Performance evaluation of Indian air routes

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Abstract. India is witnessing a massive growth in the aviation industry. In 2016, the
Government of India had launched Regional Connectivity Scheme (RCS), also known as
UDAN (Ude Desh ka Aam Naagrik) which translates as ‘let the common citizen of the country
carry’. It aims to make flying affordable for the masses, promote tourism, increase employment
opportunities and promote balanced regional economic growth. The scheme incentivises the
airlines to fly in non-financially viable regional routes. This study employs data envelopment
analysis (DEA) approach to evaluate the performance of 33 domestic air routes of India after
UDAN has launched. The parameters for evaluation of the efficiency have been established
using the literature survey and pilot studies. Four input variables (air distance between airports,
VGF (Viability Gap Funding) sought, maximum airfare, the capacity of routes) and one output
variable (load factor) are selected for the analysis. The results of DEA model demonstrate that
eight routes are relatively efficient operationally. This performance analysis can be used to
assess the management actions and strategies in developing more effective decision making for
satisfying the objectives of the owners or operators of airports.

1. Introduction
India is currently the third-largest domestic civil aviation market in the world. India is expected to
overtake UK to become the third-largest air passenger market by 2024 [1]. Major improvements in
technology, the continued growth of low-cost carriers (LCCs) and their increased penetration into
emerging markets have improved air connectivity. Airport Network of India, despite being small in
size, has complex dynamics similar to those of bigger air transportation networks. It represents an
evolving transport infrastructure of a developing nation [2].

UDAN is a regional connectivity scheme introduced by the Government of India to improve and
incentivize the growth of aviation industry in the country. The RCS aims at making regional airports
profitable by attracting airlines to enhance traffic. Instead of making it obligatory for airlines to start
operations at underserved and unserved airports by providing some rebate, the pioneering approach
adopted in RCS is to invite airlines to bid for routes suitable for airline profitability choosing the
number of subsidized seats and number of flights per week, while the government will support them
by providing VGF. A Regional Connectivity Fund (RCF) is created to fund the scheme through a levy
on certain flights. The airline operators will be supported through: (i) concessions by the central
government, state governments and airport operators and (ii) financial support to meet the gap, if any,
between the cost of operations and expected revenues on such routes.
Air transportation in India is mostly concentrated on major routes and airports. Most of the routes either begin or end in major airports. But there is also a need to interconnect our regional airports. Air routes are among the most important elements of civil aviation transport. Airlines’ operations are mainly dependent on the structure and layout of air routes [3]. Since customers, competitors and operating environments differ among air routes, managerial policies and operational plans are best proposed from a route-based perspective by treating each route as a “strategic business unit,” rather than merely employing a whole-company view. Successful operating policy and planning for individual routes depend on thoroughly understanding their performance and economic characteristics [4]. The performance analysis of air routes will assist policymakers and airport management to monitor the network performance against that of other airports.

Numerous studies have adopted DEA in the field of air transportation for performance measurement. They are mainly focused on airports and airline companies, rather than air routes, as DMUs (Decision Making Units). The efficiency of 85 European regional airports via data envelopment analysis and second-stage regressions was studied by [5]. A two-stage Data Envelopment Analysis (DEA) modelling approach was employed by [6] to investigate the effect on airport productive efficiency of two major funding sources used by US airports, namely the Airport Improvement Program (AIP) grants and the Passenger Facility Charges (PFC). Dynamic network DEA models were developed by [7] to investigate PFC-for-AIP funds substitution for US airports. DEA modelling was used to examine the performance of airports under Brazil’s state enterprise for airport infrastructure, Infraero, in 2009 and 2015, three years before and after concessions began to come into effect [8]. Very few studies have taken up the measurement of operational efficiency of air routes as a subject of study. In the Indian context, however, no such research exists focusing on reviewing the operational performance of the air routes.

2. Methodology

The performance of 33 Indian air routes which have commenced with the advent of RCS-UDAN is analysed in this study. Table 1 shows the air routes which are chosen for analysis. Data Envelopment Analysis (DEA) is a well-established tool that uses linear programming for performance measurement. DEA uses a non-parametric approach that can accommodate multiple outputs and inputs at a time with varying units—one of the major advantages of its use. Various researchers suggest different thumb rules in arriving at the appropriate number of DMUs. According to [9], a good rule of thumb is shown in equation (1):

\[ N \geq \max \{ m_s, 3(m+s) \} \]

(1)

where, \( m \) is the number of inputs, \( s \) is the number of outputs and \( N \) is the number of DMUs. This condition has specifically been taken care of in this study to enhance the discriminating power of DEA. The authors have chosen the input-oriented approach using a constant return to scale (CRS) model. For each DMU, the input-oriented and constant returns to scale (CRS) DEA model can be expressed as in equation (2):

\[ \max (u'y_k/v'x_k), \]
\[ \text{s.t. } (u'y_j/v'x_j) \leq 1, \ j = 1, 2, \ldots, n, \]
\[ u, v \geq 0, \]

(2)

where, \( x_k \) and \( y_k \) represent the input and output vectors of the evaluating \( k^{th} \) DMU; \( v \) and \( u \) are their weight vectors, respectively.
Table 1. Air routes chosen for analysis

| Air routes            | Airlines         | Air distance between airports (km) |
|-----------------------|------------------|-----------------------------------|
| Bhatinda-Delhi        | Alliance Air     | 291                               |
| Shimla-Delhi          | Air Deccan       | 313                               |
| Agra-Jaipur           | Alliance Air     | 215                               |
| Bikaner-Delhi         | Alliance Air     | 404                               |
| Gwalior-Delhi         | Alliance Air     | 278                               |
| Gwalior-Indore        | Alliance Air     | 519                               |
| Kadapa-Hyderabad      | Air Odisha       | 304                               |
| Kadapa-Chennai        | TruJet           | 260                               |
| Kadapa-Vijayawada     | TruJet & Air Odisha | 346                           |
| Ludhiana-Delhi        | Alliance Air     | 346                               |
| Nanded-Mumbai         | TruJet           | 480                               |
| Nanded-Hyderabad      | TruJet           | 246                               |
| Pathankot-Delhi       | Alliance Air     | 515                               |
| Vidyaganagar-Hyderabad| TruJet           | 306                               |
| Vidyaganagar-Bengaluru| TruJet           | 280                               |
| Bhavnagar-Ahmedabad   | Air Odisha       | 154                               |
| Diu-Ahmedabad         | Air Odisha       | 322                               |
| Jamnagar-Ahmedabad    | Air Odisha       | 272                               |
| Adampur-Delhi         | SpiceJet         | 441                               |
| Kandla-Mumbai         | SpiceJet         | 533                               |
| Kanpur-Delhi          | SpiceJet         | 487.3                             |
| Mundra-Ahmedabad      | Air Odisha       | 294                               |
| Porbandar-Mumbai      | SpiceJet         | 441                               |
| Jagdalpur-Raipur      | Air Odisha       | 245                               |
| Jagdalpur-Vishakhapatnam | Air Odisha     | 202                               |
| Jaisalmar-Jaipur      | SpiceJet         | 511                               |
| Jalgaon-Mumbai        | Air Deccan       | 404                               |
| Kolhapur-Mumbai       | Air Deccan       | 319                               |
| Mysore-Chennai        | TruJet           | 428                               |
| Ozar Nasik-Mumbai     | Air Deccan       | 185.5                             |
| Ozar Nasik-Pune       | Air Deccan       | 172                               |
| Salem-Chennai         | TruJet           | 335.6                             |
| Hyderabad-Pondicherry | SpiceJet         | 678                               |

This study uses four inputs and one output listed below:

Inputs:

a) Air distance between airports: It is the distance travelled by airlines during the flight. It is measured in kilometres. The data for air distance was calculated using the haversine formula which estimates the distance between 2 points on earth using coordinates (latitudes and longitudes). The haversine formula as shown in equation (3) is given as follows:

\[
a = \sin^2\left(\frac{\Delta \varphi}{2}\right) + \cos \varphi_1 \cdot \cos \varphi_2 \cdot \sin^2\left(\frac{\Delta \lambda}{2}\right)
\]

\[
c = 2 \cdot \tan^{-1}\left(\sqrt{a}, \sqrt{1-a}\right)
\]

\[
d = R \cdot c
\]

(3)
where, $\phi_1$ and $\phi_2$ are latitude of point 1 and 2 respectively (in radians), $\lambda_1$ and $\lambda_2$ are longitude of point 1 and 2 respectively (in radians), $R$ is earth’s radius (mean radius = 6,371 km).

b) VGF sought: Viability Gap Funding is the subsidy demanded by the airlines from the government to operate on a particular route. It has arrived after a competitive bidding procedure.

c) Maximum Airfare: It is the maximum price that the airlines have agreed on charging the passengers for the reserved subsidised seats.

d) The capacity of routes: It is the total number of available seats the airlines have in that particular route.

The data on VGF sought, maximum airfare and capacity of routes has been taken from Letter of Award as published on AAI website in RCS UDAN section, https://www.aai.aero/hi/rcs-udan.

Outputs:

a) Load factor: It is defined as the ratio of passengers enplaned plus passengers deplaned plus direct-transit passengers in unit time and capacity of aircraft during the same time. This is the foremost basic output that an airport strives to maximise. The data for actual passengers was taken from the DGCA (Directorate General of Civil Aviation) website, Domestic City Pair Traffic.

Under the UDAN scheme, various routes got operationalised at various times starting from March 2017. The data collected is from March 2017 to February 2019. The data has been collected for 33 sample Indian air routes from the Airports Authority of India (AAI) website for the UDAN phase.

Table 2 shows the descriptive statistics of the variables in consideration.

| Descriptive Statistics | Air distance between airports (km) | VGF sought (Rs) | Maximum Airfare (Rs) | Capacity of routes (No. of seats) | Load Factor |
|------------------------|------------------------------------|-----------------|----------------------|----------------------------------|-------------|
| Mean                   | 349.32                             | 2788.24         | 1973.33              | 45920.85                        | 0.49        |
| Standard Deviation     | 123.04                             | 1436.44         | 400.06               | 29876.34                        | 0.32        |
| Minimum                | 154.00                             | 0.00            | 1070.00              | 10080.00                        | 0.00        |
| Maximum                | 678.00                             | 4880.00         | 3040.00              | 96096.00                        | 0.96        |
| Count                  | 33.00                              | 33.00           | 33.00                | 33.00                           | 33.00       |

3. Results and Discussion

Table 3 shows the efficiency scores for all the selected air routes based solely on the input and output parameters considered in the study. The analysis is done in EMS (Efficiency Measurement System), Version 1.3.

The relative scores represent the position of one air route with respect to others. An air route with a score of 100% is the most efficient one compared to other air routes considered. It does not mean the air route is absolutely efficient and there is no scope of improvement. This air route can serve as a reference point for other air routes which are observed to be less efficient in the analysis. The percentage of air routes which are efficient (efficiency score=100) lies in the range of 25%. The air routes operated by Air Odisha and Air Deccan are showing very low scores compared to their peers.
**Table 3.** DEA Scores for sample air routes

| Air routes          | Airlines       | Efficiency scores (%) |
|---------------------|----------------|-----------------------|
| Bhatinda-Delhi      | Alliance Air   | 98.61                 |
| Shimla-Delhi        | Air Deccan     | 100.00                |
| Agra-Jaipur         | Alliance Air   | 34.41                 |
| Bikaner-Delhi       | Alliance Air   | 72.10                 |
| Gwalior-Delhi       | Alliance Air   | 100.00                |
| Gwalior-Indore      | Alliance Air   | 31.22                 |
| Kadapa-Hyderabad    | Air Odisha     | 78.69                 |
| Kadapa-Chennai      | TrueJet        | 73.94                 |
| Kadapa-Vijayawada   | TrueJet & Air Odisha | 56.50            |
| Ludhiana-Delhi      | Alliance Air   | 69.48                 |
| Nanded-Mumbai       | TrueJet        | 70.09                 |
| Nanded-Hyderabad    | TrueJet        | 100.00                |
| Pathankot-Delhi     | Alliance Air   | 96.65                 |
| Vidyanagar-Hyderabad| TrueJet        | 77.14                 |
| Vidyanagar-Bengaluru| TrueJet       | 90.23                 |
| Bhavnagar-Ahmedabad | Air Odisha     | 10.01                 |
| Diu-Ahmedabad       | Air Odisha     | 0.55                  |
| Jamnagar-Ahmedabad  | Air Odisha     | 0.44                  |
| Adampur-Delhi       | SpiceJet       | 100.00                |
| Kandla-Mumbai       | SpiceJet       | 100.00                |
| Kanpur-Delhi        | SpiceJet       | 100.00                |
| Mundra-Ahmedabad    | Air Odisha     | 30.52                 |
| Porbandar-Mumbai    | SpiceJet       | 100.00                |
| Jagdalpur-Raipur    | Air Odisha     | 16.06                 |
| Jagdalpur-Vishakhapatnam | Air Odisha | 7.86              |
| Jaisalmar-Jaipur    | SpiceJet       | 80.55                 |
| Jalgaon-Mumbai      | Air Deccan     | 26.30                 |
| Kolhapur-Mumbai     | Air Deccan     | 30.29                 |
| Mysore-Chennai      | TrueJet        | 43.22                 |
| Ozar Nasik-Mumbai   | Air Deccan     | 24.25                 |
| Ozar Nasik-Pune     | Air Deccan     | 21.38                 |
| Salem-Chennai       | TrueJet        | 100.00                |
| Hyderabad-Pondicherry| SpiceJet   | 97.18                |

The performance of the airlines can also be obtained based on the average DEA scores. The average DEA scores of the airlines are shown in Table 4.

**Table 4.** Average DEA Scores of airlines

| Airlines   | Average DEA Score |
|------------|-------------------|
| Air Deccan | 0.4044            |
| Air Odisha | 0.2508            |
| Alliance Air | 0.7178        |
| SpiceJet   | 0.9629            |
| TrueJet    | 0.7639            |
From the above table, we can deduce that the best performing airline is SpiceJet with an average DEA of 0.9629. The Airlines performance can be arranged as follows:
SpiceJet > TruJet > Alliance Air > Air Deccan > Air Odisha

The results have been interesting in the sense that airlines like SpiceJet took the least VGF and still performed the best. This can be attributed to their already present operational efficient organisation with bases set at various airports. SpiceJet is one of the most financially profitable airlines in the country. On the other hand, airlines like Air Odisha and Air Deccan have fared poorly. They are relatively new players in the market and they chose the non-profitable routes of UDAN connecting unserved airports. These airlines took the most VGF but still fared poorly. There are other reasons like lack of infrastructure present at the airport allotted to these airlines. These airlines have struggled to raise capital for their operations, hire trained manpower and lease planes, and have slowed down the implementation of the scheme. The services of these airlines had been irregular, often due to lack of trained pilots and when few planes have been grounded due to technical issues. Also, there is a lack of slot provision for RCS routes by the bigger airports like Delhi and Mumbai.

4. Conclusions
This study tries to analyse the efficiency of air routes selected under UDAN scheme. Eight out of 33 air routes were found relatively efficient compared to other air routes. Data Envelopment Analysis in this paper can provide an opportunity for the airport authorities to review the performance of air routes. They can make changes and decisions as required for air routes whose performance has declined. Accepting the fact that market dynamics will change over time, Ministry of Civil Aviation (MoCA) may review the Regional Connectivity Scheme provisions as and when necessary for efficiency in the accomplishment of the objectives.

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