International Aviation Forecasting Models

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Abstract:

Forecasts have been made of future international air traffic in the trans-Pacific region and of future Australian resident departures using econometric analyses. The aim of this work is to provide sound estimates of international activity on selected market segments.

The paper focuses on case studies that have involved the development of forecasts of overseas travel trends in various regions, such as the trans-Pacific area, USA, Europe and Japan.

The results of the analyses contained in the case studies should provide a basis for strategic aviation and tourism policy formulation and industry infrastructure planning.

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Introduction

Forecasts provide an important contribution to the process of aviation and tourism policy formulation, the provision of adequate navigational arrangements and infrastructure planning.

This is particularly the case given the long lead times and substantial financial, political and environmental implications of many aviation-related decisions - not the least being issues associated with airport construction in a number of countries, including Australia.

This paper presents an overview of the methodology and key results from several forecasting activities involving staff from the AVSTATS (Aviation Statistics) section of the Department of Transport and Communications. Case studies discussed cover forecasting work in which econometric models have been developed. The aim of the studies is to relate and forecast future passenger traffic trends as functions of various underlying "explanatory variables" - particularly income and price variables.

The first part of the paper looks at an econometric analysis undertaken earlier this year by the Pacific Area Transport Forecasting Group, which is established under the aegis of the International Civil Aviation Organization (ICAO). The Group comprises representatives from Australia, Canada, Chile, Singapore and the United States. Australia is represented on the Group by Jon Henchy. The methodology used and key conclusions reached are the result of work undertaken by the Group as a whole.

The second part has a more specific Australian focus as it documents the key methodologies used, and results from, the development and application of econometric models to forecast short-term departure trends for Australian residents to selected markets such as the USA, Europe and South-east Asia.

Part 1 Trans-pacific traffic forecasts

The Asia/Pacific area has been identified by national governments, airlines, international aviation bodies (such as ICAO and the International Air Transport Association), and aircraft manufacturers (Boeing, Douglas and Airbus) as being the fastest growing region in the world, economically and in terms of aviation activity. Of particular importance in this regard is aviation traffic across the Pacific.

For the purposes of the forecasting task, trans-Pacific traffic is defined as that between North America (including Hawaii) on the one side and nations in Asia and Oceania on the other.

Over the period 1980-1990 trans-Pacific passenger traffic increased from about 4.5 million to almost 12.3 million at an average annual growth rate of 10.5%. This compares with an average annual growth rate of 5.7% for world passenger traffic.

Factors affecting demand for air travel

The long-term demand for air travel is primarily determined by economic developments; notably the growth of world (and regional) income levels as measured by variations in GDP, demographic trends, and the cost of air travel as, for example, measured by yields (gross passenger revenue divided by total passenger kilometres). World energy demand, supply and prices are important both to economic progress and to the cost of air travel. Consequently it is clear that the airline industry is vulnerable to economic cycles and fuel prices, as well as being subject to political developments such as the Gulf conflict.

However, it is considered that the most important factors influencing medium to long term demand trends in airline traffic are movements in economic growth, measured by GDP movements (as a proxy for income), and cost of travel as measured by movements in airline yields (defined as gross passenger revenue divided by passenger kilometres performed).

Historical GDP growth

The primary source of economic data used is that developed by the WEFA Group (1992). Using this data between 1980 and 1990, the aggregate world economy, measured in terms of GDP, grew at an average annual rate of 2.7% in real terms.

The economies in the Asia/Pacific region experienced much stronger growth during 1980-1990. The region's economies grew in real terms at an average of 5.8% per year, compared to an average growth for the North American region of 2.8%.

Historical Airline Yields

In real terms, airline yields have declined nearly every year since the advent of jet aircraft. This is a consequence of airlines passing on to consumers most of the cost savings that have resulted from technological advances, greater competition, longer average trip lengths, and other economies of scale.

ICAO collects information on gross passenger revenue and passenger kilometres from the majority of major international airlines. This data has enabled the calculation of trends in airline yields.

Over the decade to 1990, the average world passenger yield, measured in real terms decreased at an annual rate of 2.3%. During the same period, average yield for airlines in the North American region declined 2.7% per year, while those in the Asia/Pacific region declined 1.1% per year. The trans-Pacific yields for the period also declined at a rate of 3.2%.

Trans-Pacific market forecast - methodology

The Group considered several forecasting approaches to explain historical movements in trans-Pacific passenger movements.

In the light of this review it was considered that the best econometric model was a logarithmic one that related movements in passenger numbers to movements in GDP and an index of real (constant price) yield. The logarithmic transformation of the variables means that the model is based on rates of change, rather than absolute changes in the values of the variables - or that the coefficients represent the underlying elasticities for the income (GDP) and price (yield) variables.

The model developed is:*

$$\ln (\text{Passengers}) = a_1 \ln (\text{GDP}) + a_2 \ln (\text{Yield}) + a_3$$

Having developed the above model relating passenger traffic to GDP and yield movements the next step was to develop forecasts based on different scenarios of GDP and yield movements into the future.

It was decided to vary GDP estimates as well as trends in the yield index (as a proxy for fares), in order to produce three different forecast levels one which represents a baseline or "most likely" forecast, one which represents a high forecast (optimistic) and one which represents a low forecast (pessimistic).

Forecast Scenarios

As indicated, the forecasts of traffic were developed based on different assumptions of GDP and yield. Among a number of prominent economic forecasters there appears to be a broadly consistent belief that the global economy will recover somewhat in 1992. Accordingly, the most likely underlying GDP forecast was developed utilising WEFA Group projections as the base for the period through 1996, then modified for reduced growth rates in future periods, using information from sources such as the World Bank, International Monetary Fund, Organisation for Economic Cooperation and Development and economic consulting services.

The assumptions used for future yield trends used in the scenarios envisage little future change in the real levels of fares. During the coming decade, the airline industry faces substantial inflationary pressure in the area of operating costs - particularly related to the need to replace ageing fleets.

In addition, the following factors were considered as influencing yield trends:

- airline industry consolidation through take overs and commercial alliances giving airlines greater influence over pricing;
- government withdrawal from direct support of airlines, through, for instance, privatisation moves in several nations;
- large losses sustained by the industry in recent years depleting financial reserves; and
- no major technological breakthroughs likely to result in major price cuts on the current horizon.

In view of the above factors, it is considered that the most likely scenario is to hold yield constant in real terms to the year 2000 and thereafter increase it at the rate of 0.5% per year to the year 2010.

Passenger Forecast

The coefficients computed for the model are:

$$a_1 = 1.94$$
$$a_2 = -0.71$$
$$a_3 = -4.92$$

The analysis produced an R^2 value of 0.97, a standard error of 0.003, a Durbin-Watson statistic of 2.17 and an F value of 150.9 with 8 degrees of freedom. These measures suggest that the model provides a good fit with historical data ad provides a sound basis for developing forecasts of future passenger growth trends. The different GDP and yield values that were used in the development of the model and to formulate forecasts are shown in figures 1 and 2. The forecasts of passenger traffic using this model are graphically depicted in figure 3.

Aircraft movements

The passenger forecasts developed using the above model are able to be converted directly into aircraft movement forecasts by estimating future trends in aircraft size and load factors.

Following an analysis of industry forecasts produced by the major manufacturers (e.g. Boeing, Douglas and Airbus), and load factor trends compiled by ICAO, the estimated "most likely" and "baseline" aircraft movements were derived from the passenger forecasts. These results are presented in Table 1. These forecasts assume that average aircraft size on the trans-Pacific routes will increase gradually from 335 seats in 1990 to 390 seats in 2000 reaching almost 450 seats in the year 2010. Average load factors are estimated to increase gradually from 68 % in 1990 to 71% in the year 2000 and to 72% by the year 2010.

Table 1 Trans-Pacific Aircraft Movement forecasts 1990 to 2010

Year	Pessimistic	Baseline	Optimistic
1990		67 900	
1991	67 900	68 600	69 200
1992	70 300	71 100	73 900
1993	72 700	74 900	78 900
1994	75 200	79 200	84 200
1995	77 800	83 800	90 100
1996	80 400	87 800	95 500
2000	91 600	106 000	120 900
2005	105 700	130 000	159 600
2010	124 700	160 100	208 700

Part 2 Short-term Australian resident departures

This section outlines work done to develop a robust model to assist the forecasting of short-term resident departures from Australia within different market segments. This model was then used to estimate the number of such departures until the year 2000.

The introduction referred to the value of forecasting studies. In this part, besides the policy implications relating to infrastructure, there are also important conclusions for those negotiating air service agreements. This study also complements those studies that have focussed instead on visitor arrivals to Australia.

The Forecasting Model

The type of analysis to be undertaken, and the mathematical relationship between the variables, are crucial to this study's success. An approach using a time series analysis was not favoured, although it might well give a reasonable estimate for passenger movements in the short term. This is because it does not provide information on how passenger movements vary with economic or other factors. The alternative of a standard least squares regression analysis was favoured which allows selected independent variables to be regressed against passenger movements.

There are many mathematical expressions that could describe the relationship between the number of short-term resident departures from Australia and relevant economic variables. A number of these expressions were tested using our data. The eventual functional form employed in the selected model for short-term passenger movements is one based on a log-log relationship between the dependent variable (passenger movements) and independent (economic) variables. This is equivalent to defining all variables in a rate of change form, or alternatively, expressing the dependent variable as powers of the independent variables. This means that results achieved are really only valid for small, incremental changes in the independent variables.

The general form of the equation is thus similar to that used in Part 1, and is given by:

$$\ln (P_n) = a_{0n} + \sum_{m=1,4} a_{mn} \ln (x_{mn})$$

where

P_n = the number of short term resident departures to country n;
a_{0n} = the constant of the regression for country n (to be determined);
a_{mn} = the elasticities (to be determined);
x_{mn} = variable m for country n (the data that was accumulated).

Annual data for passenger movements and the independent variables were obtained until the end of calendar year 1991, and from as early as 1969, where possible, from numerous sources (ANZ Bank (1991), Australian Bureau of Statistics (1981-1989), Australian Bureau of Statistics (1991), Australian Bureau of Statistics (database), Australian Year Books (1969-1990), Parliamentary Research Service

(1970-1989), Reserve Bank of Australia (1991), Reserve Bank of Australia (1989), Treasury Department (1970-1991)). In the Singapore market, fare information could only be obtained from 1974, while for the UK and Japan, only data since 1973 were considered appropriate. A multiple linear regression was performed and the elasticities of the independent variables were obtained. Forecasts from a number of sources (Australian Economic Advisers (1991), OECD Economic Outlook (1991), OECD Economic Outlook (1960-1988), The National Institute of Economic and Industry Research (1991), The WEFA Group (1992)) were subsequently used to forecast the likely values of the independent variables (the factors that influence air traffic demand) to the year 2000. The calculated elasticities were then applied to the forecasted independent variables to obtain the required forecasts of passenger movements.

As already discussed, there are many factors that influence the number of passenger movements. These factors might include government policy decisions, the capacity of airlines to satisfy demand, economic and political stabilities of other countries, demand and price considerations, trade and other international agreements, and changing competitive environments. Moreover, these factors might be different for different countries. There is, of course, an element of subjectivity in the selection of the most relevant economic factors. However, because our main interest is the general trend in passenger movements, devoid of seasonal and other minor perturbations, a large number of independent variables were neither required nor desired.

In the simplified model selected, three independent variables were considered optimal in the compromise between simplicity and accuracy. The first of these, real household disposable income, was used as a measure of demand. The second variable is relative price, defined as the exchange rate multiplied by the ratio of the Consumer Price Indices of the foreign country to Australia. This is an indicator of the attractiveness of the foreign country to visitors from Australia. Both of these variables have economic significance and have been used in previous studies. A third variable is one that was chosen to model prices. The standard economy air fares between Australia and the other countries concerned were selected for this purpose. Fares, however, should only be a valid variable when price itself is important in determining passenger movements. For passenger travel dominated by people who are having a holiday this is probably true. In contrast, where business travel is more dominant, a price variable might not be as appropriate.

As well as the above three variables, it was decided to lag passenger movements from the previous year in our regression analysis. This has the effect of damping oscillations in the predicted passenger movements. These oscillations might arise because there are other factors affecting passenger movements. A number of other economic variables were examined to test whether they satisfied particular statistical criteria (see for example Kennedy (1990)), but they did not meet the criteria as well as the selected variables. These criteria were that the R^2 value (indicating how the variation in the dependent variable is explained by the variation in the independent variables), the t statistics (indicating how different the coefficients or elasticities are likely to be from zero), the F statistic (indicating whether the independent variables, as a set, influence the dependent variable) and the Durbin h statistic (indicating the absence or otherwise of first-order autocorrelation where a lagged dependent variable is present) had to indicate that the variable was statistically significant.

Explicitly, the x_m in our regression equation are defined as:

x_{1n} the household disposable income for country n;

x_{2n} the relative price between country n and Australia. This is defined as

$$x_{2n} = ER_n \; CPI_{Aust} / CPI_n$$

where ER_n is the exchange rate between country n and Australia, and CPI_{Aust} and CPI_n are the Consumer Price Indexes in Australia and country n respectively;

x_{3n} fares, economy air fares where available;

x_{4n} the lagged dependent variable, i.e. the short-term resident departures to country n for the previous year.

Long-term forecasting is fraught with difficulty in that errors are compounded annually. Although little can be done to totally eradicate this problem (ideally if we had an *exact* model for the economy, all forecasts would be correct), it is worthwhile to examine high and low case scenarios. Usually definitive upper and lower scenarios are given. However, in a long-term forecast these might not be very meaningful, as the range in values after many years could be very wide. Therefore, the approach adopted was to observe how passenger movements varied with changes in the growth rates of the Australian real household disposable income by $\pm$ 1%.

Results of regression analysis

The results of the regression analyses for short-term resident departures to the USA, UK, Japan and Singapore are presented in Table 2. The most noticeable result is that real household disposable income (RHDY), the income variable, is the most dominant contributor to the passenger movements. The elasticities for RHDY are all greater than one, meaning that a 1% change in RHDY produces a greater percentage change in passenger movements. Except for Japan, the corresponding t statistics suggest that these results are significant at the 5% level of significance.

Relative prices were found to be significant contributors to passenger movements for the USA and Japan, but not so for the UK and Singapore. Similarly, fares do not contribute greatly to passenger movements. Only for the USA and UK do fares appear with the correct sign – a negative sign means that an increase in fares produces a decrease in passenger movements. According to the analyses, fares do not play a statistically significant role in describing short-term passenger movements to Japan and Singapore. As noted previously, this only refers to differential or incremental changes in fares. Naturally, a massive increase in fares would be expected to reduce passenger movements. The number of passengers lagged by a year was a small but significant contributor to the number of passengers.

The statistics relating to the regression, presented in Table 3, are very good. Values of the correlation coefficient, R^2, are excellent for this analysis. At the 5% level of significance, the Durbin h statistic indicates an absence of first-order autocorrelation.

Table 2 The coefficients (elasticities) and t statistics[a] (in parentheses) obtained from the regression of independent variables against short-term Australian resident departures for the USA, UK, Japan, and Singapore

	Real Household Disposable Income	Relative Prices	Fares	Lagged Passenger Movements (1 year)
USA	1.4	0.22	-0.19	0.64
	(2.5)	(1.0)	(-0.68)	(5.0)
UK	1.5	0.11	-0.93	0.15
	(6.6)	(0.62)	(-4.2)	(1.8)
Japan	2.5	0.78	0.51	0.64
	(0.60)	(3.5)	(1.1)	(4.6)
Singapore	1.82	0.55	0.26	0.37
	(2.5)	(0.65)	(0.21)	(1.4)

(a) to be significant at the 5% level of significance, the t statistic should be > 1.64, while at the 10% level of significance it should be > 1.28.

Predictions of passenger movements

The results of the forecast using the regression analysis are in good qualitative agreement with those obtained elsewhere (Lovrincevic (1991), Vo (1991), The National Institute of Economic and Industry Research (1991), WEFA(1992)). Forecast short-term resident departures are tabulated in Table 4. In 2000 over 560 000 people are expected to visit the USA, which is over 150 000 more than the number expected to visit the UK.

Historical and forecasted passenger movements are graphed in Figures 4 – 7. These graphs show the strong increases that are predicted in the period 1991-2000. They also show the high and low scenarios obtained by increasing or decreasing the rate of growth of household disposable income. The sensitivity of the forecast passenger movements is clearly revealed by these scenarios – as a relatively small change in forecasted real household disposable income produces a sizeable variation

Table 3 Relevant statistics relating to forecasting Australian resident movements to USA, UK, Japan, and Singapore[a]

	Data since	adjusted R^2	F statistic	Durbin h statistic
USA	1969	0.98	254	0.06
UK	1974	0.92	48	0.74
Japan	1974	0.93	54	0.00
Singapore	1975	0.90	33	0.83

Table 4 Forecasted short-term Australian resident departures (P) to the USA, UK, Japan, and Singapore for the years 1991, 1992, 1995 and 2000

	P 1991	P 1992	P 1995	P 2000	% growth
USA	308 700	307 700	357 400	561 300	6.9
UK	220 000	216 100	283 900	411 800	7.2
Japan	47 200	47 700	57 900	96 500	8.3
Singapore	98 900	104 600	99 700	123 300	2.5

between the high and low scenarios.

Reasonable annual growth factors in Australian resident passenger movements of 6.9%, 7.2% and 8.3% were found for the USA, UK and Japan for the period 1991-2000. The growth factor for Singapore is noticeably smaller at 2.5%, which is partly due to the decrease in short-term resident departures to Singapore, of about 17 000, that has occurred since 1989.

Figure 5 shows the calculated relative rates of growth of short-term resident departures to the USA, UK, Japan and Singapore.

Conclusion and summary

Trans-Pacific forecasts

Based on the most likely GDP and yield projections, the trans-Pacific traffic is forecast to increase at an average annual rate of 7.4% for the period 1990-2000, reaching almost 25 million passengers in the year 2000. A somewhat lower rate of 6.2% is forecast for the period 2000 to 2010, resulting in a forecast of some 45 million passengers by the year 2010.

On the basis of the above forecasts and future expectations of average aircraft size and load factors, aircraft movements are expected to increase from an estimated 67 900 in 1990 to 106 000 in the year 2000 at an average annual growth rate of 4.6%. Over the period 2000 to 2010 aircraft movements are expected to increase at a lower rate of 4.3% reaching approximately 160 000 movements by the year 2010.

These forecasts by the ICAO forecasting group are intended to provide an input to navigational and infrastructure planning activities by countries in the region concerned. The forecasting group has also commenced preliminary forecasting work for a number of high volume city-pairs in the Asia/Pacific area. It is intended that the models and forecasts be refined at further group meetings and the results shared with a range of interested parties, including future ATRF conferences.

Short-term Australian resident departures

A forecasting model was developed to explain short-term Australian departures to the USA, UK, Japan and Singapore. Real household disposable income, relative prices,

fares, and short-term resident departures lagged by one year, were regressed against short-term resident departures. Historical data and estimated values of the independent variables provided a basis for the calculation of short-term resident departures to 2000.

The model is simple to interpret as the coefficients in the regression analysis are the elasticities of the independent variables. In a statistical sense the results of the regression are very good, providing *a posteriori* justification for the mathematical form of the model and the variables used. In an economic sense, the use of demand and price variables to model short-term resident departures is a simple approximation. However, the surprisingly good correlation that was observed in the analysis indicates that income is the most elastic of the variables. This is in good agreement with other studies.

Also noticeable was the relative inelasticity of fares. This is not to suggest that a massive increase in price will not curb demand. However, in the region of economic activity as described by our regression, small changes in fares have little or no effect on short-term resident departures.

Our results are a basis upon which we hope to build. We intend to pursue studies of passenger movements to different markets. We also would like to further develop the methodology to the extent where predictions of passenger movements can be obtained with greater certainty.

Acknowledgments

The views expressed in this paper are those of the authors and of the ICAO trans-Pacific forecasting group (where applicable) and are not necessarily shared by the Department of Transport and Communications. We gratefully acknowledge the assistance of Tom Loncar with the econometric analysis, Yuri Rejl for background economic analysis and Joanne van der Schoot for useful comments.

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Figure 1: Asia - Pacific GDP Growth - Scenario trends 1991 -2010

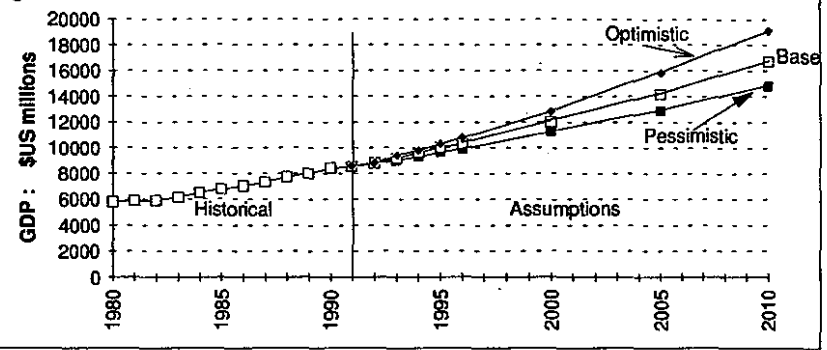


Figure 2: Asia - Pacific Yield Index Scenarios 1991 -2000

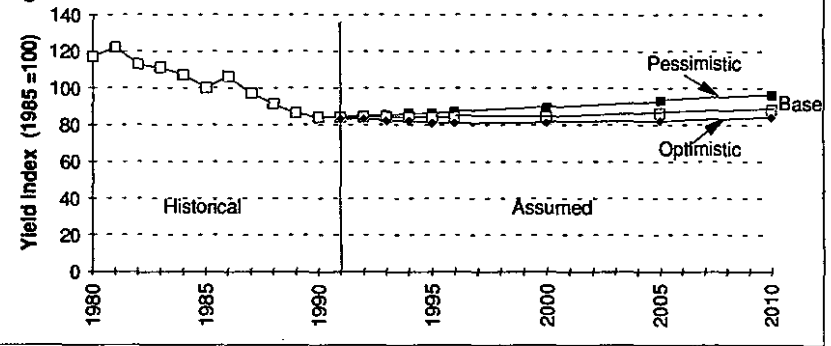


Figure 3 Trans-Pacific traffic forecasts 1991 - 2010

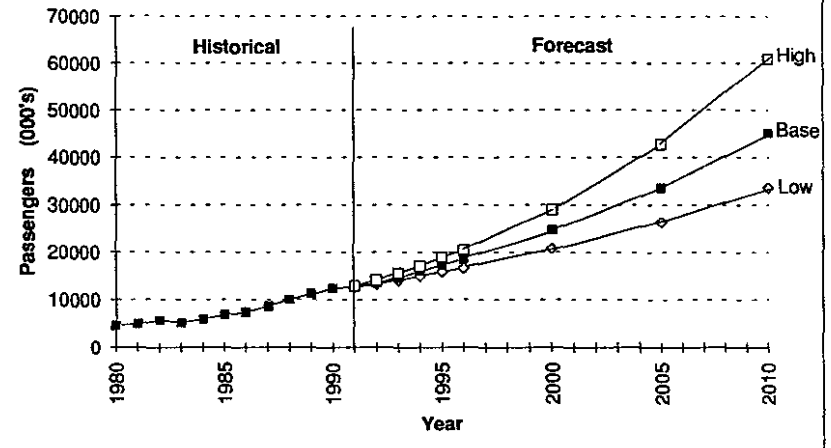
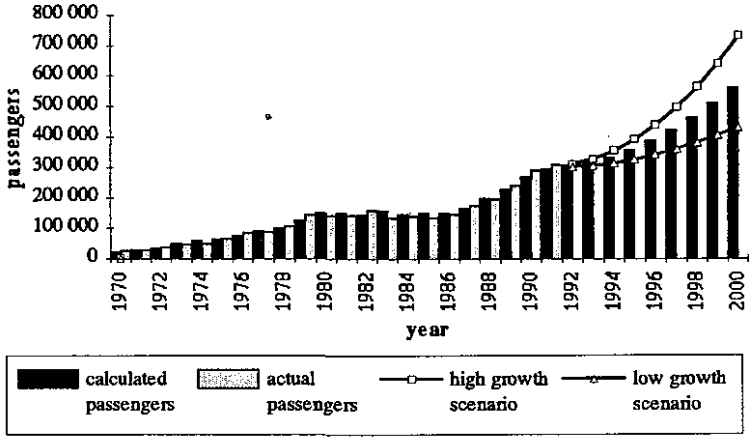
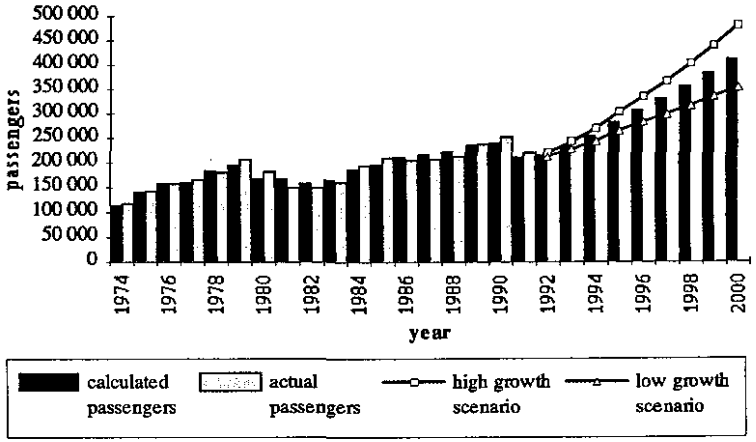


Figure 4 Short-term resident departures to the USA 1970 - 2000



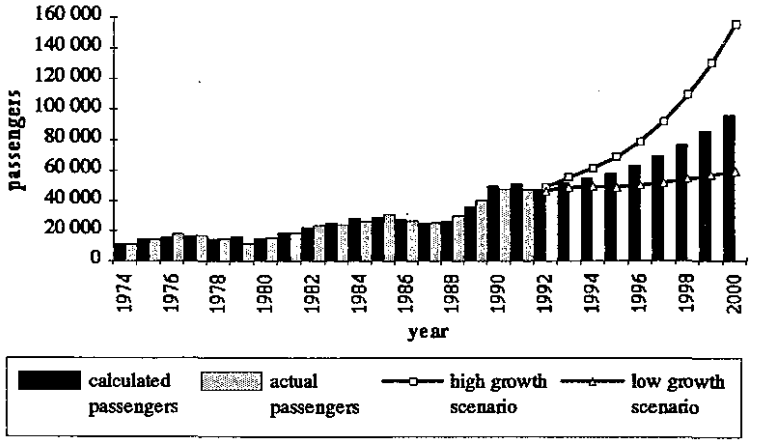
High and low scenarios are based on a 1% increase and decrease respectively in predictions of the real household disposable income.

Figure 5 Short-term resident departures to the UK 1974 - 2000



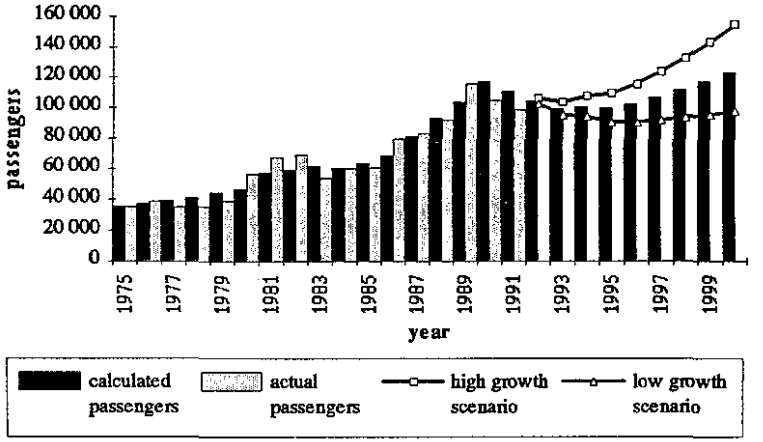
High and low scenarios are based on a 1% increase and decrease respectively in predictions of the real household disposable income.

Figure 6 Short-term resident departures to Japan 1974 - 2000



High and low scenarios are based on a 1% increase and decrease respectively in predictions of the real household disposable income.

Figure 7 Short-term resident departures to Singapore 1975 - 2000



High and low scenarios are based on a 1% increase and decrease respectively in predictions of the real household disposable income.