produced by the linear regression method were most suitable for further analysis. The regression results for each catchment area were consistent with historical trends in population. Furthermore, these estimates were considered average or conservative compared to the other two forecasting techniques. Finally, it was believed that the linear regression estimates reflected the future direction of population growth presented in Transport Canada's report resulting from change in environmental and social factors in Atlantic Canada.

The final phase of the selection process involved comparing aggregated catchment area forecasts with provincial population forecasts. This comparison acted as a check to ensure that "individual airport catchment areas did not aggregate to totals at any point in time which were in excess or significantly below" the population total for the province in which the aggregated catchment areas were located (58). The provincial forecasts were produced by applying the same 3 techniques as used in the catchment area predictions. Table F1 displays the provincial and aggregated catchment estimates as well as the historical data upon which the population forecasts were based. The results show the check to be successful since the provincial estimates were slightly higher but not in excess of the aggregated totals.

9.2.1.2 Disposable Income per Capita

To estimate future disposable income per capita, Revenue Canada publications were consulted. Since per capita income figures were not available, disposable income data were compiled for the airport catchment areas in Atlantic Canada for the years 1991, 1992, 1993, 1994, 1995, and 1996. Forecasts of the demographic variable were produced for 2001 and 2006 using linear regression, triple exponential smoothing, and log transformation relationships. Similar to the approach used for population, one of the three forecast series displayed in Table F2 was selected for further analysis. Those highlighted estimates were then divided by the population forecasts selected for further analysis in Table F1 to produce per capita disposable income. Table F3 lists the per capita disposable income values used to estimate future air passenger trips in Atlantic Canada. It is important to note that the historical data summarized in Tables F2 and F3 are presented in 1986 dollars. That is, each disposable income figure was divided by its provincial consumer price index for 1986 to adjust for the effects of inflation on income.

It is difficult to determine a set of factors, similar to those outlined in the previous section, that could influence future income growth and the selection of a forecast series. Furthermore, discussions with economics and statistics professionals indicated that the estimation of this demographic variable over the forecast period would be somewhat approximate. As a result, estimates produced by the linear regression method were selected because it was believed that these values were average or conservative forecasts of future disposable income in comparison to other methods. In fact, for some catchment areas, the smoothing and transformation techniques produced numbers that were significantly above or below the final value of the disposable income series. These estimates were considered unrealistic based on the historical trend of income growth generated from 1991 to 1996.

Similar to population, the disposable income estimates were aggregated according to province and compared to provincial forecasts to confirm that individual airport catchment areas did not aggregate to totals beyond provincial levels. The data in Table F2 show that no aggregated catchment total greatly exceeded or fell below the linear regression forecasts for the Atlantic Province.

9.2.2 Transport Supply Variables

Although the demographic characteristics of a group of people are important to consider when developing forecast models for air travel demand, the supply of air service must also be evaluated. Regression analysis determined that two transport supply variables, level of service and airfare per kilometre, influenced the level of air passenger trips generated. Similar to other demand variables, it was necessary to predict future values of level of service and airfare per kilometre in order to produce estimates of the dependent variable, air passenger trips. However, the forecasting process for the supply variables was different from the procedure developed for other demand parameters. Specifically, historic data were not collected for level of service and airfare due to time and financial limitations. As a result, the three forecasting techniques outlined in chapter 9.2.1 were not applied. Rather, low, medium and high estimates were produced based on careful examination of literature and a general knowledge of the airline industry.

The aviation industry in Canada experienced significant change in 1999 and early 2000 as the nation's two major carriers, Air Canada and Canadian Airlines, merged to form a dominant carrier. The amalgamation process began in December 1999, when the Federal Government invoked anti-trust exemption, in order to encourage the two airlines to legally discuss how the industry could be restructured. Following the announcement made by the government, a series of events occurred which led to the acquisition of Canadian by Air Canada in January 2000. (N.B. The merger, during the time frame that this thesis was developed, has impacted on the terminology used at different points in the thesis development.) Air Canada has begun restructuring Canadian to reduce its debt load and the airline has announced that the task will be complete by the end 2000. The carrier has also invested considerable resources to combine both carriers' flight schedules in an attempt to better match aircraft to specific route demand. It is therefore anticipated that airports throughout Canada will likely experience change in service levels over the next few years.

Another issue that has received attention following the merger has been airfares. Specifically, the public is concerned that ticket costs will increase as no other airline exists in Canada to promote the necessary competition to encourage cheap fares. In response to concerns over airfare and level of service, Transport Canada recently introduced new legislation that has delegated certain organizations such as the Canadian Transportation Agency, to monitor the activities of Air Canada in the future. The legislation also provides these organizations with expanded regulatory power to penalize Air Canada should the airline engage in anti-competitive or monopolistic behaviour.

It is clear that Canada's air industry is currently experiencing a period of change. Although the future of aviation is somewhat uncertain, it is important that the change is not ignored when developing forecast models. The following subsections summarize the processes by which level of service and airfare estimates were prepared as well as the assumptions on which the numbers are based.

9.2.2.1 Level of Service

Considerable time and resources were invested in the development of service level estimates. This variable was difficult to forecast given its complexity and the process was complicated by the changes that were occurring in the industry at the time the thesis was written. Under ideal conditions, low, medium and high estimates of level of service would have been produced using the forecasting methods outlined in chapter 9.2.1. However, data were only available for the design and test years thereby rendering time series techniques ineffective. Estimates of service levels in the Atlantic Region were therefore produced based on knowledge of current conditions in the market and a review of journal and media articles pertaining to the future of Canada's monopolistic air environment.

Service levels have increased in many areas of Atlantic Canada over the past years as Air Canada's regional affiliate, Air Nova, has grown and expanded its fleet and InterCanadian, one of Canadian Airlines regional carriers, gained control over routes once served by another regional affiliate, Air Atlantic (59). However, these service levels were impacted in November 1999 as InterCanadian ceased operations due to financial difficulties. It is important to recognize however, that service levels did not decrease by half when InterCanadian ceased operations. Air Nova adjusted its flight schedules to better match aircraft size and frequency with demand. Subsequently, Air Nova now provides service once supplied by two carriers.

The difficulty with estimating service levels from 2000 to 2001 is that the market is currently unstable. The future path of Canada's dominant carrier and its regional affiliates could follow any direction while its resources are restructured. However, considerable attention and pressure have been placed on Air Canada to maintain current service levels. While it is unlikely that the carrier will provide the same frequency and aircraft as pre-merger days, analysts agree that change over the next year will be gradual as Air Canada is aware of public concern.

Considering an increase in service levels over the past few years by Air Nova and InterCanadian, a recent stabilization in service due to InterCanadian's collapse, and Air Canada's awareness of public concern, the level of service along all research links were increased by 5%. It is believed that a 5% growth rate is a conservative increase while remaining practical. Furthermore, this value attempts to incorporate service trends that have occurred since 1996 as well as changes that may materialize up to 2001. Forecasts of level of service for 2001 are presented in Table F4. It is important to note that service data from 1991 and 1996 were not used as a reference when analyzing future forecasts. Two years of data is an insufficient amount of information to numerically assess historic trends. If more time and money were available, this component of the thesis could be further developed.

The long-term future of service levels (i.e. 2001 to 2006) will be interesting to follow. Air Canada has agreed to continue operating and managing Canadian Airlines over the next two years. After this period, the carrier is permitted to handle Canadian in any manner. For the purposes of research, it was assumed that Air Canada would cease operating Canadian Airlines completely. Furthermore, it was predicted that Air Canada would introduce the greatest amount of change to service levels at this time since management would be able to focus on one airline while attempting to maximize efficiency.

To produce forecasts for 2006, it was assumed that Air Canada would begin implementing service level changes commencing in 2001. The airline will continue to favour large urban centres and high volume routes where revenue is greatest. Service along medium volume links will remain relatively stable while low volume links will experience a reduction in service. Air Canada may in fact encourage smaller, local airlines to gain control of smaller volume markets. These carriers would feed passengers to the domestic airline at a series of hub airports across Canada. Air Canada's intention surrounding small airport service was recently demonstrated as a local airline, Air Labrador, commenced operations in Charlo, New Brunswick, offering air service to Montreal where travellers can transfer onto Air Canada flights. Charlo airport was once served by Inter-Canadian however, Air Nova never assumed service responsibilities following Inter-Canadian's collapse.

Based on the assumptions outlined in the aforementioned paragraph, three service level ranges were calculated for 2006. Each value calculated for 2001 in Table F4 were multiplied by the following factors: -5% (low), 0% (medium), and 5% (high). To select the appropriate growth rate, passenger volumes from 1996 were consulted. Specifically, level of service was estimated to increase by 5% along links which experienced outbound passenger volumes in 1996 in excess of 50,000 passengers. Medium range estimates were chosen for routes that accommodated 5,000 to 50,000 travellers. Finally, all routes below 5,000 passengers in 1996 were classified as low volume routes and decreases in service levels were estimated. Forecasts produced for 2006 are illustrated in Table F4 including those estimates selected for further analysis.

9.2.2.2 Airfare per Kilometre

As indicated earlier, historic airfare data were not collected due to time and financial restraints. As a result, estimates were produced by multiplying the most recent year of data (1996) by a fixed percentage. Based on discussions with professionals in the industry, it was determined that each link volume in 1996 would increase by 30, 40 or 50% for 2001 and 2006. Table F5 displays estimates of airfare for the forecast horizon years. The percentages used for estimating seem conservative considering the percent change in airfare that occurred between 1991 and 1996. According to the data presented in Appendix C, the majcrity of one-way Y fare tickets increased from 40 to 60% along links investigated as part of this research. Caution should be exercised in these circumstances however, as it is difficult to analyze trends when only two points of data are used.

The low, medium and high percentages in Table F5 were also consistent with a study conducted by the Atlantic Provinces Transportation Commission in 1997 (60). The investigation determined that airfares had increased on Atlantic routes by approximately 26% since 1995 despite a stable 2% growth rate in inflation. Assuming the same growth rate of inflation, one would expect that ticket costs would have risen over 50% by 1999/2000 - approximately the same percent increase and period of time analyzed in this research.

Certain assumptions were incorporated in the research to produce the final airfare estimates presented in Table F5. Specifically, it was assumed that inflation would continue to rise in the future at the same rate experienced between the design and calibration years. A constant growth rate of inflation enabled the percent change between 1991 and 1996 airfare levels to serve as a reference for future estimates.

Another assumption considered during the analysis was that economy fare would continue to grow at a rate similar to the rates observed between 1991 and 1996 despite the recent airline merger. The public and government has closely monitored Air Canada since January 2000 for any signs of increased airfares. The airline is aware of this fact and recognizes that any sharp increase in airfare could encounter resistance. Instead, analysts believe that Air Canada will be more discrete with their revenue generation. It is likely that Air Canada will offer fewer discount fares in the future thereby limiting the selection of cheap airfares and forcing travellers to pay more for service (61). As for economy fares, it is assumed that ticket costs will increase in the future and the rate of growth will vary depending on the route. That is, airfare will likely increase the greatest on low volume routes. Conversely, ticket costs will rise moderately on high volume routes given the demand that exists on these links.

The range for the forecast of airfares was selected based on passenger volumes experienced in 1996. Specifically, links which accommodated less than 5,000 passengers in 1996 were considered low volume routes and the high range estimates were applied for 2001 and 2006. Conversely, low range forecasts were chosen for links which experienced over 50,000 passengers in 1996. Finally, links with passenger levels between 5,000 and 50,000 were assigned an increase of 40% for both forecast years. Estimates of airfares highlighted in Table F5 were divided by the great circle distance between origin and destination to produce airfare per kilometre data to be used in the link model. Table F6 presents the airfare per kilometre data used to estimate air passenger trips for this project.

9.3 Estimation of Air Passenger Trips

The final stage of research involved estimating air passenger trips within the Atlantic Region for the years 2001 and 2006. Population forecasts produced by the linear model were inserted into the generation model to determine future passenger volumes at the catchment area level. Air passenger trip estimates from the generation model for the forecast horizon years are presented in Table 9 for each catchment area investigated in the research. Historical data from 1991 and 1996 are also included in the table for comparison purposes.

Table 9: Air Passenger Trip Estimates – Catchment Area Generation Model

Airport Catchment Area	Air Passenger Trips 1991	1996	2001	2006
St. John's	239,180	229,320	202,746	206,950
Gander	35,950	31,710	24,215	22,154
Deer Lake/ Stephenville	57,000	59,410	77,129	74,905
Sydney	60,550	42,230	42,909	40,427
Halifax	474,770	475,070	506,049	524,718
Moncton	90,060	84,030	98,971	102,614
Saint John	70,690	64,800	70,509	72,792
Fredericton	75,590	76,120	76,957	80,880
Charlottetown	70,140	68,620	70,780	73,728

The airport catchment area generation model predicted growth in air passenger travel between 1996 and 2001 for all airports except St. John's and Gander. At a catchment specific level, forecasts of passenger trips were moderate (1-9%) at Sydney, Halifax, Saint John, Fredericton, and Charlottetown while projected growth was most noticeable at Deer Lake/Stephenville and Moncton airports (> 18%). Changes to traffic levels were also high at St. John's and Gander where air trips were estimated to decrease between 1996 and 2001 (< -12%). The negative growth results predicted by the generation model seem to follow historical passenger trends at these two airports between 1991 and 1996. Estimates for 2001 however, vary above and below trends established between the two historical years of data collected for the remaining airport catchment areas. Caution should be exercised in these circumstances however, as it is difficult to analyze trends when only two points of data are used. Traffic levels for example, could have increased or decreased in between 1991 and 1996 therefore altering any previously identified trends.

During the forecast horizon, the catchment model estimated moderate growth in air travel for most airports. Gander, Deer Lake/Stephenville and Sydney were the exceptions as decreases in passenger levels between –3% and –9% were predicted. Estimates produced during the forecast period for these three airports and the remaining catchment areas were anticipated given the population projections selected in a chapter 9.2.1.1. Since population was the only independent variable selected for modeling, air passenger forecasts were influenced by changes in the demographic parameter. The three airports that were predicted to experience a loss in passenger traffic between 2001 and 2006 for example, were also the catchment areas likely to decrease in population size.

One issue that has not yet been addressed that may also be influencing the forecasted results presented in Table 9 is airport catchment size. It was discussed in an earlier chapter that catchment areas were established based on the APATS survey conducted in 1969. Modifications to the boundaries were made to better reflect current day conditions. However, these changes were approximate and the final catchment areas incorporated in the research should not be considered completely accurate. It is possible that these catchment areas may be slightly different in size compared to actual conditions. As a result, the population base using an airport, and therefore the generation of air passenger trips, could be misrepresented. However, catchment boundaries established in this thesis were selected based on knowledge of travel patterns in Atlantic Canada. Furthermore, altering catchment area size would require significant time as it would be necessary to recalibrate and evaluate the model as well as produce new population estimates. Moncton's catchment area for example, was redefined following the calculation of initial estimates produced by the generation model.

The process of respecifying study areas would also be difficult as the catchment areas are composed of counties and sub divisions. A boundary alteration would require one or more counties/sub divisions to be dropped or added translating into large changes in the collected and estimated databases. To adjust air passenger flows more gradually, it would be necessary to define catchment areas by smaller aggregation levels such as census tracts or individual communities. The collection of data at these levels would inevitably add new challenges and complexity to the research.

Estimates of air passenger travel were also produced using the link estimation model. To determine future trends, population, disposable income per capita, level of service, and airfare per kilometre data determined for 2001 and 2006 were inserted into the forecast equation. Table 10 lists the estimates for each link investigated in the research. The distribution model predicted an increase in passenger traffic from 1996 to 2001 for 73% or 90 out of 124 links. Passenger traffic was predicted to decrease in flow for the remaining 34 routes. A reduction in traffic was most evident on links beginning at Deer Lake/Stephenville, Ottawa and Toronto airports. One possible explanation for these results relates to the catchment size issue discussed earlier in the chapter. It is likely that the catchment areas established for Ottawa and Toronto airports for example, encompassed a smaller area than the actual population served by these airports. To increase flow, the catchment areas, defined by Census Metropolitan Areas, would need to be expanded. This process would likely prove problematic as it is difficult to establish catchment boundaries of sufficient size to include all users of these large facilities.

The link estimation model in general predicted positive growth in air passenger travel between 2001 and 2006. Decreases in traffic on most links however continued at those origin airports which experienced loss in 2001 when compared with 1996 data. Once again, the catchment area sizes of Deer Lake/Stephenville, Ottawa, and Toronto have likely influenced these results as the demographic data may under represent the actual population served by these airports. It is important however that the catchment size does not become the primary reason for data trends produced by the link model. There are multiple variables included in the link model that are interacting with one another to produce the estimates provided in Table 10. Any one of these influential parameters could produce results that were not anticipated.

One method of verifying that the link estimates are adequate involves expressing link traffic on a catchment level. By adding together the passenger volume generated on the links, an origin total can be calculated for each airport and that value can be compared to the estimates produced by the catchment generation model.

Table 10: Air Passenger Trip Estimates – Link Distribution Model

Origin Airport	Destination Airport	1991	1996	2001	2006
St. John's	Gander	7,730	3,560	3,590	3,528
	Deer Lake/Stephenville	18,520	15,650	15,127	13,932
	Sydney	1,210	1,360	1,560	1,659
	Halifax	48,650	45,120	49,443	49,813
	Moncton	5,760	5,520	6,950	7,692
	Saint John	3,470	3,430	3,738	3,839
	Fredericton	3,840	3,870	4,310	4,570
	Charlottetown	3,180	3,300	4,160	4,710
	Montreal	22,250	15,860	17,578	18,857
	Ottawa	18,840	19,520	19,015	18,885
	Toronto	65,300	61,360	59,865	59,838
Gander	St. John's	7,160	3,030	3,055	3,001
	Deer Lake/Stephenville	650	760	688	622
	Sydney	120	150	168	175
	Halifax	5,260	5,670	6,068	5,990
	Moncton	780	910	1,072	1,166
	Saint John	370	480	511	514
	Fredericton	430	520	566	588
	Charlottetown	180	350	431	478
	Montreal	2,080	1,790	1,857	1,956
	Ottawa	2,080	2,040	1,860	1,814
	Toronto	9,580	8,010	7,291	6,951
Deer Lake/Stephenville	St. John's	18,600	15,430	14,836	13,610
	Gander	610	760	684	617
	Sydney	510	860	881	859
	Halifax	9,040	8,810	8,618	7,962
	Moncton	1,310	1,130	1,217	1,238
	Saint John	590	500	486	458
	Fredericton	760	1,020	1,014	986
	Charlottetown	430	930	1,047	1,087
	Montreal	2,580	2,850	2,702	2,665
	Ottawa	1,470	2,730	2,275	2,077
	Toronto	9,500	11,150	9,278	8,278
Sydney	St. John's	1,340	1,340	1,549	1,655
	Gander	130	160	181	189
	Deer Lake/Stephenville	340	590	612	602
	Halifax	18,980	12,650	15,520	16,661
	Moncton	1,220	720	973	1,150
	Saint John	780	470	573	628
	Fredericton	630	470	586	662
	Charlottetown	460	440	621	749
	Montreal	5,860	3,090	3,675	4,210

	Ottawa	5,010	4,280	4,474	4,745
	Toronto	18,830	10,090	10,530	10,917
Halifax	St. John's	49,740	44,700	49,023	49,395
	Gander	5,270	5,440	5,829	5,756
	Deer Lake/Stephenville	8,790	8,900	8,760	8,125
	Sydney	19,670	12,440	15,160	16,204
	Moncton	6,460	5,950	7,628	8,503
	Saint John	12,330	11,620	13,453	13,886
	Fredericton	10,500	9,410	11,133	11,862
	Charlottetown	13,000	14,010	18,764	21,347
	Montreal	57,570	50,170	59,263	64,092
	Ottawa	56,510	53,470	55,514	55,583
	Toronto	147,600	145,490	144,535	141,776
Moncton	St. John's	5,790	5,630	7,157	7,968
	Gander	770	940	1,119	1,224
	Deer Lake/Stephenville	1,210	1,160	1,268	1,303
	Sydney	1,110	720	975	1,154
	Halifax	6,110	5,840	7,553	8,469
	Montreal	19,050	14,420	18,863	22,520
	Ottawa	8,810	8,230	9,462	10,459
	Toronto	30,840	29,560	32,520	35,215
Saint John	St. John's	3,460	3,440	3,762	3,869
	Gander	360	460	491	495
	Deer Lake/Stephenville	600	440	432	409
	Sydney	750	510	620	676
	Halifax	12,380	11,410	13,245	13,690
	Charlottetown	430	480	641	744
	Montreal	11,330	8,810	10,343	11,384
	Ottawa	6,490	4,800	4,747	4,848
	Toronto	23,240	22,050	21,772	21,733
Fredericton	St. John's	3,750	3,690	4,128	4,390
	Gander	440	460	503	524
	Deer Lake/Stephenville	690	1,000	1,004	983
	Sydney	700	520	646	729
	Halifax	10,170	9,300	11,045	11,803
	Charlottetown	600	380	519	623
	Montreal	9,460	9,780	11,747	13,367
	Ottawa	10,870	10,870	11,476	12,089
	Toronto	22,760	22,700	22,932	23,666
Charlottetown	St. John's	3,270	3,340	4,262	4,859
	Gander	190	360	449	502
	Deer Lake/Stephenville	460	820	939	986
	Sydney	470	450	638	772
	Halifax	12,450	14,240	19,289	22,098
	Saint John	450	480	647	755

	Fredericton	500	360	496	598
	Montreal	8,000	5,630	7,713	9,409
	Ottawa	10,300	8,780	10,572	11,940
	Toronto	23,540	22,860	26,339	29,142
Montreal	St. John's	20,290	15,390	17,091	18,403
	Gander	1,820	1,810	1,882	1,991
	Deer Lake/Stephenville	2,100	2,790	2,665	2,648
	Sydney	4,970	3,060	3,619	4,143
	Halifax	57,910	49,760	56,222	60,966
	Moncton	19,160	13,870	18,005	21,448
	Saint John	11,200	8,640	10,129	11,173
	Fredericton	9,550	9,740	11,669	13,287
	Charlottetown	7,090	5,500	7,459	9,069
	Ottawa	5,980	6,370	6,398	6,839
	Toronto	559,640	626,550	630,281	660,705
Ottawa	St. John's	17,930	19,350	18,718	18,559
	Gander	1,730	1,910	1,730	1,685
	Deer Lake/Stephenville	1,280	2,510	2,088	1,911
	Sydney	4,620	4,250	4,378	4,616
	Halifax	58,930	54,370	56,010	55,980
	Moncton	8,950	8,290	9,374	10,282
	Saint John	6,520	4,890	4,786	4,872
	Fredericton	10,850	10,740	11,208	11,752
	Charlottetown	9,620	8,730	10,313	11,546
	Montreal	6,200	6,280	6,251	6,646
	Toronto	329,950	332,620	291,459	281,336
Toronto	St. John's	56,640	60,360	58,338	56,648
	Gander	6,500	7,470	6,739	6,407
	Deer Lake/Stephenville	7,760	10,140	8,403	7,504
	Sydney	15,620	9,790	10,045	10,337
	Halifax	151,340	145,890	143,457	140,286
	Moncton	29,770	29,200	31,517	33,825
	Saint John	22,370	21,820	21,270	21,137
	Fredericton	22,990	22,850	22,762	23,350
	Charlottetown	22,120	23,080	26,025	28,508
	Montreal	562,380	630,360	626,910	652,790
	Ottawa	329,590	332,940	291,033	280,556

The link totals were calculated for each airport catchment area and are listed in Table 11. Since estimates were only produced for the Atlantic airports by the catchment generation model, Quebec and Ontario airports were dropped from this component of the analysis. One obstacle that interfered with the comparison of link origin and catchment area totals were the number of links investigated. As discussed earlier in the thesis, passenger traffic between 12 airports were analyzed. At some airports such as Halifax however, service was provided to airports beyond the number of destinations listed in Table 10. Since the results from the catchment generation model were based on total traffic destined for all airports, a ratio of total catchment origins (1996) divided by link origin totals (1996) was calculated and applied to each forecasted link total. This mathematical procedure assumes that air passenger ratio will remain constant between the design and forecast years.

Table 11: Comparison of Passenger Forecasts by the Catchment Area and Link Models

Airport Catchment Area	Catchment Area Trip Origins 2001	Total of Link Origins 2001	Catchment Area Trip Origins 2006	Total of Link Origins 2006
St. John's	202,746	238,035	206,950	240,589
Gander	24,215	31,517	22,154	31,101
Deer Lake/Stephenville	77,129	55,382	74,905	51,260
Sydney	42,909	48,378	40,427	51,915
Halifax	506,049	511,150	524,718	520,961
Moncton	98,971	99,720	102,614	111,591
Saint John	70,509	69,317	72,792	71,538
Fredericton	76,957	82,994	80,880	88,406
Charlottetown	70,780	85,406	73,728	97,041

Examination of the data presented in Table 11 indicate that the total passenger trips calculated by the link model agrees reasonably well with the estimates produced using the catchment area generation model. In general, estimates from both models fell within approximately +/- 30% of each other for both forecast years. The link model typically produced forecasts greater than those determined by the catchment area model. Deer Lake/Stephenville and Saint John airports were exceptions to the comparison as catchment area model forecasts were greater than the totals produced by the link model. Finally, the predicted change in air passenger trips between 2001 and 2006 at a catchment area level were similar between models excluding Sydney. The catchment area model predicted negative growth in traffic at this airport while the link equation estimated positive growth. Differences in estimates can be mainly attributed to the causal variables included in each model. The catchment area model is limited in explanatory power as estimates are influenced by the single population parameter. Forecasts of air passenger trips by the link estimation model, however, were produced through the interaction of demographic and supply variables.

The results outlined in this chapter indicate that both models are suitable at estimating future air traffic trends at catchment area and link levels. An advantage associated with the methodology presented in this thesis is that the estimates produced by both models can be compared to ensure that the forecasts have been prepared properly. Furthermore, a comparison of catchment origin totals offers an analyst greater selection flexibility if a decision based on the forecasts is required.

CHAPTER 10 FUTURE RESEARCH

The air industry has undergone significant change in recent years as air travel has increased in volume, airlines have restructured, and new government policies have been implemented. Yet, the forecasting techniques used for producing estimates have not experienced significant change. The same forecasting methods have provided analysts with the necessary tools to analyze and predict the future direction of the industry.

The Atlantic Provinces Air Transportation Study conducted in 1969 estimated future air passenger travel using regression analysis and cross sectional data. Thirty years later, the forecasting methodology implemented in APATS was revisited to explore its capability to predict air travel based on present-day conditions. Air passenger estimates were produced as part of this thesis based on a technique that appears unaffected by time or changes in the industry. It is therefore recommended that the methodology outlined in this thesis be considered in the future when updated air travel estimates are required for the Atlantic Region. While the regression approach to forecasting is reliable, future research should also attempt to develop estimates using other techniques. A new method should only be selected following an evaluation of research objectives and other factors such as data availability, time limitations, and financial constraints.

An issue that should be investigated prior to selecting any forecasting technique is the appropriateness of airport catchment areas and the definition of their boundaries. In this research, airport catchment areas closely resembled those developed for APATS.

Although the catchment zones were modified to better reflect current conditions, it is believed that the boundaries could be further refined. An effective means of identifying the area an airport serves would involve distributing a survey to passengers at various airports in the region. A survey would ask participants for their place of residence and based on their responses, new airport catchment area boundaries could be established. It is important to recognize however that these boundaries are not fixed, as catchment areas will vary according to trip purpose. For example, there is reason to believe that the catchment boundary surrounding Fredericton airport will likely encompass a larger area for vacation travellers compared to business passengers. An analyst must therefore exercise caution when aggregating data at a catchment area level.

It is also believed that a survey would help determine the approximate split between the number of passengers departing from an airport who reside in the catchment area versus those travellers who were simply visiting the area and are returning to their initial origin airport. A survey of passengers would avoid assuming a split value as performed in the research. This evaluation could also improve regression statistics, as the independent data would now be more closely related to the dependent variable consisting only of passengers from the catchment area.

Air passenger statistics were collected from a survey of tickets supplied by major and regional scheduled carriers in Eastern Canada. Local airlines such as Air Labrador and Inter Provincial were not included in the study as the number of passengers carried by these airlines fell below the limit established by Statistics Canada reporting. Despite the small number of passengers that these airlines serve, a degree of error was incurred by not including these passengers in the origin traffic totals used in the research. Future research should attempt to define more accurately the volume of passengers carried by local airlines. One possible means of collecting this information could involve contacting the smaller carriers directly. If the airlines are unwilling to provide passenger data totals, statistics at a catchment area level may be available.

As indicated earlier in the thesis, problems were encountered when developing the catchment area generation model through regression analysis on the population and disposable income variables. Specifically, regression analysis consistently found that population influenced air passenger trips while disposable income was discarded. These results were rather surprising considering that these two demographic variables appeared in a number of historic forecast models with similar research objectives such as APATS. To develop a model that included population and disposable income as causal parameters, a variety of issues were investigated and tests were implemented. Due to time limitations however, a solution to the problem was not determined and the disposable income variable was removed from the analysis. It is recommended that further analysis be performed on the demographic variables to determine if an underlying factor was influencing the performance of these parameters. It is also suggested that the generation model be recalibrated using more airport catchment areas. Increasing the number of catchment areas may improve model stability, as regression analysis will be performed on a greater number of data points. This analysis may ultimately determine that population and other independent variables contribute to the generation of air passenger trips at a catchment level.

Another variable that was found not to be significant for estimating air trips was sector employment. One of the purposes of including this variable in the original analysis was to examine trip purpose in relation to the generation of air travel. That is, the employment variable was considered as an explanatory variable as it attempted to quantify the portion of catchment population that would be likely to generate air passenger trips for business purposes. It is recommended that further research be directed towards investigating trip purpose as it relates to the business community. The analysis should also attempt to identify causal variables associated with other categories of trip purpose including vacation travel and passengers visiting friends and relatives. While disposable income, airfare, and distance could be considered indicators of trip purpose for vacation/visiting travellers, other variables should be investigated.

Finally, economic or global indicators such as Gross National Product, Gross national Expenditure, and Gross Domestic Production of Services, were not investigated in the research. According to one source, "analysis has shown that historically the growth and variation in domestic air travel over a period of years has corresponded closely to several global type variables." (62) As such, an effort should be made to incorporate these parameters in future forecast models.

CHAPTER 11 CONCLUSION

The research undertaken in the preparation of this thesis endeavored to estimate air passenger travel at a local level using regression analysis techniques. Two approaches to forecasting were selected to describe future air travel patterns. The first procedure involved developing a model that estimated the total amount of passenger traffic generated from the population surrounding an airport, also known as an airport catchment area. While the second approach also investigated passenger trips originating from a catchment area, this technique was based on the distribution of these trips on links between airports using a link estimation model. The results produced by both the link and catchment area models provide an indication of future demand for air travel. Using these results, aviation related services and government officials are able to establish service levels adequate for public demand.

The forecast methodology developed in the research offered potential particularly in terms of the ease with which the models were calibrated and evaluated. One factor which attributed to the success of the methodology was the data on which the models were based. Specifically, historical data was readily available and easily collected from sources that presented the information at levels of disaggregation satisfactory to research requirements. Conversely, the data necessary for forecasting could have been compiled using a passenger survey however, this approach would have been more time consuming and cost intensive.

While published data offered advantages, employing the survey technique might have reduced some of the problems encountered during model development. Requesting information from passengers for example would help define catchment area boundaries more accurately as well as determining the split between those who reside in the catchment area versus those travellers who are visiting and are returning to their point of origin. Future research should attempt to incorporate survey compiled data in the forecasting procedure.

The models developed in the research are limited in their estimation capabilities. However, the process of relating demographic and supply variables to air passenger trips provided an insight into air travel demand and the factors that influence travel propensity. Future research should attempt to reduce the number of errors associated with these variables and their respective databases. Particular focus should be placed on further analysis of those independent parameters that were not included in the final models. While this investigation and other recommendations presented in the thesis may not provide definitive results, they do form an important step to a better understanding of air travel demand.

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APPENDIX A

AIR PASSENGER TRIP DATA (1991 AND 1996)

Air Passenger Trips (1991 and 1996)
Catchment Area Generation Model

Origin Airport	Origin Trips 1991	1996
St. John's	239,180	229,320
Gander	35,950	31,710
Deer Lake/Stephenville	57,000	59,410
Sydney	60,550	42,230
Halifax	474,770	475,070
Moncton	90,060	84,030
Saint John	70,690	64,800
Fredericton	75,590	76,120
Charlottetown	70,140	68,620

Air Passenger Trips (1991 and 1996)
Link Estimation Model

Origin Airport	Destination Airport	Air Passenger Trips 1991	1996
St. John's	Gander	7,730	3,560
	Deer Lake/Stephenville	18,520	15,650
	Sydney	1,210	1,360
	Halifax	48,650	45,120
	Moncton	5,760	5,520
	Saint John	3,470	3,430
	Fredericton	3,840	3,870
	Charlottetown	3,180	3,300
	Montreal	22,250	15,860
	Ottawa	18,840	19,520
	Toronto	65,300	61,360
Gander	St. John's	7,160	3,030
	Deer Lake/Stephenville	650	760
	Sydney	120	150
	Halifax	5,260	5,670
	Moncton	780	910
	Saint John	370	480
	Fredericton	430	520
	Charlottetown	180	350
	Montreal	2,080	1,790
	Ottawa	2,080	2,040
	Toronto	9,580	8,010
Deer Lake/Stephenville	St. John's	18,600	15,430
	Gander	610	760
	Sydney	510	860
	Halifax	9,040	8,810
	Moncton	1,310	1,130
	Saint John	590	500
	Fredericton	760	1,020
	Charlottetown	430	930
	Montreal	2,580	2,850

	Ottawa	1,470	2,730
	Toronto	9,500	11,150
Sydney	St. John's	1,340	1,340
	Gander	130	160
	Deer Lake/Stephenville	340	590
	Halifax	18,980	12,650
	Moncton	1,220	720
	Saint John	780	470
	Fredericton	630	470
	Charlottetown	460	440
	Montreal	5,860	3,090
	Ottawa	5,010	4,280
	Toronto	18,830	10,090
Halifax	St. John's	49,740	44,700
	Gander	5,270	5,440
	Deer Lake/Stephenville	8,790	8,900
	Sydney	19,670	12,440
	Moncton	6,460	5,950
	Saint John	12,330	11,620
	Fredericton	10,500	9,410
	Charlottetown	13,000	14,010
	Montreal	57,570	50,170
	Ottawa	56,510	53,470
	Toronto	147,600	145,490
Moncton	St. John's	5,790	5,630
	Gander	770	940
	Deer Lake/Stephenville	1,210	1,160
	Sydney	1,110	720
	Halifax	6,110	5,840
	Montreal	19,050	14,420
	Ottawa	8,810	8,230
	Toronto	30,840	29,560
Saint John	St. John's	3,460	3,440
	Gander	360	460
	Deer Lake/Stephenville	600	440
	Sydney	750	510
	Halifax	12,380	11,410

	Charlottetown	430	480
	Montreal	11,330	8,810
	Ottawa	6,490	4,800
	Toronto	23,240	22,050
Fredericton	St. John's	3,750	3,690
	Gander	440	460
	Deer Lake/Stephenville	690	1,000
	Sydney	700	520
	Halifax	10,170	9,300
	Charlottetown	600	380
	Montreal	9,460	9,780
	Ottawa	10,870	10,870
	Toronto	22,760	22,700
Charlottetown	St. John's	3,270	3,340
	Gander	190	360
	Deer Lake/Stephenville	460	820
	Sydney	470	450
	Halifax	12,450	14,240
	Saint John	450	480
	Fredericton	500	360
	Montreal	8,000	5,630
	Ottawa	10,300	8,780
	Toronto	23,540	22,860
Montreal	St. John's	20,290	15,390
	Gander	1,820	1,810
	Deer Lake/Stephenville	2,100	2,790
	Sydney	4,970	3,060
	Halifax	57,910	49,760
	Moncton	19,160	13,870
	Saint John	11,200	8,640
	Fredericton	9,550	9,740
	Charlottetown	7,090	5,500
	Ottawa	5,980	6,370
	Toronto	559,640	626,550
Ottawa	St. John's	17,930	19,350
	Gander	1,730	1,910
	Deer Lake/Stephenville	1,280	2,510

	Sydney	4,620	4,250
	Halifax	58,930	54,370
	Moncton	8,950	8,290
	Saint John	6,520	4,890
	Fredericton	10,850	10,740
	Charlottetown	9,620	8,730
	Montreal	6,200	6,280
	Toronto	329,950	332,620
Toronto	St. John's	56,640	60,360
	Gander	6,500	7,470
	Deer Lake/Stephenville	7,760	10,140
	Sydney	15,620	9,790
	Halifax	151,340	145,890
	Moncton	29,770	29,200
	Saint John	22,370	21,820
	Fredericton	22,990	22,850
	Charlottetown	22,120	23,080
	Montreal	562,380	630,360
	Ottawa	329,590	332,940

APPENDIX B

DEMOGRAPHIC DATA FOR AIRPORT CATCHMENT AREAS (1991 AND 1996)

Demographic Data for Airport Catchment Areas (1991)

Origin Airport	Population	Disposable Income (CDN $) 1986=100
St. John's	302,826	2,657,016,556
Gander	121,932	888,489,238
Deer Lake/Stephenville	109,572	845,875,828
Sydney	161,686	1,246,456,295
Halifax	703,972	6,992,498,797
Moncton	259,346	2,342,611,111
Saint John	170,191	1,643,665,862
Fredericton	144,446	1,382,640,902
Charlottetown	129,765	1,119,796,664
Montreal	3,208,970	20,552,245,253
Ottawa	941,814	9,217,612,853
Toronto	3,898,933	28,729,832,288

Demographic Data for Airport Catchment Areas (1996)

Origin Airport	Population	Disposable Income (CDN $) 1986=100
St. John's	299,442	2,808,711,197
Gander	115,362	906,472,587
Deer Lake/Stephenville	104,219	841,511,969
Sydney	158,271	1,339,405,283
Halifax	717,207	7,551,602,264
Moncton	212,921	2,162,923,780
Saint John	171,361	1,763,913,110
Fredericton	150,457	1,544,769,055
Charlottetown	134,557	1,298,010,487
Montreal	3,326,510	21,815,522,164
Ottawa	1,010,498	9,665,904,832
Toronto	4,263,757	29,651,360,176

APPENDIX C

TRANSPORT SUPPLY DATA FOR RESEARCH LINKS (1991 AND 1996)

Transport Supply Data for Research Links (1991)

ORIGIN Airport (i)	DESTINATION Airport (j)	LOS	Airfare (CDN $)	Distance Btwn i and j (km)
St. John's	Gander	94.5	153	201
	DL/S	165.5	214	388
	Sydney	18.0	333	580
	Halifax	223.5	270	883
	Moncton	23.5	308	925
	Saint John	4.5	303	1,040
	Fredericton	7.5	315	1,070
	Charlottetown	5.5	301	804
	Montreal	59.0	385	1,624
	Ottawa	7.5	411	1,773
	Toronto	72.0	470	2,131
Gander	St. John's	89.5	153	201
	DL/S	85.0	174	388
	Sydney	15.5	327	515
	Halifax	69.5	270	816
	Moncton	10.5	308	823
	Saint John	9.5	308	947
	Fredericton	9.0	322	964
	Charlottetown	11.5	337	708
	Montreal	15.5	385	1,499
	Ottawa	15.5	411	1,645
	Toronto	29.0	470	2,007
Deer Lake/ Stephenville	St. John's	165.0	214	388
	Gander	52.5	174	209
	Sydney	21.5	265	393
	Halifax	139.5	240	668
	Moncton	23.5	260	646
	Saint John	14.5	260	773
	Fredericton	4.5	264	781
	Charlottetown	16.0	268	539
	Montreal	13.5	352	1,300
	Ottawa	22.0	375	1,444
	Toronto	38.0	435	1,808
Sydney	St. John's	13.0	333	580
	Gander	12.0	327	515
	DL/S	15.0	265	393

	Halifax	124.5	168	388
	Moncton	7.0	208	357
	Saint John	16.5	208	463
	Fredericton	12.0	222	503
	Charlottetown	6.0	204	238
	Montreal	18.0	336	1,066
	Ottawa	6.0	357	1,217
	Toronto	48.5	413	1,566
Halifax	St. John's	181.0	270	883
	Gander	43.5	270	816
	DL/S	92.0	240	388
	Sydney	135.5	168	304
	Moncton	82.0	152	165
	Saint John	125.0	152	193
	Fredericton	85.0	163	261
	Charlottetown	96.5	144	158
	Montreal	187.5	258	807
	Ottawa	98.5	276	957
	Toronto	200.5	336	1,292
Moncton	St. John's	9.0	308	925
	Gander	9.5	308	823
	DL/S	4.5	260	388
	Sydney	17.5	208	357
	Halifax	97.5	152	165
	Montreal	31.0	241	708
	Ottawa	39.0	264	859
	Toronto	18.0	322	1,210
Saint John	St. John's	7.5	303	1,040
	Gander	7.0	308	947
	DL/S	7.0	260	388
	Sydney	21.5	208	463
	Halifax	92.0	152	193
	Charlottetown	12.5	175	239
	Montreal	66.5	223	616
	Ottawa	15.0	249	766
	Toronto	25.5	306	1,107
Fredericton	St. John's	12.5	315	1,070
	Gander	5.0	322	964
	DL/S	10.5	264	388
	Sydney	28.0	222	503
	Halifax	92.0	163	261
	Charlottetown	13.5	194	267

	Montreal	83.0	213	563
	Ottawa	33.5	239	714
	Toronto	26.5	301	1,064
Charlottetown	St. John's	37.0	301	804
	Gander	17.5	337	708
	DL/S	6.0	268	388
	Sydney	12.5	204	238
	Halifax	95.0	144	158
	Saint John	16.5	175	239
	Fredericton	21.0	194	267
	Montreal	11.5	284	828
	Ottawa	22.5	307	979
	Toronto	7.5	373	1,331
Montreal	St. John's	38.5	385	1,624
	Gander	7.5	385	1,499
	DL/S	7.5	352	388
	Sydney	45.0	336	1,066
	Halifax	183.0	258	807
	Moncton	43.0	241	708
	Saint John	65.5	223	616
	Fredericton	74.5	213	563
	Charlottetown	34.0	284	828
	Ottawa	195.5	144	151
	Toronto	658.0	205	508
Ottawa	St. John's	7.0	411	1,773
	Gander	7.0	411	1,645
	DL/S	7.5	375	388
	Sydney	31.5	357	1,217
	Halifax	97.0	276	957
	Moncton	8.5	276	859
	Saint John	6.5	249	766
	Fredericton	23.5	239	714
	Charlottetown	27.5	307	979
	Montreal	237.0	144	151
	Toronto	386.0	179	364
Toronto	St. John's	74.5	470	2,131
	Gander	19.0	470	2,007
	DL/S	30.0	435	388
	Sydney	47.0	413	1,566
	Halifax	254.5	336	1,292
	Moncton	17.5	322	1,210
	Saint John	25.0	306	1,107

	Fredericton	26.0	301	1,064
	Charlottetown	8.0	373	1,331
	Montreal	619.0	205	508
	Ottawa	396.0	179	364

Transport Supply Data for Research Links (1996)

ORIGIN Airport (i)	DESTINATION Airport (j)	LOS	Airfare (CDN $)	Distance Btwn i and j (km)
St. John's	Gander	75.5	238	201
	DL/S	118.5	335	388
	Sydney	47.5	522	580
	Halifax	170.0	422	883
	Moncton	5.5	480	925
	Saint John	35.0	474	1,040
	Fredericton	5.5	483	1,070
	Charlottetown	59.5	472	804
	Montreal	67.0	564	1,624
	Ottawa	84.5	599	1,773
	Toronto	52.0	613	2,131
Gander	St. John's	70.0	238	201
	DL/S	41.5	263	388
	Sydney	24.0	537	515
	Halifax	52.5	435	816
	Moncton	6.0	495	823
	Saint John	17.5	488	947
	Fredericton	11.5	507	964
	Charlottetown	29.5	485	708
	Montreal	29.5	553	1,499
	Ottawa	5.5	589	1.645
	Toronto	29.5	600	2.007
Deer Lake/ Stephenville	St. John's	114.0	335	388
	Gander	53.5	263	209
	Sydney	15.0	399	393
	Halifax	67.0	393	668
	Moncton	19.0	419	646
	Saint John	23.0	419	773
	Fredericton	12.5	426	781
	Charlottetown	42.5	432	539
	Montreal	4.5	506	1,300
	Ottawa	9.5	538	1,444
	Toronto	36.0	557	1,808
Sydney	St. John's	41.5	522	580
	Gander	19.5	537	515
	DL/S	27.5	399	393

	Halifax	66.5	264	388
	Moncton	28.5	325	357
	Saint John	6.5	325	463
	Fredericton	12.5	347	503
	Charlottetown	47.0	320	238
	Montreal	5.5	515	1,066
	Ottawa	42.5	512	1,217
	Toronto	48.0	539	1,566
Halifax	St. John's	150.0	422	883
	Gander	51.0	435	816
	DL/S	89.0	393	388
	Sydney	74.5	264	304
	Moncton	70.5	237	165
	Saint John	85.5	237	193
	Fredericton	74.0	258	261
	Charlottetown	103.0	228	158
	Montreal	153.0	394	807
	Ottawa	197.5	423	957
	Toronto	280.0	438	1,292
Moncton	St. John's	40.5	480	925
	Gander	23.0	495	823
	DL/S	28.5	419	388
	Sydney	12.5	325	357
	Halifax	78.0	237	165
	Montreal	44.5	366	708
	Ottawa	28.0	377	859
	Toronto	38.0	410	1,210
Saint John	St. John's	39.0	474	1,040
	Gander	7.0	488	947
	DL/S	19.5	419	388
	Sydney	6.5	325	463
	Halifax	124.5	237	193
	Charlottetown	19.0	273	239
	Montreal	65.0	394	616
	Ottawa	20.0	377	766
	Toronto	35.0	410	1,107
Fredericton	St. John's	45.5	483	1,070
	Gander	12.0	507	964
	DL/S	17.5	426	388
	Sydney	27.0	347	503
	Halifax	85.5	258	261
	Charlottetown	6.5	303	267

	Montreal	58.5	333	563
	Ottawa	14.0	373	714
	Toronto	52.0	405	1,064
Charlottetown	St. John's	51.5	472	804
	Gander	6.5	485	708
	DL/S	7.0	432	388
	Sydney	46.0	320	238
	Halifax	95.5	228	158
	Saint John	25.0	273	239
	Fredericton	5.0	303	267
	Montreal	54.0	434	828
	Ottawa	4.5	469	979
	Toronto	16.0	476	1,331
Montreal	St. John's	48.5	564	1,624
	Gander	31.5	553	1,499
	DL/S	4.5	506	388
	Sydney	49.0	515	1,066
	Halifax	159.5	394	807
	Moncton	37.0	366	708
	Saint John	71.5	394	616
	Fredericton	64.5	333	563
	Charlottetown	60.0	434	828
	Ottawa	166.5	186	151
	Toronto	1135.0	238	508
Ottawa	St. John's	45.5	599	1,773
	Gander	25.0	589	1,645
	DL/S	24.0	538	388
	Sydney	42.5	512	1,217
	Halifax	126.5	423	957
	Moncton	6.5	377	859
	Saint John	13.0	377	766
	Fredericton	15.0	373	714
	Charlottetown	47.0	469	979
	Montreal	165.0	186	151
	Toronto	651.0	217	364
Toronto	St. John's	51.0	613	2,131
	Gander	31.5	600	2,007
	DL/S	37.0	557	388
	Sydney	49.0	539	1,566
	Halifax	244.5	438	1,292
	Moncton	35.0	410	1,210
	Saint John	51.0	410	1,107

	Fredericton	24.5	405	1,064
	Charlottetown	16.0	476	1,331
	Montreal	1145.5	238	508
	Ottawa	680.0	217	364

APPENDIX D

ACTUAL AND ESTIMATED AIR PASSENGER TRIPS (1996)

Actual and Estimated Air Passenger Trips by Airport Catchment Area (1996)

Origin Airport	Air Passenger Trips (1996) Actual	Estimated	Correction Factor, K (Actual/Est)
St. John's	229,320	177,020	1.30
Gander	31,710	42,328	0.75
Deer Lake/Stephenville	59,410	34,175	1.74
Sydney	42,230	73,725	0.57
Halifax	475,070	482,698	0.98
Moncton	84,030	113.712	0.74
Saint John	64,800	83,303	0.78
Fredericton	76.120	68,007	1.12
Charlottetown	68.620	56.373	1.22

Actual and Estimated Air Passenger Trips (1996)

ORIGIN Airport (i)	DESTINATION Airport (j)	Air Passenger Trips (1996) Actual	Estimated	K (Actual/Est)
St. John's	Gander	3,560	1,512	2.35
	DL/S	15,650	2,272	6.89
	Sydney	1,360	2,086	0.65
	Halifax	45,120	27,972	1.61
	Moncton	5,520	1,801	3.06
	Saint John	3,430	4,375	0.78
	Fredericton	3,870	1,562	2.48
	Charlottetown	3,300	3,578	0.92
	Montreal	15,860	23,483	0.68
	Ottawa	19,520	25,389	0.77
	Toronto	61,360	31,472	1.95
Gander	St. John's	3,030	1,393	2.18
	DL/S	760	510	1.49
	Sydney	150	443	0.34
	Halifax	5,670	4,743	1.20
	Moncton	910	565	1.61
	Saint John	480	939	0.51
	Fredericton	520	679	0.77
	Charlottetown	350	750	0.47
	Montreal	1,790	4,910	0.36
	Ottawa	2,040	2,021	1.01
	Toronto	8,010	7,583	1.06
Deer Lake/ Stephenville	St. John's	15,430	2,135	7.23
	Gander	760	397	1.92
	Sydney	860	350	2.45
	Halifax	8,810	4,979	1.77
	Moncton	1,130	953	1.19
	Saint John	500	1,030	0.49
	Fredericton	1,020	682	1.49
	Charlottetown	930	807	1.15
	Montreal	2,850	1,809	1.58
	Ottawa	2,730	2,564	1.06

	Toronto	11,150	8,117	1.37
Sydney	St. John's	1,340	1,896	0.71
	Gander	160	406	0.39
	DL/S	590	483	1.22
	Halifax	12,650	6,889	1.84
	Moncton	720	1,442	0.50
	Saint John	470	704	0.67
	Fredericton	470	897	0.52
	Charlottetown	440	938	0.47
	Montreal	3,090	2,663	1.16
	Ottawa	4,280	7,712	0.55
	Toronto	10,090	13,321	0.76
Halifax	St. John's	44,700	27,167	1.65
	Gander	5,440	5,053	1.08
	DL/S	8,900	4,441	2.00
	Sydney	12,440	6,676	1.86
	Moncton	5,950	8,719	0.68
	Saint John	11,620	9,306	1.25
	Fredericton	9,410	8,949	1.05
	Charlottetown	14,010	6,765	2.07
	Montreal	50,170	72,073	0.70
	Ottawa	53,470	82,415	0.65
	Toronto	145,490	166,199	0.88
Moncton	St. John's	5,630	4,961	1.13
	Gander	940	1,168	0.80
	DL/S	1,160	894	1.30
	Sydney	720	979	0.74
	Halifax	5,840	8,894	0.66
	Montreal	14,420	13,879	1.04
	Ottawa	8,230	11,478	0.72
	Toronto	29,560	22,550	1.31
Saint John	St. John's	3,440	4,620	0.74
	Gander	460	617	0.75
	DL/S	440	647	0.68
	Sydney	510	723	0.70
	Halifax	11,410	10,875	1.05
	Charlottetown	480	1,085	0.44

	Montreal	8,810	12,922	0.68
	Ottawa	4,800	7,906	0.61
	Toronto	22,050	17,944	1.23
Fredericton	St. John's	3,690	4,533	0.81
	Gander	460	722	0.64
	DL/S	1,000	547	1.83
	Sydney	520	1,356	0.38
	Halifax	9,300	9,273	1.00
	Charlottetown	380	571	0.67
	Montreal	9,780	11,599	0.84
	Ottawa	10,870	5,740	1.89
	Toronto	22,700	19,451	1.17
Charlottetown	St. John's	3,340	3,280	1.02
	Gander	360	359	1.00
	DL/S	820	272	3.01
	Sydney	450	941	0.48
	Halifax	14,240	6,206	2.29
	Saint John	480	1,229	0.39
	Fredericton	360	495	0.73
	Montreal	5,630	9,586	0.59
	Ottawa	8,780	2,724	3.22
	Toronto	22,860	8,894	2.57
Montreal	St. John's	15,390	20,077	0.77
	Gander	1,810	5,340	0.34
	DL/S	2,790	902	3.09
	Sydney	3,060	8,331	0.37
	Halifax	49,760	71,623	0.69
	Moncton	13,870	12,693	1.09
	Saint John	8,640	13,657	0.63
	Fredericton	9,740	12,313	0.79
	Charlottetown	5,500	10,324	0.53
	Ottawa	6,370	43,218	0.15
	Toronto	626,550	297,177	2.11
Ottawa	St. John's	19,350	19,113	1.01
	Gander	1,910	4,677	0.41
	DL/S	2,510	1,959	1.28
	Sydney	4,250	8,161	0.52

	Halifax	54,370	65,464	0.83
	Moncton	8,290	5,629	1.47
	Saint John	4,890	6,548	0.75
	Fredericton	10,740	6,142	1.75
	Charlottetown	8,730	9,322	0.94
	Montreal	6,280	43,999	0.14
	Toronto	332,620	186,930	1.78
Toronto	St. John's	60,360	31,788	1.90
	Gander	7,470	8,354	0.89
	DL/S	10,140	3,395	2.99
	Sydney	9,790	14,111	0.69
	Halifax	145,890	152,978	0.95
	Moncton	29,200	22,002	1.33
	Saint John	21,820	22,151	0.99
	Fredericton	22,850	13,604	1.68
	Charlottetown	23,080	9,200	2.51
	Montreal	630,360	302,480	2.08
	Ottawa	332,940	189,300	1.76

APPENDIX E

ACTUAL AND ESTIMATED AIR PASSENGER TRIPS (1991)

Actual and Estimated Air Passenger Trips (1991)

ORIGIN Airport (i)	DESTINATION Airport (j)	Air Passenger Trips (1991)		Percent Difference
		Actual	Estimated	
St. John's	Gander	7,730	4,034	-47.8
	DL/S	18,520	20,003	8.0
	Sydney	1,210	794	-34.4
	Halifax	48,650	51,630	6.1
	Moncton	5,760	10,450	81.4
	Saint John	3,470	1,207	-65.2
	Fredericton	3,840	4,278	11.4
	Charlottetown	3,180	871	-72.6
	Montreal	22,250	15,159	-31.9
	Ottawa	18,840	6,267	-66.7
	Toronto	65,300	78,575	20.3
Gander	St. John's	7,160	3,470	-51.5
	DL/S	650	1,170	80.0
	Sydney	120	120	-0.2
	Halifax	5,260	6,727	27.9
	Moncton	780	1,133	45.3
	Saint John	370	358	-3.3
	Fredericton	430	447	4.1
	Charlottetown	180	184	2.2
	Montreal	2,080	1,320	-36.5
	Ottawa	2,080	3,782	81.8
	Toronto	9,580	8,632	-9.9
Deer Lake/ Stephenville	St. John's	18,600	20,158	8.4
	Gander	610	809	32.7
	Sydney	510	1,039	103.8
	Halifax	9,040	14,168	56.7
	Moncton	1,310	1,262	-3.7
	Saint John	590	434	-26.5
	Fredericton	760	642	-15.5
	Charlottetown	430	550	27.8
	Montreal	2,580	5,418	110.0
	Ottawa	1,470	4,893	232.8

	Toronto	9,500	13,317	40.2
Sydney	St. John's	1,340	709	-47.1
	Gander	130	124	-4.4
	DL/S	340	434	27.7
	Halifax	18,980	16,488	-13.1
	Moncton	1,220	305	-75.0
	Saint John	780	710	-9.0
	Fredericton	630	418	-33.7
	Charlottetown	460	130	-71.8
	Montreal	5,860	5,602	-4.4
	Ottawa	5,010	1,633	-67.4
	Toronto	18,830	10,463	-44.4
Halifax	St. John's	49,740	48,993	-1.5
	Gander	5,270	5,169	-1.9
	DL/S	8,790	10,008	13.9
	Sydney	19,670	16,033	-18.5
	Moncton	6,460	5,812	-10.0
	Saint John	12,330	13,917	12.9
	Fredericton	10,500	9,692	-7.7
	Charlottetown	13,000	11,961	-8.0
	Montreal	57,570	57,943	0.6
	Ottawa	56,510	42,257	-25.2
	Toronto	147,600	132,930	-9.9
Moncton	St. John's	5,790	2,376	-59.0
	Gander	770	561	-27.1
	DL/S	1,210	453	-62.5
	Sydney	1,110	736	-33.7
	Halifax	6,110	5,886	-3.7
	Montreal	19,050	11,325	-40.5
	Ottawa	8,810	9,509	7.9
	Toronto	30,840	19,613	-36.4
Saint John	St. John's	3,460	1,484	-57.1
	Gander	360	467	29.8
	DL/S	600	286	-52.4
	Sydney	750	883	17.8
	Halifax	12,380	9,672	-21.9
	Charlottetown	430	338	-21.3

	Montreal	11,330	10,124	-10.6
	Ottawa	6,490	4,612	-28.9
	Toronto	23,240	20,599	-11.4
Fredericton	St. John's	3,750	1,811	-51.7
	Gander	440	287	-34.7
	DL/S	690	810	17.5
	Sydney	700	481	-31.2
	Halifax	10,170	9,249	-9.1
	Charlottetown	600	461	-23.2
	Montreal	9,460	11,820	24.9
	Ottawa	10,870	18,397	69.2
	Toronto	22,760	17,054	-25.1
Charlottetown	St. John's	3,270	2,470	-24.5
	Gander	190	500	163.0
	DL/S	460	727	58.1
	Sydney	470	194	-58.8
	Halifax	12,450	12,443	-0.1
	Saint John	450	337	-25.2
	Fredericton	500	620	24.1
	Montreal	8,000	2,349	-70.6
	Ottawa	10,300	19,465	89.0
	Toronto	23,540	14,566	-38.1
Montreal	St. John's	20,290	14,025	-30.9
	Gander	1,820	899	-50.6
	DL/S	2,100	3,943	87.8
	Sydney	4,970	2,940	-40.9
	Halifax	57,910	55,836	-3.6
	Moncton	19,160	14,251	-25.6
	Saint John	11,200	9,435	-15.8
	Fredericton	9,550	10,678	11.8
	Charlottetown	7,090	3,810	-46.3
	Ottawa	5,980	7,474	25.0
	Toronto	559,640	512,311	-8.5
Ottawa	St. John's	17,930	8,285	-53.8
	Gander	1,730	1,111	-35.8
	DL/S	1,280	1,642	28.3
	Sydney	4,620	3,802	-17.7

	Halifax	58,930	53,918	-8.5
	Moncton	8,950	9,158	2.3
	Saint John	6,520	3,865	-40.7
	Fredericton	10,850	14,838	36.8
	Charlottetown	9,620	6,644	-30.9
	Montreal	6,200	8,198	32.2
	Toronto	329,950	305,476	-7.4
Toronto	St. John's	56,640	80,540	42.2
	Gander	6,500	6,376	-1.9
	DL/S	7,760	10,707	38.0
	Sydney	15,620	10,059	-35.6
	Halifax	151,340	163,296	7.9
	Moncton	29,770	20,291	-31.8
	Saint John	22,370	16,918	-24.4
	Fredericton	22,990	25,275	9.9
	Charlottetown	22,120	15,514	-29.9
	Montreal	562,380	502,011	-10.7
	Ottawa	329,590	304,325	-7.7

APPENDIX F

INDEPENDENT VARIABLE FORECASTS FOR 2001 AND 2006

Table F1: Population Forecasts for Catchment Area

Airport Catchment Area	**Population**							
	1976	**1981**	**1986**	**1991**	**1996**	**2001**	**2006**	
St. John's	277,608	289,563	296,638	302,826	299,442	**310,300** 310,850 289,000	**315,990** 317,010 271,260	**REG** **LOG** **EXP**
Gander	126,495	127,574	125,739	121,932	115,362	**115,050** 115,130 106,250	**112,260** 112,520 94,570	
Deer Lake/ Stephenville	116,572	115,015	113,103	109,572	104,219	**102,650** 102,850 97,170	**99,640** 100,080 88,410	
Sydney	170,866	170,088	166,116	161,686	158,271	**155,330** 155,530 155,290	**151,970** 152,390 152,810	
Halifax	621,791	642,123	672,241	703,972	717,207	**747,270** 750,890 718,540	**772,540** 779,780 707,300	
Moncton	192,785	197,302	202,116	206,363	212,921	**217,100** 217,510 221,010	**222,030** 222,870 230,720	
Saint John	159,114	163,833	165,583	170,191	171,361	**175,270** 175,500 170,700	**178,360** 178,800 168,060	
Fredericton	129,902	132,369	138,021	144,446	150,457	**155,000** 155,650 156,540	**160,310** 161,700 162,650	
Charlottetown	118,229	122,506	126,646	129,765	134,557	**138,320** 138,780 140,310	**142,310** 143,240 147,080	
Montreal	2,802,547	2,828,349	2,921,360	3,208,970	3,326,510	**3,446,110** 3,465,110 3,375,290	**3,588,970** 3,631,510 3,345,440	
Ottawa	693,288	717,978	819,265	941,814	1,010,498	**1,094,050** 1,125,430 1,050,620	**1,179,870** 1,246,890 1,059,570	
Toronto	2,803,101	2,998,947	3,427,170	3,898,933	4,263,757	**4,624,770** 4,781,250 4,577,460	**5,006,900** 5,337,900 4,834,110	

Table F1 (cont'd): Population Forecasts for Atlantic Provinces

Provinces	Population 1976	1981	1986	1991	1996	2001	2006	
							527,890	+
Newfoundland	557,725	567,681	568,349	568,474	551,792	559,480	558,380	REG
						559,400	558,280	LOG
						522,840	481,160	EXP
							142,310	
PEI	118,229	122,506	126,646	129,765	134,557	138,320	142,310	
						138,780	143,240	
						140,310	147,080	
							924,510	
Nova Scotia	828,571	847,442	873,176	899,942	909,282	935,860	957,250	
						937,870	961,230	
						907,180	893,010	
							560,700	
New Brunswick	677,250	696,403	709,442	723,900	738,133	753,810	768,730	
						755,000	771,090	
						752,410	766,700	

NOTES:
Bold Text FORECASTS SELECTED
REG LINEAR REGRESSION
LOG LOG TRANSFORMED EXPONENTIAL RELATIONSHIP
EXP TRIPLE EXPONENTIAL SMOOTHING
- FORECASTS OBTAINED FROM AGGREGATION OF CATCHMENT AREAS

Table F2: Disposable Income Forecasts for Catchment Areas

Airport Catchment Area	Disposable Income (1986=100) 1991	1992	1993	1994	1995	1996	2001	2006	
St John's	2,657,016,556	2,824,783,784	2,834,132,151	2,952,221,957	2,877,955,294	2,808,711,197	**3,047,820,110**	**3,195,831,180**	REG
							3,060,299,260	3,228,427,020	LOG
							2,170,991,840	594,998,210	EXP
Gander	888,489,238	958,802,621	941,391,620	970,782,816	940,761,569	906,472,587	**948,418,240**	**957,730,360**	
							948,927,860	959,005,510	
							641,324,530	26,780,580	
Deer Lake/Stephenville	845,875,828	897,028,665	877,006,446	890,160,700	855,347,451	841,511,969	**839,169,980**	**820,068,740**	
							839,445,900	821,213,290	
							838,230,480	964,477,180	
Sydney	1,246,456,295	1,378,382,470	1,385,451,969	1,456,067,704	1,371,257,296	1,339,405,283	**1,472,976,510**	**1,546,402,960**	
							1,481,223,750	1,566,935,150	
							1,260,442,620	1,311,070,980	
Halifax	6,992,498,797	7,408,312,351	7,545,037,795	8,076,601,556	7,509,784,178	7,551,602,264	**8,292,150,660**	**8,810,935,890**	
							8,344,716,160	8,954,255,200	
							9,759,129,760	17,451,473,060	
Moncton	1,902,877,617	2,050,208,800	2,094,109,005	2,345,624,509	2,130,713,622	2,162,923,780	**2,498,679,730**	**2,754,859,840**	
							2,542,444,030	2,878,678,140	
							3,096,075,640	6,212,394,610	
Saint John	1,643,665,862	1,752,178,400	1,784,159,558	1,899,349,568	1,785,868,421	1,763,913,110	**1,946,700,270**	**2,063,485,460**	
							1,958,632,660	2,095,472,540	
							1,847,616,620	2,400,564,850	
Fredericton	1,382,640,902	1,472,072,000	1,496,335,703	1,606,179,890	1,518,444,272	1,544,769,055	**1,730,464,490**	**1,881,836,170**	
							1,751,725,770	1,941,018,800	
							2,055,657,590	3,668,931,330	
Charlottetown	1,119,796,664	1,224,534,279	1,242,631,864	1,433,441,860	1,285,957,285	1,298,010,487	**1,538,712,860**	**1,719,591,170**	
							1,575,438,230	1,824,681,330	
							1,797,510,760	3,532,830,130	
Montreal	20,552,245,253	21,173,747,475	21,326,428,352	24,062,759,130	21,607,833,588	21,815,522,164	**23,975,345,590**	**25,454,627,540**	
							24,082,778,830	25,791,580,220	
							31,135,002,790	63,401,217,230	
Ottawa	9,217,612,853	9,720,995,349	9,839,303,884	10,483,556,740	9,606,556,877	9,665,904,832	**10,300,454,520**	**10,663,654,140**	
							10,318,789,650	10,717,438,210	
							13,388,917,570	26,384,618,160	
Toronto	28,729,832,288	29,406,746,512	29,233,704,494	31,475,473,724	29,229,457,993	29,651,360,176	**30,974,855,100**	**31,877,361,260**	
							30,995,287,090	31,955,686,530	
							41,355,830,540	79,924,034,470	

NOTES:

Bold Text	FORECASTS SELECTED
REG	LINEAR REGRESSION
LOG	LOG TRANSFORMED EXPONENTIAL RELATIONSHIP
EXP	TRIPLE EXPONENTIAL SMOOTHING

Table F2 (cont'd): Disposable Income Forecasts for Atlantic Provinces

Province	Population 1991	1992	1993	1994	1995	1996	2001	2006	
								4,973,630,280	+
Newfoundland	4,734,763,245	5,021,136,773	4,980,896,857	5,149,835,322	5,002,533,333	4,886,069,498	5,148,894,760	5,273,131,820	REG
							5,155,412,640	5,289,322,790	LOG
							3,998,231,320	1,997,722,070	EXP
								1,719,591,170	
PEI	1,119,796,664	1,224,534,279	1,242,631,864	1,433,441,860	1,285,957,285	1,298,010,487	1,538,712,860	1,719,591,170	
							1,575,438,230	1,824,681,330	
							1,797,510,760	3,532,830,130	
								10,357,338,850	
Nova Scotia	8,533,674,419	9,091,160,956	9,237,011,024	9,868,249,027	9,184,323,349	9,192,630,943	10,085,688,530	10,686,475,360	
							10,145,617,090	10,848,044,270	
							11,407,160,980	19,483,870,470	
								6,700,181,470	
New Brunswick	6,564,479,066	7,093,337,600	7,189,913,112	7,666,675,570	7,287,427,245	7,310,198,171	8,211,258,510	8,895,205,220	
							8,309,198,220	9,161,037,110	
							8,491,528,310	12,667,523,220	

NOTES:

REG	LINEAR REGRESSION
LOG	LOG TRANSFORMED EXPONENTIAL RELATIONSHIP
EXP	TRIPLE EXPONENTIAL SMOOTHING
+	FORECASTS OBTAINED FROM AGGREGATION OF CATCHMENT AREAS

Table F3: Disposable Income per Capita used in Estimation of Air Passenger Trips

Airport Catchment Area	Disposable Income per Capita in Cdn $ (1986=100)	
	2001	2006
St. John's	9,822	10,114
Gander	8,244	8,531
Deer Lake/Stephenville	8,175	8,230
Sydney	9,483	10,176
Halifax	11,097	11,405
Moncton	11,509	12,408
Saint John	11,107	11,569
Fredericton	11,164	11,739
Charlottetown	11,124	12,083
Montreal	6,957	7,092
Ottawa	9,415	9,038
Toronto	6,698	6,367

Table F4: Level of Service Forecasts for Research Links

Note: Numbers in Bold = Forecasts Selected for Further Analysis

Origin Airport	Destination Airport	Passenger Volumes 1996	Level of Service Forecasts 2001 +5% since 96	2006 Low (-5%)	2006 Med (0%)	2006 High (5%)
St. John's	Gander	3,560	**79.3**	75.3	79.3	**83.2**
	Deer Lake/Stephenville	15,650	**124.4**	118.2	**124.4**	130.6
	Sydney	1,360	**49.9**	47.4	49.9	**52.4**
	Halifax	45,120	**178.5**	169.6	**178.5**	187.4
	Moncton	5,520	**5.8**	5.5	**5.8**	6.1
	Saint John	3,430	**36.8**	34.9	36.8	**38.6**
	Fredericton	3,870	**5.8**	5.5	5.8	**6.1**
	Charlottetown	3,300	**62.5**	59.4	62.5	**65.6**
	Montreal	15,860	**70.4**	66.8	**70.4**	73.9
	Ottawa	19,520	**88.7**	84.3	**88.7**	93.2
	Toronto	61,360	**54.6**	51.9	**54.6**	57.3
Gander	St. John's	3,030	**73.5**	69.8	73.5	**77.2**
	Deer Lake/Stephenville	760	**43.6**	41.4	43.6	**45.8**
	Sydney	150	**25.2**	23.9	25.2	**26.5**
	Halifax	5,670	**55.1**	52.4	**55.1**	57.9
	Moncton	910	**6.3**	6.0	6.3	**6.6**
	Saint John	480	**18.4**	17.5	18.4	**19.3**
	Fredericton	520	**12.1**	11.5	12.1	**12.7**
	Charlottetown	350	**31.0**	29.4	31.0	**32.5**
	Montreal	1,790	**31.0**	29.4	31.0	**32.5**
	Ottawa	2,040	**5.8**	5.5	5.8	**6.1**
	Toronto	8,010	**31.0**	29.4	**31.0**	32.5
Deer Lake/Stephenville	St. John's	15,430	**119.7**	113.7	**119.7**	125.7
	Gander	760	**56.2**	53.4	56.2	**59.0**
	Sydney	860	**15.8**	15.0	15.8	**16.5**
	Halifax	8,810	**70.4**	66.8	**70.4**	73.9
	Moncton	1,130	**20.0**	19.0	20.0	**20.9**
	Saint John	500	**24.2**	22.9	24.2	**25.4**
	Fredericton	1,020	**13.1**	12.5	13.1	**13.8**
	Charlottetown	930	**44.6**	42.4	44.6	**46.9**
	Montreal	2,850	**4.7**	4.5	4.7	**5.0**
	Ottawa	2,730	**10.0**	9.5	10.0	**10.5**
	Toronto	11,150	**37.8**	35.9	**37.8**	39.7
Sydney	St. John's	1,340	**43.6**	41.4	43.6	**45.8**
	Gander	160	**20.5**	19.5	20.5	**21.5**
	Deer Lake/Stephenville	590	**28.9**	27.4	28.9	**30.3**
	Halifax	12,650	**69.8**	66.3	**69.8**	73.3
	Moncton	720	**29.9**	28.4	29.9	**31.4**
	Saint John	470	**6.8**	6.5	6.8	**7.2**
	Fredericton	470	**13.1**	12.5	13.1	**13.8**
	Charlottetown	440	**49.4**	46.9	49.4	**51.8**
	Montreal	3,090	**5.8**	5.5	5.8	**6.1**
	Ottawa	4,280	**44.6**	42.4	44.6	**46.9**
	Toronto	10,090	**50.4**	47.9	**50.4**	52.9
Halifax	St. John's	44,700	**157.5**	149.6	**157.5**	165.4
	Gander	5,440	**53.6**	50.9	**53.6**	56.2
	Deer Lake/Stephenville	8,900	**93.5**	88.8	**93.5**	98.1
	Sydney	12,440	**78.2**	74.3	**78.2**	82.1
	Moncton	5,950	**74.0**	70.3	**74.0**	77.7
	Saint John	11,620	**89.8**	85.3	**89.8**	94.3
	Fredericton	9,410	**77.7**	73.8	**77.7**	81.6
	Charlottetown	14,010	**108.2**	102.7	**108.2**	113.6
	Montreal	50,170	**160.7**	**152.6**	160.7	168.7
	Ottawa	53,470	**207.4**	**197.0**	207.4	217.7
	Toronto	145,490	**294.0**	**279.3**	294.0	308.7
Moncton	St. John's	5,630	**42.5**	40.4	**42.5**	44.7
	Gander	940	**24.2**	22.9	24.2	**25.4**
	Deer Lake/Stephenville	1,160	**29.9**	28.4	29.9	**31.4**
	Sydney	720	**13.1**	12.5	13.1	**13.8**
	Halifax	5,840	**81.9**	77.8	**81.9**	86.0
	Montreal	14,420	**46.7**	44.4	**46.7**	49.1
	Ottawa	8,230	**29.4**	27.9	**29.4**	30.9
	Toronto	29,560	**39.9**	37.9	**39.9**	41.9
Saint John	St. John's	3,440	**41.0**	38.9	41.0	**43.0**
	Gander	460	**7.4**	7.0	7.4	**7.7**
	Deer Lake/Stephenville	440	**20.5**	19.5	20.5	**21.5**
	Sydney	510	**6.8**	6.5	6.8	**7.2**
	Halifax	11,410	**130.7**	124.2	**130.7**	137.3
	Charlottetown	480	**20.0**	19.0	20.0	**20.9**
	Montreal	8,810	**68.3**	64.8	**68.3**	71.7
	Ottawa	4,800	**21.0**	20.0	21.0	**22.1**
	Toronto	22,050	**36.8**	34.9	**36.8**	38.6

Origin Airport	Destination Airport	Passenger Volumes 1996	Level of Service Forecasts 2001	2006		
			+5% since 96	Low (-5%)	Med (0%)	High (5%)
Fredericton	St. John's	3,690	47.8	45.4	47.8	50.2
	Gander	460	12.6	12.0	12.6	13.2
	Deer Lake/Stephenville	1,000	18.4	17.5	18.4	19.3
	Sydney	520	28.4	26.9	28.4	29.8
	Halifax	9,300	89.8	85.3	89.8	94.3
	Charlottetown	380	6.8	6.5	6.8	7.2
	Montreal	9,780	61.4	58.4	61.4	64.5
	Ottawa	10,870	14.7	14.0	14.7	15.4
	Toronto	22,700	54.6	51.9	54.6	57.3
Charlottetown	St. John's	3,340	54.1	51.4	54.1	56.8
	Gander	360	6.8	6.5	6.8	7.2
	Deer Lake/Stephenville	820	7.4	7.0	7.4	7.7
	Sydney	450	48.3	45.9	48.3	50.7
	Halifax	14,240	100.3	95.3	100.3	105.3
	Saint John	480	26.3	24.9	26.3	27.6
	Fredericton	360	5.3	5.0	5.3	5.5
	Montreal	5,630	56.7	53.9	56.7	59.5
	Ottawa	8,780	4.7	4.5	4.7	5.0
	Toronto	22,860	16.8	16.0	16.8	17.6
Montreal	St. John's	15,390	50.9	48.4	50.9	53.5
	Gander	1,810	33.1	31.4	33.1	34.7
	Deer Lake/Stephenville	2,790	4.7	4.5	4.7	5.0
	Sydney	3,060	51.5	48.9	51.5	54.0
	Halifax	49,760	167.5	159.1	167.5	175.8
	Moncton	13,870	38.9	36.9	38.9	40.8
	Saint John	8,640	75.1	71.3	75.1	78.8
	Fredericton	9,740	67.7	64.3	67.7	71.1
	Charlottetown	5,500	63.0	59.9	63.0	66.2
	Ottawa	6,370	174.8	166.1	174.8	183.6
	Toronto	626,550	1191.8	1132.2	1191.8	1251.3
Ottawa	St. John's	19,350	47.8	45.4	47.8	50.2
	Gander	1,910	26.3	24.9	26.3	27.6
	Deer Lake/Stephenville	2,510	25.2	23.9	25.2	26.5
	Sydney	4,250	44.6	42.4	44.6	46.9
	Halifax	54,370	132.8	126.2	132.8	139.5
	Moncton	8,290	6.8	6.5	6.8	7.2
	Saint John	4,890	13.7	13.0	13.7	14.3
	Fredericton	10,740	15.8	15.0	15.8	16.5
	Charlottetown	8,730	49.4	46.9	49.4	51.8
	Montreal	6,280	173.3	164.6	173.3	181.9
	Toronto	332,620	683.6	649.4	683.6	717.7
Toronto	St. John's	60,360	53.6	50.9	53.6	56.2
	Gander	7,470	33.1	31.4	33.1	34.7
	Deer Lake/Stephenville	10,140	38.9	36.9	38.9	40.8
	Sydney	9,790	51.5	48.9	51.5	54.0
	Halifax	145,890	256.7	243.9	256.7	269.6
	Moncton	29,200	36.8	34.9	36.8	38.6
	Saint John	21,820	53.6	50.9	53.6	56.2
	Fredericton	22,850	25.7	24.4	25.7	27.0
	Charlottetown	23,080	16.8	16.0	16.8	17.6
	Montreal	630,360	1202.8	1142.6	1202.8	1262.9
	Ottawa	332,940	714.0	678.3	714.0	749.7

Table F5: Airfare Forecasts for Research Links

Note: Numbers in Bold = Forecasts Selected for Further Analysis

Origin Airport	Destination Airport	Passenger Volumes 1996	Airfare Forecasts (CAD) 2001 Low (30%)	2001 Med (40%)	2001 High (50%)	2006 Low (30%)	2006 Med (40%)	2006 High (50%)
St. John's	Gander	3,560	309	333	**357**	381	**428**	**476**
	Deer Lake/Stephenville	15,650	436	**469**	503	536	**603**	670
	Sydney	1,360	679	731	**783**	835	940	**1,044**
	Halifax	45,120	549	**591**	633	675	**760**	844
	Moncton	5,520	624	**672**	720	**768**	**864**	960
	Saint John	3,430	616	664	**711**	758	853	**948**
	Fredericton	3,870	628	676	**725**	773	869	**966**
	Charlottetown	3,300	614	661	**708**	755	850	**944**
	Montreal	15,860	733	**790**	846	902	**1,015**	1,128
	Ottawa	19,520	779	**839**	899	958	**1,078**	1,198
	Toronto	61,360	**797**	858	920	**981**	1,103	1,226
Gander	St. John's	3,030	309	333	**357**	381	428	**476**
	Deer Lake/Stephenville	760	342	368	**395**	421	473	**526**
	Sydney	150	698	752	**806**	859	967	**1,074**
	Halifax	5,670	566	**609**	653	696	**783**	870
	Moncton	910	644	693	**743**	792	891	**990**
	Saint John	480	634	683	**732**	781	878	**976**
	Fredericton	520	659	710	**761**	811	913	**1,014**
	Charlottetown	350	631	679	**728**	776	873	**970**
	Montreal	1,790	719	774	**830**	885	995	**1,106**
	Ottawa	2,040	766	825	**884**	942	1,060	**1,178**
	Toronto	8,010	780	**840**	900	960	**1,080**	1,200
Deer Lake/ Stephenville	St. John's	15,430	436	**469**	503	536	**603**	670
	Gander	760	342	368	**395**	421	473	**526**
	Sydney	860	519	559	**599**	638	718	**798**
	Halifax	8,810	511	**550**	590	629	**707**	786
	Moncton	1,130	545	587	**629**	670	754	**838**
	Saint John	500	545	587	**629**	670	754	**838**
	Fredericton	1,020	554	596	**639**	682	767	**852**
	Charlottetown	930	562	605	**648**	691	778	**864**
	Montreal	2,850	658	708	**759**	810	911	**1,012**
	Ottawa	2,730	699	753	**807**	861	968	**1,076**
	Toronto	11,150	724	**780**	836	891	**1,003**	1,114

Origin Airport	Destination Airport	Passenger Volumes 1996	Airfare Forecasts (CAD) 2001			2006		
			Low (30%)	Med (40%)	High (50%)	Low (30%)	Med (40%)	High (50%)
Sydney	St. John's	1,340	679	731	783	835	940	1,044
	Gander	160	698	752	806	859	967	1,074
	Deer Lake/Stephenville	590	519	559	599	638	718	798
	Halifax	12,650	343	370	396	422	475	528
	Moncton	720	423	455	488	520	585	650
	Saint John	470	423	455	488	520	585	650
	Fredericton	470	451	486	521	555	625	694
	Charlottetown	440	416	448	480	512	576	640
	Montreal	3,090	670	721	773	824	927	1,030
	Ottawa	4,280	666	717	768	819	922	1,024
	Toronto	10,090	701	755	809	862	970	1,078
Halifax	St. John's	44,700	549	591	633	675	760	844
	Gander	5,440	566	609	653	696	783	870
	Deer Lake/Stephenville	8,900	511	550	590	629	707	786
	Sydney	12,440	343	370	396	422	475	528
	Moncton	5,950	308	332	356	379	427	474
	Saint John	11,620	308	332	356	379	427	474
	Fredericton	9,410	335	361	387	413	464	516
	Charlottetown	14,010	296	319	342	365	410	456
	Montreal	50,170	512	552	591	630	709	788
	Ottawa	53,470	550	592	635	677	761	846
	Toronto	145,490	569	613	657	701	788	876
Moncton	St. John's	5,630	624	672	720	768	864	960
	Gander	940	644	693	743	792	891	990
	Deer Lake/Stephenville	1,160	545	587	629	670	754	838
	Sydney	720	423	455	488	520	585	650
	Halifax	5,840	308	332	356	379	427	474
	Montreal	14,420	476	512	549	586	659	732
	Ottawa	8,230	490	528	566	603	679	754
	Toronto	29,560	533	574	615	656	738	820
Saint John	St. John's	3,440	616	664	711	758	853	948
	Gander	460	634	683	732	781	878	976
	Deer Lake/Stephenville	440	545	587	629	670	754	838
	Sydney	510	423	455	488	520	585	650
	Halifax	11,410	308	332	356	379	427	474
	Charlottetown	480	355	382	410	437	491	546
	Montreal	8,810	512	552	591	630	709	788
	Ottawa	4,800	490	528	566	603	679	754
	Toronto	22,050	533	574	615	656	738	820

Origin Airport	Destination Airport	Passenger Volumes 1996	Airfare Forecasts (CAD) 2001 Low (30%)	2001 Med (40%)	2001 High (50%)	2006 Low (30%)	2006 Med (40%)	2006 High (50%)
Fredericton	St. John's	3,690	628	676	725	773	869	966
	Gander	460	659	710	761	811	913	1,014
	Deer Lake/Stephenville	1,000	554	596	639	682	767	852
	Sydney	520	451	486	521	555	625	694
	Halifax	9,300	335	361	387	413	464	516
	Charlottetown	380	394	424	455	485	545	606
	Montreal	9,780	433	466	500	533	599	666
	Ottawa	10,870	485	522	560	597	671	746
	Toronto	22,700	527	567	608	648	729	810
Charlottetown	St. John's	3,340	614	661	708	755	850	944
	Gander	360	631	679	728	776	873	970
	Deer Lake/Stephenville	820	562	605	648	691	778	864
	Sydney	450	416	448	480	512	576	640
	Halifax	14,240	296	319	342	365	410	456
	Saint John	480	355	382	410	437	491	546
	Fredericton	360	394	424	455	485	545	606
	Montreal	5,630	564	608	651	694	781	868
	Ottawa	8,780	610	657	704	750	844	938
	Toronto	22,860	619	666	714	762	857	952
Montreal	St. John's	15,390	733	790	846	902	1,015	1,128
	Gander	1,810	719	774	830	885	995	1,106
	Deer Lake/Stephenville	2,790	658	708	759	810	911	1,012
	Sydney	3,060	670	721	773	824	927	1,030
	Halifax	49,760	512	552	591	630	709	788
	Moncton	13,870	476	512	549	586	659	732
	Saint John	8,640	512	552	591	630	709	788
	Fredericton	9,740	433	466	500	533	599	666
	Charlottetown	5,500	564	608	651	694	781	868
	Ottawa	6,370	242	260	279	298	335	372
	Toronto	626,550	309	333	357	381	428	476
Ottawa	St. John's	19,350	779	839	899	958	1,078	1,198
	Gander	1,910	766	825	884	942	1,060	1,178
	Deer Lake/Stephenville	2,510	699	753	807	861	968	1,076
	Sydney	4,250	666	717	768	819	922	1,024
	Halifax	54,370	550	592	635	677	761	846
	Moncton	8,290	490	528	566	603	679	754
	Saint John	4,890	490	528	566	603	679	754
	Fredericton	10,740	485	522	560	597	671	746
	Charlottetown	8,730	610	657	704	750	844	938
	Montreal	6,280	242	260	279	298	335	372
	Toronto	332,620	282	304	326	347	391	434

Origin Airport	Destination Airport	Passenger Volumes 1996	Airfare Forecasts (CAD) 2001			2006		
			Low (30%)	Med (40%)	High (50%)	Low (30%)	Med (40%)	High (50%)
Toronto	St. John's	60,360	797	858	920	981	1,103	1,226
	Gander	7,470	780	840	900	960	1,080	1,200
	Deer Lake/Stephenville	10,140	724	780	836	891	1,003	1,114
	Sydney	9,790	701	755	809	862	970	1,078
	Halifax	145,890	569	613	657	701	788	876
	Moncton	29,200	533	574	615	656	738	820
	Saint John	21,820	533	574	615	656	738	820
	Fredericton	22,850	527	567	608	648	729	810
	Charlottetown	23,080	619	666	714	762	857	952
	Montreal	630,360	309	333	357	381	428	476
	Ottawa	332,940	282	304	326	347	391	434

Table F6: Airfare per Kilometre Data used in Estimation of Air Passenger Trips

Origin Airport	Destination Airport	Airfare per Kilometre 2001	2006
St. John's	Gander	1.78	2.37
	Deer Lake/Stephenville	1.21	1.55
	Sydney	1.35	1.80
	Halifax	0.67	0.86
	Moncton	0.73	0.93
	Saint John	0.68	0.91
	Fredericton	0.68	0.90
	Charlottetown	0.88	1.17
	Montreal	0.49	0.63
	Ottawa	0.47	0.61
	Toronto	0.37	0.46
Gander	St. John's	1.78	2.37
	Deer Lake/Stephenville	1.02	1.36
	Sydney	1.56	2.09
	Halifax	0.75	0.96
	Moncton	0.90	1.20
	Saint John	0.77	1.03
	Fredericton	0.79	1.05
	Charlottetown	1.03	1.37
	Montreal	0.55	0.74
	Ottawa	0.54	0.72
	Toronto	0.42	0.54
Deer Lake/Stephenville	St. John's	1.21	1.55
	Gander	1.89	2.52
	Sydney	1.52	2.03
	Halifax	0.82	1.06
	Moncton	0.97	1.30
	Saint John	0.81	1.08
	Fredericton	0.82	1.09
	Charlottetown	1.20	1.60
	Montreal	0.58	0.78
	Ottawa	0.56	0.75
	Toronto	0.43	0.55
Sydney	St. John's	1.35	1.80
	Gander	1.56	2.09
	Deer Lake/Stephenville	1.52	2.03
	Halifax	0.95	1.22
	Moncton	1.37	1.82
	Saint John	1.05	1.40
	Fredericton	1.03	1.38
	Charlottetown	2.02	2.69
	Montreal	0.72	0.97
	Ottawa	0.63	0.84
	Toronto	0.48	0.62

Halifax	St. John's	0.67	0.86
	Gander	0.75	0.96
	Deer Lake/Stephenville	1.42	1.82
	Sydney	1.22	1.56
	Moncton	2.01	2.59
	Saint John	1.72	2.21
	Fredericton	1.38	1.78
	Charlottetown	2.02	2.60
	Montreal	0.63	0.78
	Ottawa	0.57	0.71
	Toronto	0.44	0.54
Moncton	St. John's	0.73	0.93
	Gander	0.90	1.20
	Deer Lake/Stephenville	1.62	2.16
	Sydney	1.37	1.82
	Halifax	2.01	2.59
	Montreal	0.72	0.93
	Ottawa	0.61	0.79
	Toronto	0.47	0.61
Saint John	St. John's	0.68	0.91
	Gander	0.77	1.03
	Deer Lake/Stephenville	1.62	2.16
	Sydney	1.05	1.40
	Halifax	1.72	2.21
	Charlottetown	1.71	2.28
	Montreal	0.90	1.15
	Ottawa	0.74	0.98
	Toronto	0.52	0.67
Fredericton	St. John's	0.68	0.90
	Gander	0.79	1.05
	Deer Lake/Stephenville	1.65	2.20
	Sydney	1.03	1.38
	Halifax	1.38	1.78
	Charlottetown	1.70	2.27
	Montreal	0.83	1.06
	Ottawa	0.73	0.94
	Toronto	0.53	0.69
Charlottetown	St. John's	0.88	1.17
	Gander	1.03	1.37
	Deer Lake/Stephenville	1.67	2.23
	Sydney	2.02	2.69
	Halifax	2.02	2.60
	Saint John	1.71	2.28
	Fredericton	1.70	2.27
	Montreal	0.73	0.94
	Ottawa	0.67	0.86
	Toronto	0.50	0.64
Montreal	St. John's	0.49	0.63
	Gander	0.55	0.74

	Deer Lake/Stephenville	1.96	2.61
	Sydney	0.72	0.97
	Halifax	0.68	0.88
	Moncton	0.72	0.93
	Saint John	0.90	1.15
	Fredericton	0.83	1.06
	Charlottetown	0.73	0.94
	Ottawa	1.72	2.22
	Toronto	0.61	0.75
Ottawa	St. John's	0.47	0.61
	Gander	0.54	0.72
	Deer Lake/Stephenville	2.08	2.77
	Sydney	0.63	0.84
	Halifax	0.57	0.71
	Moncton	0.61	0.79
	Saint John	0.74	0.98
	Fredericton	0.73	0.94
	Charlottetown	0.67	0.86
	Montreal	1.72	2.22
	Toronto	0.78	0.95
Toronto	St. John's	0.37	0.46
	Gander	0.42	0.54
	Deer Lake/Stephenville	2.01	2.58
	Sydney	0.48	0.62
	Halifax	0.44	0.54
	Moncton	0.47	0.61
	Saint John	0.52	0.67
	Fredericton	0.53	0.69
	Charlottetown	0.50	0.64
	Montreal	0.61	0.75
	Ottawa	0.78	0.95