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**MACROSCOPIC MODELING FOR THE REGIONAL AIR TRAVEL DEMAND  
TO ANALYZE THE POTENTIALITY OF HUB-SPOKE AIR TRANSPORT  
SYSTEM IN SOUTH ASIA**

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## **Abstract**

The marked economic growth of the South Asian countries is paving the way for the development of a potential Hub and Spoke air transport system for this region. This paper addresses the present condition and future potentiality of air transportation in the South Asia region by analyzing the scope of potential Hub-and-Spoke air transport system, the level of facilities, the air travel passenger and freight demand structure, and the network shape and its configuration. The model developed to predict the passenger and freight demand in South Asia relates certain regional economic variables. Potentialities of hub cities are evaluated by ranking the airports competing each other for the gateway for Europe and Far East. Geographic potentiality are investigated using locational criteria which illustrates that hub cities in west and east part of the region have immense positional advantages saving an operators fuel costs as much as \$ 12.5 million annually. A network shape index, which is a measure of airlines interregional network concentration based on Herfindahl-Hirschman index, is described. Finally, a model developed for major airline's profitability to show the overall returns to scope and density based on the integrated regional network shape. The developed model can be used to explore the potential for Hub-and-Spoke system and to achieve better financial performance for South Asian air transport operators over the next two decades.

## **1. INTRODUCTION**

Air transport system is one of the most dynamic and fast-changing industries in the world and a vital component of economic development of any region. Instigate development and a great potentiality for future prospect has marked impact on the air transportation industry of the region, partly, with the help of tourism industry. Geographically South Asian air transportation has strong regional characteristics serving more than one-fifth of world population in seven SAARC's countries (South Asian Association of Regional Cooperation). Its importance has increased with the inflated business and its future prospects and recent deregulation in several countries in South Asia. Realizing the immense potential development of air transportation in the region, a number of private airline companies have started their operation and large airports is in under expansion which would result a superior and competitive market for South Asian air transport system. This paper explores the present condition and great potentiality of air transportation in South Asia by analyzing the organization and operation of air transportation systems, the countrywide and econometric regional air travel demand structure, and probable Hub-Spoke network configuration in South Asia (SA).

In recent years, South Asia shows noticeable growth in air travel demand. Air transport is one of the major mode of transport especially land locked country like Nepal and Bhutan and small island country like Maldives. In terms of value of time and efficiency, air transport is vitally important for the development of trade and commerce. Moreover, a large portion of South Asian population is living in abroad and thus creates a continuous demand for air travel in this region.

The recent trend of pluralization, the code sharing agreement between the South Asian airlines forming the regional blocks and the formation alliances with foreign carriers increases the tremendous competition between the airlines of the region. Western airlines have now joined the fray of enticing South Asian passengers and freight. However, South

Asian airlines should brace themselves more strongly either individually or collectively against the Western air carriers for their future existence. This trend will shape the South Asian air transport system to counter the entry of foreign carriers in the South Asian market. It is therefore important that proper research be done in air transportation of this region.

This paper attempts to develop the air transport systems for South Asia by modeling a macroscopic nationwide air passenger and freight demand assessing the effects of certain economic and socio-economic variables on nationwide demand for air travel. This paper also develops a particular airport concentration index to ascertain the possible hub cities that serve the whole south Asia with minimum costs. In addition a particular model based on the returns to scope, density and economics of scale aspires the effect and nature of degree of hubbing in airline performances. The developed model can be used to explore the potential for hub and spoke system development with the brawny regional characteristics in South Asia over the next two decades.

## 2. SOUTH ASIAN AIR TRANSPORTATION NETWORK

South Asia (SA) is composed of seven countries viz., Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Srilanka and each of them has air transport networks function independently. This paper also includes Myanmar as its position inside to this region. The resurgence of economic activity and strong regional integrity develops flourishing tourist industry among these countries, which unified their regional air networks.

**Figure 1: Air Transport Network in South Asia**



On the contrary, several small countries or island within SA, such as Maldives, Bhutan and even Srilanka, have no or few domestic air network. Civil war in Srilanka and internal political problem in Myanmar demarcate severely the growth of air travel demand.

**Figure 2: Trend of Air Travel Demand**

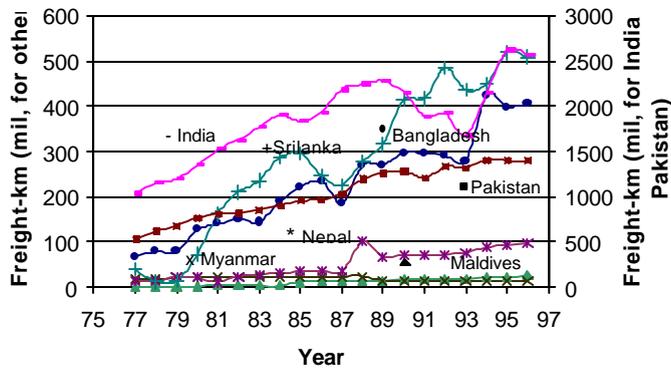


Figure 1 shows the important regional air transportation networks of the major airlines in the eight SA countries. The major airlines are: Biman Bangladesh Airlines, Bangladesh; Air India and Indian Airlines, India; Air Lanka Srilanka; PIA, Pakistan; Air Maldives, Maldives, Myanmar Airways International, Myanmar and Royal Nepal Airlines, Nepal. The followings points are observed in the

air transport networks:

1. The major hub airports of these regional air networks are located in key cities – Delhi and Mumbai for India, Karachi for Pakistan, Dhaka for Bangladesh and Colombo for Srilanka.
2. In certain regional area, secondary hubs are established to serve the outlying feeder airports, such as Calcutta, Madras and Trivandrum, India; Lahore and Islamabad, Pakistan; Chittagong and Sylhet, Bangladesh; Male, Maldives; Pokhara, Nepal; and Yangon, Myanmar.
3. India and Pakistan is a large country having extensive domestic network compared with the rest. Bangladesh being a riverine country and Nepal a mountainous country also depends on air transport to connect the other part of the countries.
4. Large labor market of SA population living abroad generates a huge demand for international market in Middle East, Europe and South-East Asian countries.
5. Tourist center like Male, Colombo, Chittagong, Paro and Kathmandu influences the air travel demand among the SA countries. Competitions of gateway airports in the western region are dominated by Karachi, Mumbai and Islamabad and eastern region between Calcutta, Dhaka, Chittagong and Yangon.

**Figure 3: Trend of Air Cargo Demand**

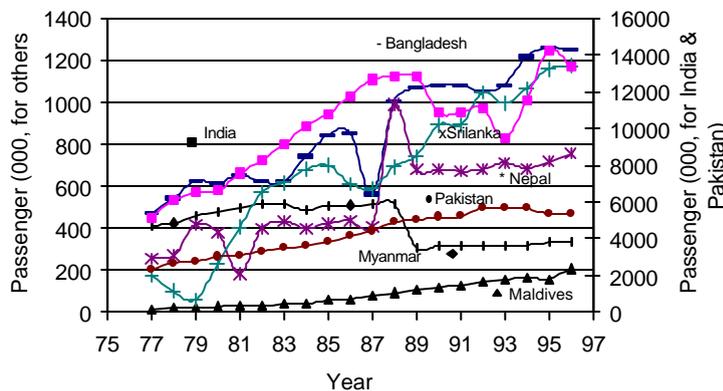


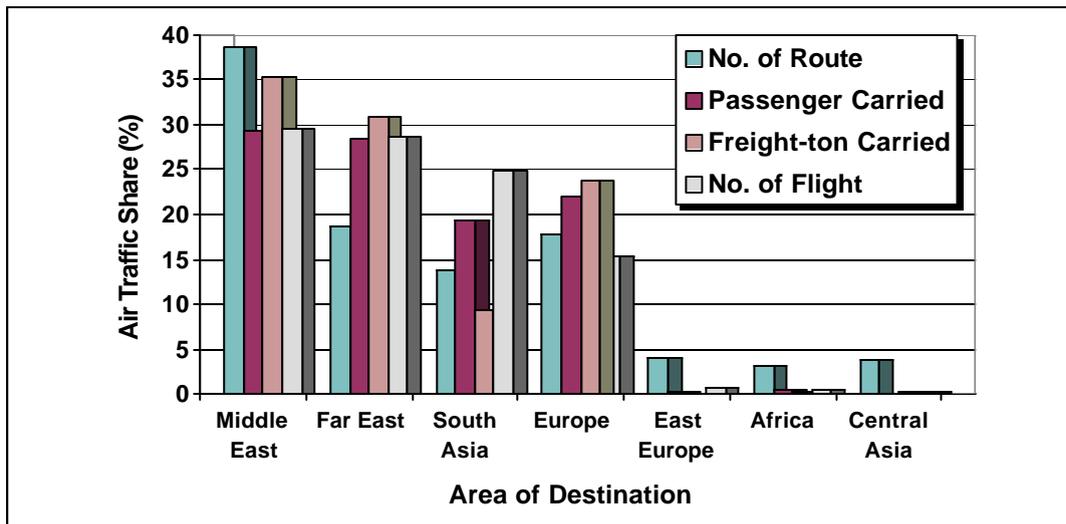
Figure 2 and 3 show the upward trend of both domestic and international passenger and air cargo demand for the SA countries. Being the most populous, India and Pakistan have the highest passenger and cargo demand compared to the rest. The freight demand in Srilanka is higher than Bangladesh for the reason

that Colombo is the only one air transport center in Srilanka and all the cargo have to transport to this airport. But in Bangladesh, aside from that in Dhaka, there are two more international airports, Chittagong and Sylhet and hence all the goods don't have to be

conveyed to Dhaka.

Figure 4 compares the international air transport characteristics generated from South Asian airports. From SA countries airports 38 percent routes generated towards Middle East followed by 18 percent towards South East Asian countries and 17 percent in Europe and 14 percent within the SA. Airlines operated from SA carries 29 percent passenger and 35 percent cargo towards Middle whereas towards South East Asian country the amount is 28 percent and 33 percent respectively. Although within SA, passenger movement is 19% but cargo demand is only 9 percent because shorter routes passenger usually carries less cargo compare to long distance routes like Europe. Destination towards Europe shares 32 percent passenger kilometer compare to 35 percent in Middle East. In terms of profitability, European routes are much more attractive for the airlines operating from SA having an average of 79 percent load factor.

**Figure 4: Air Traffic Destination Share Generated from South Asia (1998)**



## 2.1 Trend in Air Transportation Market in SA region

SA airlines as well as foreign airlines anticipate the expansion of air transportation market in this region. They seem to be inclined to adapt deregulation, to bring about competition, on both airline and airport management in order to make the industry stronger. Four trends could be identified that are taking shape in the current SA air transportation market-

1. The trend of pluralization of carriers,
2. The trend of privatization of air carriers,
3. The trend towards the formation of regional blocks by code share agreement to counter the entry and expansion of foreign carriers in the SA market, and
4. The trend towards competition as a gateway airport to achieve hegemony of local market.

Several reasons could be attributed to these trends

1) South-East Asian and Western carriers have strong constitution and who have obtained full victories in their own market, are now seeking new market and therefore come to SA region. Also, Middle East carriers try to expand to this region in order to fortify and

supplement their air flight market. To resist the threat posed by the East and Western airlines, the air carriers of the SA region have to make constitution of their air carriers more stronger through privatization and expansion of market share by acquisition of new air route. Also, private airlines can ask their government to develop and expand their routes in international destinations.

2) With many air carriers involved to lure the SA passenger, there are also tends of establishing market blocks in the region. Much attention should be given to several recent airline agreements.

Deregulation already started in several SA country like in India from 1978 (partially), in 1993 Pakistan and Maldives, Bangladesh 1994, Nepal 1992 and Myanmar 1993. Code sharing agreement among the SA Asian airline started in 1997 and in 1998 SA airlines started to join alliances with foreign carriers. Although initial suspension private airlines high, but gradually many of them established their business and resume their service.

## 2.2 Research Scope

Most of the reports are only airport project pertaining to SA air transport. A few research have conducted on the problem concerning air transport network system. Rengaraju and Arasan (1992) develop a model for domestic air travel demand for India only. Jayalath and Bandara (1999), discuss the viability of Colombo airport to serve as a hub without developing any specific model. Karim and Alam (1998), conducted several research concerning the demand and supply structure of Bangladesh domestic air transport network, analysis of new entrants after privatization and the basic Hub-and-Spoke network configuration for SA. But there is no appropriate research conducted integrating the whole SA air transport system. The effect of Hub-and-Spoke system on airline performance still to be explored. This paper emphasizes on the potentiality of hub and spoke system for SA to analyze the interaction between airports and airlines considering the influence of network shape on airline performance.

## 3. STRUCTURE OF AIR PASSENGER AND FREIGHT DEMAND MODEL

This section develops a macromodel that relates South Asian air travel passenger and freight demand to certain explanatory variables. Macromodel uses only aggregate measures of socioeconomic variables (SE), economic activities (EC) and the air transportation service (S). The general structure of the empirical model takes the following form:

$$T_i \text{ or } F_i = f(SE_i, EC_i, S_i) \quad (1)$$

where  $T_i$  and  $F_i$  refers to total annual enplanements and freight transportation respectively from all the airports in country  $i$ .

The vector SE consists of a set of descriptors of the nature and level of the socioeconomic activities that are likely to generate the demand for air travel from a given country. For passenger demand, population (P) and per capita income (I) and for air cargo, urban population (UP) is commonly used as a representative of the socioeconomic characteristic of passengers and cargo. The vector EC consists of number of economic activities, which includes the value of exports and imports of a country (EI), foreign remittance (FR), long

term capital (C) and income from tourist's (T). SA have a unique air travel characteristics having a large population living in foreign countries and remittance from them represents the influence on air travel demand. Long term capital is related to air cargo activities. The vector air transport supply S includes average airfare per mile (AF) for travel from a given country.

Based on the above discussion, an aggregate passenger demand model takes the following form

$$T_i = \alpha \cdot P_i^{\hat{\alpha}} I_i^{\tilde{\alpha}} EI_i^{\tilde{\alpha}} FR_i^{\zeta} T_i^{\epsilon} AF_i^{\theta} \hat{\alpha} \quad (2)$$

And air cargo demand model becomes

$$F_i = \alpha \cdot UP_i^{\hat{\alpha}} I_i^{\tilde{\alpha}} EI_i^{\tilde{\alpha}} C_i^{\tilde{\alpha}} AF_i^{\theta} \hat{\alpha} \quad (3)$$

where  $\alpha$ ,  $\hat{\alpha}$ ,  $\tilde{\alpha}$ ,  $\zeta$ ,  $\epsilon$ ,  $\theta$ ,  $\hat{\alpha}$ ,  $\tilde{\alpha}$ ,  $\tilde{\alpha}$  and  $\tilde{\alpha}$  are the co-efficient to be estimated and  $\hat{\alpha}$  is the error term of estimation. The model in Equation 2 and 3 is somewhat related to traffic generation models in urban transportation (Kanafani, 1983 and Fleming and Ghobrial, 1994).

### Empirical Results

In order to demonstrate the application of macroanalysis to estimate the countrywide passenger and air cargo demand, Equation 2 and 3 was estimated using time series data from for all SA countries except Bhutan over a period from 1977-1993. The models was transformed to log-linear form and was estimated by two-stage least square procedure to eliminate simultaneity bias.

A vector of hub dummy variable H is included in the model for those countries, which have major connecting hubs and international gateways. The presence of these types of airports is likely to generate additional traffic and cargo that is unrelated to the economic characteristics of the countries. The variable H takes on the value of one for India (for passenger) and Pakistan, Bangladesh and Srilanka (for cargo) and zero otherwise. Due to unavailability of data, the airfare variable was dropped from the model specification.

The aggregate demand model now takes on the following forms for passenger and cargo respectively

$$T_i = \alpha \cdot P_i^{\hat{\alpha}} I_i^{\tilde{\alpha}} EI_i^{\tilde{\alpha}} FR_i^{\zeta} T_i^{\epsilon} \exp(\theta H_i) \hat{\alpha} \quad (4)$$

$$F_i = \alpha \cdot UP_i^{\hat{\alpha}} I_i^{\tilde{\alpha}} EI_i^{\tilde{\alpha}} C_i^{\tilde{\alpha}} \exp(\theta H_i) \hat{\alpha} \quad (5)$$

Table 1 and Table 2 show estimation results of passenger and cargo demand model respectively. In Table 1, Model I include all variables, Model II with only population and per capita income and Model III excludes these variables. Model I and III results demonstrate that air travel demand is inelastic to population. Increase in per capita income has a positive impact on air travel demand. Per capita income is inelastic with respect to passenger demand but elastic to air cargo demand.

However, the exports and imports variables have weak statistical significance for passenger demand and strongly significant for freight demand. The variable incomes from

tourist are highly significant which demonstrates the underlying relationship between the demand for air travel and regional economic variables. Foreign remittance variable are strongly related to air passenger demand which validate the assumption that the SA population living outside the country have a strong influence on this regions air travel activity. Table 2 shows the long term capital has important influence on the level air caro demand. The assumption of urban population has much more effect on freight demand rather than total population, which were varied by the strong statistical significance of the variable.

**Table 1: Results of Estimating Demand Model**

Variable	MODEL I		MODEL II		MODEL III	
	Estimated Co-efficient	t-Statistics	Estimated Co-efficient	t-Statistics	Estimated Co-efficient	t-Statistics
Constant (á)	-0.621	-0.402	2.209	1.666	2.513	5.059
State Population (P)	0.373	3.127	0.764	21.368	-	-
Per Capita Income (I)	0.501	1.875	0.250	1.065	-	-
Exports and Imports (EI)	0.079	1.541	-	-	0.065	1.246
Foreign Remittance (FR)	0.354	5.328	-	-	0.53 5	12.812
Income from Tourist (T)	1.216	6.963	-	-	1.011	5.669
Hub Dummy Variable (H)	0.763	2.585	-	-	1.549	11.078
R-square	0.961		0.904		0.952	
Adjusted R-square	0.942		0.883		0.931	
F-statistic	51.57 (22,46)		43.279 (18,83)		47.152 (20,46)	

**Table 2: Results of Estimating Cargo Demand Model**

Variable	Estimated Co-efficient	t-Statistics	The hub dummy in both passenger and cargo demand model is positive and statistically significant at 0.05 level. It indicates that, other being equal, country with major hubs and secondary express cargo center are likely to generate about 63% and 58% higher passenger and cargo demand respectively. These emerging hubs have undoubtedly diverted a good portion of
Constant (á)	-8.234	-5.645	
Urban Population (UP)	0.326	4.886	
Per Capita Income (I)	1.535	6.043	
Exports and Imports (EI)	0.257	2.898	
Long Term Capital (C)	0.418	4.710	
Hub Dummy Variable (FH)	0.807	5.047	
R-square	0.922		
Adjusted R-square	0.899		
F-statistic	40.36 (21,72)		

connecting traffic away from the other countries.

#### 4. PROSPECTIVE HUB LOCATION

Although deregulation allows an airline the freedom to enter and exit cities at will and therefore the option to move hubs as markets and traffic flows change, the expense and difficulty of moving hubs severely limits an airline's ability to do so. Consequently, the decision of where to place a carrier's hubs is important. This section find out the probable optimal location of various levels airports in SA.

#### 4.1 Cluster Analysis

**Table 3: Comparative Activity Statistics**

Passenger Enplanements	Cluster 1	Cluster 2	Cluster 3
Airports	Mumbai Delhi Karachi	Dhaka Colombo Calcutta Islamabad Madras	Kathmandu Lahore Yangon Trivandrum Male
Total	55.2%	29.4%	15.4%
Domestic	56.4%	27.5%	16.1%

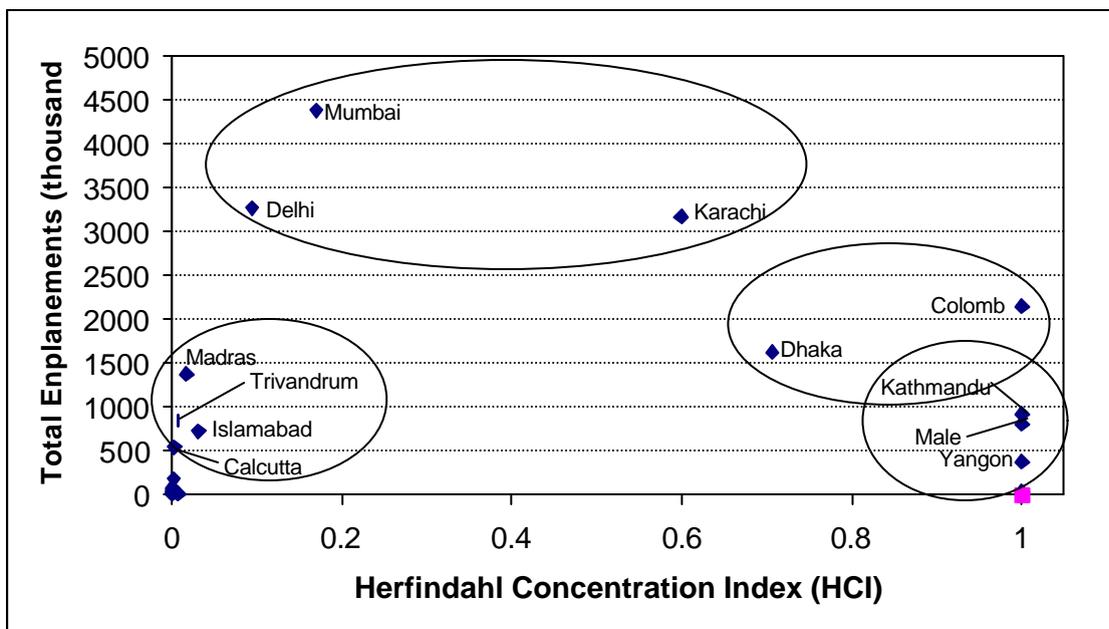
This section briefly reviews the status of South Asian airports by cluster analysis. In order to understand the different level of airports in South Asia, these systems were classified in three groups by K-means cluster analysis using Minkoski distance. Cluster 1 could be considered for the candidate of

“large hubs”, followed by “medium hubs” of which Dhaka and Colombo could be considered as a secondary hubs and the others act as a minor hubs. Last cluster airports acts as a good transport point to support the large and secondary hubs. Thus, for South Asia “Multiple Hub” system could be much more preferable instead of single airport system due to capacity restrictions and minor airline’s trend to follow the point-to-point service rather than concentrating at one airport.

#### 4.2 The Degree of Hubbing of SA Airports

The Herfindahl concentration index (HCI) is used to confirm the level of degree of hubbing of various airports in SA. Hansen and Weidner (1997) uses HCI to measure the degree to which passenger activity is concentrated at a single airport within the region. This paper uses HCI to measure the concentration of passenger activity within the country and hence it could be referred as “Nationwide Airport Concentration (NAC). It is calculated as the sum of the squared international traffic shares (“Traffic” mean enplaned passengers) of each airport within the country. The country having only one international,

**Figure 5: Comparison between Total Enplanements and Airport Concentration**



NAC is 1.0. For NAC where traffic is evenly divided among N airports, the NAC is  $1/N$ .

Within the data set NAC ranges from 1.0, where there is only one airport, to 0.003 where the airport share is insignificant having several large airports within the same country. Figure 5 shows that in 1996 Mumbai, Delhi and Karachi currently occupies countries major international passenger share. After 1996, all these airports cross over one million passenger's enplanements annually. Dhaka and Colombo passenger enplanements are higher than the other airport in Cluster 2 (Table 3), which indicates that these two have the potentiality to serve as a secondary hub to distribute the international passengers among the SA countries. Kathmandu, Male and Yangon could act as an attractive transit point especially for tourists.

### **4.3 Geographic Potentiality**

Another important factor in determining hub placement is that it should be centrally located. The hub should be near the midpoint of the cities it will be serving, weighted by the volume of traffic between each of the cities (i.e. it should be at the point of minimum aggregate travel). The importance of locating hubs at or near the weighted midpoint of the cities served by that hub stems from the desirability of minimizing network circuitry and total elapsed travel time of traffic flowing through a carrier's system (Wheeler, 93). Minimizing network circuitry results in lower fuel consumption and crews pay time as well as higher yields.

#### **4.3.1 Hub Location within South Asian Market**

Prospective hub location within South Asia differs markedly geographically. The following analysis considers the proximity of each cities to 15 major South Asian important airports (Figure 1) : Dhaka, Chittagong (Bangladesh); Paro (Bhutan); Bangalore, Calcutta, Delhi, Madras, Mumbai (India); Male (Maldives); Yangon (Myanmar); Kathmandu (Nepal); Islamabad, Karachi, Lahore (Pakistan); and Colombo (Srilanka). These cities are among the region's largest air transport centers and represent all the region's major industrial and commercial powers.

To serve these cities with minimum flight costs, the SA hub would have to be in the middle of Northern India – precisely where capacity shortages are most severe (Table 4, Column a). For example, the operator of a Calcutta hub could be serve these region's with 19221 km of flight service, compared with 27030 km at Karachi and 27721 km at Colombo. South Asian central region posses central points where there is no airport has international air traffic movements. For these reason, the operators with a hub in Calcutta differs with Dhaka, Delhi, and Mumbai with only 3-8% greater flight km to serve the region's 15 important air traffic centers. Hub in Calcutta could serve whole South Asia with 40.6% fewer flight km with a Karachi hub and 44.2% at Colombo hub. Clearly, Calcutta has formidable advantages of location if all the cities are weighted equally.

Operating costs differ vastly between the hub cities. On the basis of average fuel costs of \$2.60/flight-km (Schwietermn, 96), a Calcutta hub would save \$2.06 million to \$ 12.5 million annually relative to the hubs outside the central South Asia (Table 4, Column b). By reducing the number of flight hours, crew expenses also would be reduced.

If the amount of passenger and cargo shipped to each destination is proportional to the destination's 1996 total passenger and cargo throughput (Table 5), the hub location shifts 1650 km west to Mumbai as expected before to minimize the total passenger and tonne kilometers. This shift occurs because the markets in the western part of the region tend to be larger than those in the eastern part. The operator of a Mumbai could serve the 15 major centers with 33.6% fewer passenger kilometer and than with a Karachi hub. In terms of tonne kilometers Mumbai operator could save 36%, 86.6% and 70.8% fewer tonne kilometers with respect to Karachi, Colombo and Dhaka respectively. Thus, a Mumbai hub would have important passenger and logistical advantages whereas Karachi and Delhi would have inherent limitations as large hubs.

**Table 4: Cumulative Flight Distance for Potential Hub Location**

Airports	(a) Flight Distance		(b) Annual cost vs. Calcutta (millionUSD) <sup>b</sup>
	Cumulative Distance	Index <sup>a</sup>	
Dhaka	20534	1.07	1.25
Chittagong	21645	1.13	2.30
Paro	21799	1.13	2.45
Bangalore	22093	1.15	2.73
<b>Calcutta</b>	19221	<b>1.00</b>	<b>0.00</b>
Delhi	20701	1.08	1.40
Madras	21395	1.11	2.06
Mumbai	20786	1.08	1.49
Male	32388	1.69	12.50
Yangon	28412	1.48	8.72
Kathmandu	19911	1.04	0.65
Islamabad	27539	1.43	7.89
Karachi	27030	1.41	7.41
Lahore	24274	1.26	4.80
Colombo	27721	1.44	8.07

Prospective hubs in Mumbai are equally impressive with respect to average travel distance. Under the same set of assumptions, the average aircraft kilometer flown per flight is 1339 km using a Mumbai hub and 1557 km and 1505 km using Calcutta and Karachi hubs respectively (Table 5). By contrast, average distance per shipment using hubs in Mumbai is 1292 km compared with 1498 km and 1411 km to Karachi and Delhi hub respectively to serve as an express cargo center. Obviously, a carrier with a Mumbai or Delhi Hub offer customers the most attractive flight frequency and cargo delivery schedules.

Note:- a: Flight distance to serve 15 major destinations.  
 Index numbers are based on distances relative to Calcutta.  
 b: Based on \$ 2.6 fuel cost per flight kilometer

#### 4.3.2 Central Location for Middle-East and South Asian Market

The choices of the mix of cities will also affect the attractiveness for prospective hub location. This situation could clearly realized from U.S.A airports where western airport like Los Angeles serve a hub for flight coming from Asia and western airports like New York are dominated by the flight from Europe. Similarly same circumstances prevail in South Asia also. This section briefly examines the potential hub location if South Asian hubs serve Middle East markets where South Asia has most of the business connection and working manpower.

**Table 5: Cumulative Passenger and Tonne Kilometer for Potntial Hub Location**

Airports	Pass-km Index <sup>a</sup>	Freight -tonne Index <sup>a</sup>	Kilometer flown/flight	Average Travel Time <sup>b</sup>	Kilometer Flown / Shipment	Average Travel Time <sup>b</sup>
Dhaka	1.63	1.71	1692.77	3.76	1761.66	3.91
Chittagong	1.74	1.83	1720.33	3.82	1750.86	3.89
Paro	1.78	1.9	1669.51	3.71	1724.38	3.83
Bangalore	1.39	1.38	1373.89	3.05	1325.13	2.94
Calcutta	1.48	1.56	1557.87	3.46	1559.08	3.46
Delhi	1.12	1.17	1355.42	3.01	1411.25	3.14
Madras	1.40	1.38	1496.83	3.33	1433.01	3.18
<b>Mumbai</b>	<b>1.00</b>	<b>1.00</b>	1339.55	2.98	1292.94	2.87
Male	1.95	1.93	1976.43	4.39	1890.57	4.20
Yangon	2.23	2.36	2291.75	5.09	2265.56	5.03
Kathmandu	1.41	1.50	1439.73	3.20	1451.42	3.23
Islamabad	1.61	1.71	1668.09	3.71	1680.99	3.74
Karachi	1.34	1.36	1505.11	3.34	1498.11	3.33
Lahore	1.37	1.45	1393.37	3.10	1411.93	3.14
Colombo	1.88	1.86	1962.14	4.36	1939.55	4.31

Note:- a: Passenger and tonne kilometers to serve 15 major destinations. Index numbers are based on distances relative to Mumbai.  
b: Based on typical aircraft cruising speed on an average of 450 kilometers per hour to serve within South Asia.

To analyze the effects of choice of the mix cities for Middle East ten major destinations were selected on the basis of most frequent departure generated from South Asia which are: Abu-Dhabi, Dubai and Sharjah (U.A.E); Jeddah, Riyadh, Dhahran (Saudi Arab); Kuwait; Bahrain, Doha (Qatar); and Muscat (Oman). Ten major destinations were selected for South East Asia are: Bangkok (Thailand); Hong Kong, Shanghai (China); Jakarta (Indonesia); Kuala Lumpur (Malaysia); Manila (Philippines); Seoul (South Korea); Singapore; Taipei (Taiwan); and Tokyo (Japan).

If Middle East Markets were to be served, the hub location have to be shifted to Karachi to serve as a western gateway for the whole South Asian region. Table 6 shows that the operator in Karachi hub to serve Middle East countries could save \$ 20 million compare to Colombo, \$ 3.3 million from Delhi and \$ 13.1 million from Calcutta. If Middle East is weigh in terms of size of passenger and cargo volume, Karachi still remains a prospective western gateway for SA. Potential gateway in Karachi also impressive for with respect average travel distance and time that could save 3.38 hours compared to most eastern remote point

If major cities of South-East were to be served, the optimal site shifted to Chittagong, which have just finished its capacity expansion project to serve for international markets. Operating costs differs markedly from \$ 12.4 million for Delhi, \$ 15.6 million for Mumbai and 26.6 million for Karachi if each of them were selected to serve South-East markets (Table 6). If these cities are weighted for passenger O-D traffic volume location shifts to Yangon which currently have political problem with international communities. However, Chittagong has attractive site at least to serve near South-East Asian market such as Bangkok, Singapore and Kuala Lumpur. However, ignoring the negligible difference with Yangon, the optimal hub location remains squarely within the eastern part of Bangladesh.

**Table 6: Western and Eastern Gateway for South Asia to Serve Middle East and South East Asian Destination**

Airports	Gateway for Middle East				Gateway for South East Asia			
	Distance Index <sup>a</sup>	Annual Cost vs. Karachi	Passenger-km Index	Average Travel	Distance Index	Annual Cost vs. Chittagong	Passenger-km Index	Average Travel Time
Dhaka	1.39	16.06	1.86	5.02	1.02	0.76	1.12	4.85
<b>Chittagong</b>	1.46	18.89	1.96	5.15	<b>1.00</b>	<b>0.00</b>	1.08	4.61
Paro	1.39	16.12	1.84	4.84	1.07	3.25	1.17	4.99
Bangalore	1.23	9.41	1.49	3.95	1.27	13.10	1.49	6.38
Calcutta	1.32	13.16	1.76	4.77	1.01	0.67	1.16	5.01
Delhi	1.08	3.30	1.22	3.64	1.25	12.36	1.47	6.49
Madras	1.27	11.00	1.58	4.32	1.20	9.95	1.41	6.11
Mumbai	1.02	0.95	1.13	3.42	1.32	15.62	1.58	7.10
Male	1.53	21.63	1.74	4.63	1.53	25.62	1.55	6.64
<b>Yangon</b>	1.75	31.06	2.29	6.17	1.06	2.91	<b>1.00</b>	<b>4.31</b>
Kathmandu	1.25	10.22	1.61	4.31	1.10	4.92	1.26	5.43
Islamabad	1.19	7.66	1.34	3.63	1.47	23.06	1.63	7.05
<b>Karachi</b>	<b>1</b>	<b>0</b>	<b>1</b>	<b>2.79</b>	1.55	26.64	1.77	7.72
Lahore	1.11	4.58	1.26	3.36	1.38	18.62	1.58	6.78
Colombo	1.49	20.05	1.83	4.93	1.36	17.60	1.51	6.51

## 5. AIR NETWORK AND AIRLINE PERFORMANCE

This section develops a numerical measure of network shape (Hogendorn C, 1996) called the network shape index (NSI) using the hub location result and level of airport activity from the previous section. The measure is derived from the HHI, which is used to measure the airport network concentration in the previous section. It is designed to measure the effect of network shape on airline's performance considering the whole South Asian network integrally. Reason behind this concept is that South Asian airlines currently do not operate outside the country to compete each other except very few cases. The airline operating in international routes are taken in account which one have flights within South Asia.

### 5.1 NSI – Measure of Network Shape

The NSI is based on the logic of the HHI, but it is applied to just one airline rather than to the whole industry. Each airline's network is made up of many nodes, which are the airports served by that airline. At each airport, the airline makes available a certain number of flights and hence a certain number of seats every day. This is the output of the airline broken down by airport.

Airline networks are not perfectly symmetric, so some airports originate more flights than others. These airports have a higher share of the total number of origination's made by the airline. Other airline shave different levels of concentration. A one-hub airline is generally more concentrated that an airline with several hubs. For example, Sahara India has a point-to-point network, and in 1998 its largest airport was Bangalore, India, which originated only 18 percent of total flights.

From example, its natural to think of individual airlines as industries and airports as firms within those industries. The NSI is calculated in the same manner as the HHI – it is the

sum of the squared origination shares of each of the airports.

**Table 7: Concentration of Departures Among the Airports for the South Asian Major Airlines (1998)**

Country	Airline	Herfindahl Index <sup>a</sup>	One-Airport Concentration <sup>b</sup>	Two-Airport Concentration <sup>c</sup>	Airport Served	No. of Intl' Points
Bangladesh	Biman Bangladesh	0.423	0.423	0.567	13	33
	*GMG Airlines	0.239	0.354	0.623	6	-
Bhutan	Druk Air	1	1	N/A	1	5
India	Air India	0.252	0.382	0.659	8	51
	Indian Airlines	0.150	0.206	0.368	63	34
	*Sahara India	0.122	0.183	0.355	11	-
	*Jet Airways	0.112	0.258	0.401	37	-
	*Gujrat Airways	0.129	0.307	0.406	21	-
Maldives	Air Maldives	0.314	0.5	0.706	5	6
Myanmar	MAI	1	1	N/A	1	4
	*Yangon Airways	0.197	0.34	0.512	9	-
	*Air Mandalay	0.19	0.309	0.519	8	-
Nepal	Royal Nepal Airways	0.294	0.467	0.598	18	13
	*Necon Air	0.328	0.538	0.653	9	2
	*Skyline Airways	0.232	0.409	0.545	9	-
	*Buddha Air	0.377	0.579	0.711	6	-
	*Gorkha Airlines	0.294	0.504	0.644	9	-
	*Yeti Airlines	0.261	0.467	0.613	13	-
Pakistan	PIA	0.294	0.420	0.681	6	69
	*Aero Asia	0.299	0.462	0.677	5	6
	*Shaheen Air International	0.269	0.500	0.750	4	6
	*Bhoja Air Pvt. Ltd	0.351	0.536	0.821	3	1
Srilanka	Air Lanka	0.306	0.500	0.682	8	37

Note: a: - Computed by summing the squares of airport shares of the airlines total scheduled departures  
b: - The share of the airline's total departures from the airport where the airline had the most departures  
c:- The combined shares of the airline's total departures from the airports where the airline had the most departures.  
N/A- Not Applicable  
\*:- New Entrants after each countries deregulation

A caveat associated with index is that it is not very helpful for very small airlines like non-scheduled or charter service oriented airlines. When an airline first starts out, it usually serves just a few cities and therefore will appear very concentrated. That does not mean that the airline is necessarily following a strategy of extremely high concentration. Because of this problem, this paper will only examine more established flag carrier and new entrants with more developed network shapes. Airlines are always evolving their network shapes. Relating NSI to profits shows how NSI might affect profits over time.

## 5.2 Comparison Between NSI and HHI

To measure the degree of hubbing, an indicator of the degree of hubbing (Hansen and Kanafani, 1989) was calculated to which operations of the airlines were concentrated at one or small number of airports and compares with NSI. Three specific measures of concentration, all based in the distribution of annual scheduled departures, were used. HHI for international departures were compared with other network concentration measures in Table 7.

The NSI and the HHI have different maximum values. An HHI of  $100^2 = 10,000$  indicates a monopoly with 100 percent of industry output. In an airline network, all flights must operate on both directions; the most concentrated airline possible would serve just two airports with an NSI of  $50^2 + 50^2 = 5,000$ .

Most of the developed airline shows lower concentration compare to new entrants except the airline serving international destinations. For international departure major airline uses top two-three airports as a hub and thus increases the concentration. High one airport concentration indicates airlines having international departure from a single hub.

### **5.3 Network Measures in 1998**

In 1998, the networks of the South Asian Carriers showed a variety of characteristics. Predictably, the new entrants served fewer airports than the major airlines. They tended to have a lower route density, and their networks had shapes different from those of the major airlines.

The total number of airports served is a measure of the aggregate scope of an airline network. The major airlines have opted to serve a great number of airports in their quest for ubiquity. The smaller new entrants cannot serve as many cities. Table 8 shows the scope (airport served) of the airlines in the sample in 1998.

The shape of the airlines' networks is measured by the NSI described earlier. Figure 6 shows the NSI's for the airlines in the sample in 1998. The figure suggests that airlines can be divided into those with a high ( $>2500$ ), medium (1500-2500), or low (1000-1500) NSI. The airlines with high NSI's are mostly new entrants whose operations are concentrated at just few airports such as Nepalese and Myanmar private airlines. The medium NSI airlines are the major flag carriers, whose networks include several hubs, whereas the low-NSI airline, like Jet Airways and Sahara India, has a point-to-point network. Among the majors Air Lanka stands out for its very high NSI, a result of its single Hub at Colombo.

### **5.4 Model of Airline Performance**

Since airline networks differ in scope, density and shape, it is natural to investigate what are the effects of these characteristics on airline performance. This section builds a model of airline profitability presented by Hogendorn C, (1996) and Hansen and Kanafani (1990).

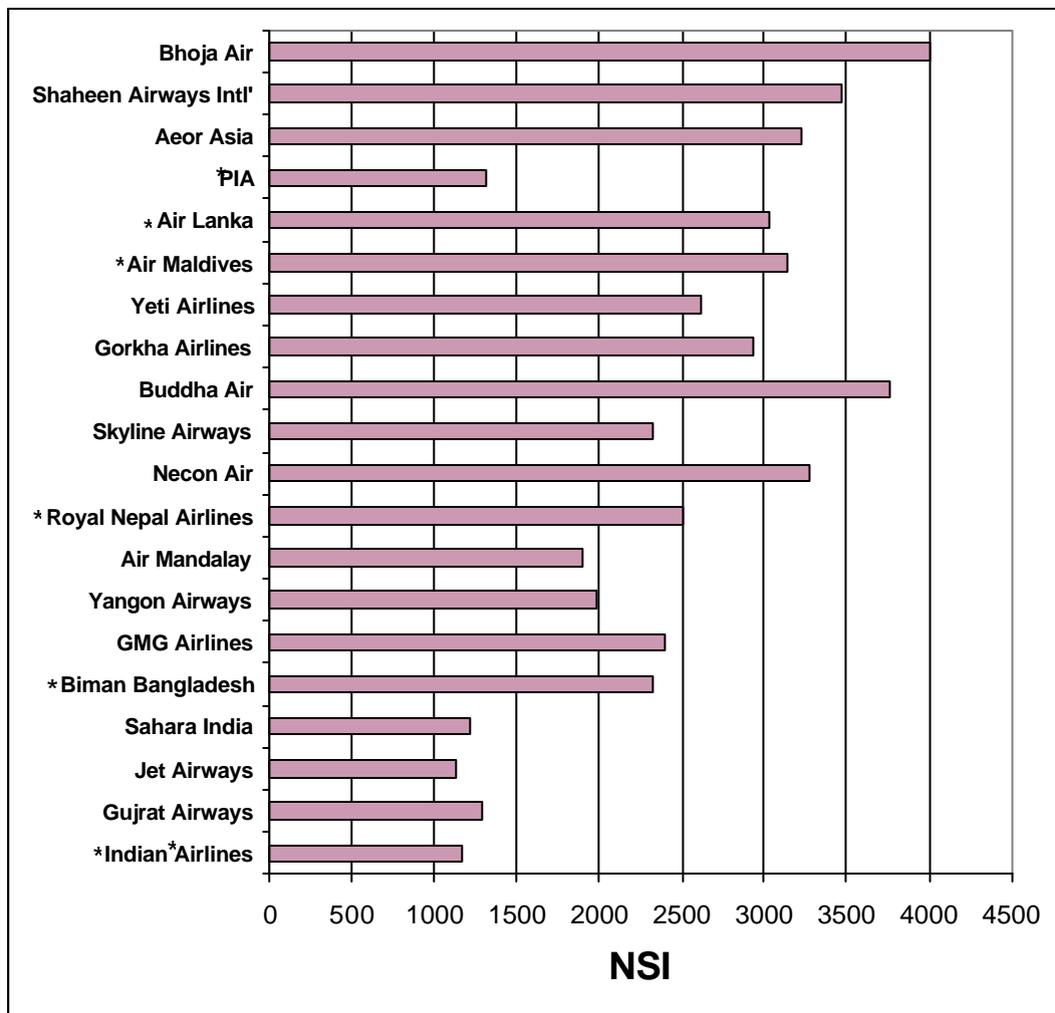
Hogendorn concentrate on the relative performance of difference between the new entrants and major airlines and latter one developed a cost function analysis to measure the effects of degree of hubbing on airline costs. This paper concentrates only major airline performance for integrated SA air transport network. Main concern here is how the network shape index and the elements Hub-and-Spoke system effects SA major airline's profitability.

#### **5.4.1 Details of Model**

The model to be estimated gives profit per ASM (Available seat kilometer) as a function of employee compensation, maintenance expense, aircraft related variables such as ASM, aircraft size and trip length, the network measures of scope, density, stage length, airport

concentration and absolute relative NSI. All measures are adjusted to 1995 dollars using the GDP deflector.

**Figure 6: NSI in 1998**



Note: \*:- Countries Flag Carrier

Operating profit (P) per ASM is calculated between the difference of total operating revenues and total operating expenses divided by ASMs. Employee compensation costs (EC) was given in dollars per ASM and maintenance expenses (MC) in dollars per aircraft day. Trip length (TL) and aircraft size (AS) refers average distance covered by the airline per flight and ASM represents airline capacity.

Aggregate scope (S) is the total number of airports served where the airline offers at least some service and aggregate density (D) is ASMs per airport served. Stage length (SL) is the total aircraft kilometer divided by number of departures. Each of the three concentration measures used in Table 7 were alternatively tried in the models. These variables may be correlated to each other and hence warrants separate model. The one-airport concentration (AC1), for example, is not well suited for systems with multiple hubs. The two air concentrations (AC2), while in some respects better suited for multiple-hub systems fails to detect changes in the concentration of departures among the top two airports.

The shape measure is the absolute relative NSI (q), which is value of the difference between the airline's own NSI and average of the new entrants private airlines. This emphasizes indirectly the niche networks concept of new entrants. The assumption is that a major airline i.e. flag carrier will be more profitable if it concentrates on more profitable routes leaving its operation from the low demand route which are not suitable for large aircraft's owned by the major airline and thus increasing economics of scale on long range and high demand routes. New entrants will be more profitable if it can mold its operation around niche shape (Hogendorn, 1996).

The form of airline performance model is therefore:

$$P = \hat{\alpha} . EC^{\hat{\alpha}} MC^{\hat{\alpha}} TL^{\hat{\zeta}} AS^{\hat{\epsilon}} C^{\hat{\epsilon}} S^{\hat{\epsilon}} D^{\hat{\epsilon}} SL^{\hat{\theta}} q^{\hat{\iota}} AC1^{\hat{\delta}} AC2^{\hat{\delta}} \quad (6)$$

The parameters were estimated by performing two-stage least squares analysis on the log-transformed version of Eq. 6. The analysis was based on international airlines of flag carrier of SA countries: Biman Bangladesh Airlines, Air India, Indian Airlines, Air Lanka, PIA and Royal Nepal Airlines. The data source for the airline financial information and NSI is ICAO yearly data series over a period of 1988 to 1996 except Royal Nepal Airlines (1986-1989).

#### 5.4.2 Estimation Results

**Table 8: Estimated Results of Airline Performance Model**

Variables	Co-efficient	t-value
Constant ( $\hat{\alpha}$ )	-71.745	-2.92
Employee Compensation costs (EC)	4.194	0.90
Maintenance expense (MC)	-3.185	-1.65
Trip Length (TL)	-3.984	-0.65
Aircraft Size (AS)	0.473	0.17
ASM (C)	1.573	1.86
Scope (S)	0.722	0.21
Density (D)	-0.736	-2.07
Stage Length (SL)	1.898	1.96
NSI (q)	4.806	2.15
One-Airport Concentration (AC1)	-12.020	-1.99
One-Airport Concentration (AC2)	11.227	2.47
R-square	0.86	
Adjusted R-square	0.79	

Table 8 presents estimated co-efficient along with their t-statistics for the airline performance model. The table shows only one-model results, which include all the network shape measures together with other variables. The variables for employee costs, stage length, aircraft size and scope are all insignificant. This probably due to some multicollinearity between the variables; the four together are jointly significant at the 3 percent level. All variables retained in the model for the seek of interest of a better co-efficient estimate for relative network measures.

The regression results indicate that the remaining network variables have a statistically significant effect on profitability. Density was shown to reduce profits, whereas a higher NSI increases profits. It appears that the airlines could achieve returns to density by changing shape but not increasing the

aggregate level of density. Further, the two-airport concentration is positive whereas one-airport concentration becomes negative indicating the establishment of two or three

airport “multiple hub system” can obtain a significant effect on profit. Negative sign of stage length and ASM (capacity) implies that if hubbing resulted in higher average aircraft sizes, it would also result higher profits.

## 6. SUMMARY AND CONCLUSIONS

From the results of the performed analyses, we find that as air transport increases, the tendency is to respond by growth together with development, by adding the capacity to airports and improving the air transportation system. The regional air travel demand provides a strategic planning for air transport related organizations with the introduction of proper level of activity, optimization of their capacity and improvement of service and operation. Furthermore the airport with significant hub probability currently serves three regions. Western airports like Karachi and Mumbai is used as a gateway for Middle East and European countries and eastern airports have the potentiality to act as gateways for South East Asian countries. Locational analysis provides a concrete evidence for this concept. Airline performance model shows the influence of network shape to alleviate their current financial problem. From the findings of the analysis it can be inferred that air transport system in South Asia has reached the point in which hub could be introduced in a systematic compartment and in which airports could, therefore, become a competitive industry within region. It is important to realize that improved air transport system could ultimately lead to a more innovative and dynamic air transportation system in South Asia. Our findings will help to establish the condition under which hub-spoke system may be viable. The detail investigation of South Asian air transports system including the alliance effects and guidelines for new entrants are in progress.

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