Air Transportation Analysis: Passenger Demand in Brazil

This article examines the evolution of overall domestic air passenger transport demand in Brazil, considering recent changes that have affected civil aviation markets, particularly the Brazilian market. Although only the Brazilian domestic market is discussed, it has been affected by world-level economic changes. The Department of Civil Aviation, responsible for air transport sector planning in Brazil, traditionally uses econometric models to forecast how passenger demand will evolve. However, such modelling introduces great uncertainty into the process of forecasting independent variables. A time series methodology is used to question the results obtained in traditional modelling. Using a time series approach, the forecasts for overall domestic passenger demand can be seen to offer better consistency. Econometric models offer a good level of explanation of the phenomenon, but rather uncertain results when used for forecasting.

By Elton Fernandes and Ricardo Rodrigues Pacheco

Demand forecasting is a crucial first step in planning Brazil's civil aviation system (*Sistema de Aviação Civil*, SAC). Such planning underlies the whole endeavour to develop the infrastructure necessary to meet demand. Underestimated forecasts will lead to SAC congestion, and thus to inefficiency and high operating costs. In addition, users (passengers, airlines etc.) will perceive low levels of service. On the other hand, if forecasts are overestimated there will be surplus capacity in the SAC, generating additional asset maintenance costs. In that case, users and the general public have to defray the costs of idle capacity, which is not a healthy situation given the limitations on investment funding. Airport price management in congested conditions is addressed in considerable detail in the literature. Such management can reduce the impact of inadequate infrastructure. However, one of the functions of planning is to avoid congestion, so as to ensure appropriate service levels and to direct investment efficiently. In Brazil, where nearly all airport infrastructure connected with regular passenger transport is managed by a public enterprise, it is fundamentally important to optimize infrastructure in order for the SAC to evolve. For that purpose, demand forecasting is fundamental to the planning process.

This paper aims to discuss the process of estimating overall demand for passenger kilometres in regular domestic air transport in Brazil. Although disaggregated forecasts for each airport are more useful for planning capacity, the aggregate forecast for the SAC as a whole is a valuable indicator of the planning process and helps delimit the disaggregated models of future demand. The aggregate forecast is updated periodically by the Civil Aviation Department (*Departamento de Aviação Civil*, DAC), attached to the Ministry of Defence, which at present forms the basis for the recently-created National Civil Aviation Agency (*Agência Nacional de Aviação Civil*, ANAC), whose role is to regulate the sector.

The methodology currently used involves a complex set of hypotheses on evolution of Brazil's GDP and domestic passenger yield (YPD), besides using a dummy variable in order to absorb contingent effects in the economy. Although the dummy variable is used in connection with an explanation of an economic crisis that occurred from 1991 to 1992, it can be argued that this realignment forms part of a cycle proper to the sector. In addition, the uncertainty of the forecast is greatly increased by the various uncertainties involved in forecasting the explanatory variables of the econometric model. By contrast, the observed historical series signals the possibility of a simple time series approach that could be updated very easily with no loss in forecast accuracy, and even improved estimates of future demand.

This paper shows that overall regular domestic passenger transport demand can be forecasted as an aggregate variable using time series, thus avoiding a set of unreliable hypotheses – such as the rates adopted for forecasting future GDP – which are rarely borne out. In fact, if actual GDP growth rates are used – and this is the variable that predominates in the econometric model – to evaluate the accuracy of the estimated models, actual demand is observed to distance itself even further than the forecast offered in this study. This indicates that the forecast is based on a very poor estimate of the explanatory variable, which does not recommend the econometric model as appropriate for forecasting, even though it does produce good statistical results for the parameters estimated in the model. This paper discusses the forecasts of the most recent version of the overall demand study prepared by Brazil's civil aviation department (DAC, 2000) and compares it with the results from a simple time series model.

Although there is a great deal of uncertainty as regards the accuracy of forecasting models, managerial – and particularly investment – decisions largely involve forecasts of some kind. Makridakis and Wheelwright (1989) offer a ample discussion of managerial forecasting methods. They emphasise that the choice of which model to use depends largely on the analysts' knowledge. In that regard, they suggest analysing the various possible models by using out-of-sample information as the criterion for ascertaining which is the most appropriate. Pindyck and Rubinfeld (1991) consider that constructing predictive models is an art difficult to describe in words, because it consists largely in intuitive judgements that take place in the modelling process. Zografos and Madas (2003) discuss approaches to managing airport service demand and supply. Their discussion centres on the increasingly limited slack between airport service supply and demand, which poses the issue of managing demand against available capacity. They observe that, as air traffic has grown continuously, demand management has become highly prominent among the concerns of air sector management and policy-making authorities. What can be seen in the literature generally is that research has concentrated on demand management issues (Brueckner, 2002 and 2005; Daniel, 1995; Daniel and Pahwa, 2000; Le et al., 2004; Schank, 2005). Grubb and Mason (2001) discuss aggregate passenger demand forecasting in the United Kingdom. Using the Holt-Winters method they show that demand trend is the main component in long-term airline passenger forecasting. They conclude that, for estimating long-termdemand, forecasting by way of single univariate time series has some advantages over forecasting by multivariate econometric models. Univariate forecasting depends only on the time series observed in the past and not on estimating relationships between the series and exogenous variables, and neither does it depend on forecasting exogenous variables, which itself can be subject to great uncertainties. By analyzing the most recent passengerkilometre figures published officially by the air transport authority in Brazil, this study confirms the arguments of Grubb and Mason (2001) for using time series in forecasting air transport demand.

Methodology

In generating the forecasts of the univariate series, the Holt (1957) exponential smoothing model was used. In order to produce the forecasts, this model uses smoothed estimates for the trend and for the series level, and uses two smoothing constants with values between 0 and 1. Equation 1 shows the forecasting model.

$$F_{t+m} = S_t + b_t m \quad (1)$$

Equations 2 and 3 show the two smoothing constants, α and γ.

$$S_t = \alpha X_t + (1-\alpha)(S_{t-1} + b_{t-1}) \quad (2)$$

$$b_t = \gamma(S_t - S_{t-1}) + (1-\gamma)b_{t-1} \quad (3)$$

Where,

F_{t+m} - forecast for the period t+m from base-line t;

S_t - series level smoothing at end of period t;

b_t - series trend smoothing at end of period t;

α - smoothed parameter for series level;

X_t - value observed in period t;

Case study

Until 2006 the authority governing Brazil's *Sistema de Aviação Civil* (SAC) was the *Departamento de Aviação Civil* (DAC), attached to the Ministry of Defence. In 2006 the recently created *Agência Nacional de Aviação Civil* (ANAC) is absorbing that department's functions. The DAC, meanwhile, is conducting studies through its *Instituto de Aviação Civil* (IAC) to generate input to civil aviation policy making in Brazil. Among the periodical studies it makes is the overall demand study (DAC, 2000), which includes forecasts of passenger, cargo and mail traffic demand to 3, 5 and 10 year horizons. As 1997 was the most recent data-year available to the study considered here, the forecast horizons are 2000, 2002 and 2007. In the case study in question the authors concentrate on discussing passenger kilometre demand in regular domestic traffic in Brazil and analyse forecasts for 2000 and 2002. The DAC study involves a multivariate econometric model with one independent and three explanatory variables. The independent variable is the domestic passenger kilometre (PKTD), the explanatory variables are Brazil's gross domestic product (GDP), mean revenue yield per domestic passenger kilometre (YPD), and one dummy variable with the value 1 (one) for the period from 1992 to 1997 and also throughout the forecast period. This variable absorbs the fall in demand levels that occurred between 1991 and 1992. The estimated model, the Napierian logarithm (LN) of the variables in brackets, is shown in equation 4.

$$LN(PKTD/10^3) = -10.133371 + 1.453319 \times LN(GDP/10^3) - 0.245187 \times LN(YPD \times 10^6) - 0.283245 \times DUMMY$$

$$(t=-2.24) \quad (t=8.20) \quad (t=2.23) \quad (t=-6.19) \quad (4)$$

$$R^2 = 0.89 \quad F = 54.09 \quad DW = 1.78$$

Statistical tests of this model (t statistic of the parameters, R2 regression adjustment, regression F statistic and DW autocorrelation of residuals) give good results, confirming the validity of the estimated parameters. The hypothesis used in defining projected GDP was taken from a study by Brazil's economic and social development bank (Além et al., 1997). The study was carried out by the planning sector of the bank's economic development department. In order to project YPD, a log-linear regression was adjusted (equation 5) considering ANO (year) and a dummy variable with value 1 (one) in years 1995, 1996 and 1997, as well as in the forecast years.

In this model, the results of the statistical tests (t statistic of the parameters, R2 regression adjustment, regression F statistic and DW autocorrelation of residuals) are not as good as those for the demand forecast model. Nonetheless, they can be said to confirm the validity of the estimated parameters. In this context, for its forecasting between 1997 and 2002, the DAC used the following GDP annual

$$LN(YPD \times 10^6) = 70.571467 - 0.029456 \times ANO + 0.244717 \times DUMMY$$

$$(t=5.88) \quad (t=-4.88) \quad (t=2.51)$$

$$R^2 = 0.54 \quad F = 12.10 \quad DW = 1.74$$

growth forecast hypotheses: 3% pessimistic; 4% mean; and 5% optimistic. Using equation 5, the following YPD values, in R$ per passenger kilometre, were forecast with a 95% confidence interval: pessimistic 0.188376 (2000) and 0.180629 (2002); mean0.147884 (2000) and 0.139424 (2002); optimistic 0.107392 (2000) and 0.098218 (2002). Using equation 4, the following PKTD, in millions, were forecast with a 95% confidence interval: pessimistic 15124 (2000) and 16651 (2002); mean 16739 (2000) and 19033 (2002); optimistic 18876 (2000) and 22234 (2002).

The PKTD values (in millions) actually observed in years 2000 and 2002 were 21219 and 28122, respectively. Considering the PKTD values actually observed in years 2000 and 2002, there was a reasonable difference between the forecast and estimated values. The actual values are even greater than the optimistic estimate. This demonstrates that equation 4 did not produce appropriate forecasts, despite the impression of trustworthiness given by statistical testing.

Another important point is how the independent variables of the model evolved. Firstly GDP: the mean hypothesis of 4% annual growth would indicate GDP growth of 12.49% from 1997 to 2000, and 21.67% from 1997 to 2002. Actual GDP growth was 5.32% from 1997 to 2000, and 8.76% from 1997 to 2002 (IPEA, 2006). Thus, applying actual observed GDP to equation 4, the values would be even lower, indicating that the relations estimated in equation 4 were not corroborated for the future. A second point is the YPD variable: this is projected by way of an annual trend, which was subjected to regression adjustment using a dummy variable. The YPD values actually observed for years 2000 and 2002, in R$ per kilometre, were 0.2539 and 0.2916, respectively (DAC, 2006). These values are much higher than the forecast values, and as their coefficient is negative in equation 4 this would entail still further reduction of the forecast values.

Time series results and discussion

Applying the time series methodology described in item 2 of this paper, using the same data series from 1966 to 1997, values of 0.99 and 0.33 were produced, respectively, for the smoothed parameters ? and ? , resulting in estimates much closer to the values actually observed in 2000 and 2002. Table 1 shows the forecasts obtained in the 95% confidence interval; 2.5% for the lower limit and 97.5% for the upper limit.

Table 1 – Time series model forecasts

Year	PKTD Forecasts (million)		
	Lower 2.5	Forecast	Upper 97.5
1997	13592		
2000	11521	18876	26231
2002	9980	19767	29554

Note that, with 95% confidence, the values actually observed lie between the mean and upper limits for the forecasts produced by the time series model (equation 1). Meanwhile, using the multivariate econometric model (equation 4) at the same level of confidence, the values are well above the upper limit. In addition, the independent variables of the econometric model were very distant from the values actually observed, aggravated by the fact that they were slanted in order to produce a higher estimate – for example, much higher GDP growth than observed and, conversely, a much lower Yield forecast than observed.

Although working with a short time series, this model is more accurate than the multivariate econometric model. It is certainly much easier to monitor and update the process of forecasting through time series models, which does not entail making hypotheses about exogenous variables. The hypotheses presented for forecasting using the econometric model proved very distant from the future reality. Statistical testing of the econometric model gave a false impression of accuracy. The relationship between the structure of the air transport sector and socio-economic variables seems to be changing in Brazil. The facts observed here indicate that income elasticity (GDP proxy) is rising, thus not confirming past relationships.

Conclusion

The comparative analysis presented in this paper shows the benefits of using time series in the process of forecasting air transport demand: they are accurate and simple to apply. The intention is not to criticize studies that use econometric models to explain the phenomenon, because such models are very useful for understanding the socio-economic relationships governing the sector and, in addition, they are a significant aid in the planning process. The good results obtained here recommend a continuous process of time series use, adding further information in each period. Such a procedure should lead to a better understanding of sector trends, as shown in the study by Grubb and Mason (2001). Extending the series should lead to more accurate forecasting with narrower confidence intervals.

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