First Draft

Efficiency of Delhi International Airport Using Data Envelopment Analysis:A Case of Privatization and Deregulation[1]

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ABSTRACT

We work out the efficiency index of the Delhi Airport using monthly data(March 2000 through July 2004) of international and total traffic of aircraft's, passengers & cargo movements . The study compares the Delhi Airport technical efficiency index with the efficiency indexes of some selected domestic airports of India in 2000-01.The study uses data envelopment analysis for working out the technical efficiency using data on aircraft movements(output of the airport) and passenger movements and cargo traffic(both inputs to aircraft movements) .The airport production frontier at each point in time is constructed using deterministic, nonparametric (mathematical programming) methods (essentially, finding the smallest convex cone enveloping the data) and efficiency is measured as the (output-based) distance from the frontier.

We find technical efficiency scores are higher based on time series evidence while they are quite low if we use cross sectional evidence of some selected domestic airports.The latter evidence favors privatization of the Delhi Airport.

We study the impact of foreign direct investment/index of production, reserves/index of production, trade openness/index of production and terrorist attack on September 2001 on Twin Towers on the efficiency index of the Delhi International airport.While the first three variables have no significant impact on the efficiency index ,the terrorist act on September 2001 had a significant detrimental impact on passenger traffic and efficiency of the Delhi International Airport. However, Aircraft movements is significantly impacted by Foreign Investment/Index of Production (FI/IP) ,Reserves/Index of Production(R/IP) and dummy variable(D) of terrorist attack.The above results confirm that foreign direct investment and foreign exchange reserves could be used to upgrade air navigation system so that the Delhi Airport can have larger movements of aircraft's originating from Delhi International Airport.This could bring more revenues for the airport.The regression results also confirm that efficiency has more to do with efficient management and corporatization of airports rather than funding alone.The Airport Authority of India need to inculcate the spirit of professionalization in their day to day operations.
The study also discusses various models of privatization and examines the benefits and costs of each one of them .The study gives framework of an efficient regulatory framework for the Airports in India.Given the limitations in India's airport infrastructure, a more suitable method of privatization seems to be to introduce "competition for the

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market" in airport services, where an existing airport is given on a concession(long term leasing), through a competitive bidding process(as is done for Delhi ,Mumbai,Kolkata and Chennai airports). However, this essentially represents a case of a public monopoly being turned over to the private sector, and regulation is important to ensure that the private sector does not gouge airlines and passengers

I. INTRODUCTION:

There are 449 airports/airstrips in India.Of these,the Airport Authority of India owns and manages 94 airports and 28 civil enclaves at defense airfields and provides air traffic services over the entire Indian airspace and adjoining oceanic areas.In 2000-01,these 122 airports/civil enclaves handled about 490,000 aircraft movements involving 28 million domestic and 14 million international passengers,and about 288,000 metric tonnes of domestic and around 558,000 metric tonnes of international cargo.Over 50 percent of the passenger traffic was handled at the two international airports at Mumbai and Delhi.As a result,the limited terminal capacity at these airports has led to increased congestion, bunching of flights and delay in passenger clearances.

This study estimates the efficiency index of the various airports in India using data of 2000-01 and of the Delhi Airport on monthly basis from March 2000 through July 2004.We use data envelopment analysis for working out the technical efficiency using data on aircraft movements(output of the airport) and passenger movements and cargo traffic(both inputs to aircraft movements) .The airport production frontier at each point in time is constructed using deterministic, nonparametric (mathematical programming) methods (essentially, finding the smallest convex cone enveloping the data) and efficiency is measured as the (output-based) distance from the frontier. These data-driven methods do not require specification of any particular functional form for the technology, nor do they require any assumption about market structure or about the absence of market imperfections; market imperfections, as well as technical inefficiencies, are possible reasons for airport index falling below the airportwide production frontier.

We also work out the impact of trade openness,foreign investment(sum of portfolio and direct investment),foreign exchange reserves and terrorist attack on September,11 on the efficiency of the Delhi international airport. The impact of these explanatory variables along with the impact of passenger traffic and cargo traffic as additional explanatory variables is examined on the aircraft movements from the Delhi International airport.

Traditionally, all over the world,the airport has been under government control.In India ,the aviation sector can be broadly classified into three distinct functional segments all working under the aegis of Ministry of Civil Aviation,Government of India..One,operations,including the activities of Indian Airlines(IA) and its wholly owned subsidiary Alliance Air(AA),Air India(AI),Pawan Hans Helicopter and other priavte operators;second,infrastructure under the purview of the Airport Authority of India and thirdly regulation and development,the responsibility of the Directorate General of Civil Aviation(DGCA), and the Bureau of Civil Aviation Security(BCAS).The move towards airport privatization is a relatively recent phenomenon and is driven in India on the

primae facie evidence of two factors.First due to continous increases in passenger traffic across the world,there was an urgent need to expand existing capacity and invest in additional facilities.Government was unable to undertake the necessary investment as continued public financing of airport infrastructure was becoming increasingly difficult,given the operational needs of tax revenues.Secondly,the declining level of operational efficiency and technical efficiency since September,2001 makes a strong case for involving the private sector.In India four international airport-Delhi,Mumbai,Kolata and Chennai have been selected for leasing(one way of privatizing the airports).

Can the revenue obtained from commercial activities be higher when an airport is privately owned than when it is under the government ownership.Betancor and Renderio(2003) in their study on Spanish airports show that revenue earned from privatization is indeed greater than when it is under government control.

The nature of privatization depends to a large degree on government policy,the existing financial condition of the airports and the state of capital makets.We describe in the paper at least three different ways in which privatization process can occur,outline relevant case studies and present the benefits and drawbacks of each model.

Given the potential for abuse of monopoly power in the Delhi international airport activities,the airport operations should be kept under the purview of an independent regulator.We identify some policies for setting overall airport charges and safety regulations in the face of private participation.
The paper is organized in the following manner.Section II gives the objectives of the paper.Section III gives some data on international and total traffic of aircraft movements,passenger and cargo movements originating from the Delhi airport and gives some forecasts in years to come.This section also discusses the data envelopment methodology and uses the same for calculating the efficiency index of some selected airports in India using total traffic data in 2000-01.Section IV gives the efficiency index of the Delhi International Airport based on monthly data of international traffic and also discusses the determinants of technical efficiency.Section V discusses the various privatization models of the airports and Section VI is on regulation of airports.Section VII ends with summary and conclusions.References and Appendix Tables I and II are at the end.

II.Objectives of the Study:

1).Study trends of the air traffic in India and give some forecasts. Work out the efficiency index of the Delhi Airport using monthly data of international and total traffic of aircraft, passenger & cargo movements originating from the Delhi Airport. Compare such index with the efficiency indexes of some selected domestic airports of India
2) To study and examine the determinants of the monthly efficiency index and aircraft movements from the Delhi International Airport
3)To study various models of privatization and examine the benefits and costs of each one of them
4)To frame an efficient regulatory framework for the Delhi and other Airports in India.

III.International Traffic & Forecast of Traffic in India and Efficiency Index of Some of the Airports in India

III.I International Traffic

Table I below presents the data concerning volume and pattern of traffic at various airports in India

Table I:Volume and Pattern of Traffic at Various Airports in India during 2000-01

Airp.	Int. (Aircraft Movement'000	Dom. (Aircraft Movement'000	Tot (Aircraft Movement'000	Int Passen. Million	Dom Passen. Million	Total Passen. Million	Int. (Cargo'000 tonnes	Dom. (Cargo'000 tonnes	Total (Cargo'000) tonnes
Mumbai	34.60	73.81	108.41	5.175	7.002	12.177	211.01	76.60	287.61
Delhi	28.75	52.84	81.59	3.950	4.984	8.934	173.60	61.43	235.03
Chennai	12.06	25.29	37.35	1.834	2.232	4.066	82.03	23.93	105.96
Kolkata	6.66	19.54	26.20	0.632	2.055	2.687	25.07	28.78	53.85
Bangalore	2.84	28.97	31.81	0.170	2.274	2.444	29.02	29.59	58.61
Hyderabad	2.10	16.59	18.69	0.236	1.374	1.610	2.93	14.16	17.09
Thiru.	5.55	3.66	9.21	0.760	0.251	1.011	23.58	2.01	25.59
Ahmedabad	0.96	9.32	10.28	0.186	0.661	0.847	1.73	7.76	9.49
Goa	1.46	6.47	7.93	0.250	0.627	0.877	0.60	3.14	3.74
Kochi	2.34	8.41	10.75	0.316	0.456	0.772	4.02	2.34	6.36
Calicut	3.06	3.22	6.28	0.284	0.202	0.486	3.62	2.92	6.54
Guwahati	0.00	8.40	8.40	0	0.451	0.451	0.00	6.56	6.56
Pune	0.00	4.87	4.87	0	0.415	0.415	0.00	3.28	3.28
Lucknow	0.15	6.17	6.42	0.015	0.287	0.302	0.01	1.36	1.37
Jaipur	0.00	6.94	6.94	0	0.273	0.273	0.00	0.97	0.97
Jammu	0.00	4.61	4.61	0	0.230	0.230	0.00	0.58	0.58
Srinigar	0.00	1.29	1.29	0	0.253	0.253	0.00	1.04	1.04
Coimbatore	0.02	4.78	4.80	0	0.263	0.263	0.00	3.10	3.10
Mangalore	0.00	3.04	3.04	0	0.214	0.214	0.00	0.26	0.26
Varanasi	0.75	3.60	4.35	0.030	0.190	0.220	0.00	1.29	1.29
Nagpur	0.00	3.57	3.57	0	0.199	0.199	0.00	1.03	1.03
Agartala	0.00	1.64	1.64	0	0.207	0.207	0.00	2.99	2.99
Vadodra	0.00	3.39	3.39	0	0.212	0.212	0.00	0.77	0.77
Patna	0.42	4.16	4.58	0.009	0.168	0.177	0.00	2.21	2.21

Udaipur	0.00	4.68	4.68	0	0.159	0.159	0.00	.08	0.08
Indore	0.00	4.10	4.10	0	0.180	0.180	0.00	1.12	1.12
Bhub.	0.00	2.85	2.85	0	0.149	0.149	0.00	0.55	0.55
Visaka.	0.00	2.69	2.69	0	0.134	0.134	0.00	0.42	0.42
Others	1.49	67.68	69.17	0.162	0.916	1.078	0.52	8.09	8.61
Total	103.2	386.5	489.79	14.009	28.018	42.027	555.77	288.37	846.14

Source:Airport Authority of India Air Traffic News

Trends in traffic at the four major international airports since the inception of the International Airports Authority of India in 1972[3] are presented in Table II.

Table II:Trends in Traffic at the Four International Airports Selected for Leasing (Passgengers in Million and Cargo in Thousands Metric Tonne)

Year	Pass Nger (Mumbai)	Cargo (Mumbai)	Passenger Delhi	Cargo Delhi	Pass Enger (Kolkata)	Cargo (Kolkata)	Pass Enger (Chennai)	Cargo (Chennai)	Pass Total	Cargo Total
1972	2.37	37	1.753	20	0.966	18	0.500	6	5.595	81
1977	4.100	70	2.630	46	1.174	15	0.747	18	8.651	149
1982	6.44	119	4.113	79	1.507	22	1.240	26	13.30	246
1987	9.14	181	6.062	125	2.386	35	1.013	41	19.50	382
1992	8.44	167	5.519	130	2.075	32	2.029	48	18.07	377
1997	11.01	254	7.820	203	2.513	47	3.500	75	24.84	579
1998	11.01	244	7.883	198	2.521	49	3.524	74	24.94	565
1999	11.56	277	8.314	219	2.599	54	3.647	100	26.12	650
2000	12.17	288	8.934	235	2.686	54	4.066	106	27.86	683
Av.Annual Growth Rate	6.01	7.60	5.99	9.20	3.72	4.00	7.77	10.80	5.90	7.91

Note:Year Represents financial year April-March.
Source:Airport Authority of India Annual Reports

Some important conclusions which emerge from the Table I and Table II are give below
1)The four major international airports handle a very large proportion of both passenger and cargo traffic.The international traffic is largely concentrated at these airports
2)The traffic at these airports has been continuously growing.On an overall basis,the average growth rate per annum for all the airports for passenger traffic was about 5.9 % and for cargo traffic 7.9 %.However,the growth has been fluctuating from year to year from one period to another period.
3)Among the four airports,Chennai achieved the highest growth in respect of both passenger and cargo traffic.On the other hand,Kolkata recorded the lowest growth,both in passenger and cargo traffic.While Delhi and Mumbai recorded almost similar growth rate

[3] International Airport Authority and National Airport Authority were merged and made into Airport Authority of India(AAI) in 1994.

in passenger traffic,Delhi recorded a higher growth rate in case of cargo traffic.While in the case of passenger traffic,Mumbai recorded a higher growth rate than Delhi in the seventies,in in subsequent years,Delhi recorded higher growth rates.

III.II Forecasts of Traffic

Airport Authority of India forecasts of traffic at its airports for the next 10-11 years.Table III presents the figures of traffic and the average annual growth rates

Table III:Forecasts of Traffic at Indian Airports

Item of Traffic	Base2000-01	Forecast2006-07	Forecast 2011-12	Average Annual Growth Rate(%)
Aircraft Movements('000)				
5 Major International Airport	262.76	338.87	419.59	4.3
6 Other International Airports	78.82	89.08	108.38	4
Domestic Airports	148.21	189.91	223.11	3.3
Total	489.79	617.87	751.08	4
Passenger(Million)				
5 Major International Airports	28.88	40.48	53.86	5.8
6 Other International Airports	6.34	8.12	10.89	5.9
Domestic Airports	6.81	9.76	12.74	5.2
Total	42.03	58.36	77.49	5.7
Cargo '000 tonnes				
5 Major International Airports	708.05	1056.49	1476.37	6.9
6 Other International Airports	95.58	129.50	183.89	6.8
Domestic Airports	42.51	64.28	82.72	4.9
Total	846.14	1250.26	1742.99	6.8

Source:Airport Authority of India

It appears that in future the highest growth in traffic is likely to be recorded by the five international airports, namely, Mumbai, Delhi, Kolkata, Chennai and Thiruvanthapuram followed by the other six international airports and the remaining domestic airports.Thus,the concentration of traffic at larger airports is likely to increase in future. Among the four major international airports,Chennai is projected to register the highest growth rate of 8 % per annum in international passenger traffic followed by Delhi(6%) and Kolkata(5%).Mumbai is expected to register the lowest growth rate of 4 %.In contrast,Mumbai is expected to lead other international airports in respect of domestic passenger traffic with a growth rate of 7 % per annum,followed by Delhi and Chennai(both 6 %) and Kolkata 4 %.In the case international cargo traffic,Kolkata and Chennai are expected to be leaders each with a growth rate of 8 % per annum,followed by Delhi(7 %) and Mumbai(6%).The domestic cargo traffic at all these airports is expected to growth at the rate of 7 % per annum.

III.III Efficiency Index of Airports in India

Data Envelopment Analysis is the methodology used in this study to construct the Technical Efficiency of the Delhi Airport

Our approach to constructing the Indian States airport production frontier and associated efficiency levels of individual airports (distances from the frontier), motivated in part by the first such effort in this direction by Charnes et. al(1978), Fare, Grosskopf, Norris, and Zhang (1994),followed by Kumar and Russell(2002) and Henderson and Russell,(2003) which in turn is based on the pioneering work of Farrell (1956) and Afriat (1972). The basic idea is to envelop the data in the "smallest", or "tightest fitting", convex cone, and the (upper) boundary of this set then represents the "best practice" production frontier. Although this data-driven approach, implemented with standard mathematical programming algorithms, requires no specification of functional form, it does require an assumption about returns to scale of the technology (as well as free input and output disposability).

In our simple case, we deal with only three macroeconomic variables: aggregate output(proxied by Aircraft Movements) and two aggregate inputs: labor(proxied by Passenger Traffic) and capital(proxied by Cargo Traffic). Let $\left(Y_t^j, L_t^j, K_t^j\right), t = 1,..,T, j = 1,...J,$ represent T observations on these three variables for each of the J countries. The constant-returns-to-scale reference technology (the "Farrell cone") for the airport in period t is defined by

$$\tau_l = \left\{(Y,L,K) \in R_+^3 \mid Y \le \sum_j z^j Y_t^j, L \right. \quad (1)$$

$$\left. \ge \sum_j z^j L_t^j, K \ge \sum_j z^j K_t^j, z^j \ge 0 \forall j \right\}$$

In this construction, each observation is interpreted as a unit operation of a linear process, zj represents the level of operation of the process and every point in the technology set a

linear combination of observed output/input vectors or a point dominated by a linear combination of observed points. The constructed technology is a polyhedral cone, and isoquants are piecewise linear.4

Or course, typically some observed input-output combinations will be redundant in constructing the technologies, in that the observed output can be produced by some other process (generated by an alternative observed input-output vector) or by some linear combination of other processes using less of one input and no more of the other. These dominated processes are technologically inefficient. The Farrell (output-based) efficiency index for airport) at time t is defined by

$$E(Y_t^j, L_t^j, K_t^j)$$

$$= \min\left\{\lambda \mid (Y_t^j \setminus \lambda, L_t^j, K_t^j) \in \tau_t\right\} \qquad (2)$$

This index is the inverse of the maximal proportional amount that output Y_t^j can be expanded while remaining technologically feasible given the technological τt and the input quantities L_t^j and K_t^j ;it is less than or equal to 1 and takes the value of 1 if and only if the jt observation is on of the period t production frontier. In this case of a scalar output, the output-based efficiency index is simply the ratio of actual to potential output evaluated at the actual input quantities, but in multiple-output technologies the index is a radial measure of the (proportional) distance of the actual output vector from the production frontier.

The Farrell efficiency index can be calculated by solving the following linear program for each observation:

$$\min_{\lambda, z^1, \ldots, z^j} \lambda \text{ subject to}$$

$$Y^j / \lambda \leq \sum_k z^k Y_t^k$$

$$L^j \geq \sum_k z^k L_t^k$$

$$K^j \geq \sum_k z^k K_t^k$$

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4 The non increasing-returns-to scale (NIRS) technology is constructed by restricting the process operation levels as satisfy $0 \leq z^j \leq 1$ for all j, so that observed process can be radially contracted but not expanded. The variable-returns-to-scale (VRS) technology is constructed by adding the restriction $\sum_j z^j \leq 1$, resulting in increasing returns as scale at low levels of input. By construction, efficiency indexes calculated under the assumption of constant returns to scale are no higher than those calculated under the assumption of NIRS, which in turn are no greater than those constructed under the assumption of VRS (see Fare et al. [1994] for details).

$$z^k \geq 0 \forall k.$$

The solution value of λ in this problem is the value of the efficiency index for airport j at time t.

Using data in columns 4(Aircraft Movements as output),7(total passenger movements as first input),and 10(cargo traffic an another input) in Table I we work out the technical efficiency index of different airports in year 2000-01.The methodology described above gives an account of the data envelopment analysis which is used in this study throughout to work out the efficiency index..Table IV summarizes the results.

Table IV:Technical Efficiency of Some Airports in India based on Total Air Traffic in 2001

Airport	Fi(y,x | C,S)(Technical Efficiency)
Mumbai	0.14
Delhi	0.14
Chennai	0.14
Kolkata	0.15
Bangalore	0.2
Hyderabad	0.18
Thiruvanthnapuram	0.14
Ahmedabad	0.19
Goa	0.19
Kochi	0.22
Calicut	0.2
Guwahati	0.29
Pune	0.18
Lucknow	0.44
Jaipur	0.58
Jammu	0.52
Srinigar	0.11
Coimbatore	0.28
Mangalore	0.43
Varanasi	0.36
Nagpur	0.35
Agartala	0.12
Vadodra	0.36
Patna	0.4
Udaipur	1
Indore	0.41
Bhubneshwar.	0.43
Visakapatnam	0.48
Others	1

Source:Authors calculations using Onfront Software.Note higher values means higher technical efficiency while value one means that the airport is working along the best production frontier.

From the table IV it seems quite peculiar that airports which handle less of international traffic have a value one(most efficient).The interpretation of this finding is that such airports have relatively low aircraft and passenger movements because it seems that they are relatively undercapitalized and not because they make inefficient use of the relatively meager capital inputs that it has. Another(perhaps more plausible) interpretation is that the DEA method of constructing the best -practice frontier-a lower bound on the frontier under the assumption of constant returns-fails to identify the 'true' but unknown frontier, especially at low capital labour ratios[5].All the major international airports(Delhi,Mumbai,Kolkata,Chennai) which handle maximum number of traffic surprisingly have quite low relative technical efficiencies.This may be because with limited terminal capacity in such airports, congestion increases and delays the passenger clearances.This situation is exacerbated by outdated infrastructure, inadequate ground handling systems and night landing facilities and poor passenger amenities. The poor utilization of existing capacity has impeded development and growth of the sector..Also, improvements in air traffic control and groundside facilitation as well as in the existing mechansim for slot allocation can increase capacity and thereby provide some relief from shortage of capacity.The above results provides some evidence in favour of privatization of the airport to gain in efficiency

Slots

As airports become congested, it is crucial for airlines to be assured of access to such airports by way of the right to take off and land at a particular time of day. Such rights, commonly referred to as slots, are normally provided on a first-come-first-served basis and subsequently "grand fathered". The allocation of slots is complex matter because of the need to ensure compatibility between slots at either end of each particular route (and in cases involving multiple sectors, at each point on the route). Allocation of slots pertaining to international routes is effected through twice yearly slot allocation conferences that take place between members of the International Air Transport Association (IATA), in accordance with procedures developed by IATA. Airlines routinely exchange slots on a reciprocal basis and a seldom-publicised "fact" is that airlines may ask for, and receive, some financial consideration while exchanging valuable slots with less attractive slots.

There is economic evidence that capacity constraint on slots and gates translate directly into market power. For instance, in the U.S., of the 43 airports which are classified by the Federal Aviation Authority (FAA) as "large hubs", the fares are generally much higher at the ten airports which suffer from capacity constraints. Across countries, a variety of policies have been tried to prevent airlines from acquiring and strengthening a dominant position in slots, with mixed results. Under the slot trading system introduced in the U.S., the dominant incumbent airlines

[5] We should note that these mathematical programming methods take no account of measurement error, sampling error and other stochastic phenomena. Recent research(Leopold Simar,1996;Alois Kneip et.al,1998;Irene Gijbels,1999;Simar and Paul W.Wilson,2000) has made substantial progress on the use of bootstrapping method to construct confidence intervals around efficiency index .In this study, however ,we are more concerned about the statistical significance of changes in the distributions of efficiency indexes and the components of tripartite decomposition of net value added per worker changes.

have succeeded in increasing their proportion of the total slots, despite explicit provisions to ensure that slots become available to new entrants. Yet another mechanism is "use it or lose it", which requires an airline to use a slot at least 80% of the time or face having the slot revoked by FAA. A far more drastic mechanism proposed by the Port Authority of New York and New Jersey envisaged a modest withdrawal of air carrier slots, not to exceed 3% on an annual basis, for reallocation to new entrants and small incumbents by lottery.

In summary, it appears that regardless of the approach adopted for allocation of slots, there is strong possibility for anti-competitive behaviour, since a dominant operator would be willing to pay more than a competitor for acquiring valuable slots. In due recognition of this reality, many countries rely primarily on competition law to prevent airlines from attaining a dominant position in slots.

IV Efficiency of Delhi Airport: Time Series Evidence & its Determinants

IV.I Efficiency of Delhi Airport :Time Series Evidence

Using monthly international and total traffic data on airport movements,passenger traffic and air cargo traffic, efficiency index from March2000 through July 2004 is worked out of the Delhi airport and shown in Table V below.The figures for the output and inputs data are given below in the Appendix Table I and Appendix Table II

Table V:Efficiency Index of Delhi Airport Based on International and Total Traffic Data

Months	Fi(y,x | C,S)Efficiency Index(Based on International Traffic Data)	Fi(y,x | C,S)Efficiency Index(Based on Total Traffic Data)
Mar-00	0.81	0.85
Apr-00	0.83	0.85
May-00	0.94	0.87
Jun-00	0.88	0.88
Jul-00	0.86	0.87
Aug-00	0.88	0.88
Sep-00	0.92	0.89
Oct-00	0.91	0.86
Nov-00	0.88	0.9
Dec-00	0.9	0.88
Jan-01	1	0.98
Feb-01	0.91	0.88
Mar-01	0.85	0.85
Apr-01	0.9	0.91

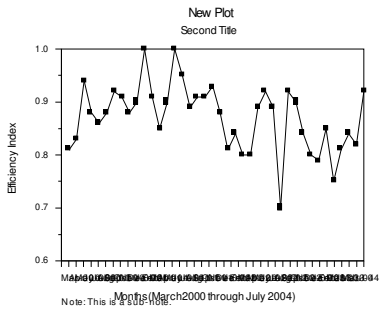
May-01	1	0.96
Jun-01	0.95	0.94
Jul-01	0.89	0.95
Aug-01	0.91	0.93
Sep-01	0.91	0.97
Oct-01	0.93	0.97
Nov-01	0.88	0.95
Dec-01	0.81	0.91
Jan-02	0.84	1
Feb-02	0.8	0.96
Mar-02	0.8	0.94
Apr-02	0.89	1
May-02	0.92	0.98
Jun-02	0.89	1
Jul-02	0.7	1
Aug-02	0.92	0.95
Sep-02	0.9	0.94
Oct-02	0.84	0.87
Nov-02	0.8	1
Dec-02	0.79	0.89
Jan-03	0.85	0.88
Feb-03	0.75	0.88
Mar-03	0.81	0.92
Jul-03	0.84	0.93
Mar-04	0.82	0.91
Jul-04	0.92	0.92
Average	0.87075	0.9225

Source:Authors calculations.Note higher values means higher technical efficiency while value one means that the airport is working along the best production frontier.

The average efficiency is 0.87075 for the period March2000 through July 2004 ,while the corresponding figure based on total traffic data is 0.9222.It seems that year 2002 had maximum number of efficiency(based on total traffic) scores of one,while the efficiency index(based on international traffic) was one for the months of January,2001 and May,2001 only.

In this study we will focus on the efficiency index based on international traffic dataThe figures of Table V(column 2) are plotted in Figure I to study the trend of the efficiency index based on international traffic data(statmost statistical software is used).

Figure I:Efficiency Index Plotted Against Months March2000 to July 2004)



The above clearly shows that efficiency index shows lot of cyclical movements around the secular trends.The index ,however, shows a declining trend since September,2001. These cyclical movements may be partly due to cyclical effects in passenger traffic,aircraft movements and cargo traffic(see figures II,III and IV)

Figure II:Passenger traffic Plotted against Months March2000 to July 2004)

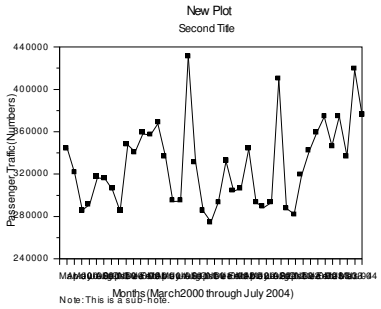


Figure III:Aircraft Movements(Plotted against Months March2000 to July 2004)

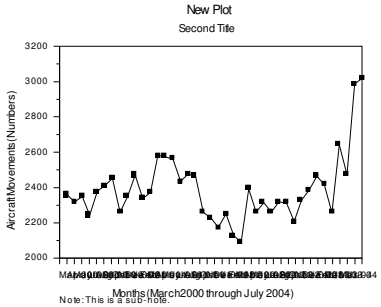
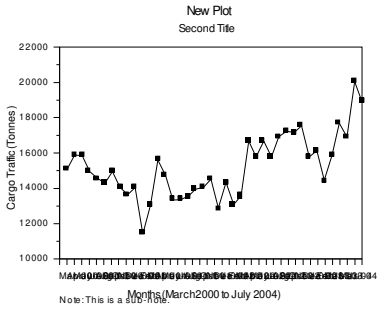


Figure IV:Cargo Traffic(Plotted against Months-March2000 to July 2004)



IV.II Determinants of the Technical Efficiency Based on International Traffic Data:

We study the impact of foreign direct investment/index of production, reserves/index of production, trade openness/index of production and terrorist attack on September 2001 on Twin Towers on the efficiency index of the Delhi International airport. We use regression analysis for the same. Dummy variable is created for capturing the impact of the terrorist attack on the efficiency index. The data on or before September 2001 are given zero values and value one is given to all subsequent values till July 2004.The first three variables captures the trade and capital market liberalization impact on the efficiency .Table VI below gives the data set for executing the regression of technical efficiency on its determinants.

Table VI:Technical Efficiency and Determinants of Technical Efficiency

	Fi(y,x | C,S) Technical Efficiency	x+m/iip	di+pi/iip	r/iip	dummy	x+m (Million US $)	di+pi (Million US $)	Reserves (Million US $)
Mar-00	0.81	44.2341	4.20934	214.034	0	7860.4	748	38034
Apr-00	0.83	51.2651	4.34504	242.147	0	8023	680	37896
May-00	0.94	49.9625	3.83125	232.781	0	7994	613	37245
Jun-00	0.88	49.0380	-0.18076	237.120	0	7596	-28	36730
Jul-00	0.86	50.4536	0.84984	231.508	0	7896	133	36231
Aug-00	0.88	49.3532	1.43310	225.865	0	7783	226	35619
Sep-00	0.92	50.6112	1.50598	223.301	0	8032	239	35438
Oct-00	0.91	51.277	0.68615	221.721	0	8071	108	34899
Nov-00	0.88	49.8775	0.71034	239.069	0	8145	116	39040
Dec-00	0.9	43.1958	0.72632	232.870	0	7434	125	40077
Jan-01	1	43.6459	2.88980	241.031	0	7446	493	41120
Feb-01	0.91	43.5456	3.62980	250.048	0	7246	604	41608
Mar-01	0.85	48.0459	2.12766	236.735	0	8581	380	42281
Apr-01	0.9	46.5523	2.73067	265.124	0	7467	438	42526
May-01	1	50.4861	3.31076	264.56	0	8204	538	42991
Jun-01	0.95	45.97484	3.660377	273.2956	0	7310	582	43454
Jul-01	0.89	48.9463	2.23815	272.630	0	7851	359	43730
Aug-01	0.91	49.3279	5.68434	279.642	0	8001	922	45358
Sep-01	0.91	47.6376	1.33580	277.532	0	7703	216	44877
Oct-01	0.93	48.1540	1.47349	279.013	1	7810.59	239	45256
Nov-01	0.88	46.3125	2.31137	280.784	1	7734.2	386	46891
Dec-01	0.81	41.3820	1.428571	271.6657	1	7328.76	253	48112
Jan-02	0.84	48.02691	2.091577	279.7004	1	8495.96	370	49479
Feb-02	0.8	42.82742	2.413388	298.1562	1	7293.51	411	50776
Mar-02	0.8	46.5462	5.912052	293.7351	1	8573.81	1089	54106
Apr-02	0.89	49.11311	0.60479	330.8383	1	8201.89	101	55250
May-02	0.92	54.15597	3.534279	331.844	1	9163.19	598	56148

Jun-02	0.89	48.80758	0.770156	349.2178	1	8111.82	128	58040
Jul-02	0.7	54.17421	1.146682	349.0047	1	9307.13	197	59959
Aug-02	0.92	53.6489	1.167247	357.0732	1	9238.34	201	61488
Sep-02	0.9	54.61746	0.593714	366.5308	1	9383.28	102	62970
Oct-02	0.84	58.99902	2.33871	371.6014	1	10242.23	406	64510
Nov-02	0.8	54.60949	1.989649	384.8706	1	9496.59	346	66929
Dec-02	0.79	50.20005	2.994681	374.6968	1	9437.61	563	70443
Jan-03	0.85	54.43676	2.425847	389.7299	1	10277.66	458	73581
Feb-03	0.75	48.1949	1.4764	399.978	1	8781.11	269	72876
Mar-03	0.81	56.62482	2.041026	386.8051	1	11041.84	398	75427
Jul-03	0.84	55.84113	3.599126	461.9388	1	10224.51	659	84581
Mar-04	0.82	67.56588	9.501661	529.8908	1	14236.13	2002	111648
Jul-04	0.92	64.80519	-1.08258	589.5821	1	12870.31	-215	117091

Source:fi and di are foreign portfolio investment and direct foreign investment(total foreign investment) is in million US $,Exports(x) and Imports(m) figures are in million US $,Reserves(r) are also in million US $.All figures are from Reserve Bank of India(RBI) monthly bulletin on Indian Statistics ; also available at www.circonindia.com.Index of Production(iip) is available from the Annual Survey of Industries and also availabe from www.circonindia.com

The regression of technical efficiency on the explanatory variables yielded the following estimated regression equation.We have used Splus software for our regression analysis and principal components multivariate statistics.

Technical Efficiency=0.8702 +.006Trade Openness/Index of Production-.0042Foreign
t (8.6) (0.19) (.40) Investment/Index of
Production+.0001 Reserves/Index of production -.0686 Dummy
t (0.24) (-2.4)

```
Residual standard error: 0.05724 on 35 degrees of freedom
Multiple R-Squared: 0.2469
F-statistic: 2.868 on 4 and 35 degrees of freedom, the p-value is
0.03726
```

The above equation signifies that none of the trade and liberalization variables significantly have an impact on the technical efficiency.Only the dummy variable is significant and negative confirming our earlier perception that the terrorist attack on the WTC buildings led to fall in international traffic and efficiency of the airports since September2001.The results did not change much when we took absolute values of trade and liberalization variables rather than ratios.-none of the trade and liberalization variables significantly have an impact on the technical efficiency(not shown). To counter the multicollinearity problem we constructed principal components from the three trade and liberalization variables and used the first principal component(explaining 60% of the variation in all three variables) as an explanatory variable.The results again showed that the dummy variable was the only significant variable and came with a negative sign.The coefficient for the principal components,though,positive was insignificant.The regression with the first principal component and dummy variable as an explanatory variable is given below

Dependent Variable:Technical Efficiency Index(monthly basis)

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	0.9039	0.0144	62.6039	0.0000
Dummy	-0.0631	0.0216	-2.9147	0.0060
Comp.1	0.0029	0.0080	0.3553	0.7244

Residual standard error: 0.05635 on 37 degrees of freedom
Multiple R-Squared: 0.2285
F-statistic: 5.48 on 2 and 37 degrees of freedom, the p-value is 0.008234

The above results confirm that efficiency has more to do with efficient management and corporatization of airports rather than funding alone.The Airport Authority of India need to inculcate the spirit of professionalization in their day to day operations.

Aircraft movements, however, is significantly impacted by Foreign Investment/Index of Production(FI/IP) ,Reserves/Index of Production(R/IP) and dummy variable(D) of terrorist attack.We regress Aircraft Movements on foreign direct investment/index of production, reserves/index of production, trade openness/index of production(T/IP) and terrorist attack on September 2001 on Twin Towers.The results are shown below.

Dependent Variable:Aircraft Movements(from Appendix Table I)

Coefficients:

	Value	Std. Error	t value	Pr(>|t|)
(Intercept)	1584.5189	187.8827	8.4336	0.0000
T/IP	5.3238	5.3561	0.9940	0.3271
FI/IP	17.5783	9.2373	1.9030	0.0653
R/IP	2.1183	0.4483	4.7255	0.0000
DUMMY	-301.6246	51.9661	-5.8043	0.0000

Residual standard error: 106.9 on 35 degrees of freedom
Multiple R-Squared: 0.7088
F-statistic: 21.3 on 4 and 35 degrees of freedom, the p-value is 5.632e-009

The above regression with two additional explanatory variables are given below

```
Dependent Variable:Aircraft Movements(Data from Appendix I)
Coefficients:
                 Value Std. Error    t value
(Intercept)  1143.3340   227.6962     5.0213
       T/IP     2.4286     5.9801     0.4061
      FI/IP    10.3951     8.7930     1.1822
       R/IP     1.6227     0.4475     3.6265
      DUMMY  -277.5673    51.8539    -5.3529
         PT     0.0012     0.0005     2.6140
         CT     0.0225     0.0161     1.4003
                        Pr(>|t|)
  (Intercept)              0.0000
         T/IP              0.6873
          FI/IP            0.2456
         R/IP              0.0010
        DUMMY              0.000

PASSENGER TRAFFIC(PT)      0.0134
    Cargo Traffic(CT)      0.1708

Residual standard error: 97.85 on 33 degrees of freedom
Multiple R-Squared: 0.7701
F-statistic: 18.42 on 6 and 33 degrees of freedom, the p-
value is 2.902e-009
```

The above results show that foreign direct investment and foreign exchange reserves could be used to upgrade air navigation system so that the Delhi Airport can have larger movements of aircraft's originating from Delhi International Airport.This could bring more revenues for the airport.Thus in particular the airports could utilize funds for the use of satellite technology like CNS/ATM(Communications,Navigation,Surveillance/Air Traffic Management),opening of polar routes and adoption of reduced vertical separation minima(RVSM).

V Privatization of Airports:Some Alternative Models

The following sections discuss various models, outlining relevant case studies and present the benefits and drawbacks of each model.

As described in Table VII below, airport privatization largely falls in three categories depending on the degree of private sector involvement.

Table VII:Options for Private Sector Participation at Airports

	Option 1	Option2	Option3
ALLOCATION OF RESPONSIBILITIES			
OWNERSHIP	**State**	**State**	**Private Sector/Mixed**

INVESTMENT	State	Private Sector/Mixed	Private Sector
MANAGEMENT &OPERATION	Private sector	Private Sector	Private Sector
COMMON STRATEGIES FOR PRIVATE PARTICIPATION	Service Concessions	Build -Operate-Transfer	Wraparound additions
	Contracting Out	(BOT) Schemes	Trade sales
	Management Contracts	Long term Leases	BOT Schemes
	Multiple Concessions	Master Concessions	Strategic Buyouts Capital markets
Recent Cases and Examples	Aerports Du Cameroon,Cameroon, Santigo,Chile Kai Tak Airport,Hong Kong	Athens International Airport,Greece El Dorado Airport,Bogota,Columbia Stewart Airport,NY Argentina	British Airports Authority,UK Belfast International Airport,Scotland Australia

Source:Privatizing Airports-Options and Case Studies,Public Policy for the Private Sector,World Bank(1996)

V.I.1 Management Contracts

In the case of a management contract(also referred to as Service Concession and Contracting Out), the public sector operator continues to own the airport infrastructure and is still responsible for operation of core activities such as managing runways and air traffic control facilities. The private sector operator manages airport assets such as passenger terminals and other activities for a fee, which is typically linked to revenues from these activities[6]. This model of private participation allows the private operator to introduce best practices across airport activities thereby increasing revenues and enhancing profitability of airport operations. The drawback with this model is that the public sector operator still has the responsibility of raising financing for investment in the airport infrastructure.

Management contracts have been used extensively in developed economies as a mechanism for increasing the efficiency and cost-effectiveness of airports and airport services. In developing economies too, where capital markets are often not developed enough to undertake full privatization, management contracts often serve as an intermediate mechanism to improve performance and profitability through private

[6] Also referred to as Service Concession and Contracting Out. An example of a management contract is evident in Cameroon, where the Government of Cameroon created an independent company, Aeroports Du Cameroon, to operate 7 out of the 14 airports in the country for a fifteen year period. The company comprises a joint venture between Aeroports de Paris (34%), Cameroon Government (24%), with the remaining shares being held by airline carriers and financial institutions. Other examples of management contracts can be seen in Albania, in the case of Tarana Airport, in Hong Kong for Kai Tak airport, and in Chile for the management of a terminal in the international airport in Santiago.

sector management.

V.1.2 Concession Contracts and Variants

Concession contracts are an innovative arrangement for airports that allow for the benefits of private sector involvement without releasing ownership of a public asset. Larger economic benefits generally can be obtained through such long-term contracts, in comparison to short-term management contracts, and as a result concession agreements are becoming increasingly common, especially in less developed countries.The majority of airport privatization have been carried out through concession contracts.

In the concession model (also known as a BOT scheme), control of all or some of the core assets of the airport is transferred to a private investor who is responsible for financing investment and managing the operations of the airport for the term of the concession, typically 15-20 years. The private operator usually pays concession fees to the government through the concession period and in return the private operator gets all the revenues from airport operations and bears the commercial risk for the period of the concession contract, after which it reverts to the government. The concession contract may be regulated in regard to prices being charged and the quality of the services. A prominent example of a BOT scheme is the case of the El Dorado Airport at Bogota in Colombia.

Long-term leases are variations of concession contracts, which typically involve transferring the management and development of the airport to a private operator for a fixed period while the government retains ownership of the airport. Long-term leases tend to be longer than typical concession contracts and are usually awarded for over 30 years, and can extend up to 50 or even 99 years. On the expiry of the lease, the management and operation of the airport is returned to the government, unless there is an option to extend the lease.In the case of privatization in Australia,airports were awarded through a fifty year lease that has an in built option to renew for another 49 years. The U.S. has opted for the long-term lease route in privatizing Stewart Airport in New York. In 1998, New York State opted to lease Stewart Airport for 99 years to a U.K. firm, National Express Group, plc. over four other finalists, having offered $35 million in cash up-front, plus a percentage of airport revenues.

There is some downside to concession contracts/leases. First, the process of conducting economic and technical studies and choosing a concessionaire can be a complex and time-consuming process. Secondly, the concessionaire's costs could be inflated due to uncertainty of how compensation clauses at the end of the concession will actually play out. Additionally, the lack of ownership rights could make it difficult and costly for private investors to raise the required capital and may restrict the private operator's ability to operate independently.

V.1.3 Strategic Sale or Partnership

In the strategic sale / partnership model, a private company or consortium acquires a stake in an airport or a state owned airport operator. This option entails the partial transfer of ownership to a strategic investor in the private sector. The government has the option of determining what proportion of private ownership is required and the advantage is that the transfer of ownership can occur in stages.

Strategic partnerships also allow the government to get access to private capital and thereby help to relieve financial constraints. The government benefits from private sector decision making and involvement in management, which can have a direct impact on operational efficiency.
A similar model, also known as partial divestiture occurs when the shares of a public owned airport or airport operator are sold to private investors, usually through a flotation. An instance of a strategic sale is the case of Vienna Airport in Austria, which was originally owned by the government, and is today partially privately owned by Amsterdam Schiphol Airport, which has a share in the 48% stake that was divested to the private sector.
This model has mainly been used in developed countries, where capital markets are mature and there is a high degree of interest from qualified private investors. In developing countries, a partial divestiture may not interest foreign investors, unless management is also transferred.

V.1.4 Full Privatisation (Complete Sale)

Full privatization involves the sale of airport infrastructure from a public operator to a private entity/investor through a flotation or a trade sale. The privatised entity is then wholly responsible for all airport operations and financing of any new activities or investments. The British government kicked off the airport privatization trend by announcing the public sale of the British Airports Authority (BAA), a government agency that owned and managed seven of the country's largest airports, including London Heathrow, the world's busiest international airport. A phenomenal 1.4 billion shares of stock were sold to 2.2 million citizens in the initial public offering, and the newly privatized BAA (BAA plc.) remained as manager of the airports. A single golden share was retained by the government and 25% of the equity was reserved for employees. The Airports Act also provided for the regulation of BAA plc. in order to avoid any misuse of monopoly power.
A little over fifteen years later, Britain's privatization program has been a success by every measure. As a private company, BAA has increased the number of flights and passengers (its airports account for 71% of all passenger traffic in Britain), earned higher profits, increased capital investments, and managed at the same time to lower per passenger charges in real terms. Heathrow, for example, dropped from being the 18th highest charger of airline fees in 1990 to 26th in 2000.

V.2 Private Participation in Indian Airports

As described above, India's airports urgently need to improve and, in varying degrees, undertake investments for capacity addition. In view of the international experience outlined earlier, the study is in favour of encouraging private participation in the airports and, where feasible, introducing elements of competition.
Since air travel is predominantly location-specific and is driven by a variety of considerations ranging from the commercial to the cultural, and the huge investments involved, airports exhibit a strong characteristic of natural monopoly. Therefore, there is scope for introducing competition in a variety of ways. First, airport operators in developed markets can face competition from nearby airports, such as in the case of London or New York, where more than one airport services a geographic

area and airlines and consumers have a choice between airports. Secondly, there is often scope in large hub airports for creating competition within an airport, given the numerous services provided by airports. For example, terminals could be given out to different operators who would compete directly with each other, and therefore price services competitively. However, in India, given the traffic levels at most of the destinations and the limited number of terminals even at major airports, there appears to be little scope for introducing competition any time soon through these methods. Given the limitations in India's airport infrastructure, a more suitable method would be to introduce "competition for the market" in airport services, where an existing airport is given on a concession, through a competitive bidding process. However, this essentially represents a case of a public monopoly being turned over to the private sector, and regulation is important to ensure that the private sector does not gouge airlines and passengers (detailed in Section VI on Economic Regulation). Within such concessions, one could introduce additional safeguards such as requiring the airport operator to allow – either through concession or mandated free entry – multiple third-party operators for certain commercial services such as ground handling, cleaning and land-side services such as banks, foreign exchange counters and restaurants.

Against the above backdrop, the paper suggests a strategy for improving the quality and affordability of airport services in India, in three broad areas, viz., privatization of existing airports, greenfield airports and uneconomical airports, as detailed in subsequent sections.These suggestions are in line with the recommendations made by the Ministry of Civil Aviation,2003 and Naresh Chandra Committee report on 'open sky policies' (2004).

V.2.1 Privatisation of Existing Airports

The Cabinet has recently taken a decision on the long-standing issue of privatization of the New Delhi and Mumbai airports, and approved the proposal to set up joint ventures for these airports where AAI will have 26% equity, and the private partners will own the rest (74%).The recent Cabinet decision has approved the privatization of the airports through the joint venture route, where 74% will be held by the private sector. More importantly, the government has not restricted the level of foreign investment, allowing upto 74% foreign equity participation via the direct approval route. While initially the plan is to privatize Mumbai and Delhi airports only, the model of privatization adopted at these airports will provide the basis for privatization of other airports as well. In other words, the government has chosen to encourage private participation through a concession contract route, which has been used extensively elsewhere.This move towards privatization comes as a much-needed impetus to the reform. Private sector management is needed for effective and nimble decision making and larger financing that the government may not be able to provide. However, there are several factors that could impact on the privatization of these airports and therefore need to be addressed on a priority basis.

First, the airport charges in India should be substantially brought down to levels comparable to neighboring South East Asian countries. Such a benchmarking exercise should be completed prior to the bidding process, as it would affect the valuation of the concession.

Secondly, one of the key features of the current privatization model envisions the transfer of existing employees of AAI to the new privatized joint venture for a period of three years so that there is no retrenchment.
The government should reconsider this decision and as an alternative can choose to compensate these employees from the general exchequer through voluntary retirement schemes (as it indeed has for some PSU employees).
Thirdly, at present, the AAI bears significant costs in providing adequate security for each of these airports, whereas that these costs should be borne by Ministry of Home Affairs. This should be clearly settled prior to the bidding process.
Fourthly, there needs to be effective co-ordination and streamlining of security, immigration, and passenger management services (i.e., check-in, boarding, etc.) to ensure that the efficiency gains from private service provision are not outweighed by delays in other government-run services.
Fifthly, there is the important issue of existing tenants who have occupied airport space in the past, who may have to be relocated or compensated.
Lastly, it is important to ensure that the qualification criteria are not too stringent, so as to limit competition in the bidding process. While it might be desirable to attract private entities that have a strong track record in airport management, these criteria may be limited to ensuring that one member of the bidding consortium has prior experience in managing airports.
These issues if not handled effectively before the start of the bidding process could derail the privatization initiative on two counts. First, highly qualified international bidders might choose not to participate in the bidding process, and secondly even if the airport attracts qualified bidders, their ability to improve the efficiency level of airport operations will be hampered..
Successful privatization of these two airports, which account for over 40% of total traffic will also serve the interest of promoting general aviation in the country and will have spill-over effects into other airports. The same privatization model can be applied to other profitable airports, once the four metros are privatized. In the absence of private interest in concession contracts for less viable airports, the government may consider the use of management contracts.

V.2.2 Greenfield Airports

Recently, a Greenfield airport has been promoted at Kochi, by the Government of Kerala in the private sector. The Union government has also accorded in-principle-approval for two new proposed greenfield airports near Hyderabad and Bangalore with majority private sector participation. In a major development, the Union Cabinet in April approved the much-awaited amendments to the Airports Authority of India Act, 1994, which will help to grant independent status to the long-pending Bangalore international airport project.Bangalore International Airport Ltd (BIAL) has reached consensus with the Ministry of Finance,Government of India on the concessional agreement for 30 years. It has agreed to a concessional fee of four percent of total annual revenue, payable from the first year of operation. The government will extend a grace period of 10 years, and the company will pay the fee from the 11th year of operation together with 10 percent of accumulated fees. BIAL can pass on the fee to airport users at any point of time, with the intervention of the government. Lenders on the project have agreed to facilitate financial closure in Nov, and commencement of work in Dec 2003.

The new international airport proposed at Shamshabad, 20 km from Hyderabad, is the other proposed greenfield airport. The airport is a joint venture between the Andhra Pradesh government and the Airports Authority of India (AAI), with each holding 13 per cent equity. A private consortium, led by GMR Vasavi Infrastructure Ltd and Malaysia Airports Holding Berhard, is holding 74 per cent balance.

Recently, the government has decided to review the provision in the National Policy on Airports, 2002, that "no greenfield airport will normally be allowed within an aerial distance of 150 kilometres of an existing airport." Given the difficulties and delays associated with greenfield projects, the paper recommends that the government may focus its efforts on harnessing efficiency gains through better management of existing capacity. It is critical that investment decisions regarding greenfield airports should be based purely on commercial considerations. Accordingly, central and state governments may refrain from extending concessions in general and subsidies in particular to greenfield airports which might impinge on the viability of existing airports. Additionally, greenfield airports that are envisaged to meet social/strategic considerations can be addressed through the proposed Essential Air Services Fund (EASF).

There are many tourist centres in India which can attract a large number of international tourists if they can be easily accessed by chartered flights. The study, therefore, recommends that the Government should actively encourage ventures, including in the private sector, to set up small no-frill airports for catering to the needs of chartered flights. Similarly, ventures should also be encouraged to set up heliports, wherever there is a demand for such services.

V.2.3 Uneconomical Airports

The case for privatisation becomes exceedingly difficult when considering the case for smaller uneconomical airports. These airports are typically loss-making and serve social obligations of providing nation-wide connectivity, rather than presenting profitable investment opportunities. Countries have developed different mechanisms to deal with what is commonly known as "essential air services" in order to provide connectivity services to remote areas that might not be commercially viable, and are unlikely to attract private investment.

In India too, a large number of airports do not generate enough revenue to meet their operational costs and, as a consequence, the AAI is not in a position to upgrade existing small airports or develop new ones. Hence, financial support for the development and maintenance of essential but commercially unviable airports will be necessary for some time to ensure adequate air connectivity throughout the country. In this context, the Ministry of Civil Aviation should develop objective and transparent criteria for selecting airports that need to be provided with financial support.

In order to improve the efficiency of operations at selected essential but commercially unviable airports, the government can award them to the private sector using minimum subsidy bidding either through a one-time capital grant or annual. payment Funding for such a subsidy programme can be met through the proposed Essential Air Services Fund (EASF)

VI.Regulatory Issues

VI.1 Economic Regulation

Given the potential for abuse of monopoly power in airport activities, the airport operations should be kept under the purview of an independent economic regulator.

One of the areas that is most vulnerable to monopolistic behavior is the setting of overall airport charges.Airport charges are defined as charges levied on aircraft operators in connection with the landing,parking or take-off activities and charges levied on airport passengers Here the most common tool for regulating monopoly power is price regulation. In the past, most countries followed ICAO and IATA guidelines and essentially had similar pricing structures based on a landing fee calculated according to aircraft weight and a departure fee for passengers. However, with increased private participation, this uniformity is likely to come under pressure, as airports look to increase efficiency in pricing. A good example of price regulation is prevalent in the U.K. and Australia, where they have adopted a form of multi-year price-cap regulation, known as RPI-X regulation[7] which is applied to revenues from airport charges. The price cap is a weighted tariff basket of annual changes in prices for aeronautical charges. The cap requires that the prices for these services should rise by no more than RPI-X, where RPI is the Retail Price Index (RPI)[8] and a factor X, which is determined for a fixed period of time, say five years after which the level of X is re-examined. This form of regulation provides a strong incentive for airport operators to reduce costs and has proved to be an effective method of regulation provided it is coupled with extensive monitoring of service quality standards.

Further, to ensure that the operator is not abusing its monopoly power in other airport activities, the regulator can apply the principle of "single-till" regulation. This method involves calculating the appropriate level of airport charges for an operator, by deducting revenues generated by the operator through commercial activities. The single-till method has been applied both in the U.K. and Australia. However, there is an important concern that remains unaddressed in this method, namely, an opportunity to the operators for cross-subsidization or "price gouging" in some commercial services.

Since, unlike most other regulated businesses airport operators often derive a significant portion of their revenue from other commercial services (see Table VIII below), which include ground handling services and airport retail and rental services, it is important to enhance competition in these areas.

Table VIII : Revenues of London Airports (Figures in Million Pound Sterling)
2001-02 Percent

	2001-02	**%**
Airport charges	531	39%
Other operational Activities	794	58%
Non-operational activities	39	2%

[7] The RPI-X regulation has formalised regulatory lag to give companies incentive to operate efficiently in the interval between reviews. The idea is that a private operator is required to keep the increase in its prices to less than the increase in a specified price index, so that prices decline by X percent a year in real terms.

[8] In India, a comparative measure would be the Consumer Price Index (CPI)

Notes: Airport charges include runways, taxiways, airfield supervision and emergency services. Other operational activities relate to refuelling hydrants, electricity, retail (commercial) property management, check-in, baggage claim, car parks, etc. Non-operational activities predominantly comprise advertising.

Source: "Report on the Economic Regulation of the London Airport Companies", BAA plc, October 2002.

There are two ways to increase competition in these commercial activities.
One approach, currently being considered in the U.K., would be to adopt dual till regulation. This approach allows for separate regulation of airport activities and other operational (i.e., commercial) activities and therefore prevents the operator from cross-subsidising or abusing its monopoly power in both areas. Alternatively, another method would be to provide effective competition by (a) requiring the operator to issue multiple concessions in commercial services; or (b) mandating free entry into these services where possible. This provision, while ensuring that the operator is not granted exclusivity over these services, is likely have a direct impact on the price that the operator is willing to pay for the concession and should be clearly specified before the bidding process is initiated.
Going forward, given the increasing level of privatization, it is recommended that the responsibility for ensuring the appropriate level of regulation be vested with an independent Aviation Economic Regulatory Authority (AERA) .
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Another area of airport operations that requires regulation is the allocation of slots for airlines(as discussed earlier). While slot allocation is carried out differently across countries, the key is to ensure that the dominant airline, typically the national or incumbent airline does not hold undue sway over the process and hoard otherwise under-utilized slots(level playing field must be exercised). The introduction of a profit-maximizing airport operator, as is the case that is being proposed in India, will have strong incentive to extract the maximum revenue possible from each take-off and landing, and will use careful price discrimination between different carriers and routes. However, care needs to be taken to ensure that smaller carriers are not excluded from airport slots and that there is a transparent mechanism for slot allocation and the pricing mechanism for slots prevents hoarding by dominant operators.
Deregulation and autonomy is needed in fares charged by the airline operators and in deciding about the number of aircraft seats .Also, the operators should decide about when, who and to whom to provide their services.

VI.2 Safety Regulation

The role of the regulator in ensuring safety standards broadly consists of two key elements. First, private operators have to adhere to safety and quality standards laid down by the regulator, which needs to be monitored stringently. Secondly, in order to reduce impact on passengers, safety procedures should be streamlined effectively with passenger services to ensure efficient functioning of airports. The DGCA has traditionally been responsible for the implementation and monitoring of stipulated standards regarding the safety of airport and aircraft operations, licensing of personnel and civil airports and it is recommended that this should continue

VII.SUMMARY AND CONCLUSIONS

We work out the efficiency index of the Delhi Airport using monthly data(March 2000 through July 2004) of international and total traffic of aircraft's, passengers & cargo

movements . The study compares the Delhi Airport technical efficiency index with the efficiency indexes of some selected domestic airports of India in 2000-01.The study uses data envelopment analysis for working out the technical efficiency using data on aircraft movements(output of the airport) and passenger movements and cargo traffic(both inputs to aircraft movements) .The airport production frontier at each point in time is constructed using deterministic, nonparametric (mathematical programming) methods (essentially, finding the smallest convex cone enveloping the data) and efficiency is measured as the (output-based) distance from the frontier.

We find technical efficiency scores are higher based on time series evidence while they are quite low if we use cross sectional evidence of some selected domestic airports.The latter evidence favours privatization of the Delhi Airport.

We study the impact of foreign direct investment/index of production, reserves/index of production, trade openness/index of production and terrorist attack on September 2001 on Twin Towers on the efficiency index of the Delhi International airport.While the first three variables have no significant impact on the efficiency index ,the terrorist act on September 2001 had a significant detrimental impact on passenger traffic and efficiency of the Delhi International Airport. However, Aircraft movements is significantly impacted by Foreign Investment/Index of Production(FI/IP) ,Reserves/Index of Production(R/IP) and dummy variable(D) of terrorist attack.The above results show that foreign direct investment and foreign exchange reserves could be used to upgrade air navigation system so that the Delhi Airport can have larger movements of aircraft's originating from Delhi International Airport.This could bring more revenues for the airport.Thus in particular the airports could utilize funds for the use of satellite technology like CNS/ATM(Communications,Navigation,Surveillance/Air Traffic Management),opening of polar routes and adoption of reduced vertical separation minima(RVSM).The regression results also confirm that efficiency has more to do with efficient management and corporatization of airports rather than funding alone.The Airport Authority of India need to inculcate the spirit of professionalization in their day to day operations.
The study also discusses various models of privatization and examines the benefits and costs of each one of them and also gives framework of an efficient regulatory framework for the Airports in India.Given the limitations in India's airport infrastructure, a more suitable method of privatization at the Delhi and other airports in India would seem to be the introduction of "competition for the market" in airport services, where an existing airport is given on a concession(long term lease), through a competitive bidding process(as is done for Delhi ,Mumbai,Kolkata and Chennai airports). However, this essentially represents a case of a public monopoly being turned over to the private sector, and regulation is important to ensure that the private sector does not gouge airlines and passengers .A good example of price regulation is prevalent in the U.K. and Australia, where they have adopted a form of multi-year price-cap regulation, known as RPI-X regulation which is applied to revenues from airport charges. The price cap is a weighted tariff basket of annual changes in prices for aeronautical charges. The cap requires that the prices for these services should rise by no more than RPI-X, where RPI is the Retail Price Index (RPI) and a factor X, which is determined for a fixed period of time, say five

years after which the level of X is re-examined. This form of regulation provides a strong incentive for airport operators to reduce costs and has proved to be an effective method of regulation provided it is coupled with extensive monitoring of service quality standards.Further, to ensure that the operator is not abusing its monopoly power in other airport activities, the regulator can apply the principle of "single-till" regulation. This method involves calculating the appropriate level of airport charges for an operator, by deducting revenues generated by the operator through commercial activities. Given the potential for abuse of monopoly power in the Delhi international airport activities, the airport operations should be kept under the purview of an independent regulator. We identify some policies for setting overall airport charges and safety regulations in the face of private participation.

There are important factors like connecting Metro Railways(recently introduced in Delhi) with the airport, which is likely to have significant impact on the efficiency of the Delhi airports.This factor is not included in the present study due to paucity of time.It can be taken by researchers in future.

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Appendix Table I:International Traffic Originating from Delhi International Airport from March2000 through July 2004

International Traffic	Passengers(numbers)-INPUT	CARGO(TONNES) IMPUT	Aircraft Movements(numbers) OUTPUT
Mar-00	343946	15096	2357
Apr-00	321012	15891	2318
May-00	285966	15844	2348
Jun-00	291307	14948	2243
Jul-00	316529	14572	2379
Aug-00	315580	14305	2411
Sep-00	305454	14956	2452
Oct-00	285161	14038	2258
Nov-00	347602	13656	2352
Dec-00	340941	14044	2469
Jan-01	357897	11426	2338
Feb-01	356993	13054	2372
Mar-01	367369	15605	2583
Apr-01	336327	14725	2572
May-01	294137	13345	2562

Jun-01	294526	13358	2436
Jul-01	431389	13542	2476
Aug-01	331522	13954	2462
Sep-01	285161	14038	2258
Oct-01	274891	14520	2226
Nov-01	293425	12876	2175
Dec-01	332155	14332	2251
Jan-02	303573	13081	2129
Feb-02	306916	13567	2087
Mar-02	343800	16671	2392
Apr-02	293179	15788	2263
May-02	288285	16660	2314
Jun-02	293179	15788	2263
Jul-02	409395	16925	2319
Aug-02	287510	17237	2312
Sep-02	282192	17160	2209
Oct-02	318634	17546	2329
Nov-02	341406	15788	2386
Dec-02	359373	16136	2464
Jan-03	374365	14457	2417
Feb-03	346619	15864	2257
Mar-03	374564	17672	2641
Jul-03	337098	16906	2473
Mar-04	418500	20041	2987
Jul-04	376208	18890	3016

Source:Airport Authority of India Traffic News(various months)

Appendix Table II:Total Traffic Originating from Delhi International Airport from March2000 through July 2004

	Passengers(numbers) INPUT	CARGO(TONNES)INPUT	Aircraft Movements(numbers) OUTPUT
Mar-00	750069	20730	6867
Apr-00	731158	20922	6788
May-00	726955	21224	6975
Jun-00	701300	20055	6721
Jul-00	694563	19821	6603
Aug-00	685365	19364	6600
Sep-00	675132	19987	6681
Oct-00	759053	19955	6921
Nov-00	802765	18390	6835
Dec-00	814150	19602	7054
Jan-01	796866	16436	6693

Feb-01	761491	18268	6572
Mar-01	784962	21012	7144
Apr-01	736167	19142	6998
May-01	736120	18345	7193
Jun-01	714335	18578	7021
Jul-01	727670	19020	7253
Aug-01	714338	19305	7148
Sep-01	651277	19327	7020
Oct-01	633469	19567	6903
Nov-01	686388	18191	6924
Dec-01	784282	20512	7509
Jan-02	696609	18611	7439
Feb-02	685489	19197	7135
Mar-02	733065	23254	7870
Apr-02	679406	21366	7715
May-02	732352	22953	8106
Jun-02	679406	21366	7715
Jul-02	664849	23964	7634
Aug-02	699491	24165	7598
Sep-02	690929	24099	7438
Oct-02	785330	24041	7708
Nov-02	818395	19097	7909
Dec-02	889942	23246	8348
Jan-03	838343	21122	7527
Feb-03	802041	21781	7615
Mar-03	812149	24134	8333
Jul-03	800317	25114	8434
Mar-04	980395	28417	9792
Jul-04	956009	27604	9654

Source:Airport Authority of India Traffic News(various months)