Cost Forecasting for International Airline Operations

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Cost models are constructed and calibrated to describe airline operating costs in selected international markets. These models are then used to demonstrate how operating costs can be forecast for relatively short time horizons, such as three years. The models confirm the concept that operating costs in different markets of the world air transportation system are significantly different. The reasons for this include the geographic characteristics of the different markets in terms of stage lengths and network structure and the differences in input prices for items such as fuel and labor. Fleet mix is also an important determinant of operating costs. The use of wide-body aircraft is seen to have a significant impact on reducing airline operating costs. Recently, operating costs have tended to decline in real terms but to increase in current terms. The forecasts made for a three-year period indicate that these trends might continue. These forecasts, however, are strongly dependent on assumptions regarding fuel prices.

In an era of technological and economic change in air transportation, it has become even more important than before to assess current operating costs and to forecast future costs. Analysis of air transportation policy has become more dependent than ever on a sound understanding of the factors that affect costs. Air fares have to be justified on the basis of airline costs and, in view of the novel pricing approaches that are evident in many air transportation markets, cost analyses have become indispensable.

Other policy analyses in which cost forecasts constitute an important input include the planning of airline capacity, the planning of fleet renewal and aircraft acquisition, agreements between carriers or governments on capacities and fares, and financial planning for airline operations. Cost forecasts provide a basis for pricing and for financial planning for the year of the forecast. In other aspects of airline policy analysis, the comparison of cost and revenue forecasts provides the basis for evaluating the potential performance of a carrier or a market.

In this paper, a system of cost models is presented that is used to forecast airline operating costs in 13 markets that cover the majority of world air transportation activities. Forecasts made by using these models are presented as illustrations. These forecasts depend on specific assumptions, or scenarios, concerning the economic factors that affect costs and that are exogenous to the policy framework in question.

HISTORIC TRENDS OF AIRLINE COSTS

The evolution of airline operating costs in the past decade is characterized by two features. The first is the continuous decline in real operating costs until 1973 and 1974, when the sharp increase in fuel price reversed the trend. Thereafter, the tendency of costs is again toward stabilization and a decline similar to, albeit not as rapid as, that preceding the 1973-1974 period. The second feature is the sharp quantum jump in operating costs brought about in the 1973-1974 period by increases in fuel prices. The rise in costs is significant even when measured in real terms. In many markets, 1974 operating costs in real terms were brought back up to their 1964 levels, and the results of 10 years of technological advances and productivity increases were lost. The 1973-1974 increases in fuel prices were responsible, however, for bringing about some changes in operating technologies that resulted in a decrease in operating costs. The most important of these is the common practice of speed reduction, which resulted in significant savings in fuel consumption per unit of output. Another interesting result of the fuel price change is that, in many markets of the world and for the first time, direct operating costs exceeded indirect costs, which would indicate that improving the efficiency of flight operations became relatively more important for reducing costs than improving managerial and support-activity productivity.

These features of operating-cost trends are clearly visible in the charts shown in Figures 1 and 2. Figure 1 shows trends in operating costs for the South Pacific (North America-Australasia) market for the period 1969 to 1976. It is interesting to note that by 1976 complete recovery from the effects of the fuel price increases of 1973 and 1974 was achieved, and a level of operating cost was achieved that could have been a continuation of the decline from 1969 to 1973. It is possible, of course, that all of the technological possibilities for cost reduction were used to achieve this recovery, such as speed reduction, increased use of wide-body equipment, and higher-density seating. If this were the case, further decreases in costs would become more difficult to achieve. Figure 2 (1) shows a similar operating-cost history for the U.S. domestic trunks for the period 1964 to 1975. Although domestic trunk operating costs are generally lower than those for the South Pacific market, the same general trends are observed.

The reasons for the decline in operating costs can be found in two factors, both of which are related to improvements in aircraft technology and airline operating efficiency. The first is the increase in fuel efficiency brought about by the introduction into the fleet of wide-body aircraft. This results from both the economy of scale of aircraft size and the more efficient engines that equip such aircraft. Figure 3 (1) shows trends in fuel efficiency for the domestic trunks of the United States. Similar fleet-changing trends in international operations are resulting in similar improvements in fuel efficiency for these operations. The two noticeable downward jumps in the curve shown in Figure 3 are caused by the introduction of wide-body aircraft in 1970 and the reduction in speeds that occurred in 1974.

The second factor that contributes to the reduction in operating costs is the increased labor productivity of airlines. Aided by such innovations as computer ticketing and reservation systems, airlines have been able to increase output faster than labor inputs. This is also caused by the introduction of larger aircraft, which have definite economies of scale. Figure 4 (1) shows a trend in airline labor productivity for U.S. domestic trunks. Jumps similar to those observed in the fuel-consumption trends are evident here as well.

It may be evident that technological advances have contributed to the reduction or at least the stabilization of airline operating costs and that with current technology the airlines can be said to have managed to

absorb the effects of fuel price increases. But the crucial question for cost forecasting is whether such technological improvements have been exhausted, so that costs will start rising again, or whether there remain further opportunities to cope with current inflationary trends and maintain stability in those costs. This question is addressed here by analyzing costs in selected international air transportation markets and by constructing explanatory models of their evolution. These models are then used to forecast costs on the basis of plausible scenarios of the technical and economic environment of international air transportation.

ANALYSIS FRAMEWORK

Operating costs can be analyzed either by carrier or by market and can be based on time-series or cross-sectional information. In this study, the analysis of costs is based on time-series information for two reasons:

1. Different world markets are likely to differ significantly in their technical and economic operating environments. Even the same airline is likely to have different operating economics in different world markets. To pool all markets together in a cross-sectional analysis would mask many potentially very important determinants of operating costs.
2. This study is aimed at forecasting trends, and time-series analysis is more suitable for investigating cost trends and future potentials. What cross-sectional analysis does is to reveal any scale characteristics and permit the quantification of scale economies. In this case, however, no significant scale economies are expected, as many previous studies seem to indicate (2, 3).

The only cross-sectional analysis done here is in the comparison of costs by carrier and by market to determine which classification is more suitable for cost modeling.

Clearly, most policy analysis is done at the carrier level. Thus, cost forecasting needs to be performed at that level in order to be useful in such analysis. But, since there is strong suspicion that there are important intermarket differences that cannot be ignored, it fol-

Figure 1. Trend of average operating cost per available seat kilometer for the South Pacific market.

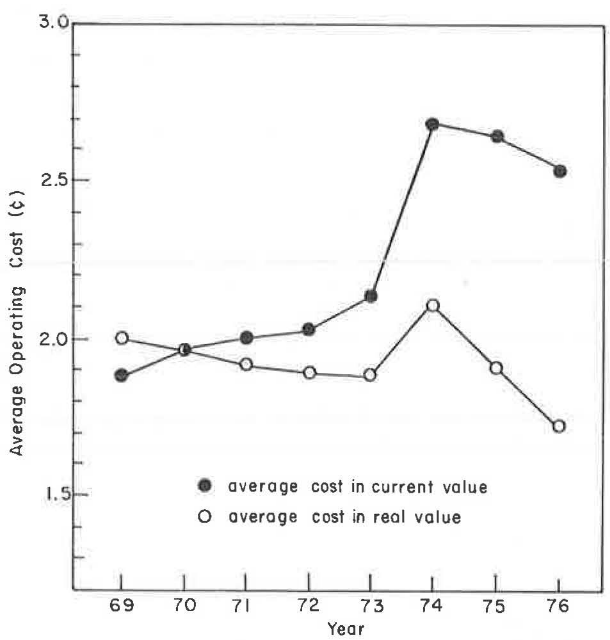


Figure 2. Trend in total real operating costs per unit of distance.

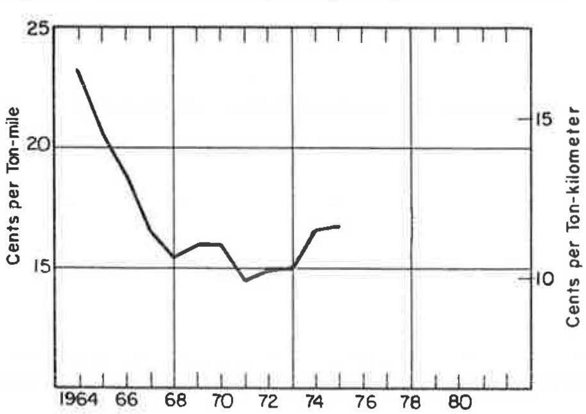


Figure 3. Trends in fuel consumption.

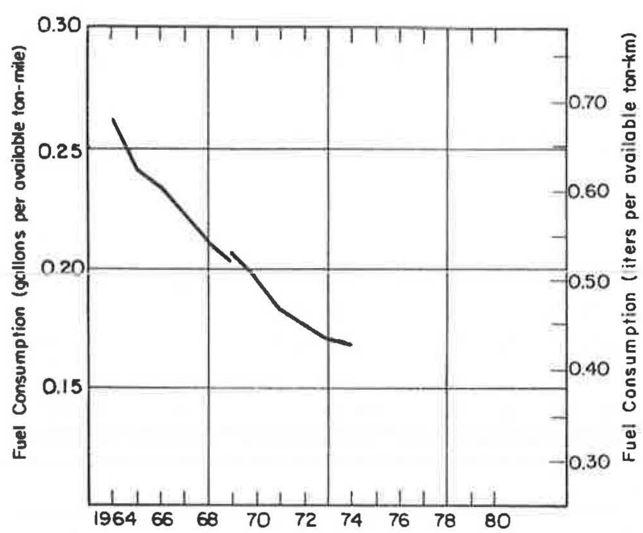
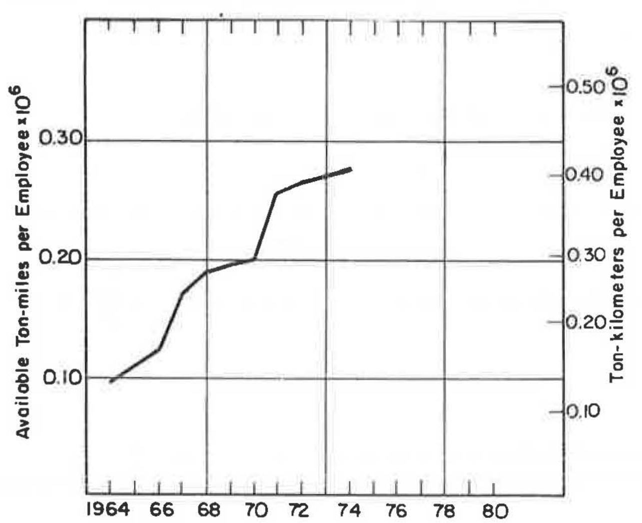


Figure 4. Trends in airline labor productivity.



lows that the analysis should be performed by carrier and separately for each market. Such analysis would require excessive information regarding the economic factors that affect each carrier's cost function in each market. For this reason, it was necessary to limit the scope of the analysis to only one dimension—that is, either market or carrier. After an investigation into the historic evolution of costs in 13 international air travel markets, it became clear that the variations in costs between markets were significantly larger than the variations in costs between carriers within each market. Since two of the major inputs—fuel and labor—are secured locally and their costs vary from place to place, this is the expected result. The models are therefore constructed to estimate total operating costs per available seat kilometer or available ton kilometer on a market-by-market basis.

Market Definition

A market is usually defined on the basis of a region pair; each region might include a number of countries of geographic proximity. In this study, 13 world markets are defined to cover more than 90 percent of total world revenue passenger kilometers of traffic. For the sake of brevity, the results for five markets are presented:

1. North Atlantic—traffic between North America and Western Europe and points beyond,
2. North America-South America—including for South America only countries south of Panama,
3. South Atlantic—traffic between Europe and Africa on one end and points in America south of Rio de Janeiro on the other end,
4. Europe-Middle East—traffic between Western Europe and points in the Middle East no further east than Tehran and including Egypt, and
5. South Pacific—traffic between America and points in the Pacific south of Hawaii, including Australia and New Zealand.

Data Base

The data used in the study were compiled as part of a larger data-management system for the analysis of international air transportation policy that has been developed at the Institute of Transportation Studies of the University of California, Berkeley. Included in the data base are total operating costs for the period 1969 to 1976, data on total capacity in each market, and fleet mix, fuel price, seating configurations, and inflation rates in selected countries that represent each market. For some markets, data were available on a carrier basis. These were used to compare the variations between carriers with those between markets to determine the feasibility of analysis by market (4).

ANALYSIS

The cost trends for the markets are shown in Figure 5. A remarkable similarity is observed in these trends. For all five markets, costs in 1969 appear to have been in the neighborhood of 2 cents/available seat kilometer (3.2 cents/available seat mile) and to have experienced a major upward jump in the 1973-1974 period, presumably because of the increase in fuel costs (throughout this paper, seat kilometers and seat miles indicate available capacity). By 1976, costs in these markets appear to be closer to 3 cents/seat-km (5 cents/seat mile), except in the Europe-Middle East market, where they are 4 cents/seat-km (6.4 cents/seat mile), and the

Figure 5. Comparison of average operating costs per available seat kilometer in different markets.

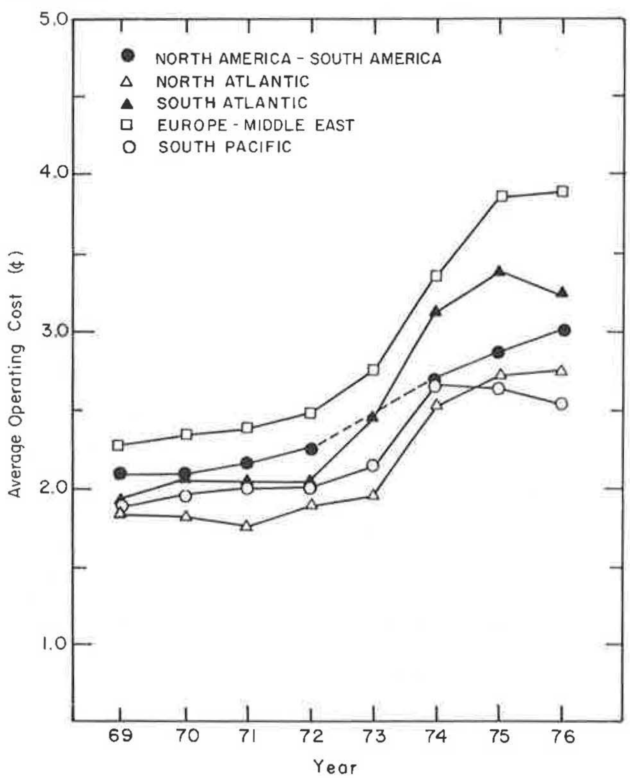
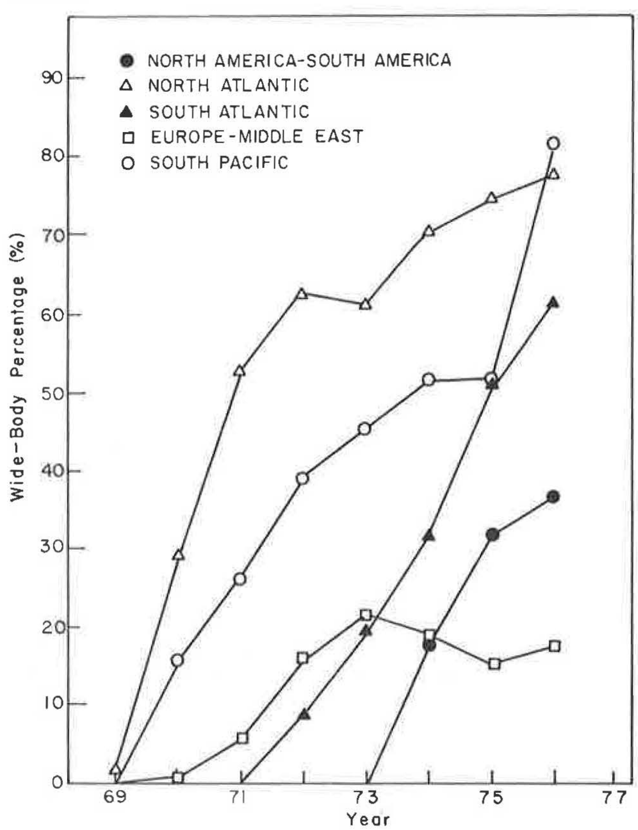


Figure 6. Comparison of wide-body percentages for different markets.



South Pacific market, where they are closer to 2.5 cents/seat-km (4 cents/seat mile). The differences between market trends are to be sought in the differences between some of the exogenous variables that affect costs in these markets. For that reason, and in order to permit the forecasting of costs, cost models are calibrated.

The explanatory variables for the cost models are allowed to vary from market to market. It appears from the results, however, that some explanatory variables are significantly universal. Fuel price is perhaps the single most important such variable and explains to a large extent the jump observed in costs in the 1973-1974 season. Other variations in costs have been explained by changes in fleet mix. In particular, the percentage of wide-body aircraft in the fleet appears to be significant in many markets. In fact, if one looks at Figure 6, which shows the historic trend of this variable, one sees the strong correlation between it and total operating costs. The North Atlantic market, which has the lowest costs, has the highest percentage of wide-body aircraft; conversely, the Europe-Middle East market, which has the highest costs, has the lowest percentage of wide-body aircraft. Seating configuration, represented by the percentage of total first-class available seat kilometers, appears in some markets. Finally, total capacity is examined to explain some of the cost variations.

As mentioned earlier, no significant economies of scale are expected. However, in some low-volume markets, it may be possible to find such economies because such markets would still be in the early stages of growth and might gain some cost advantages from capacity expansions. Thus, although one might not expect economies of scale in a market as mature as the North Atlantic market, it would be no surprise to find such characteristics in markets such as the Europe-Middle East market.

COST MODELS

In its simplest form, the cost model will have a linear specification with a constant term that indicates a fixed average operating cost per available seat kilometer and an additive modifier that reflects the effects of the exogenous variables. In markets that have scale economies, one of these modifiers will be capacity in available seat kilometers. The calibrations of the models for the five markets are discussed separately below.

North Atlantic

The North Atlantic, a mature market, has the largest annual volume of any international market. In 1976, North Atlantic carriers supplied 96 billion seat-km (60 billion seat miles) and carried almost 16 million passengers. The large proportion of wide-body aircraft in the North Atlantic fleet contributes to lowering average operating costs. The increase in costs shown in Figure 5 is attributable mostly to increased fuel prices. In attempting to isolate the effects of inflation, and since the forecasting of inflation rates is not within the scope of this analysis, costs are analyzed in real terms. To do this, a composite price index is constructed by weighing the price indices of eight countries in the North Atlantic market, including the United States, Canada, and six Western European countries.

The resulting linear model of real costs for the North Atlantic is

$$\begin{aligned} AVC = {} & 1.8234 - 0.005\,86(WB) + 0.3054(OIL) \\ & (0.037)\ (0.0008)\ (0.0089) \qquad R^2 = 0.905;\ F_{(2,5)} = 24.0 \end{aligned} \tag{1}$$

where

AVC = average cost (cents/seat-km),
WB = percentage of total capacity in wide-body aircraft, and
OIL = price of U.S. no. 6 at New York Harbor ($\$/m^3$).

Figures in parentheses below the equation line are standard errors of the estimated parameters.

The results of this calibration are shown in Figure 7. In real terms, it is apparent that operating costs in the North Atlantic have not increased over the past seven years. In this market, increased use of wide-body aircraft is an important determinant of this result. The significance of wide-body equipment is not only that the larger aircraft offer scale economies in the production of seat kilometers but also that these aircraft are more fuel efficient and therefore permit carriers to absorb increases in fuel prices more easily than they could if they used smaller aircraft. For this reason, one would be tempted to specify a model with an interaction term between the two variables. Such an attempt does not seem to produce any statistically significant results, however, and the simpler linear cost model is preferred for forecasting purposes.

North America-South America

The North America-South America market is much smaller than the North Atlantic market, with 13 billion seat-km (8 billion seat miles) in 1976. It is characterized by the absence of wide-body aircraft until 1974, but it is favorably affected by lower fuel costs in Venezuela, where a sizeable proportion of the traffic passes. The low volume in this market suggests that economies of scale may still be present. Indeed, in a linear model of costs in the North America-South America market, available capacity appears with a significant, albeit small, effect:

$$\begin{aligned} AVC = {} & 2.9478 - 0.021\,215\,(WB) + 1.997\,(OIL) - 0.000\,189\,(ASK) \\ & (0.415)\ (0.0061)\ (0.0952)\ (0.000\,06) \\ & R^2 = 0.97;\ F_{(3,3)} = 33.9 \end{aligned} \tag{2}$$

where OIL is the price of fuel ($\$/m^3$), averaged for the United States and Venezuela, and ASK is available capacity in seat kilometers. All other variables are as indicated for the previous model. The real-term costs are obtained by using a price index based on a weighted average for Canada, the United States, Colombia, and Brazil.

The results of this calibration are shown in Figure 8 (data for 1973 are missing). Again, it can be seen that significant reductions in real costs have been possible in this market. The sharp increase in the use of wide-body aircraft, the increase in capacity, and the use of some scale economies are probably responsible for that. By 1976, the percentage of wide-body aircraft in this market had increased from 0 percent in 1973 to 36 percent of the total fleet; this contributed to a total decrease in real operating costs of almost 0.7 cent/seat-km (1 cent/seat mile). The low 36 percent figure, in comparison with the 80 percent of the North Atlantic market, indicates that a potential exists for further reduction in costs.

Available capacity in the North America-South America market increased from 9 billion to 13.5 billion seat-km (from 5.6 billion to 8 billion seat miles) in the period between 1969 and 1976. This increase contributed approximately 0.8 cents to the decrease in real operat-

ing costs. Whether such scale economies can be expected to continue in future years is not clear. Further analysis of cost trends in future years is needed to determine the extent to which these scale characteristics will continue.

The price of oil has an important effect on total costs in this market. Variations in real fuel price in the period of the analysis resulted in an increase in real operating costs of approximately 0.8 cent/seat-km (1.3 cents/seat mile).

South Atlantic

The South Atlantic market has an even smaller traffic volume than the North America-South America market. In 1976, total traffic in the South Atlantic market amounted to 5.5 billion revenue passenger-km (3.4 billion revenue passenger miles), and total capacity was 11.3 billion seat-km (7 billion seat miles). This market has experienced strong growth, however; 1976 volumes were almost double those of 1970. Although operating costs have risen sharply in market value (Figure 5), inflation rates in both Western Europe and the southern portions of South America (particularly Brazil) have been of such magnitude that real-term costs have in fact declined appreciably.

The cost model calibrated for this market has the same structure and specification as the previous one:

$$\begin{aligned} AVC = {} & 2.2914 - 0.007\,(WB) + 0.6447\,(OIL) - 0.000\,095\,(ASK) \\ & (0.168)\quad (0.0026)\quad (0.018)\quad (0.000\,023) \\ & R^2 = 0.978;\ F_{(3,4)} = 59.3 \end{aligned} \tag{3}$$

The results of the calibration of this model are shown in Figure 9, where the sharp difference in the cost trends in real and current terms is clear. A rather sharp increase in the use of wide-body aircraft is instrumental in reducing real operating costs. Wide-body mix in the South Atlantic fleet increased from 0 percent in 1971 to 60 percent in 1976, and this contributed to the reduction of real operating costs by 0.42 cent/seat-km (0.67 cent/seat mile). The small effect of available capacity is indicated by the small (but significant) parameter value. The sharp increase in South Atlantic capacity from 4.9 billion to 11.2 billion seat-km (from 3 billion to 7 billion seat miles) during the analysis period contributed to a reduction of 0.6 cent/seat-km (0.96 cent/seat mile). With a net decline in total operating costs of 0.8 cent/seat-km (1.3 cents/seat mile), it follows that increases in fuel price resulted in an increase of real operating costs of only 0.2 cent/seat-km (0.32 cent/seat mile).

Europe-Middle East

The Europe-Middle East market is characterized by a sharp increase in traffic and capacity during the period of analysis. Total traffic rose from 3.9 billion to 9.4 billion revenue passenger-km (from 2.4 billion to 5.8 billion revenue passenger miles), and during the same period available capacity increased from 8.3 billion to 15.4 billion seat-km (from 5.1 billion to 9.5 billion seat miles). Interestingly, wide-body aircraft were not in common use until 1976. As Figure 6 shows, wide-body aircraft never constituted more than 15 percent of the total fleet in the market and, in fact, declined between 1973 and 1976.

Figure 5 shows that the Europe-Middle East market was consistently the market with the highest operating costs. Not surprisingly, the calibrated model for this

Figure 7. Actual and modeled operating costs per available seat kilometer: North Atlantic.

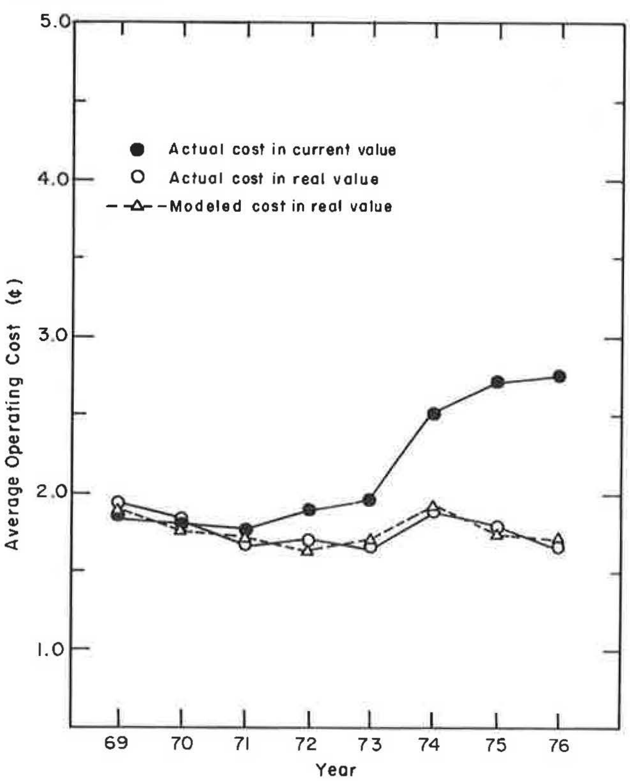
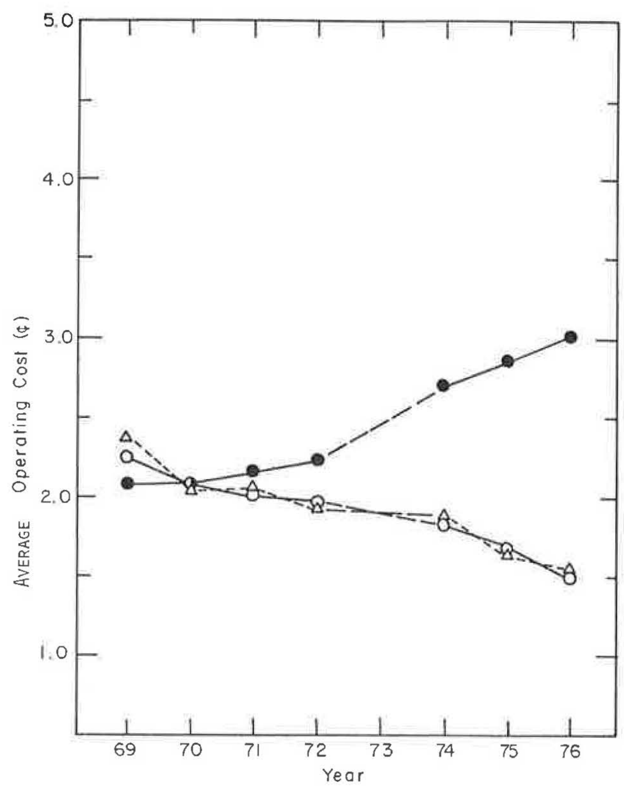


Figure 8. Actual and modeled operating costs per available seat kilometer: South Atlantic.



market does not include a WB variable:

$$AVC = 3.1462 + 0.2727\ (OIL) - 0.000\ 119\ (ASK)$$
$$(0.0608)\ (0.011)\ (0.000\ 01) \qquad R^2 = 0.98;\ F_{(2,5)} = 19.8 \qquad (4)$$

The calibration results of this model are shown in Figure 10, where, again, the effects of high inflation rates are shown in the large differences between costs in real and current terms. Economies of scale are probably the principal factor that permits costs to rise at a rate slower than that of inflation. Capacity increase according to this model was responsible for a reduction in real operating costs of approximately 1 cent/seat-km (1.6 cents/seat mile). The effect of trends in fuel prices in this market is much less than that in the other markets.

South Pacific

The South Pacific market has a medium traffic level and is characterized by relatively longer stage lengths than many of the other markets studied. It experienced strong growth during the analysis period: Traffic and capacity doubled between 1969 and 1976. The relatively lower operating costs of this market are probably due to the longer stage lengths in its operations, although there are a number of multiple-stop routes in it. Operations in this market do not exhibit any economies of scale, as shown in the following calibrated cost model:

$$AVC = 1.8914 - 0.006\ 25\ (WB) + 0.311\ (OIL)$$
$$(0.027)\ (0.0007)\ (0.006) \qquad R^2 = 0.94;\ F_{(2,5)} = 39.2 \qquad (5)$$

The results of this calibration are shown in Figure 11, where it is seen that, because of the relatively low U.S. inflation rates, the difference between real and current costs is not as large as it is for the other markets. Changes in fleet mix contributed significantly to the reduction in real operating costs. The percentage of wide-body aircraft in the South Pacific rose from 0 percent in 1969 to 81 percent in 1976 and contributed to a reduction in operating costs of approximately 0.5 cent/seat-km (0.8 cent/seat mile) in real terms.

COMPARATIVE INTERPRETATIONS

Some insights into the evolution of airline operating costs can be gained from a comparative evaluation of the results of the model calibrations for the five study markets. First, the table below compares the current and real (1970 value) costs for the five markets in 1976 (1 cent/seat-km = 1.6 cents/seat mile):

Market	Cost (¢/seat-km) Current	Real	Deflator
North Atlantic	2.753	1.650	1.663
North America-South America	3.009	1.498	2.008
South Atlantic	3.225	1.271	2.537
Europe-Middle East	3.896	1.766	2.206
South Pacific	2.531	1.726	1.466

As mentioned earlier, the deflators used in calculating real costs are based, for each market, on an average of the consumer price indices for a selected number of representative countries in the market, weighted by the capacity offered by the carrier of each of these countries. The values of these deflators are shown in Figure 12. Notice that, although there are wide variations in current operating costs between the markets, the values in real 1970 terms are much closer to their mean value of 1.579 cents/seat-km (2.5 cents/seat

Figure 9. Actual and modeled operating costs per available seat kilometer: South Atlantic.

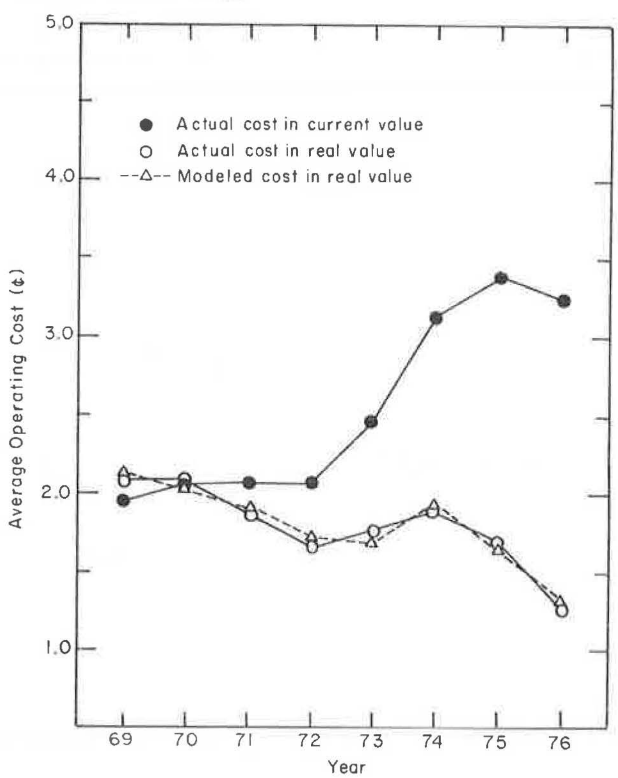


Figure 10. Actual and modeled operating costs per available seat kilometer: Europe-Middle East.

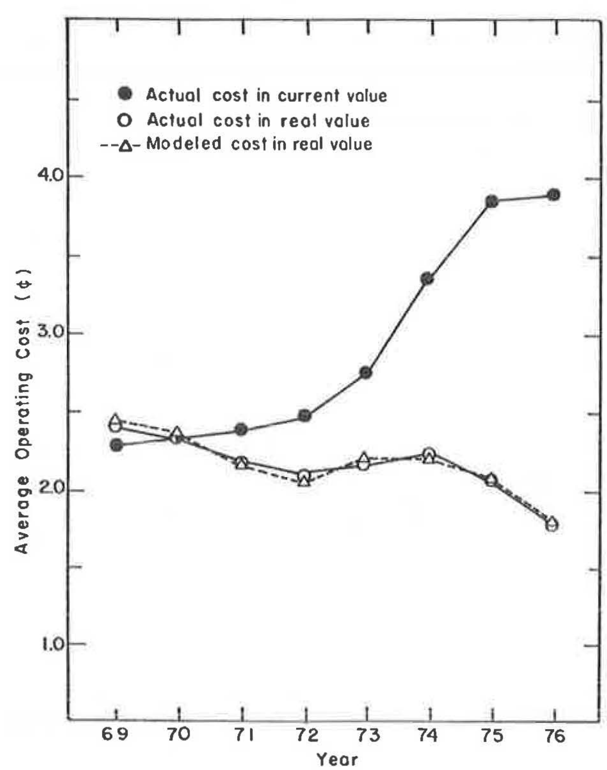


Figure 11. Actual and modeled operating costs per available seat kilometer: South Pacific.

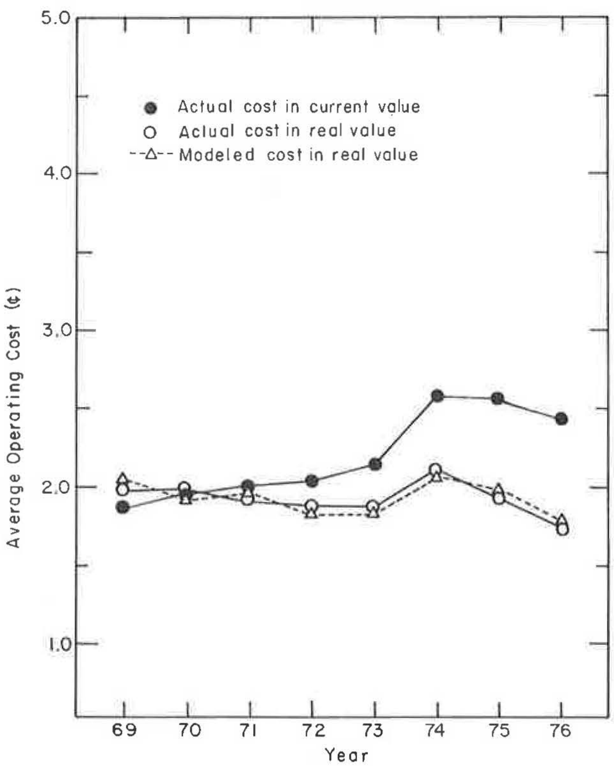
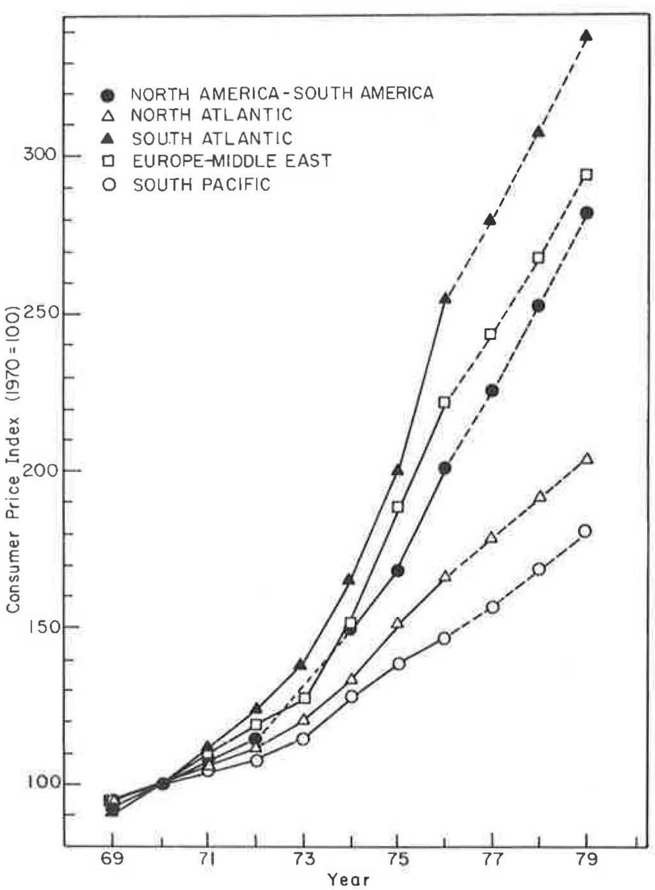


Figure 12. Actual and forecast consumer price index for five markets.



mile). This value is lower than the actual cost average in 1970—2.05 cents/seat-km (3.3 cents/seat mile)—which indicates that a significant reduction in real costs has been possible in these markets during the period from 1970 to 1976. Put in another way, it has been possible to keep the increase in operating cost to a rate lower than that of inflation. This also indicates that operating costs are "higher" in markets where everything else is costlier (as shown by the higher inflation index), markets such as the Europe-Middle East or the South Atlantic markets. If anything, this seems to indicate that there are not as many technological differences in the production of air transportation between the various markets as would be implied by the large variations in current-value operating costs. If that is the case, one cannot expect any more technological opportunities for cost reduction in the newer markets than in the more mature ones. Real operating costs in the North Atlantic and Europe-Middle East markets were indeed very close in 1976: 1.65 and 1.76 cents/seat-km (2.6 and 2.8 cents/seat mile), respectively.

A comparison of the effects of the various exogenous factors on cost trends for the five markets, as indicated by the elasticities of the cost function, is given below:

Market	Elasticity: Percentage Wide Body	Oil Price	Capacity
North Atlantic	-0.275	0.185	—
North America-South America	-0.51	1.275	-1.710
South Atlantic	-0.336	0.400	-0.847
Europe-Middle East	—	0.279	-1.045
South Pacific	-0.295	0.200	—

Since the cost functions are linear, implying variable elasticities, the elasticity values for 1976 are calculated for comparison. It is interesting to note the relatively small ranges for the elasticities with respect to wide-body fleet mix and capacity, the former being significantly lower than the latter. This does not, however, mean that capacity increase has had a more important effect on costs than fleet-mix changes, since the incremental changes in capacity are relatively much smaller than those of the percentage of wide-body aircraft. As mentioned earlier, capacity nearly doubled in all five markets during the 1969-1976 period, whereas the percentage of wide-body aircraft increased much more than that in all markets except the Europe-Middle East market.

An interesting feature of the elasticity values is revealed when one compares the elasticities of oil price and capacity for the North America-South America market with those for the South Atlantic market. These elasticities for the North America-South America market are large, which implies the presence of large but compensating effects of fuel price and capacity. For the South Atlantic market, the two elasticities are relatively small, which indicates that no single effect is dominating. It is hard with the present data base of seven yearly cost figures to infer much from this and other comparisons. Even though the parameter values obtained are highly significant, additional data would be needed to improve confidence in the parameter values and to allow more elaborate comparisons.

FORECASTING SCENARIOS

To forecast operating costs in the five study markets, it is essential to define, by assumption or by policy, the values of the exogenous variables of the cost models. There are in fact two types of variables: exogenous economic variables and policy variables. The former

are outside the scope of airline policymakers, and their values for forecasting have to be assumed. The latter are under the control of policymakers, and their values are associated with a set of policies for which the forecasts are needed for evaluation.

The exogenous economic variables in the cost models include the inflation rate and the price of fuel. In dealing with these two variables, a basic assumption is made—that fuel prices will increase by the same rate as inflation, as measured by weighted consumer price indices, and will in effect remain constant in real terms. This assumption is made for all five markets and is only considered valid for the duration of the forecast, which extends through 1979. The assumptions regarding the inflation rates themselves are made essentially by projecting recent trends in the consumer price indices. When forecasting for such a short range as in this case (three years), simplifying assumptions of this type can be made without too much loss of confidence in forecasts.

The policy variables included in the cost models are available capacity in seat kilometers and the percentage of operations that is provided in wide-body aircraft. The determination of the values of these variables for planning is a major part of the airline planning problem, and it is here that the forecasts of cost can be helpful. In other words, the values used in a forecast should be thought of as policy alternatives subject to an evaluation, and the cost forecasts that correspond to these values are inputs to the evaluation process. Of course, it often happens that these variables are predetermined by other policies or constraints. For example, a constraint on fleet expansion may force a carrier, or carriers, to keep capacity unchanged or not to change the percentage of wide-body aircraft. In such cases, the values for cost forecasting are set and no assumptions are necessary. Other policy scenarios are possible in which a freeze is placed on total operating costs; in such a case, the cost model is used to determine the appropriate capacity and fleet policies required to meet that constraint.

For the forecasts presented here, the policy scenarios described briefly below have been defined for each of the five markets. The values of the assumed policy variables as well as the exogenous economic variables for these markets are given in Table 1. Again, the inflation rates are based on simple projections of recent trends, shown in Figure 12, and fuel prices are assumed to be constant in real terms.

North Atlantic

The North Atlantic market already has a large proportion of wide-body aircraft. An increase of 5 percent is assumed for 1977, and no further increases are assumed for 1978 and 1979. Capacity does not enter into the specification of this model and need not be set for forecasting future average costs. Note, however, that, in order to forecast future total costs, an assumption concerning capacity would be necessary.

North America-South America

There exists a further potential for increasing the use of wide-body aircraft in the North America-South America market. Many of the South American carriers operating in it are still in the stages of relatively vigorous fleet expansion. For this reason, the scenarios assumed for this market include a 10 percent increase in wide-body aircraft in 1977 and 5 percent increases in 1978 and 1979. Much of this increase will be the result of fleet replacement rather than pure expansion. Capacity will therefore not increase as fast. It is assumed that capacity in this market will increase by 5 percent in 1977 and 1978 and will not increase in 1979.

South Atlantic

Similar conditions exist in the South Atlantic market for the evolution of the fleet, and the same values pertain for the percentage of wide-body aircraft as those assumed for the North America-South America market: 10 percent in 1977 and 5 percent in 1978 and 1979. However, if the latest trends are any indication, capacity increases will be larger in this market. It is assumed that available seat kilometers would increase 10 percent in 1977 and 5 percent in 1978 and 1979.

Europe-Middle East

In the Europe-Middle East market, wide-body aircraft do not enter into the specification of the cost model, a situation that, as mentioned earlier, must reflect past trends and suggests strongly that the models be re-evaluated by using more recent results. In any case, no assumption is made for this forecast concerning the percentage of wide-body aircraft. Capacity increases are assumed to be similar to those of the South Atlantic market, since both markets show vigorous, but not necessarily staggering, growth. Thus, 10, 5, and 5 percent are the assumed increases in capacity in this market in 1977, 1978, and 1979, respectively.

South Pacific

The South Pacific market has fleet characteristics that are similar to those of the North Atlantic market—namely, a large proportion of wide-body aircraft. A similar assumption is therefore made concerning the percentage of wide-body aircraft for the forecasting period: Because of a leveling off of opportunities to increase the use of wide-body aircraft in this short term, a 5 percent increase is assumed for 1977 and no increases are assumed for 1978 and 1979. As for the North Atlantic market, the cost model for this market does not include a capacity variable, and consequently no assumption on that variable is necessary for forecasting average costs.

COST FORECASTS

Forecasts of total average operating costs are obtained for each market for the period 1977 to 1979 by using the scenario values discussed above. These forecasts are given in Table 2 and shown in Figure 13. A range is obtained on each forecast by including the expected value within an interval of width equal to twice the standard error of the estimate.

Although the forecasts show rising costs in current terms, it can be seen, by comparing the data in Figure 13 and in Table 2, that costs will decline in real terms. In other words, costs will not rise as fast as other prices in the markets. Interestingly, the two markets that experience a significant increase in wide-body aircraft—the South Atlantic and North America-South America markets—show a decline in operating costs even in current terms. The Europe-Middle East market, which has no wide-body effect in the cost model, continues to show the highest cost figures and the sharpest rise. It is doubtful whether this will continue much beyond 1979. Recent fleet changes in that market are likely to result in an increased role for wide-body equip-

Table 1. Forecasting scenarios.

		Change (%)			
Market	Year	Percentage Wide Body	Capacity	Unit Price of Fuel	Inflation Rate
North Atlantic	1977	+5	-	+7	+7
	1978	+0	-	+7	+7
	1979	+0	-	+7	+7
North America-South America	1977	+10	+5	+12	+12
	1978	+5	+5	+12	+12
	1979	+5	+0	+12	+12
South Atlantic	1977	+10	+10	+10	+10
	1978	+5	+5	+10	+10
	1979	+0	+0	+10	+10
Europe-Middle East	1977	-	+10	+10	+10
	1978	-	+5	+10	+10
	1979	-	+0	+10	+10
South Pacific	1977	+5	-	+7	+7
	1978	+0	-	+7	+7
	1979	+0	-	+7	+7

Table 2. Forecast average operating cost per available seat kilometer.

	Cost ($)					
	1977		1978		1979	
Market	Forecast	Range	Forecast	Range	Forecast	Range
North Atlantic	2.906	2.866-2.947	3.110	3.071-3.151	3.327	3.289-3.370
North America-South America	2.918	2.857-2.979	2.828	2.768-2.890	3.047	2.988-3.111
South Atlantic	3.139	3.087-3.190	3.205	3.155-3.258	3.526	3.476-3.580
Europe-Middle East	3.844	3.814-3.874	3.961	3.933-3.995	4.358	4.330-4.391
South Pacific	2.668	2.636-2.701	2.855	2.825-2.889	3.055	3.026-3.090

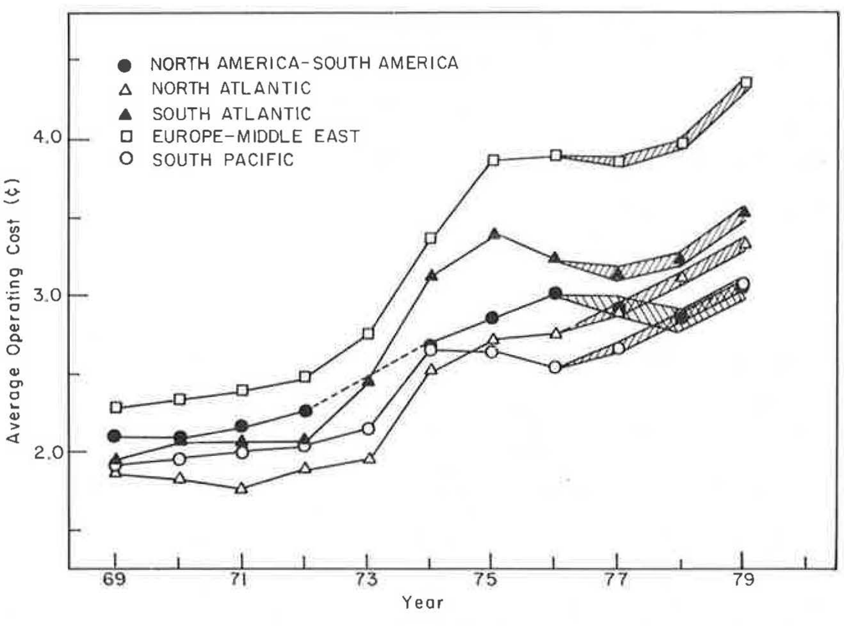


Figure 13. Actual and forecast operating costs per available seat kilometer for five markets.

ment and a savings in operating costs. These recent changes are not included in the current data base.

CONCLUSIONS

Short-term forecasts of operating costs can be made by using simple models with linear specifications. In many markets, average costs appear to be constant with respect to capacity and to indicate no economies of scale. The constant average cost per available seat kilometer in such markets is affected by the price of oil and by the percentage of wide-body aircraft in the fleet mix. In real terms, it seems that operating costs have managed to decline despite the rises in factor inputs. Most of this decline can be attributed to the introduction of wide-body aircraft in the fleet. Markets in which further changes in the fleet mix include more use of wide-body aircraft show promise of reducing operating costs even in current terms. For some markets, available capacity appears to have a negative effect on cost, which indicates economies of scale. This phenomenon seems to occur in the markets that have lower volumes; economies of scale tend to disappear as a market reaches higher traffic volumes, a characteristic often referred to as market maturity.

The results of this analysis indicate that the possibilities of controlling the rise of operating cost are linked to the possibilities of fleet modification and the

introduction of wide-body aircraft. Of course, they also depend on the prospects of controlled rises in fuel prices. If it is assumed that fuel prices will not rise faster than the rate of inflation, costs can be expected to decline. This decline, however, is associated with the use of larger aircraft and implies an increase in available capacity if level of service, as measured by flight frequency, is to be maintained. Therefore, whether fleet changes in any one market are feasible cannot be evaluated on the basis of the cost implications alone. The evaluation would require an integration of cost forecasting with the analysis of demand in the market in question, particularly with regard to price elasticity. It is a known fact in air transportation that larger aircraft bring about unit cost savings and a reduction in break-even load factors. But the use of such aircraft is feasible only if it does not cause more reduction in actual load factors, which is a possibility when larger aircraft are used. In other words, productivity alone must not be evaluated in the absolute sense but within the framework of a given market and socioeconomic environment.

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Forecasting Airport Traffic: Mexico City as a Case Study

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A procedure for preparing forecasts of airport traffic is presented, and its use is illustrated through application to Mexico City. The underlying objectives are to identify the principal factors that cause changes in airport traffic and then to develop a model of how these causes specifically influence growth. In view of the demonstrably poor overall performance of purely theoretical forecasts, a pragmatic approach is recommended in which much emphasis is placed on identifying key causes of growth. The procedure recommended involves four phases: a detailed examination of the data to determine unusual or particular events, identification of the principal causes of past and future changes, introduction of these causal factors into statistical analyses to extend recent patterns of activity into short-range forecasts, and, finally, creation of long-range forecasts with suitably wide margins of uncertainty by use of scenarios of possible developments. The case study illustrates each of these phases. The results suggest that much of future airport traffic will be caused by external influences, such as the total recreational expenditures of the United States, and is beyond the influence of airport planners.

This paper treats two topics simultaneously: (a) the question of how to forecast traffic, particularly for airports, and (b) the specific application of this methodology to the current situation in Mexico.

The general question of how best to forecast traffic is a troublesome one. Airport authorities typically spend a lot of money to obtain poor results. A traffic study for a major airport in the United States can easily cost about \$250 000, yet the forecasts generated are notoriously inaccurate. An analysis of the five-year forecasts of total aviation traffic of the Federal Aviation Administration has shown that those forecasts were off by more than 20 percent half the time (1). And forecasts for any component of the aviation system, such as an airport, are necessarily more inaccurate since their errors do not cancel each other as they would in the aggregate. It does not take much to imagine that one might get equal value for less money by simply guessing at the future. It is easy to believe that the processes now used are highly cost-ineffective. The issue is, Can we deploy our engineering and analytic skills more productively to obtain reasonable, possibly better, results more cheaply?

This paper presents a suggestion as to how better forecasts of airport traffic might be obtained at less cost. The specific situation of Mexico City is used to illustrate the process. The discussion of Mexico City is also interesting as an example of how to prepare forecasts for nations similar to Mexico. The issue here is how to proceed when the kinds of data we are used to in the United States are unavailable and when the causes of growth are substantially different. This issue is particularly topical because most new airports are likely to be built in developing countries.

BACKGROUND

Essentially all of the participants in the planning, construction, and operation of the Mexico City International Airport were elements of the federal government of