Forecasting Air Cargo Demand in India
Munmun Basak, Martin West, S.P.S Narang

Abstract—Air cargo industry in India has an important role in nation’s trade and economy because of its significant contribution for the economic prosperity and well-being of the country. Transporting goods via air except perishable or sensitive products, was once costly affair for the businesses to afford in frequent basis but due to the recent forces of globalization, liberalisation, privatisation and cut-throat competition among the companies, have changed the face of global logistics and supply chain management throughout the world. In today’s competitive environment, efficient logistics planning and managing supply chain in a most cost-efficient manner such as initiating JIT (just-in-time) production and distribution approach that enables companies to reduce inventory carrying cost, are among the key factors for company’s success and existence in local and international market and which in turn have made air cargo the most lucrative option than other mode of cargo transportation. This paper evaluates the growth potential of air cargo industry by analyzing the relationship between air cargo and major factors influencing cargo growth. Multiple linear regression analysis substantiates the strength of association between air freight, gross domestic product (GDP), foreign trade and jet fuel price. Furthermore to assess and examine growth potential of Indian air cargo industry, various forecasting techniques—such as double exponential smoothing, trend analysis are carried out along with proposed econometric model of forecasting to derive results from non-stationary data and finally the predictive ability of the models is assessed based on statistical criteria.

Index Terms—Double exponential smoothing, Forecasting, GDP, Multiple linear regressions, Trend analysis.

I. INTRODUCTION

Indian economy is one of the fastest growing economies in the world and fourth largest in terms of purchasing power parity. In order to maintain this sustainable economic development, country has to improve its transportation and infrastructure sector. Air transportation is indispensable for crossing international and national boundaries and consequently stimulates expansion of trade and economic growth. According to Boeing, India is the largest submarket in Southwest Asia, comprising about 63% of international flows in the region, and it possesses a vibrant domestic market as well [3]. India’s air cargo business is having much more potential in revenue generation than passenger business but still air cargo market is untapped. Statistics indicate that airlines spend more than 75% on transporting passengers, while only 25% is spent on cargo. According to the Airport Authority of India, the total cargo volume is expected to increase by 11.5% from 2007-08 to 2011-12 in which international cargo traffic expected to increase 12.1% of CAGR and domestic cargo by 10.1% CAGR during the same period. However the rising fuel cost is one of the major concerns which can dampen the growth as fuel accounts for 20-30% of the operating cost. The purpose of this study is to foresee the future demand and potential in Indian air cargo industry based on the historical data pattern and by critically examining the factors on which the growth of air cargo is dependent on. The study will help the industry, stakeholders in decision making and planning future action as well as for the government to implement policy that will drive the growth much faster.

II. LITERATURE REVIEW

The Air Transport industry is undoubtedly an important element of national and global economies so there exists abundance of literature on various aspects of airports and airline market such as prediction of air transport demand from regional airports [2], air transport demand and economic growth [19], importance and role of yield management for airlines [21], air transport accessibility and economic performance [17] & [11], air transport passenger analysis with neural modelling [15], air transport liberalisation and sustainability [10], [1], [20]. A rich body of literature is found on forecasting air traffic flows by Shaw [24], Matsumoto [9], Grubb and Mason [6], Jorge-Calderon [12], Abed et al., [27]. There are few papers available on Indian air transport sector [16], [14] but as far as air cargo industry is concerned, limited research has been done.

In today’s economy, air cargo sector has become indispensable to facilitate global trade, logistics and supply chain management. So there exists strong demand for predicting air cargo growth. Jiang et al. [8] forecasted China’s air cargo demand till 2020 by using econometric and extrapolation methods. As economic growth is considered the prime driver for air cargo demand, the forecast of China’s air cargo is projected based on the relationship between air cargo demand and economic development (GDP) through econometric methodology which is used to determine the GDP and air cargo relationship and GDP projections are obtained by trend analysis. Kasarda and Green, [13] had shown the same empirical relationship between air cargo and economic indicators such as trade and GDP and...
considered air cargo as lead factor for economic development. Chang and Chang [28] had shown empirical relationship along with long run equilibrium and bi-directional relationship between air cargo expansion and economic development. Heng et al. [7] has established support vector machine (SVM) model for air cargo demand forecasting taking historical data of cargo volume as forecasting specimen and prediction model was compared with Brown’s cubic exponential smoothing based on fitting effect and forecasting accuracy. The forecast report generated by Boeing reflects that world air cargo traffic will triple over the next twenty years compared to 2009 levels with an average annual growth rate (AAGR) 5.9% in spite of global economic downturn such as rising jet fuel price, weak economic growth, turmoil in financial markets etc. GDP growth not only drives international trade but also stimulates air freight which will grow at nearly double the GDP growth rate [4]. Totamane et al, [25] proposed a multi producer/consumer solution for predicting cargo demand through weighted majority learning algorithm of a specific airline in a given route and cargo load factor for its flight schedule.

To handle the variety and complexity of managerial forecasting problems multiple forecasting techniques have been developed. These methodologies such as econometric modeling, judgmental analysis, trend analysis and potential analysis are considered useful to provide forecast. Econometric modeling helps to determine the overall importance of underlying economic factors like GDP, trade, fuel price etc. and enables forecasts to be linked to expectations for those factors. This method is useful for medium and long range forecasts in regional markets. Judgmental modifications often account for expected changes in non-econometric growth factors like trade quotas, air service agreements etc. A simple trend analysis is often used to evaluate changes in economic factors. This approach is useful in evaluating general changes in the marketplace that can be attributed to the combined effects of a number of factors. Potential analysis is useful, particularly for forecasting markets in their early stages of development. Each methodology has its special application according to the situation, therefore special care must be taken to select one or multiple techniques [5], [4].

From the above literature review it is evident that there exists good scope of doing research particularly in the field of Indian Air cargo industry when Asian market is booming. Previous researchers have forecasted air cargo demand by establishing the relation between air cargo, GDP and trade. Although economic activity is having strong influence on air cargo growth, other factors must be considered [25]. In this study fuel price is also considered having significant impact on air cargo growth along with GDP and trade. This research focuses on examining the impact of economic factors (GDP, trade, fuel price) on air cargo growth then generating the forecast of air cargo demand in India using multiple forecasting techniques and finally predictive ability of the model has been assessed based on fitting effect and forecast accuracy through error measurement.

III. DATA SOURCE

To conduct this study, we are considering four variables- volume of air cargo, GDP, trade and jet fuel price. As volume of air cargo is dependent on various factors but for sake of the simplicity of the study only those factors are considered which have greater influence on air cargo. For analysis, dependent variable is considered as total air cargo traffic (in ’000tonnes) i.e. international and domestic cargo handled in all Indian airports between the period of 1988-89 to 2007-08 (Source: Airport Authority of India, Directorate General of Civil Aviation (DGCA), Ministry of Civil Aviation (MOCA)) and independent variables are the value of gross domestic product (GDP in USD) of India (Source: World Bank), foreign trade (in USD) of India (Source: Directorate General of Commercial Intelligence and Statistics) and jet fuel price (cents per gallon) in Asia Pacific Region (Source: Energy Information Administration (EIA)) for the period of 1988-89 to 2007-08. Fig. 1, showing available data for volume of air cargo, Fig. 2, showing economic indicator GDP, Fig. 3, showing the growth in trade, Fig. 4, showing the jet fuel price from 1988-2008 and Fig 5, is reflecting variations in individual data over the time. From the observed data it is obvious that the trend in data series is exponentially increasing with the time.
Fig. 1: Year wise total air cargo traffic of India
Fig. 3: Year wise total trade of India

Fig. 2: Year wise Gross domestic product (GDP) of India

Fig. 4: Year wise jet fuel price in Asia Pacific region

Fig 5: Variations in air cargo, GDP, trade and jet fuel price over time
Initially, the relationship between air cargo movement and factors impacting air cargo movement has been established which will help to make decisions that impact on the future. Multiple linear regression (MLR) model is formed to explain variations in air cargo movement due to variations in GDP, trade and jet fuel price, using cross sectional data. In the linear regression model, the dependent variable is assumed to be a linear function of one or more independent variables plus an error introduced to account for all other factors. The goal of regression analysis is to obtain estimates of the unknown parameters or coefficients which indicate how a change in one of the independent variable affects the values taken by the dependent variable. The equation estimated in the regression model is given by:

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + e \]  

(1)

In the above regression model, \( Y \) is the India’s total air freight volume (dependent variable), \( X_1 \) is India’s real GDP, \( X_2 \) is India’s total trade, \( X_3 \) is jet fuel price (independent variables) and \( e \) is the disturbance or error term, \( \beta_0 \) is the intercept and \( \beta_1, \beta_2 \text{and } \beta_3 \) are the slope coefficients. By using least square method the equation derived from the model is given below as:

\[ \text{AirC } \text{arg } o(Y) = 24.56 + 1.57 \text{GDP} + 0.33 \text{Trade} - 0.78 \text{Fuel } \text{price} + e \]  

(2)

This model depicts that, there exists a positive relationship between volume of air cargo handled in Indian airports, GDP and trade. However the relationship between volume of air cargo and jet fuel price is negative. This indicates that, with increasing fuel price the operating cost of cargo airline increases, which in turn reduces the growth in cargo business. The coefficient of GDP and trade indicates that with 1% increase in GDP and trade will increase the cargo by 1.57% and 0.33% respectively. The coefficient of determination \( R^2 \) indicates the proportion of variation in cargo volume can be explained by GDP, trade and jet fuel price. In this model \( R^2 \) is 0.88, which tells 88% of total variation in cargo volume can be explained by these three independent variables.

A. Forecasting air cargo growth

Once the relationship has been established the next step is to forecast air cargo growth. Various forecasting methods have been proposed in the literature as effective. For predicting the growth of cargo volume in India till 2020, an important step is the selection of appropriate forecasting method after considering the type of data pattern. Here multiple forecasting methods such as trend analysis, double exponential smoothing, econometric modelling with multiple variable (EMMV) as well as with single variable (EMSV) and compound annual growth rate (CAGR) have been considered for evaluating performance and fitting effect of different approaches.

1) Trend analysis is considered as the simplest form of forecasting. A trend line represents long-term movement in data after other components have been accounted for. It tells whether a particular data set such as air cargo volume has increased or decreased over the period of time. A trend line could simply be drawn through a set of data points, but more properly their position and slope is calculated using statistical techniques like linear regression. The equation for linear trend analysis is described below-

\[ X_t = \alpha + \beta t \]  

(3)

Here \( \alpha \) and \( \beta \) are the two coefficient, \( t \) is the number of period for which forecast has to be generated and \( X_t \) is the forecasted air freight volume. The comparison of the actual and predicted values of a linear trend fit is shown in Fig. 6.
Fig. 6: Comparison of actual and predicted values in linear trend analysis

Fig. 6, shows actual cargo volume has been shown in the y-axis and predicted cargo volume has been considered in x-axis. Actual value has been plotted against 1:1 predicted line. The purpose of the graph is to indicate the predictive ability or fitting effect of the forecasting method with respect to actual value. This is clear from the figure that linear fit would not be a good choice of forecasting Indian cargo market.

2) After trend analysis, Brown’s one parameter linear exponential smoothing method is used for producing the forecasts as the plotted data in the graph are nonstationary and nonseasonal but trending over time (Fig. 1). Exponential smoothing models have regularly performed well in comparative performance evaluations [22]. Exponential smoothing methods imply exponentially decreasing weights to the past observations. Here In double exponential smoothing both the single and double smoothed values lag the actual data when a trend exists, and the difference between the single and double smoothed values can be added to the single smoothed values to adjust trend. After that selection of smoothing constant is the next important step to minimize forecasting error. For this purpose smoothing constant $\alpha=0.9$ has been considered as it gives minimum error.

Fig 7: Comparison of actual and predicted values in double exponential smoothing

Fig 7 shows that actual values were plotted against the 1:1 predicted line and double exponential smoothing will be a good choice to forecast air cargo volume in India.
3) However we cannot deny one of the popular methods of forecasting used in the aviation industry is the CAGR (compound annual growth rate) method. From the previous observation the CAGR has been calculated as 10.28% for the period of 1988-89 to 2007-08. The equation for CAGR can be given by:

\[
CAGR = \left( \frac{x_n}{x_0} \right)^{\frac{1}{(T_n - T_0)}} - 1
\]

(4)

Where \(X_n\) is the value of cargo at the end year \((T_n)\) and \(x_0\) is the value of cargo at the beginning year \((T_0)\) of observed data. The CAGR was found out by considering base year as 1988-89.

![Graph showing CAGR 10.28% and comparison with actual cargo volume](image)

**Fig. 8:** Best fit with CAGR 10.28% and comparison with actual cargo volume

The predictive ability of the CAGR method has been shown by plotting the predicted value on x-axis and actual value on the y-axis. Fig. 8, shows that the predicted CAGR method is in good agreement with the actual data.

4) As trend analysis can’t generate better forecast then a nonlinear exponential fit has been attempted as the trend of the cargo volume shows an approximate exponential growth in Fig 1. The econometric model proposed here combines all the independent variables used and the relationship found in MLR analysis mentioned above. The proposed econometric model with multiple variables (EMMV) can be explained as:

\[
Carg o = a \exp \left( \frac{t \cdot JFP^c}{GDP \cdot Trade^d} \right) \frac{GDP^c \cdot Trade^d}{JFP^d}
\]

(5)

where \(a, b, c\) and \(d\) are the constants and can be found out by least square method, \(t\) is the time in year, JFP is the jet fuel price, Trade is the total of India’s foreign exports and imports and GDP is gross domestic product of India. The model gives minimum error with \(a = 19.34, b = 0.11, c = 0.13\) and \(d = 0.63\)
Fig. 9: Best fitted econometric model with multiple variables for cargo forecasting

Fig. 9, shows the comparison of actual and predicted volume of cargo and plotted against 1:1 curve. This gives better fit than linear fitting. There are reports on forecasting of China’s natural gas production and consumption by exponential law [18]. However, this method will be useful if we have the availability of the predicted value of the independent variables (GDP, Trade, and JFP).

5) If the previous model can’t be applied due to unavailability of explanatory variables then following model can be useful. As the cargo market increases exponentially with time econometric model only with respect to time can be applied here for prediction of cargo volume. The econometric model with single variable time (EMSV) can be expressed as:

\[ y = C \exp^{-xt} \]  

(6)

where \( x \) and \( y \) are the constants and can be found out by least square method, \( t \) is the only variable here which is time in year, The model gives minimum error with \( x = 233.80 \) and \( y = 0.09 \)

Fig. 10: Best fitted econometric model with single variable (time) for cargo forecasting

In this method only time has taken as the changing variable and cargo has been predicted. The predicted and the actual values were plotted on the same graph to show how the predicted values are compared with the actual value
in Fig. 10. Therefore the econometric model with single variable (EMSV) method can be used for future forecasting.

B. Error measurement

To evaluate predictive ability of the model error measurement is essential. No single error measure captures the distributional features of the errors when summarized across data series [22]. In this study five error measures [26] have been used to find out forecast accuracy- 1) Root mean square error (RMSE) 2) Mean absolute error (MAE) 3) Mean absolute percentage error (MAPE) 4) Mean squared error (MSE) 5) Standard deviation of error (SDE). The model which is having minimum error is considered for generating better forecast.

Table. 1, shows the individual values of the errors calculated from different methods. The study reflects econometric model with single variable time (EMSV) gives minimum error and trend analysis gives maximum error in comparison to other methods. CAGR and DES are the second and third best method as per error measurement. The econometric model with multiple variables (EMMV) proves better method than trend analysis.

<table>
<thead>
<tr>
<th>Error/Methods</th>
<th>EMSV</th>
<th>CAGR</th>
<th>DES</th>
<th>EMMV</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSE</td>
<td>0.090</td>
<td>0.091</td>
<td>0.092</td>
<td>0.105</td>
<td>0.158</td>
</tr>
<tr>
<td>SDE</td>
<td>0.092</td>
<td>0.093</td>
<td>0.094</td>
<td>0.107</td>
<td>0.162</td>
</tr>
<tr>
<td>MSE</td>
<td>0.00820</td>
<td>0.00829</td>
<td>0.00850</td>
<td>0.011</td>
<td>0.025</td>
</tr>
<tr>
<td>MAE</td>
<td>0.067</td>
<td>0.066</td>
<td>0.072</td>
<td>0.077</td>
<td>0.145</td>
</tr>
<tr>
<td>MAPE</td>
<td>13.38</td>
<td>12.50</td>
<td>12.34</td>
<td>14.27</td>
<td>25.31</td>
</tr>
</tbody>
</table>

Based on the above discussion and different approaches applied to generate forecast of Indian air cargo industry till 2020.

C. Forecast of air cargo growth in India

Fig. 11, shows the forecasted value of air cargo volume till 2020. Forecast through double exponential smoothing (DES) has predicted cargo volume will reach to 3.59 million tons at the end of the forecasting period i.e in the year
2019-20 and the projections made by Trend analysis, reflect 2.23 million tons which is considered as lower band value. The proposed EMSV method in equation (4) predicts 5.65 million tons and CAGR method in equation (4) indicates 5.53 million tons at the end of 2020 which is considered to be upper bound solution. The forecast has been started from the year 2008-09 purposefully to compare the actual data with forecasted value. After this sensitivity checking has been carried out.

D. Sensitivity checking

Forecasted data from 2008-09 to 2016-17 were collected from AAI source and reports from Deloitte and FICCI and our calculated CAGR of 10.2% and EMSV forecasting methods were compared.

Fig. 12: Sensitivity checking for the proposed EMSV method of forecasting

Fig. 12 shows the sensitivity checking for the proposed forecasting method. The proposed EMSV forecasting method is in good agreement with others.

V. CONCLUSION

Air cargo facilitates transporting goods much faster from one part of world to another and consequently initiates international business to grow and expand quickly than other mode of transportation. This study demonstrates the potential of Indian air cargo industry by analyzing the impact of major economic factors playing role in air cargo growth. Multiple linear regression analysis has shown GDP and trades are having positive impact on the growth of air cargo where as fuel price is having significant negative relation. The calculation also shows that cargo growth will be more than that of GDP growth. Several forecasting methods were applied along with the proposed econometric model with multiple variables and single variable with time to compare their predictive ability and fitting effect with respect to actual value. In this paper the forecast air cargo demand of India has been generated with simple mathematical models rather than using sophisticated software or solution. However there is always a good scope of using sophisticated algorithm, time series methods to predict future air cargo growth. Hence, these simple generalized forecasting methods discussed above can be used to predict air cargo demand of any country and eventually help them to make strategies to boost the predicted growth.

ACKNOWLEDGMENT

We do hereby acknowledge to all those their name do not appear here for immense help and cooperation for successful completion of this study. Special thanks to Mr. Indranil Guha for his support throughout this journey. This work was accepted for presentation at ATRS World Conference 2012.

REFERENCES


AUTHOR BIOGRAPHY

Munmun Basak at present working in the supply chain management of Oil and Gas Industry in Australia. She has a post-graduation (MBA) degree in Aviation from University of Petroleum and Energy Studies, India and worked more than 7 years in EPCM, Aviation, Energy industries. Her research interests are in SCM, E-procurement, and Logistics.

Martin West is an Associate Professor at Curtin University, Australia. He has a PhD degree from University of Pennsylvania and MBA degree from University of South Africa. Prior to joining Curtin University he has worked in micro economics, SCM and logistics in various industries. His research interests are in strategy, regulatory economics, supply chain management, information system policy & governance and logistics & transportation

Maj. Gen S.P.S Narang at present is a Distinguished Professor and director at the University of Petroleum and Energy Studies, India. He has an M.Sc degree in Defence Studies, MPhil degree in International System & Conflict Resolution and a PhD degree in Social Sciences. His specializations are HRM, Organizational Behavior, Business, and Communication & Negotiation.