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MACROSCOPIC MODEL FOR PLANNING AND MANAGEMENT OF DOMESTIC AIR TRANSPORT IN BANGLADESH

Md. Jobair Bin Alam [1], Dewan Masud Karim [2] and Alamgir M. Hoque[1]

ABSTRACT: Air transport plays an important role in the development of a country. Its importance in Bangladesh has increased with the privatization of domestic air transport market. For planning and management of air transport operations and improvement of the facilities and services, it is necessary to understand demand and cost structure under present and future conditions. This paper presents a set of demand and cost models as well as their application to understand the effects of demand and supply side input variables on the performance indicators including change in profit and reduction of supply costs. The analyses are based on aggregate data, which resulted in macroscopic models, focusing on aggregate demand and cost. The paper also highlights the difference of management efficiency between the private and public sector airline companies operating in the country. The results of this study can be incorporated in the development of policies in air transport sector in Bangladesh.

KEYWORDS: Domestic airlines, Demand, Supply, Cost, Equilibrium.

INTRODUCTION

Demand for air transport is increasing very rapidly in recent years. During the last six years, demand for air transportation in domestic sector has increased by 38.9 percent (BBS, 1999). With the introduction of larger and faster aircraft and improved logistics in the form of "Hub-Spoke" network system, the demand is expected to increase further. Also, the development of regional and sub-regional co-operation in the form of SAARC and SAPTA will have a significant influence on the air transport system of this region. Bangladesh may have to play an important role in these cooperative frameworks. For this purpose, the air transport system of the country needs to be analyzed rigorously.

At present air transportation satisfies only about 2% of the total inter-city travel demand of the country which is dominated by road transport carrying about 58% of the same (BBS, 1999). Although air transport carries a very small portion of inter-city traffic of the country, it plays a vital role by providing a fast and reliable alternative for those who need it. Sometimes, especially during floods, the need for air transport increases further. Realizing its importance in national development and inability of public sector to provide adequate service, the Government of Bangladesh has opened the domestic air transport

[1] Department of Civil Engineering, BUET, Dhaka-1000, Bangladesh
[2] Nippon Hoho Co. Limited, Japan

market to private sector in 1996. To attract investment in this sector, it is required to know the information about present and future demand of air transport in the country, cost structure of aviation industry and demand-supply equilibrium condition in different scenarios.

This paper focuses on air transport system of Bangladesh. Initially a demand model is developed with the introduction of cost related variables (fare and generalized cost ratio). Subsequently a cost function is developed to assess the management strategies of the operators. In this regard, the paper analyzes the difference of management efficiency between private airline companies and government airline operator (Biman) with the consideration of various variables which generally vary in organization type, operation size and service level. Then an equilibrium analysis is presented that converges dynamically towards the equilibrium of factors affecting the quantity demanded and the factors that determine the quantity supplied.

The findings of this study can be used to assist the management of various airlines in developing the guidelines for operating in domestic routes and to help the planning and design of future infrastructure development of air transport system in Bangladesh.

AIR TRANSPORT SYSTEM IN BANGLADESH

Airport Network

The civilian domestic air transport network in Bangladesh, as of 2001, comprised of eight conventional (full-size) airports. These airports handle widely varying traffic volumes. The largest airport is Zia International airport in Dhaka and the smallest one is Cox's Bazar airport. The most important corridors, as measured by air passenger volumes, are those between Dhaka, at one end, and Chittagong, Jessore, Sylhet at the other end. The location of the airports and the air transport network is shown in Figure 1.

Bangladesh is a small country with an area of 147,570 sq. km and the distance between the capital and farthest major city is less than 400 km. The distances between the major cities are not large enough for air transport to be very effective. But it is competitive with other modes if surface transport time, safety and security are considered. Most of this country is covered by large rivers which is a great barrier for surface transport and, fast and continuous road or rail network does not exist in many areas of the country. In general railway is inefficient and slow and roadways are highly congested and accident-prone. Thus, a relatively low level of service for surface transport enhances the market for domestic air travel. This is most clearly visible in northern and southern parts of Bangladesh where air transport competes with relatively inferior condition of road, rail and water transport modes. The per capita air travel frequency in these areas is approximately 1.5 times higher than the national average for the same, despite the fact that income is generally lower in the northern areas (BBS, 1999).

Air Transport Operators

The present condition of domestic air transport in Bangladesh is presented in Table 1. Biman and three private airline companies operate in the conventional domestic network. The private companies have recently started operating in Bangladesh. Aero Bengal Airlines is the first private airline in the country that started its operation in 1995. Subsequently, Air Parabat and GMG Airlines started their operations in early 1998. GMG Airlines has emerged to become the leading private airline company of the country. At present only GMG Airlines is in operation. The list of inventories of these airlines is provided in Table 1. For all these companies, fares are subjected to the approval of the civil aviation authorities and certain minimum standards of service are imposed on their operation. Average passenger load factors typically approach 80-85 percent for private companies and 55-60 percent for Biman, and annual traffic volumes appear to be determined almost completely from the demand side. Routine in-flight surveys reveal that majority of the passenger trips are business trips (55 percent). Among the rest, 20 percent is tourist trip, 15 percent is government official trip and 10 percent is recreational trip (BSPR, 1999). From the past records of domestic air transport of Bangladesh, it is observed that domestic section of Biman has always been a losing sector due to lack of appropriate size of aircraft, inefficient level of operation and inefficient management.

The increase in economic activity may have a marked impact on domestic air transport of Bangladesh and increase the demand for the service. Its importance will increase further if the elements of time, speed and efficiency are considered for other modes of transport of the country. Anticipating the potential of domestic air transport business, private airline companies have now joined the fray of enticing Bangladeshi passenger and freight. This trend is expected to continue in future.

METHODOLOGY OF ANALYSIS

For planning and management of a service it is required to know its demand and supply structure as well as mechanism of their interaction. Demand and supply models are usually developed for this purpose. Figure 2 illustrates the overall structure of the model. It is composed of 'Demand Model' which forecasts the demand for air transport based on some socio-economic and transport system variables and a 'Supply Model' which relates operating costs incurred by the airline companies with their fare level and profit. The models developed in this study are based on aggregate data such as population income, GDP etc. and provides aggregate output in the form of total demand and total cost.

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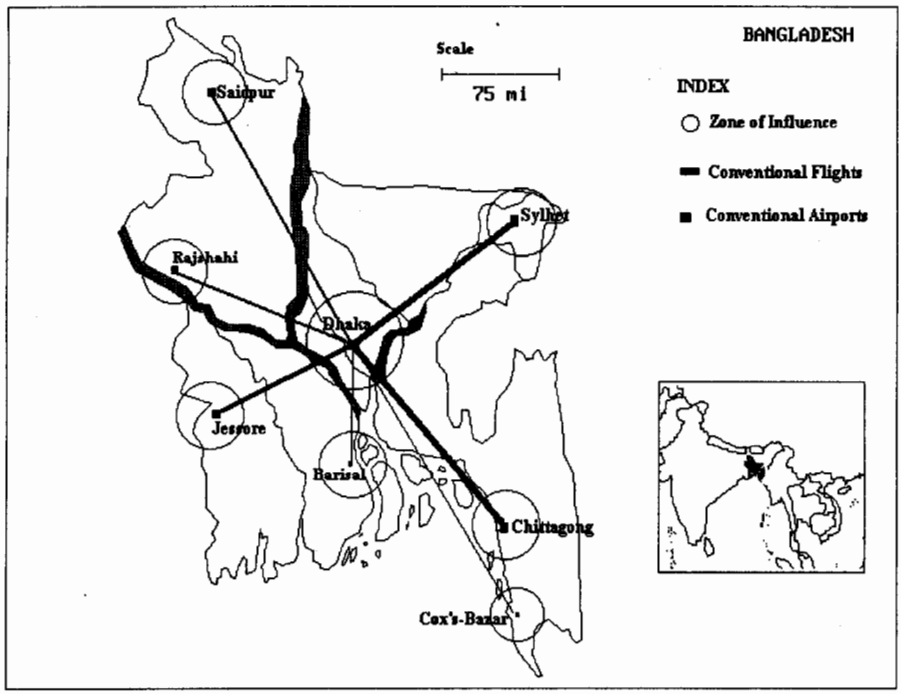

Fig 1. Domestic Air Transportation Routes in Bangladesh

Table 1. Description of the Airlines Operating in Domestic Air Transportation in Bangladesh (Source: Civil Aviation Authority)

Name of The airlines	No of Air craft	Type of Aircraft	No. of seats	No of flights (One way per week)	Avg. Passenger Load factor	Avg. pass. Carried (per week)
Biman Bangladesh	4	2 F-28 2 ATP	85 70	68	55-60% (approx.)	5134
Aero Bengal*	3	1 AN-24 2 Y-12	48 17	18	75-80% (approx.)	1016
Air Parabat Limited*	1	2LET 410 UVPE	19	56	80-85% (approx.)	1294
GMG Airlines	4	CANADA -08	37	35	80-85% (approx.)	1520

*Not in operation at present.

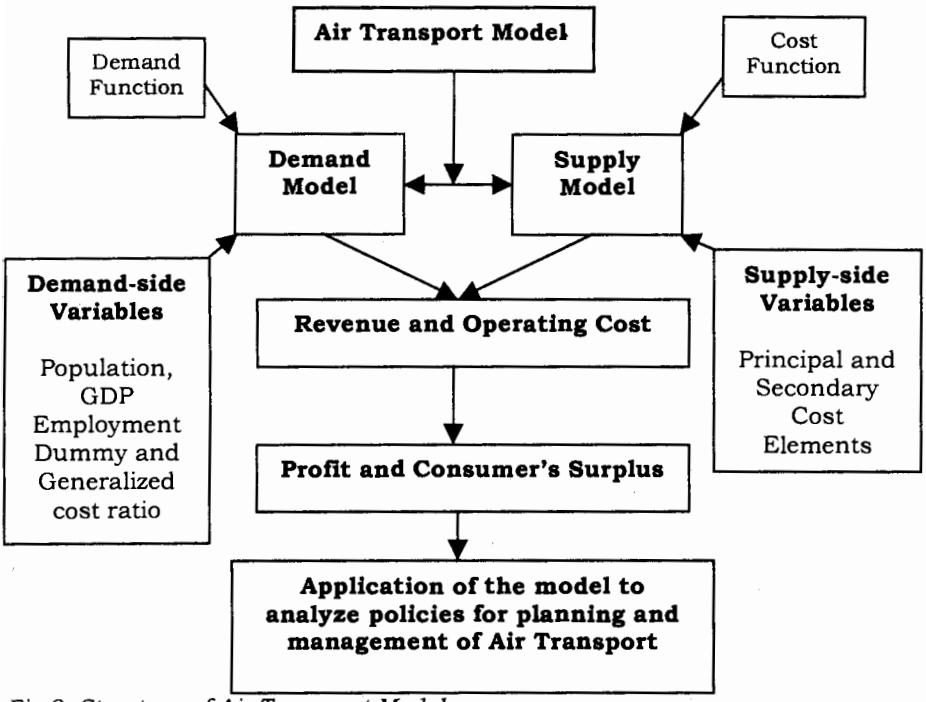

Fig 2. Structure of Air Transport Model

As a whole these models provide estimation of operating cost including capital cost for properties based on demand models, optimization of the systems by equilibrium analysis and assessment of total surplus when an operator provides a particular service. The calculation is based on a set of environmental parameters (socio-economic variables) and characteristics of operators. In the model the operators can control marginal and total profit, frequency of service, operation area and fares.

Demand Model

The demand model usually relates travel demand with a few explanatory variables that include socio-economic, demographic and transport system variables. The models are usually calibrated using cross sectional and panel data.

Structure of the Demand Model

It is observed that 'city-pair' type model provides the most suitable methodology for the analysis (Verleger, 1972, Moore and Soliman; 1981 and Kanafani, 1983). In city-pair models of air travel demand, the

socioeconomic characteristics of the cities of origin and destination are considered as the demand variables. It is assumed that there exists no competition among destinations and the traffic between any two cities depends only on their characteristics (Kanafani, 1983). In general, the structure of most city-pair models is of the gravity type where the demand for travel is proportional to a product form of the demand variables for the city-pair in question and of the supply variables of the air transport system between them (Verleger, 1972 and Moore and Soliman, 1981). On this basis the following functional form has been selected for forecasting demand for air transportation (Tij) on the basis of socio-economic variables (Sij), demographic variables (Dij) and transportation system variables (Aij).

$$T_{ij} = k.f(S_{ij}).f(D_{ij}).f(A_{ij}) \quad (1)$$

Demand Variables

Logical content and availability of data are the major considerations in the selection of demand variables. Data have been collected from various sources that include Bangladesh Bureau of Statistics, Bangladesh Biman, and private airlines. Air travel between seven city pairs involving eight cities in Bangladesh has been analyzed in the study. The zone of influence of each airport has been allocated very carefully. Usually it is identified by in-flight passenger survey (Rengaraju and Arasan, 1992).

Generally in 'City-pair Model' the independent variables are defined as an additive or multiplicative combination of the same variable for the two concerned cities. But in the case of air transport in Bangladesh, all the trips either emanate from or end at Dhaka. So the variables related to Dhaka can be eliminated from the models and the socio-economic variables included in the study are the property of the other end of the trips.

The variables included in the model are Population (P_i), Employment (E_i), GDP (Gross Domestic Product, G_i), Generalized Cost Ratio (R_{ij}) and a Dummy Variable (X_{ij}). The values of these variables are measured on the basis of influence zones.

Population is the most important variable in aggregate demand analysis. The population of the influence zone served by the airport rather than just the city in question is used in the analysis. The 'Employment' variable includes total number of employed persons in the higher income group. GDP is considered as the measure for the level of economic activity in the influence zone.

Generalized Cost Ratio (R_{ij}) includes the time and cost elements of the concerned mode as well as the same of the competing modes. Preliminary investigations demonstrated that the best quality road transport in the form of private car and luxurious buses are the alternatives contemplated by the passengers of air mode. The cost of transport is complex and multidimensional, and it extends beyond the

monetary components to include various characteristics of transport system. For this reason, access time, in-vehicle time, waiting time as well as value of time are included in this variable. 'Generalized Cost Ratio' is defined as the ratio between the total cost of using air transport mode and the same of high quality road transport.

Dummy Variable (X_{ij}) is included in a quantitative regression equation to deal with some special cases. Two special cases are considered in this analysis which require dummy variable - one is for Cox's Bazar airport due its tourist attraction and the other is for Sylhet airport due to additional flights from Dhaka carrying a substantial amount of immigrant passengers from the United Kingdom in addition to normal demand.

Data have been collected for each of the variables from the Statistical Yearbook of Bangladesh (BBS, 1999). Data on the influence zones were collected from routine in-flight surveys on the initial origins and final destinations of the passengers. The data on population, GDP and employment were prepared on the basis of the zone of influence. The Generalized Cost of road network was calculated on the basis of road distance, average speed (considering obstacles like ferry) and value of time obtained from the study of Alam et al. (1999). Air transportation demand data were collected from Biman and the private airline companies of Bangladesh. Analyzing the data of the variables explained above, it is observed that employment and GDP are highly correlated. Based on this observation two models have been calibrated, one of which includes Employment and the other includes GDP. The resulting models are shown below.

Model 1 (Employment Model) $$T_{ij} = e^{a}(P_j)^{b}(E_j)^{c}(R_{ij})^{d}(X_j)^{e} \quad (2)$$

Model 2 (GDP Model) $$T_{ij} = e^{a}(P_j)^{b}(G_j)^{f}(R_{ij})^{d}(X_j)^{e} \quad (3)$$

For calibration purpose, data have been collected from Civil Aviation Authority and private airline companies for all six origin-destination (OD) pairs for the last ten years. Yearly data were available for 31 OD pairs segregated on weekly basis. Weekly data were used for calibration purpose. The results of the calibration of Models 1 and 2 are presented in Tables 2 and 3, respectively. The goodness of fit statistics and t-statistics (at 5% level of significance) are satisfactory for all the variables except 'Generalized Cost Ratio' (GCR). This variable is significant at 85% level of confidence in Model 2 (GDP model), whereas it is not acceptable even at lower level of confidence in Model 1 (Employment model). For this reason, GDP model is used for further analysis in this study.

All the coefficients have signs consistent with expectation. The demand for air travel will increase with the increase of population, GDP and Employment. On the contrary, the demand will reduce with the increase in GCR. In both the models, population is the most dominant variable.

TABLE 2: Estimated Parameters of Employment Model (Model 1)

Model 1 (Employment Model)		
Parameter	Value	t-value
Y-Intercept	0.01834	0.04159
Population	1.83111	3.02273
Employment	1.20339	2.38523
Generalized Cost Ratio	-0.19356	-1.0456
Dummy	2.57777	13.06811
R-Square-0.90 Adj. R-Square-0.904 Sample Size-31 OD Pairs		

TABLE 3: Estimated Parameters of GDP Model.(Model 2)

Model 2 (GDP Model)		
Parameter	Value	t-value
Y-Intercept	0.06446	0.14214
Population	2.11609	3.90011
GDP	1.07819	2.14232
Generalized Cost Ratio	-0.33678	-1.43687
Dummy	2.65699	12.04513
R-Square-0.95 Adj. R-Square-0.953 Sample Size-31 OD Pairs		

Supply Model

Knowledge of demand function alone is not sufficient for the prediction of quantity demanded or consumed, nor of any of the other variables associated with it. If the quantity demanded be known, then the demand function will permit the determination of that price which brings about that quantity. Later, the quantity supplied at the price, known from supply function, will bring about the equilibrium condition for the system to predict the total amount that will occur under specified conditions and the associated prices and levels of service. For the analysis of market equilibrium the supply model must be developed.

The supply of transport services can be characterized in terms of the performance of the transport system and the costs incurred in building, maintaining, and using the system.

Structure of Cost Function

In order to construct the supply function for intercity air transport, a system is considered consisting of two airport serving two cities. The supply of passenger air transport between these two airports is related to the operator's average cost function. In long-distance air travel, this function is dominated by the airfare, which depends directly on the cost recovery scheme used by the airlines providing the service and is influenced by regulation and market characteristics. For this study all the elements of costs are calculated from the actual monthly cost data supplied by various airlines.

Cost Variables

For the development of cost function nine principal cost elements are included in the analysis. The cost variables included in the analysis are discussed below. The values of these variables are calculated on the basis of twenty-two secondary factors that are also mentioned along with these principal cost variables.

Number of flights per week (FL): The Required number of flights (FL) per week to accommodate the demand is calculated as follows.

$$FL = INT\left[q/(IQ) + 0.4\right] \quad (4)$$

In the analysis it is assumed that an additional flight might be introduced in a route if demand can satisfy at least 60% of the capacity.

Administrative Cost (C1): It includes ground employee cost, office service cost and sales cost.

Maintenance Cost (C2): It includes major maintenance cost for aircraft operation and regular maintenance

Marketing Cost (C3): This element of cost contains airline promotional activities such as advertising, sponsoring etc.

Civil Aviation Charges (C4): It contains night surcharge (Ns) and charges for hanger (Hn), parking (Pa), landing (La), security (Su) and navigation (Na).

Running cost (C5): It consists of unit travel cost which is calculated from average cost of fuel (Taka per liter), aircraft fuel consumption rate (liters per kilometer of travel) and the trip distance (in kilometer).

Capital Cost (C6): This is calculated on the basis of leasing cost, as many of the private airline companies and some aircrafts of Biman are operated on leased basis. For other aircrafts, capital cost is calculated in terms of 'Diminishing Balance Depreciation Method' (Pyle and Larsen, 1981).

Contingency Cost (C7): This is a reserve fund for the smooth operation of airlines in future. It comprises about 10 to15 percent of the total cost discussed above.

Procurement Cost (C8): This fund is earmarked for purchasing new aircrafts for the expansion of the operation.

Profit (C9): It is considered to vary between 8 to12 percent of the total cost mentioned above which is suggested by the private airlines.

The cost model has been calibrated on the basis of monthly cost data obtained from Biman and the private airline companies.

Features of Supply Analysis

This section describes some salient features of the cost functions that have been analyzed in this study.

1) Important Cost Element: To describe the supply analysis conveniently all the costs are grouped under two headings: TOMC (Total operating and maintenance cost includes administrative, maintenance, aviation charges, running, capital and marketing costs) and TC (Total cost which includes TOMC, contingency and procurement cost). Among

the nine principal cost elements, running cost is the most important one (on an average 39 percent of TOMC). Other important cost elements are capital cost (33 percent) and maintenance cost (19 percent). So small variations in these figures may lead to significant changes in operator's revenue and profit.

2) Nature of costs: Among the nine cost elements, administrative, civil aviation charges and marketing cost do not vary significantly although these costs include both fixed and variable costs. Fixed cost is the major portion of these costs and they do not vary significantly with the increasing number of flights.

3) Scale of operation: As the demand is small and distances are short, using small-scale aircraft, Civil Aviation charges and capital cost can be saved significantly. For larger aircraft higher charge is imposed by the Civil Aviation Authorities. Also the capital cost, which is a function of cost per hour of operation and fixed charge, depends on the size of the aircraft. For example, private airlines use small aircraft, thus saving 20 percent in the Civil Aviation charges and 40 percent in the capital and running costs per passenger. For these aircrafts, a small amount of saving may also be realized on maintenance and running costs. Small aircraft can be used to operate with full capacity.

4) Contingency and Procurement Cost: One of the main problems of air transport is unexpected accident or technical fault of aircraft during the operation period. Contingency and procurement costs are 15 percent and 12 percent of TC, respectively. If operators can maintain their aircraft more efficiently they can save these costs significantly.

5) Classification of routes: Depending on profit making criterion, the existing seven routes can be classified into three groups: a) More profitable routes: Chittagong, Sylhet and Jessore are included in this category. These routes are also demand oriented. b) Less profitable routes: Saidpur, Rajshahi and Cox's-Bazar are included in this category. Increasing a flight or two can substantially increase the profit but demand does not permit such changes. Flights to Rajshahi make a little profit occasionally. c) Losing routes: Only the route to Barisal can be categorized in this group. Although Dhaka-Barisal route is not profitable at the moment, in near future this route can emerge as a profitable one because Barisal has the potential to develop as a business center and may also serve as the gateway to a newly developed tourist spot at Kuakata sea beach.

Comparison between Cost Elements of Public and Private Airlines

Here, the important differences between the cost structure of public and private airline companies are illustrated. In the above analysis, the cost function for private and government airlines are analyzed separately considering different input data for the two types of operators. In these cost functions organizational types of the operators are considered carefully in order to assess their influence on management efficiency.

Table 4 shows difference of cost elements between these two types of operators on the basis of per passenger trip between each origin-destination pair. These results suggest that the major difference in cost structure of public airline (Biman) and private airline companies occurred in maintenance, administrative and marketing costs. Specifically, maintenance cost of Biman is one and a half times more than that of private airlines. From Table 4 it is clear that running and capital costs of Biman are 20-30 percent and 10-15 percent higher than those of private operators under the same level of service. One of the significant reasons of the higher running cost of Biman is the use of costlier fuel for its aircraft fleet. For Biman, higher capital cost results from the use of larger aircrafts although demand in domestic routes does not allow these aircrafts to operate in full capacity.

Table 5 shows the difference between the current and estimated fare levels for the two types of organizations under present demand situation. Biman's fare is always lower than the estimated fare. On the other hand, the current fare of the private companies is higher than the estimated fare. Recently, Biman has increased the fare to reduce the discrepancy. The private airline companies have the flexibility to change their fare according to demand situation.

TABLE 4: Performance Comparison between Public and Private Airline Companies

Routes	Adm Cost	Maint Cost	Av. Char.	Run. Cost	Cap. Cost	Mark Cost	Cont Cost	Proc Cost	Profit
DAC-CHI	1.6	1.37	1.23	1.16	1.04	1.15	1.17	1.23	-3.46
DAC-ZYL	1.58	1.31	1.23	1.19	1.07	1.11	1.22	1.21	+.01
DAC-JSR	1.66	1.39	1.23	1.21	0.98	1.16	1.19	1.14	-2.38
DAC-SPD	1.88	1.56	1.19	1.03	1.14	1.19	1.06	1.09	-1.46
DAC-RJH	1.89	1.57	1.19	1.39	1.28	1.21	1.26	1.25	-1.16
DAC-CXB	1.93	1.44	1.24	1.04	1.11	1.11	1.08	1.09	+0.26
DAC-BZL	1.51	1.14	1.24	1.04	1.03	1.12	1.41	1.23	-1.36

Note: Values are expressed in terms of ratio between the various cost elements for Biman and the same for the private airlines on average.

TABLE 5: Comparison of Fare between Public and Private Airlines

Routes	Private Airlines Fare					Biman Bangladesh Airlines				
	Act. (Tk.)	Model (Tk.)		Diff.(%)		Act. (Tk.)	Model (Tk.)		Difference (%)	
		Emp	GDP	Emp	GDP		Emp	GDP	Emp	GDP
DAC-CHI	1600	1527	1460	4.80	9.6	1450	1673	1690	-13.3	-14.2
DAC-ZYL	1300	1222	1156	6.40	12.5	1250	1360	1356	-8.1	-7.8
DAC-JSR	1050	1060	1037	-0.94	+1.3	1000	1143	1170	-12.5	-14.5
DAC-SPD	1600	1578	1669	+1.4	-4.1	1250	1626	1777	-23.1	-29.7
DAC-RJH	1100	1158	1228	-5.00	-10.4	1050	1330	1484	-21.1	-29.3
DAC-CXB	2000	1976	2054	0.71	-2.6	1950	1970	2092	-1.0	-6.8
DAC-BZL	1050	1593	1321	-34.1	-20.5	950	1824	1650	-47.9	-42.4

Price Equilibrium Analysis

For the analysis of various policies it is required to estimate the equilibrium price under different scenarios. The equilibrium price can be calculated from demand and supply functions developed earlier.

Table 6 presents a comparison among equilibrium fares and demands for Biman and private airlines. From this comparison it is evident that airfare set by the private airline companies, with the minimum fare approved by the Civil Aviation Authority, conform to equilibrium fare. In the case of Biman, Civil Aviation Authority sets the airfare which is usually lower than the equilibrium case.

Figure 3a and 3b show that the predicted demand (trips/week in each direction) and cost converges with the observed values. It is also observed that the cost model slightly underestimates the cost for Biman and overestimates the cost for the private airlines.

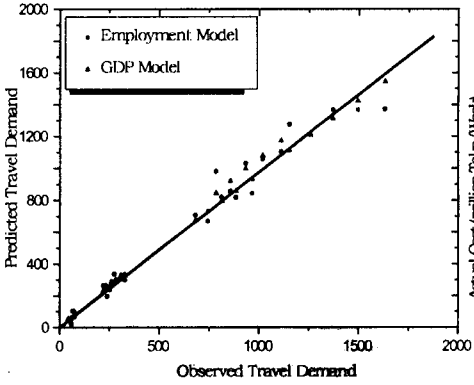

Fig 3a. Observed vs. Predicted Demand (Trips per week)

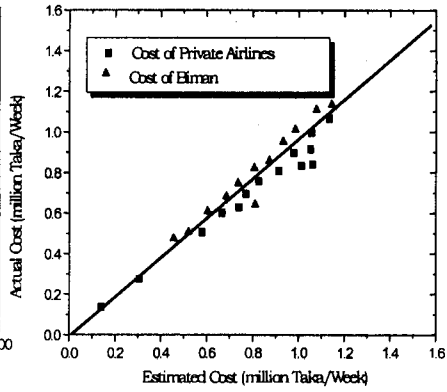

Fig 3b. Actual vs. Estimated Cost (Million Taka per week)

TABLE 6: Predicted Demand (Pass/w) and Fare (Tk) at Equilibrium

Routes	Equil Fare	Estimated Fare		Percent Diff.		Equil. Demand	Est. Demand	Per. Dif.
		Private	Biman	Private	Biman			
DAC-CHI	1523	1527	1673	-0.26	-9.8	1590	1589	0.06
DAC-ZYL	1209	1222	1360	-1.1	-11.1	1131	1128	0.27
DAC-JSR	1063	1060	1143	+0.28	-7.0	966	967	-0.1
DAC-SPD	1639	1578	1626	+3.86	+0.8	273	327	-16.5
DAC-RJH	1123	1158	1330	-3.02	-15.6	268	321	-16.5
DAC-CXB	1971	1976	1970	-0.25	-0.05	71	73	-2.74
DAC-BZL	1238	1593	1824	-22.3	-32.1	65	49	+32.6

APPLICATION OF THE RESULT

This section presents an application of the results in the management of the operators of air transport in Bangladesh. The changes in the variables of demand and supply functions are used to predict the effects on the profit and revenue of the operators. The analyses are based on the models discussed above.

Effect of change of demand variable on demand and profit

In this section the effects of the changes in various demand variables on the demand of air transport in Bangladesh and corresponding profits of the airline operators are summarized.

1) Effect of population change: Effects of change in population on the profit and demand are shown in Fig 4. Profit elasticity with respect to population is 1.8 times higher than that of demand elasticity. There are several points on the profit curve where profit reduces suddenly. These points correspond to the demand levels that require a new flight with minimum number of passengers. The reduction of profit is very prominent in low demand cases. When the demand increases the relative effect reduces gradually.

2) Effect of GDP change: Effects of the changes in GDP on the demand and profit are shown in Fig 5. It shows that, 7-10 percent change of GDP results in 12-20 percent change in profit and 8-10 percent change in demand. It implies that average profit elasticity with respect to GDP is twice that of demand elasticity.

3) Effect of fare level change: Figure 6 shows that profit elasticity with respect to fare is lower than demand elasticity. Also, change in fare can significantly influence the profit.

Effect of Change for Cost Elements

Figures 7 to 12 show the changes of demand and profit due to changes in cost elements. From these analyses it is observed that a small change in demand can cause comparatively large change in the operator's profit. Slope of the profit curve is 15 to 20 times higher than that of demand curve. As the figures are plotted in terms of percent change of the variables, the slopes of these curves provide the elasticities. Both profit and demand elasticities are calculated for the better explanation of the results.

1) Administrative and marketing cost effect: Both these costs have little effect on demand and profit. As shown in Fig 7, for administrative cost profit elasticity is about -3.33 whereas demand elasticity is only -0.03. Change of marketing cost has similar effect on demand but smaller effect on profit (profit elasticity is -2) as shown in Fig 8.

2) Maintenance cost effect: Profit elasticity, shown in Fig 9, of maintenance cost is –3.33. Compared with administrative and marketing cost, it has slightly higher demand elasticity (-0.15).

3) Contingency and procurement cost: These two cost elements are same in nature and their elasticity results support this argument. For these costs, profit elasticity varies between –9 and –12. Demand elasticity with respect to the cost elements is –0.12 (Fig 10 and 11).
4) Fuel cost effect: Figure 12 shows that fuel cost is an important cost element that affects profit. Profit elasticity with respect to fuel price is –5 and demand elasticity with respect to the same is –0.05. It implies that even small increase in demand caused by reduction in fuel price will result in relatively large increase in profit.

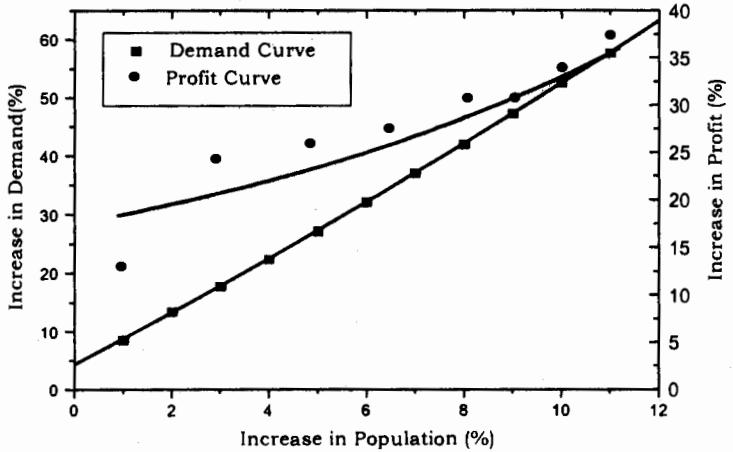

Fig 4. Effect of Increase of Population on Demand and Profit

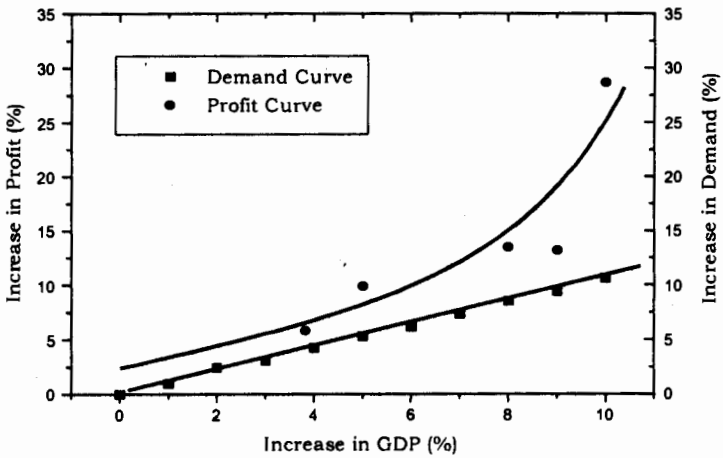

Fig 5. Effect of Increase of GDP on Demand and Profit

3) Contingency and procurement cost: These two cost elements are same in nature and their elasticity results support this argument. For these costs, profit elasticity varies between –9 and –12. Demand elasticity with respect to the cost elements is –0.12 (Fig 10 and 11).

4) Fuel cost effect: Figure 12 shows that fuel cost is an important cost element that affects profit. Profit elasticity with respect to fuel price is –5 and demand elasticity with respect to the same is –0.05. It implies that even small increase in demand caused by reduction in fuel price will result in relatively large increase in profit.

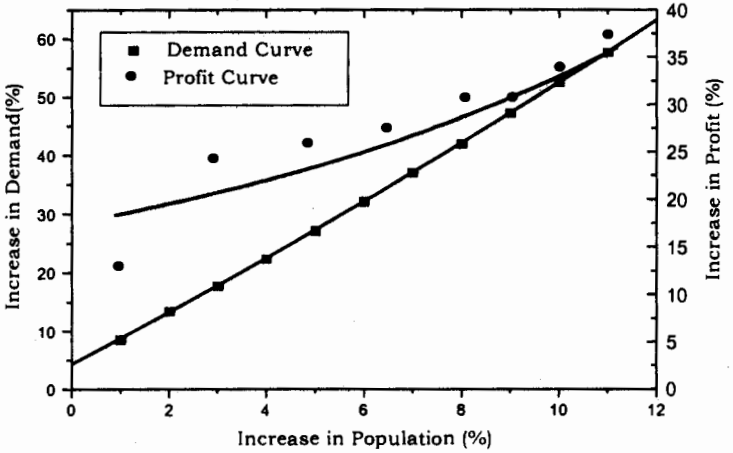

Fig 4. Effect of Increase of Population on Demand and Profit

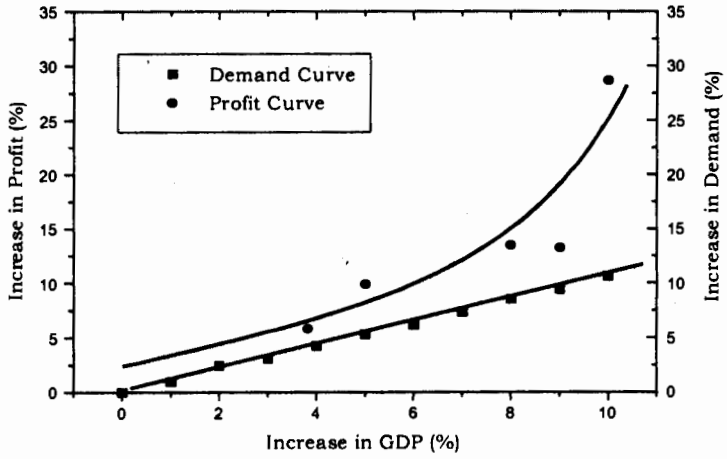

Fig 5. Effect of Increase of GDP on Demand and Profit

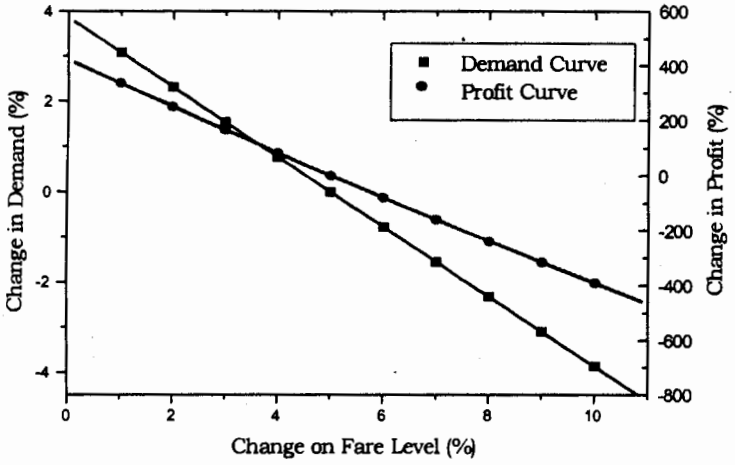

Fig 6. Effect of Change of Fare Level on Demand and Profit

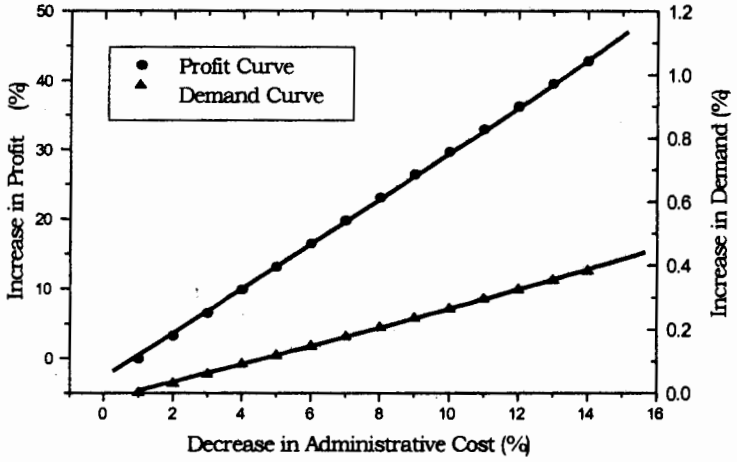

Fig 7. Effect of Decrease of Administrative Cost on Demand and Profit

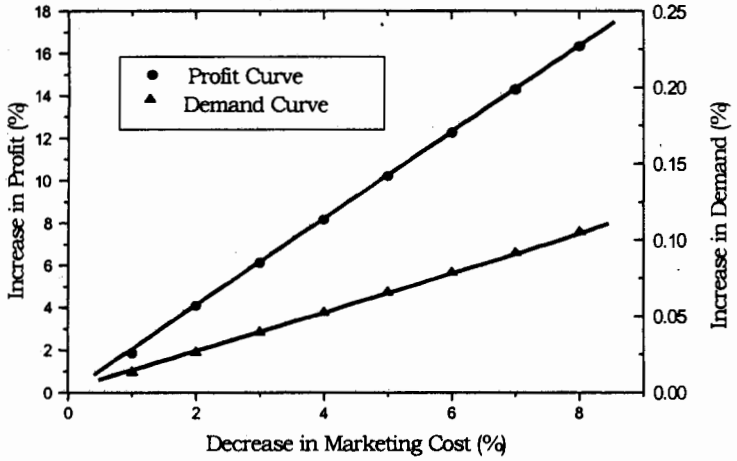

Fig 8. Effect of Decrease of Marketing Cost on Demand and Profit

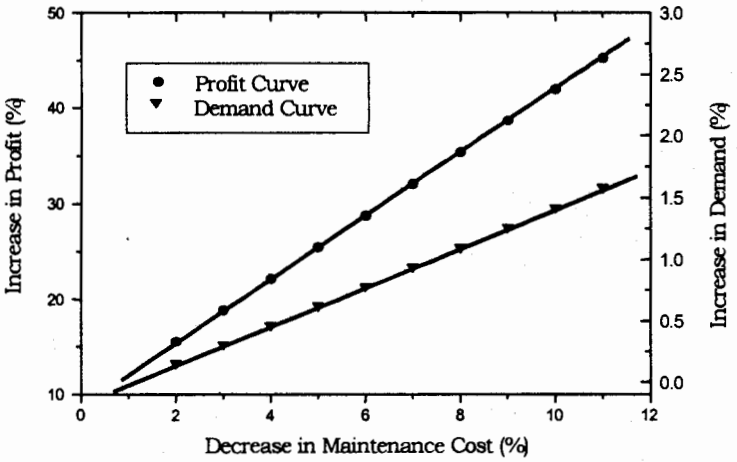

Fig 9. Effect of Decrease of Maintenance on Cost Demand and Profit

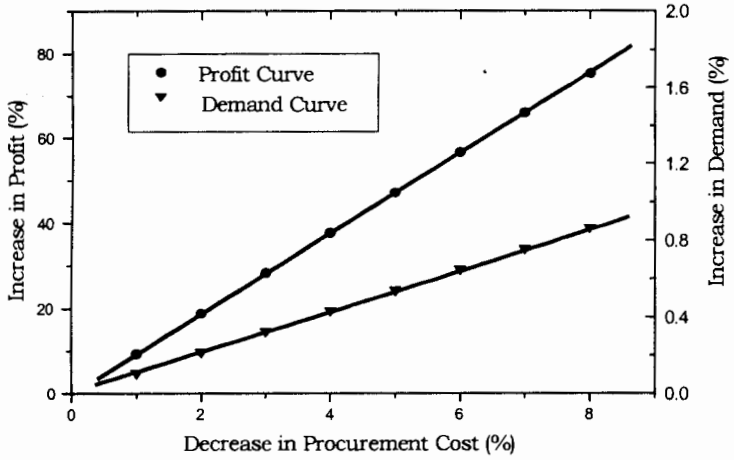

Fig 10. Effect of Decrease of Procurement Cost on Demand and Profit

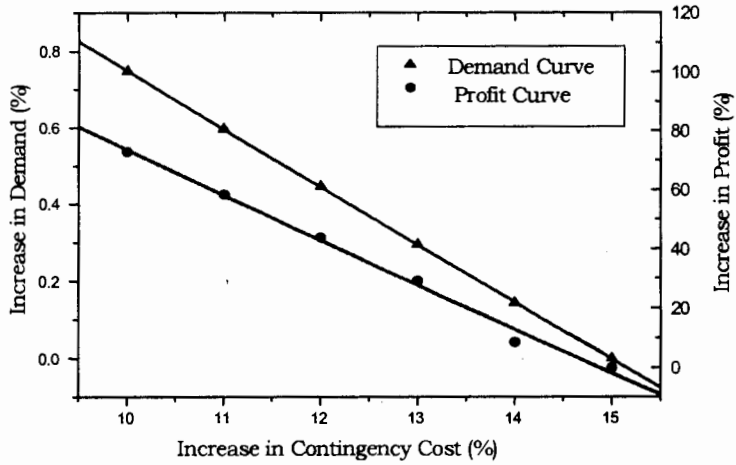

Fig 11. Effect of Increase of Contingency Cost on Demand and Profit

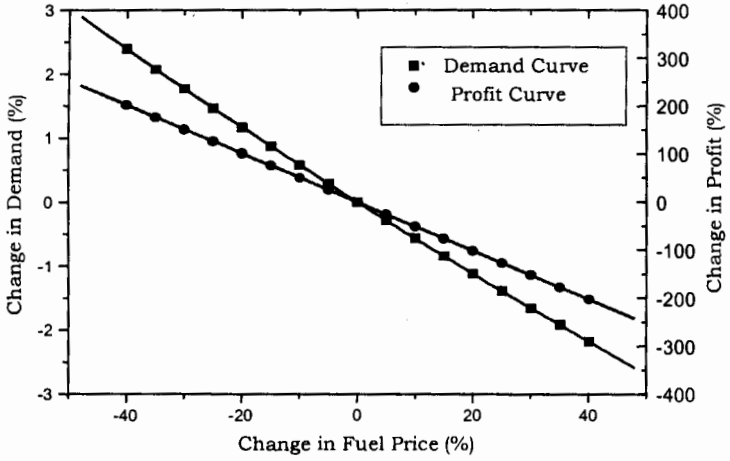

Fig 12. Effect of Change of Fuel Price on Demand and Profit

CONCLUSION

A detailed analysis of domestic air transport in Bangladesh has been presented in the paper. A set of demand and supply model has been presented in the paper to analyze air transportation system of Bangladesh. The models were calibrated and successfully applied to analyze several policy variables under different scenarios. The analysis may assist the management of the operators of domestic air transport in Bangladesh to find out ways to maximize profit by changing the influencing factors and to evaluate their performance comparing their cost elements with the same obtained from the models.

This study developed macroscopic demand and supply models, which are described by the appropriate equations, to analyze the situation of air transport operations between the large cities of Bangladesh. The models can be applied to analyze the future demand of air transportation system of the country and develop infrastructure accordingly.

The difference in management efficiency between private operators and government operators and the scale of economy in air transport operating costs are significant. The operating cost of public operator is about 25-30 percent higher than that of private operators under the same level of service.

In some routes even private operators tend to fall into deficit because of very low demand. This causes defensive management strategy in those routes which is demonstrated by reducing frequency or closing operation. Therefore, it is necessary for the government to assist the operators to continue the service to these routes for future development. Cross-subsidies may be devised in this regard to assist the development in these zones. This practice already exists, in some form, for the case of Dhaka-Barisal trip. In this case, the equilibrium fare is about 45 percent higher than the actual fare (Table 5).

Finally, although this study illustrates and analyses present situation of domestic air transport in Bangladesh, the following points need to be incorporated to improve the analysis: (1) International air transport demand in Bangladesh; (2) Future structure of domestic and international air transport in the country especially in the light of Hub-Spoke network system; and, (3) Impact of regional and sub-regional co-operation on air transport system of the region.

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NOTATION

Tij	Passenger trips per week between cities i and j
Sij	Vector of socio-economic variables
Dij	Vector of demographic variables
Aij	Vector of transport system variables
Ej	Number of employees in j (expressed in 10,000)
Gj	GDP per capita at current price (expressed in billion)
Ep	Elasticity with respect to price
Pj	Total population for city j (expressed in million)
Rij	Travel time ratio for travel between cities i and j
Xj	Dummy variable (1 for Sylhet and Cox's Bazar and 0 for others)
I	Load factor
Q	Average capacity of aircrafts
Q	Total passenger flow per week in one direction
a-f	Parameters of the demand function
K	Constant

ABBREVIATIONS

SAARC	South Asian Association of Regional Cooperation
SAPTA	South Asian Preferential Trade Agreement
CAAB	Civil Aviation Authority of Bangladesh
GCR	Generalized Cost Ratio
DAC	Dhaka
CHI	Chittagong
ZYL	Sylhet
JSR	Jessore
SPD	Saidpur
RJH	Rajshahi
CXB	Cox's-Bazar
BZL	Barishal