
Race to the Bottom or Swimming Upstream

MITRE



Performance Analysis of US Airlines*

Dipasis Bhadra

In this paper, I offer a data envelopment analysis to evaluate airlines efficiency. Using 22 years' of data (1985-2006), both inter-temporal and peer group efficiency have been measured. Results indicate that airline performance is converging over time. In particular, airlines inter-temporal inefficiency peaked earlier and converged during the later part of the sample. Furthermore, I formulated Tobit regressions to explain the variations in airlines inefficiencies using variables representing structural demand intensity, operational factors and structural cost and revenue indicators. Results from those regressions show that while demand intensity matters less in determining airlines inter-temporal inefficiency, their influence is stronger in determining peer group inefficiency. Block time, a representative of operational factors, tends to negatively impact airlines efficiency by imposing burdens on airline operations. Among the structural cost and revenue

factors, fuel cost tends to affect inter-temporal inefficiency more robustly than it does to peer group efficiency. Labor pay, on the other hand, tends to reduce inefficiency in case of inter-temporal while increasing peer group inefficiency. The events of September 11, 2001 (9/11) have had little or no impact on inter-temporal inefficiency but tended to reduce peer group inefficiency in a significant way. Finally, airlines efficiency tends to be robustly affected by block hours; reducing them increases efficiency. Thus, fundamental changes in the route structures and underlying procedures accompanied with appropriate investments in next-generation technologies are necessary.

*' Paper forthcoming at the [Journal of Air Transport Management](#), 2008.

You (Expect to) Get What You Pay For

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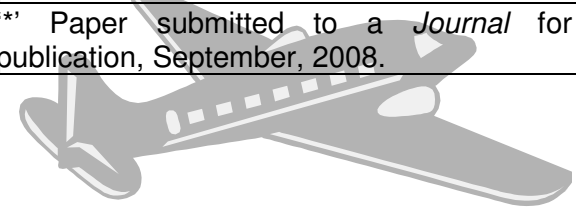
A System Approach to Delays, Fares and Complaints *

Dipasis Bhadra

In this paper, we have laid out an analytical framework that integrates delays, fares and complaints with passenger air travel.

Examining aggregate monthly data for U.S. domestic air travel, we have identified causal relationships among fares, complaints, and levels of delay. An analytical framework is proposed that formalizes these relationships in an integrated manner. This integrated framework is then estimated in a set of simultaneous equations by using 118 months of data from January 1997 to October 2006. We find that complaints are influenced by levels of delays. However, complaints are positively influenced by average yield. These findings lead us to support the central hypothesis that complaints are responsive to levels of delays, but they tend to vary according to fare. That is, air travelers are less likely to complain in return for lower fares, even when faced with the same or even higher levels of delays. These findings have important policy implications, including the passengers' bill of rights and regulator's choice between market and operational performances.

*' Paper submitted to a *Journal* for publication, September, 2008.



Fasten Your Seat Belts: Major Turbulence Ahead

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Analysis of Present Industry Situations in US Air Transportation*

Roger Schaufele** and Dipasis Bhadra

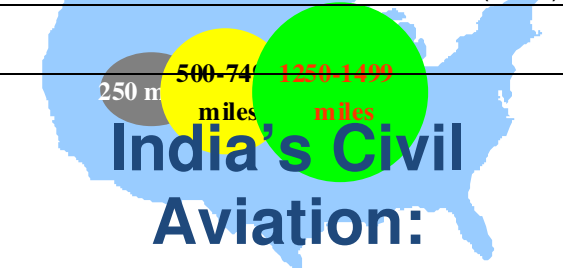
The man who flies an airplane ... must believe in the unseen.— Richard Bach

The unseen may look pretty scary today, living in May 2008! Record fuel price that makes the best of aircraft appear inefficient, a weakening global economy, weak fare environment caused by intense competition, exhausted scope for further cost restructuring, rigid regulatory and institutional environment, and to top it all off, stricter environmental regulations in the horizon. Consequently, airlines industry is in turbulent times. Times like these require imaginative thinking, bold strategies, and rapid actions. As unfolded many times before, the industry demonstrated tremendous resilience; and this time too, we believe it will show once more. This paper provides a brief discussion on the nature of turbulence, outlines major steps that the industry is taking and future prospects, with

a special emphasis on the US airlines industry.

** Paper forthcoming at the [Journal of Airport Management](#), September, 2008.

*** Manager, Statistics and Forecast branch of the FAA's Office of Aviation Plans (APO).



Great Opportunities and Many Challenges Part I: Airport Sector Liberalization

MITRE



Analysis of Civil Aviation in India: Airport Liberalization*

Dipasis Bhadra

India's civil aviation has been experiencing rapid growth in recent years. This remarkable growth, however, is slowing down this year as aviation worldwide faces volatile and increasingly expensive fuel. In

conjunction with economic development and tapping into latent demand, the country's civil aviation has been growing at an average rate of 20% during the past few years. While the low base has allowed this rapid expansion, further growth will require undertaking massive investments in infrastructure, redesigning airspace and improving the overall air traffic management system together with changes in procedures while maintaining strict adherence to the international standards of safety and security. In this paper, I review the country's civil aviation with a special emphasis on airports. In particular, trends in air traffic together with the present status of the infrastructure provide clear insights into the challenges that the country may face in the near term in dealing with airport development.

** Paper forthcoming at the [Journal of Airport Management](#), September, 2008.



Cost at FAA's En Route Centers

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Analysis of Cost at FAA's En Route Centers: An Empirical Perspective*

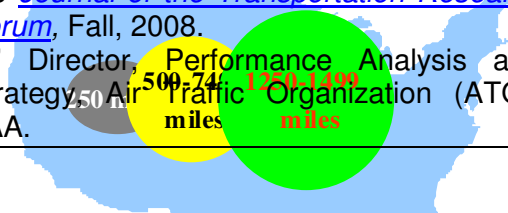
Dipasis Bhadra, David Chin**, Tony Dziepak and Kate Harback

In this paper, we have laid out an empirical framework using economic principles in order to examine the relationships between variable costs and levels of activities at the FAA's en route centers. Using data for three fiscal years and employing time-series pooled cross section econometrics, we have found that the ATO's service provisions in the en route centers enjoy some economies of scale. Furthermore, we have found that while controllers' wage is important, it is not statistically significant in unit cost measured in aircraft flight operation counts. However, it is statistically significant when unit variable cost is measured and estimated in terms of aircraft flight operation hours. We have also found that degree of complexity, a measure of service attributes, does not impact cost. These findings combined with on-going policy discussion on users' fees imply that ATO may be well positioned to implement average cost pricing if cost is to be fully recovered for en route services. The implementation of marginal cost pricing may

require exogenous funding, perhaps from general funds of the US treasury.

** Paper presented at the 7th ATIO/AIAA conference in Belfast, N. Ireland. Conference proceedings, Paper No. AIAA-2007-7850. Revised paper forthcoming at the [Journal of the Transportation Research Forum](#), Fall, 2008.

*** Director, Performance Analysis and Strategy, Air Traffic Organization (ATO), FAA.



India's Civil Aviation: Great Opportunities and Many Challenges

Part II: CNS/ATM, Human Resources and Institutions

MITRE



Analysis of Civil Aviation in India: CNS/ATM, HR and Institutions*

Dipasis Bhadra

India's civil aviation has been experiencing rapid growth recently. In conjunction with economic development and tapping into

latent demand, the country's civil aviation has been growing at an average rate of 20% during the past few years. While the low base has allowed this rapid expansion, further growth will require undertaking massive investments in infrastructure, redesigning airspace and improving the overall air traffic management system together with changes in procedures while maintaining strict adherence to the international standards of safety and security. In this paper, I review the country's civil aviation. In particular, trends in air traffic together with the present status of the infrastructure provide us clear insights into the challenges that the country may face in the near term.

** Paper forthcoming at the [Journal of Airport Management](#), September, 2008.

Route Choice



MITRE



Choice of Route Networks: A Qualitative Model for Over-Land and Over-Water Routes*

Dipasis Bhadra and Brendan Hogan

In this paper, airlines and other users' route choice behaviors in the national airspace

system of the United States have been examined. A binary logit regression model was used to determine the choice of routes by the users employing instrument flight rules. By categorizing routes into two types – over-land and over-water – and using a sample of almost 98,500 observations from the Federal Aviation Administration's Enhanced Traffic Management System, it was found that operational characteristics, such as distance, commercial flights, and altitudes of the flights are critical in determining route choice. Inflationary environment, caused by sectoral jet fuel prices and overall economy-wide prices, leads to the choice of over-water routes. Busier months as well as peakier times of the day lead to the choice of over-water routes. Finally, airspace redesign tends to make over-water routes more attractive vis-à-vis over-land routes.

“**” [Journal of Aircraft](#), 2008. Vol. 45(1), January-February 2008, pp. 56-63.

Core Market Analysis



MITRE CAASD



Structure and Dynamics of the Core US Travel Markets: An Analysis of Domestic Passenger Demand*

Dipasis Bhadra and Jackie Kee

In this paper, we have provided an analysis of fundamental structure and dynamics of the O&D or core air travel markets and passenger demand in the US domestic markets using 1995 – 2006 time series data. The number of markets served demonstrates strong seasonality but this seasonality is not so pronounced in the passenger demand. Despite the industry consolidating its network following the events of 9/11, passenger flows between O&D markets have exhibited strong growth in recent years. When segmented by types of markets, we found that while super-thin markets lost service, other market segments gained service. A majority of passengers use the thick market segment which accounts for only a small portion of the total number of markets and the demand has continued to grow over time. Relatively speaking, much fewer passengers fly between the thin and super-thin markets, but they account for a substantial portion of the total number of markets.

“**” Paper presented at the 29th International Symposium on Forecasting, June, 2007; [Journal of Air Transport Management](#), Vol. 14(2008), pp. 27-39.

Air Traffic Performance Over Time



MITRE CAASD

Air Traffic Performance by Market Segments*

Dipasis Bhadra

How is air traffic performance affected by type and location of markets? Is there any pattern to how air traffic performs with respect to the size and structure of markets, type of networks, and size of aircraft? In this paper, an empirical framework has been developed to examine the determinants of air traffic performance. Air traffic performance is defined as the ratio of airborne time to total ramp-to-ramp time. Using quarterly segment traffic data (i.e., T100 segment of Form 41) for the period 1995-2006, an econometric model is constructed to estimate and evaluate performance measures defined over market segments and networks. This econometric framework establishes and evaluates

empirical linkages between performance measures and size of the markets, locations, distance, seasons of the year, and aircraft type over time. Statistical estimates indicate that size of market, type of aircraft, industry structure, and distance play important roles in influencing performance measures.

“*” *Proceedings of the 4th Annual ATIO/AIAA meeting* (No. 2004-6495), September 20-23, 2004; revised version appeared at the [Journal of the Transportation Research Forum](#), vol. 46(2), 2007, pp. 47-62.

Aviation Forecasts for FAA: Terminal Facilities



Probabilistic Forecasts for Aviation Traffic at FAA's Commercial Terminals*

Dipasis Bhadra and Roger Schaufele**

Forecasting air travel in uncertain times is a challenging task. Airlines are continuously restructuring their cost and network structures reflecting changing fiscal and market realities thus making forecasting at

the airports that much harder. Even if the structure of demand remains unchanged over time, uncertainty rooted in airlines decisions make forecasting at an airport level very difficult, especially in the short run. The combined effects of these uncertainties in addition to the usual errors emanating from estimation of demand prevent deterministic or point forecasts from representing an uncertain future. In this paper, we lay out a framework that takes into account uncertainty for which the nature and sources are unknown. A parametric distribution fitting the past growth rates capture probabilities associated with those outcomes representing the future uncertainty at the airports. Using this process and combining with Monte Carlo simulation, we generate probabilistic forecasts at the top 50 commercial airports of the United States. This paper illustrates the process using Atlanta airport. Probabilistic forecasts provide an important tool for investment and personnel planning in uncertain times.

“*” Paper presented at the *annual meetings of the INFORMS*, Pittsburgh, November 5-8, 2006; and at the 86th *annual meetings of the Transportation Research Board (TRB)* during Jan. 24-27, 2007. [Transportation Research Record: Journal of the Transportation Research Board](#), 2007-2007 issue, pp. 37-46.

“**” Manager, Statistics and Forecast branch of the FAA's Office of Aviation Plans (APO)

Aviation Forecasts for FAA: En Route Facilities

MITRE



Improving Aviation Forecasts for FAA's En Route Facilities*

**Dipasis Bhadra, Brendan Hogan
and
Roger Schaufele****

In this paper, we introduce the technique to forecast flight hours at the Federal Aviation Administration's (FAA's) en route centers. A transfer function approach that models aircraft flight hours at the en route centers as a function of aircraft flight counts, among other things, sits at the core of this process. Furthermore, probabilistic ranges around the base forecasts have been incorporated to enrich forecast fidelity. Using time series data (January 1998 – February 2005) from the enhanced traffic management system, the generalized model structures have been used to produce forecasts for both flight counts and flight hours by service classes and categories of users for the period March 2005 – September 2010. We present both the framework and the resulting forecasts in this paper using Houston Center as an example. The forecasts from this exercise can be used for budgeting and personnel

planning, including formulation of business planning for the en route centers.

“**” An earlier version of the paper was presented by Mr. Schaufele at the 5th ATIO/AIAA Technical Forum, 2005. A revised version has appeared at the *Journal of Air Traffic Control*, April-June, 2006

“***” Manager, Statistics and Forecast branch of the FAA’s Office of Aviation Plans (APO).

Understanding Investment Framework

MITRE



Analysis of System-wide Investment in the National Airspace: A Portfolio Analytical Framework and an Example*

Dipasis Bhadra and Frederick Morser

The United States’ National Airspace System (NAS) contains a network of air transportation markets linking 485 commercial airports located in and around 363 metropolitan statistical areas (MSAs). The total number of origin-destination (O&D) markets in the NAS ranges somewhere between 36,000 – 40,000 pairs

depending upon seasons and economic cycles. This expansive network renders an annual commercial value of around US \$70-\$110 billion for scheduled and around US \$25-40 billion for unscheduled aviation services. Maintaining this network is expensive. The Federal Aviation Administration (FAA) spends over US \$14 billion annually to fund facilities and equipment (P&E: approx. US \$3b), operations (approx. US \$7b), airports (approx. US \$3b), and research and engineering (approx. US \$0.200b) expenditures. The FAA’s NAS modernization program, the impetus behind F&E funding, consists of three elements: the NAS Architecture Plan (i.e., the engineering blueprint); the Capital Investment Plan (CIP); and the Operational Evolution Plan (OEP). The FAA has 6 goals which are the primary focus of their CIP investing strategy: maintain a high level of safety; enhance mobility throughout the NAS; promote economic growth; promote harmony with human and natural environment; attain a high degree of national security; and maintain organizational excellence [see FAA Flight Plans (2005)]. At present, there are 190 identified programs in the CIP, rolled up into 90 investment programs, designed to serve these broad 6 goals. Most of these programs have been evaluated individually using cost-benefit ratio, net present value, and internal rate of return, etc. to determine their effectiveness in meeting the stated goals. The evaluation framework used by the FAA and many other government agencies is fairly limited in incorporating program interdependencies. Consequently, a system wide

comprehensive financial optimization is not possible. This limitation leads us to look into a broader methodology that ties programs with potential economies of scope, and benefit from interdependencies.

In this paper, we have reviewed the FAA’s current program investments and laid out a preliminary analytical framework to undertake projects that may address some of the noted deficiencies. By drawing upon the well developed theories from corporate finance, we offer an analytical framework that can be used for choosing FAA’s investments taking into account risk, expected returns and inherent dependencies across NAS programs. The framework can be expanded into taking multiple assets and realistic values for parameters in drawing an efficient risk-return frontier for the entire FAA investment programs.

“**” A complete version of this paper appeared in the annual proceedings of the 5th ATIO/AIAA Technical Forum, 2005. A revised version is forthcoming at the *Journal of Air Transportation*, Vol. 11, No. 1, 2006; also recipient of the Sorenson Best Paper Award of the JAT, 2006.

Modeling Airline Network

MITRE



Determinant of Network: A Preliminary Analysis of US Air Transportation*

Dipasis Bhadra and Brendan Hogan

How does the air traffic network evolve over time? Is there any pattern to how the air traffic network evolves with respect to the size of the markets, type of competition, geospatial features, and structural changes following the events of 9/11? Are the changes transitory or permanent in nature? Can we lay out the trajectory possibilities of the network and determine factors influencing them?

The National Airspace System (NAS) in the United States is structured primarily around a web of air transportation markets linked to each other through a network of 465 commercial airports located in and around 363 metropolitan statistical areas (MSAs). The total number of origin-destination (O&D) markets in the NAS ranges somewhere between 36,000 – 40,000 pairs depending upon seasons and economic cycles. In its present structure, these markets are hierarchical; a small number of markets accounts for the largest number of

passengers and, hence, air traffic flows. For example, there were approximately 105 markets (0.3% of the total) which had 1,000 or more passengers a day (i.e., thick markets), but these accounted for almost 17% of the total passengers. On the other hand, there were almost 28,000 markets (78% of the total) with 10 or fewer passengers a day that accounted for only 6% of total passengers in 2003. These O&D market pairs have been served, generally speaking, by 52,000-56,000 segments depending upon the extent and intensity of network. In recent years, however, the network segments have increased sizably to an average of 67,000-72,000 segments leading to increased fragmentation [Bhadra and Texter (2004)].

We use a multinomial logit model to analyze and determine itinerary choices in the US scheduled airline industry. Using 10% ticket sample data for the 2nd quarter of 2003, we find that passengers, weighted average fare, average distance and types of air carriers empirically determine the itinerary choices. This simple model captures lower-order itinerary choices (i.e., those with less than 3 stops) fairly well for the sample of almost 360,000 itineraries.

^{*,**} A complete version of this paper appeared in the annual proceedings of the 5th ATIO/AIAA Technical Forum, 2005.

Understanding Aircraft Fleet Mix

MITRE



Choice of Aircraft Fleets in the US NAS: Findings from a Multinomial Logit Analysis*

Dipasis Bhadra

How does passenger demand influence the choice of aircraft? Can we derive the choice of aircraft and fleet mix for origin and destination (O&D) pairs from the knowledge of passengers' demand for scheduled air services? How does this demand affect the overall demand for air traffic services (i.e., en route, and terminal radar approach control (TRACON) facilities), in the short- and medium-term?

The National Airspace System (NAS) in the United States had an inventory of 5156 big jets at the end of December 2002, of which 4085 were narrowbodies, and 1071 can be classified as wide bodies. In addition, there were 1180 regional jets and 660 turboprops in the system at that time. Empirical research reveals that there is a critical link between the flow of scheduled passenger services and the choice of aircraft used by the airlines in any O&D market pair. This relationship can be empirically retrieved without the detailed knowledge of airlines'

behavior and used for analyzing traffic patterns in the NAS. This is a natural *segué* from the econometric modeling of passenger demand [Bhadra (2003)]. Although the demand for scheduled passenger services provides important information, it cannot be directly used to generate demand for air transportation management (ATM) services. Hence, the empirical linkages between demand for scheduled air services and the demand for aircraft fleets by O&D pairs will have to be established. This paper is an attempt to establish the empirical linkage.

The fleet mix in O&D market and segment pairs (i.e., T100 market and T100 segment of Form 41, respectively) are the primary data used for this work. Using the T100 market and segment data from the latter part of the last decade (1995-2002), we build multinomial qualitative choice model, e.g., logit choice model. In this paper, we use two sample periods, 2002: month 3; and 2002: month 6 to demonstrate empirical relationships between aircraft choice and passengers, distance, and types of airports. This framework establishes empirical linkages between aircraft choice, six categories based on all observed equipment types in the system, and passenger flows in addition to distance, and types of airport hubs. Estimated models demonstrate that both passengers and distance play important roles in selecting types of aircraft. Using the estimated coefficients from the qualitative econometric choice model and varying assumptions (i.e., number of passengers in particular), we can easily generate forecasts of aircraft choices for

O&D pairs and the fleet mix. This can, then, be used to derive demand for ATM services and distribution of the TRACON and en route workload.

‘**’ A complete version of this paper appeared in the annual proceedings of the 3rd ATIO/AIAA Technical Forum, 2003. A revised [Journal of the Transportation Research Forum](#), Vol. 44(3), Fall, 2005, pp. 143-162.

Air Transportation and State Economies in the United States

MITRE 

Air Travel by State: Its Determinants and Contributions in the United States*

Dipasis Bhadra and Michael Wells

This paper considers the regional pattern of passenger air travel in the United States, along with its determinants and effects. Passenger demand and the location of airport facilities are shown to be heavily influenced by the location of population and economic activities. This relationship is

empirically examined at the state level. By combining origin and destination data with state-level economic activities, a system of two equations is tested and empirically estimated in order to capture the simultaneous impact of airport infrastructure on economic activity, and economic activity on air travel. As expected, we find that there are benefits to a region of having a large hub airport located within or near its boundaries. These benefits take the form of increased overall productivity, attractiveness to high-tech/high-wage firms, and, of course, the multiplier effects of direct airport and airline employment. The increased state-level economic activity, in turn, increases the passenger demand for air travel in the state. While these conclusions are not new to the existing empirical literature, this work fills an important void that existed between estimation of passenger air travel and levels of economic and demographic activities at the state level. Until now, there has been very little empirical work establishing these links for the state. Furthermore, a system equation approach lends empirical rigor in direction of causality and simultaneity in relationships between aviation infrastructure, economic activity, and demand for passenger air travel.

‘**’ A complete version of this paper appeared in [Public Works Management and Policy](#), Vol. 10(2), October, 2005, pp. 119-137.

Understanding Airline Schedule

MITRE



**Future Air Traffic Timetable Estimator
(FATE)***

**Dipasis Bhadra, Jennifer Gentry,
Brendan Hogan, and Michael Wells**

In this paper, we offer a conceptual and empirical framework to predict future aviation timetables. Future timetables are critical for simulating the national airspace system. In the past, timetables have been derived by iteratively scaling up an observed origin and destination trip distribution matrix to match forecasts of airport terminal operations into individual flights. This allocation mechanism has a few shortcomings. Furthermore, it does not use rich data that are presently available. Using an econometrically estimated demand driven passenger flow model, combined with forecasted values of economic and demographic variables for local metro areas, we derive forecasts for origin and destination passenger flows. Passenger itineraries are then assigned using the existing allocations as a guide for predicting the future network. Aircraft type and the number of operations between airports have been derived by using a multinomial aircraft choice model

that ties enplanements to aircraft choices. Once flight counts have been forecast, we calibrate the model to align with the baseline OAG. Following this calibration, we use the forecasted values of O&D flows to derive the future aviation timetables. The resultant model performs fairly well in predicting future OAG for US airports. Improved aviation timetables are expected to improve the quality of simulation models designed to evaluate safety, performance and efficiency, and policy measures.

‘**’ A complete version of this paper appeared at the [*Journal of Aircraft*](#), vol. 2 (42), pp. 320-328, April, 2005 (0021-8669).

Passenger Demand for Scheduled Air Transportation in Small Communities of the United States

MITRE



**Air Travel in Small Communities:
An Econometric Framework and Results***

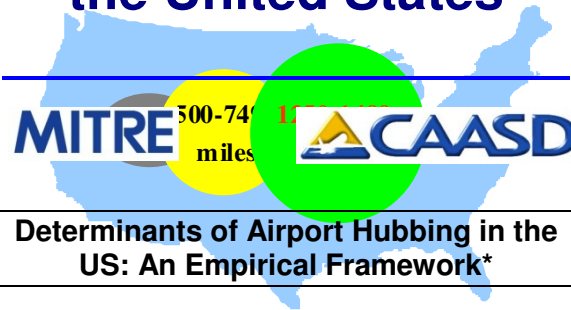
Dipasis Bhadra

In this paper, we examine the relationship between origin and destination (O&D) travel and local area characteristics for small communities. By combining data from Bureau of Transportation Statistics/United States Department of Transportation (BTS/DOT) on O&D travel with that of local area economic and demographic activities supplied by the United States Bureau of Economic Analyses (BEA), Department of Commerce, we specify a semi-log linear demand relationship for O&D travel in small communities. The resultant dataset covering the period 1999-2000 has more than 4700 observations; 2686 for communities without any small hubs, and 2087 for communities with small hubs. Using a weighted least squares method, we estimate demand for air travel, defined by O&D pairs, for smaller communities. Our results indicate that

average fare affects passenger demand negatively for both types of communities. Our results also confirm that local area income affects travel positively in both cases. However, the levels of travel tend to be affected by population differently; origin population affecting traffic negatively for smaller communities without any hub and positively for communities with small hubs. Presence of smaller hubs affects air travel positively; and market concentration of airlines affects O&D travel negatively. We demonstrate in this paper that factors affecting the economic framework are the ultimate factors driving the demand for air travel in the small communities in the long run. We also discuss approaches using our methodology for deriving bottom-up forecasts or projections for the future. These projections have distinct characteristics that may make them more useful for analyzing flow features, such as passenger and aircraft flows by local areas, determining and prioritizing infrastructure investment requirements by local areas, and determining revenue potential from these travels.

“*” A complete version of this paper appeared in the Spring issue of the *Journal of the Transportation Research Forum*, 2004.

Understanding Location of Hubs in the United States



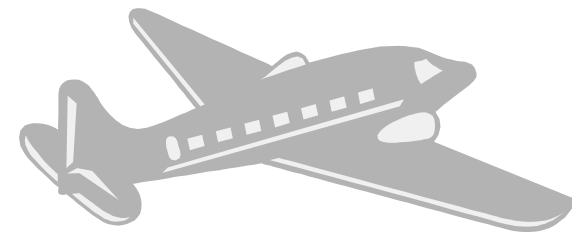
Determinants of Airport Hubbing in the US: An Empirical Framework*

Dipasis Bhadra and David Hechtman

In this paper, we examine the relationship between hub status of airports and their determinants. The factors governing the status of large hubs may not be the same as those determining the status of medium and small hubs. By using a binary logit model, we find that hubbing is more relevant in defining an airport than classifying a broader geographical area, such as metropolitan statistical area (MSA). An MSA containing a large hub and few small and medium hubs may essentially be different even within its sample unit. Local area development may be consistent with balanced economic development supportive of multiple equally important airport nodes than is suggested by presently observed primate structure. Results from our economic choice model defined over airport sample indicate that large hubs are qualitatively different than medium and small hubs. Thus, aviation activities captured in all hub airports as one

continuous variable, e.g., passenger enplanements, may not be appropriate for modeling purposes. An appropriate modeling may require grouping two broad categories of airports, or perhaps three, within the hub airport classifications. This may provide better insights into the traditional modeling techniques for terminal area forecasts (TAF) and similar forecasts. Finally, our model determines an optimal size of the market that is presently served by hub airport. This finding has implications for both airport planning and future investment.

“*” A complete version of this paper appeared in the *Public Works Management and Policy*, Vol. 9, No. 1, July, 2004, pp. 26-50.



Understanding Emergence of New Markets and Impact on Air Traffic Management



Airlines Entry and Exit and the Impact on Air Traffic Management: An Analytical Framework for Zero-Sum and Positive-Sum Outcomes*

Tom Berry, Dipasis Bhadra, Jennifer Gentry, and Gregory Nelson

Passenger airline service can have a significant impact on a metropolitan region's economy in terms of direct spending and employment, as well as on indirect spending related to industries such as tourism and the service sector. In the past decade passenger service levels have changed considerably in many markets due to a wide variety of events including increased competition, terrorism, and a downturn in the economy. Airlines have responded to these challenges in a variety of ways. Some of the traditional network carriers have been forced into bankruptcy in an attempt to reduce their costs and compete more effectively with the low cost carriers.

In contrast, the low cost carriers have expanded service and entered new markets at a rapid pace.

This paper examines the economic evolutionary process whereby a dominant carrier competes intensely in one market against a similar airline and retreats in another where new, lower cost entrant expands service. The relevant literature is examined for evidence pertaining to the market's response to a network carrier's financial distress, its impact on airport service levels, and implications for local economies. A zero sum case is explained using a recent example. A positive sum case is explored, where the positive contributions of the entering carrier exceed those left behind by the resident carrier. In the process, depending on the types of gains and nature of the evolving airlines' network, the patterns of air traffic may also change. Using these experiences, an analytical framework is proposed that attempts to explain the emergent behavior of low cost carriers when they enter new markets. In addition, the impact of these changes on the air traffic management system is also examined.

* A complete version of this paper appeared in the [*Journal of the Transportation Research Forum*](#), October, 2004, pp. 139-158.

Understanding Airline Networks

MITRE



Airline Networks: An Econometric Framework to Analyze Domestic US Air Travel*

Dipasis Bhadra and Pamela Texter

In this paper, we examine the domestic airline network in the United States. Using an exhaustive definition of the airline network and a cross-section pulled time series dataset for 35 consecutive quarters covering 1995:Q1 – 2003:Q3, we have analyzed domestic scheduled air transportation. Results suggest the existence of increased fragmentation of market segments following the events of September 11, 2001. The expansion of Southwest Airlines affects all variants of the network positively, with a proportionately larger impact on the point to point over the hub and spoke variants. The effects of 9/11 have impacted all classes of network, with the largest impact falling on the point to point variant. Results of this study are expected to benefit aviation operations and policy communities alike. Results may also hold useful information for manufacturers with regard to the size and mix of aircraft

fleet that are compatible with the evolving network.

** A complete version of this paper appeared in the [Journal of Transportation and Statistics](#), vol. 7, no. 1, December, 2004, pp. 87-102.

Passenger Demand for Scheduled Air Transportation in the United States

MITRE



Bottom-up Econometric Estimation and Forecasts by Origin-Destination Pair*

Dipasis Bhadra

The National Airspace System (NAS) is constantly evolving, and recent developments indicate the possibility of significant changes in the patterns of use. Low cost carriers are challenging the business models of the major airlines and questions are being raised about the future of current yield management, hubs, schedules, and airport regulations. This dynamic situation complicates attempts to model future NAS operations.

Given this situation, this research focuses on the underlying passenger demand for scheduled air transportation that drives the flight operations we observe in the NAS. A better understanding of the likely response of passenger demand to changes in the NAS is needed improve the quality of operational impact assessments and forecasts.

We ask the following questions:

- ❖ Are there *local conditions*, along with industry characteristics, that can explain observed travel patterns between origin (O) and destination (D) cities?
- ❖ By applying these relationships, can we develop short and medium-term forecasts of flow by O-D city pairs?
- ❖ Can these O-D market traffic flow forecasts help us to better plan future infrastructure and traffic flow management?

Bottom-up Approach

Our analytical framework owes much to the standard economics literature. However, in contrast to the standard top-down approach that begins with gross domestic product (GDP), then estimates revenue passenger miles and finally allocates activity across airports, we are testing a bottom-up approach that estimates O-D passenger demand as a function of the economic, demographic, airport and airline characteristics of the O-D city pair. By explicitly examining O-D markets and incorporating data on connecting

passengers, this approach better captures the network effects that are essential to many studies of the NAS. Summing over these results, we arrive at a national estimate that can be compared to the existing top-down estimates.

To implement this approach, we have merged passenger ticket data by O-D pair from the Bureau of Transportation Statistics (DOT) with local economic and demographic measures supplied by the Bureau of Economic Analysis (DOC). The resulting econometrically estimated relationships can then be combined with forecasts of local area conditions from DRI-WEFA and possible industry and infrastructure scenarios to develop O-D market forecasts.

Applications

Many of the local and O-D market changes of current interest, e.g., hubs, yield management, regional jets, and low-cost competition, which are not clear at the macro level, can be better understood under our bottom-up approach. We gain insights into the drivers of traffic, both passengers and aircraft, by O-D market. This approach can estimate passenger demand responses to many NAS-policy changes and provide long-range studies with projections that incorporate anticipated economic and demographic shifts.

Consequently, we foresee our user community consisting of infrastructure planners, traffic flow managers, and aviation analysts and policy-makers.

^{**} A complete version of this paper appeared at [Journal of Air Transportation](#), Volume 8, number 2, September, 2003, pp. 19-56.

Egypt's Aviation System

MITRE



Egypt's Aviation System:

An Econometric Framework with
Forecasts Outlook*

**Dipasis Bhadra,
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In this paper, we examine Egypt's aviation sector with an aim to develop a quantitative framework that will facilitate developing forecast scenarios. Egypt's tourism is a vibrant sector. Given the geographical location and political situations in neighboring countries, aviation is used as a dominant mode of transportation. Thus, both credit and responsibilities lie with the aviation sector for tourism's development. With an estimated value of US \$2 billion, the aviation sector is expected to grow 2-3 fold over the next 20 years. With 7 principal airports accounting for more than 99% of

the passengers, the country is in need for developing infrastructure, both physical and institutional. While increasing policy moves encouraging privatization through build-own-transfers of airports has become common, the government has expanded its institutional reforms in other areas as well. The Egyptian Civil Aviation Authority (ECAA) has been corporatized by the Presidential decrees nos. 156 and 72 in April, 2001. Four corporate entities have come to existence as the direct results of the Presidential decrees. The Egyptian Airports Company (EAC), the Egyptian Aviation and Navigation Services Company (EANS), the Egyptian Civil Aviation Holding Company (ECAHC), the independent company holding the government equity in EAC and EANS; and the regulatory authority called Egyptian Civil Aviation Supervisory Authority (ECASA) have been formed recently. The present paper is an attempt to provide a context for these important reforms, and to help recently formed companies with forecast scenarios for the sector as a whole.

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China's Aviation System

MITRE



Civil Aviation in China: Background and Forecast Scenarios*

Dipasis Bhadra

The People's Republic of China's (China's) civil aviation is poised to grow to be a considerable size over the next 20 years. Starting from its present base of 133 million passengers, the country will have somewhere between 380 to 623 million passengers in the year 2020. Correspondingly, the number of aircraft movements will increase from its present base of 3.5 million per year to more than 9 million per year. The number of jets that will be available to serve the system is expected to increase three to fourfold over the next 20 years as well. While this growth clearly translates to numerous possibilities for manufacturers, airlines, and the flying public, there will be numerous challenges along the way for the Chinese civil aviation authority. In this paper, we examine the relationship between broad indicators of the Chinese economy and their influences on China's aviation sector. The purpose of this paper is to: (a) provide a broad overview of China's civil aviation sector; (b) assess forecasts of passenger activities at different

airports and in the nation; and (c) provide resulting forecasts of aircraft movements in different airports including across the country, as a whole. We also outline numerous policy implications including that of air traffic modernization challenges that lay ahead for the country.

'*' MITRE working paper.

