Impact of U.S.-EU Open Aviation Area Treaty on U.S. Aviation: A Parametric Analysis with Simulation[1]

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The Open Aviation Area Treaty (OAA) between the European Union (EU) and the United States (U.S.) went into effect on March 30, 2008. Faced with an economic slowdown and unprecedented increase in fuel costs, factors which were uncertain a priori, the projected effects of OAA have been dampened compared to previous projections. In this paper, a framework is offered that combines a parametric approach with uncertainty in demand estimation and forecasts. This framework is then used to generate probabilistic forecasts for U.S.-EU passenger traffic for the period of 2008–2015.

INTRODUCTION

After a series of prolonged negotiations over the years, the European Union (EU) and the United States (U.S.) finally implemented the Open Aviation Area (OAA) treaty on March 30, 2008. The new treaty replaces existing bilateral agreements and provides unlimited, but still cabotaged (or absence of the right to transport passengers within the domestic borders of another country), market access between the U.S. and the enlarged EU with all its 27 members. A second-stage negotiation began within 60 days of implementation of the first stage of the OAA treaty and took place in Slovenia[3] on June 10, 2008. It will be followed by another meeting in Washington D.C., later in 2008. In 2009, all parties (i.e. EU27 and U.S.) are expected to review progress of the second stage negotiation and its implementation. In 2010, any member of the OAA treaty can re-implement some restrictions if tenets of the OAA have not been achieved.

Empirical research has indicated that the passenger volume may increase significantly – over 25 million during the next five years by some estimates, almost 50% above the present 50 million passengers that cross the Atlantic every year. This is indeed very encouraging news for air travel and the resulting economic development. However, it also puts additional pressure on the already constrained airspace system resources on both sides of the Atlantic. In order to plan for better allocation of these resources, one needs to know the magnitude of the expected increased travel, likely new destination airports, and the emerging network. This research is designed to address the potential impact of the U.S.-EU OAA agreement on the magnitude of air travel in the U.S., with explicit attention to uncertainty of air travel and subsequent impact on the network structure of the U.S. National Airspace System (NAS). In particular, the paper addresses three unique issues.

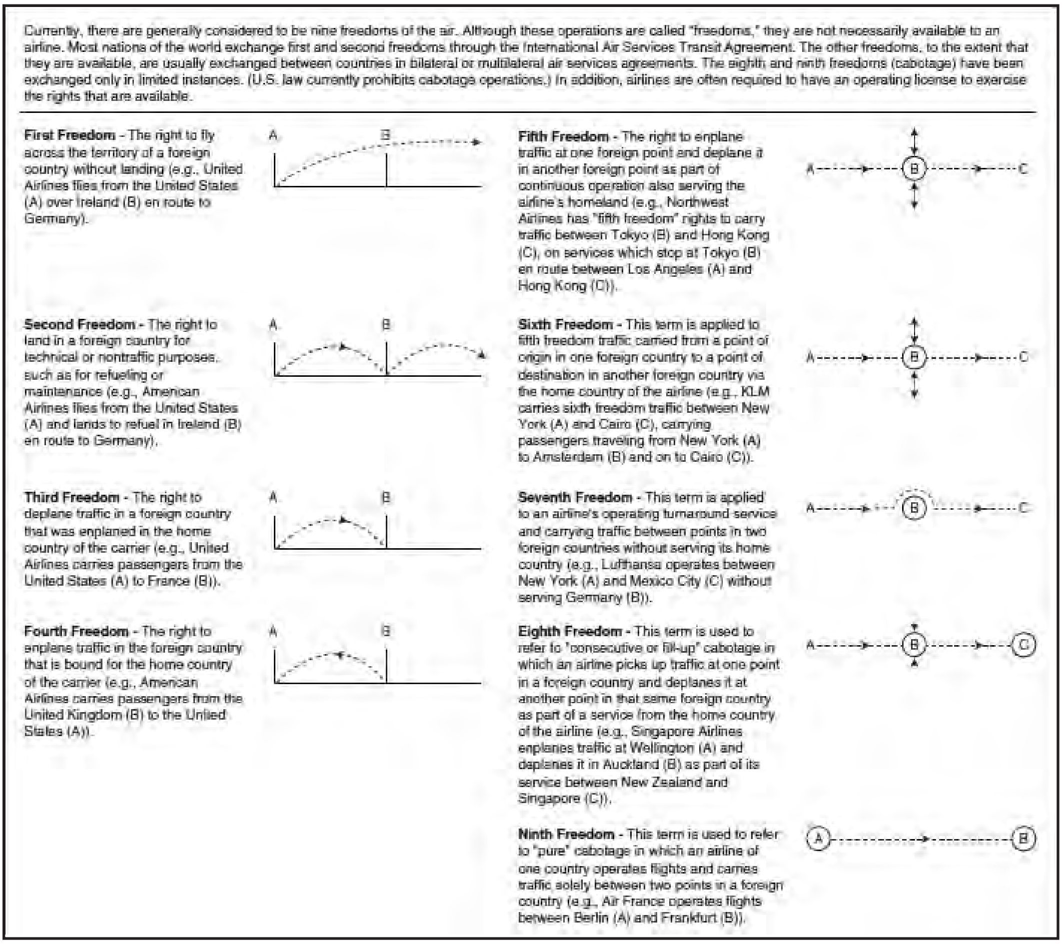
One, develop a bi-directional parametric model that can be used to estimate and forecast passenger flows. Two, given the inherent uncertainty in air travel, a probabilistic framework is introduced that explicitly incorporates features of the parametric model together with uncertainty to benchmark bounds on future passenger travel between the U.S. and selected EU countries. Incorporation of uncertainty in passenger air travel forecasting is somewhat novel and holds promises for flexibility in future planning. Finally, compare and contrast results generated from this model against the available empirical estimates. These comparisons indicate that passenger flows would be somewhat dampened in the immediate future and may not be as robust as indicated by earlier studies.

The paper is structured as follows: in the next section, the types of air freedoms and those particularly availed by the OAA within the broad framework governing international air travel are briefly introduced. Following this, available literature is briefly reviewed with a special focus on empirical evidence. The section after that discusses the framework of OAA and current conditions on both sides of the Atlantic, including the status of international alliances that are expected to play crucial roles in the future. Preceding this discussion, a simple analytical framework is introduced and empirical hypotheses have been derived. Using data from the I-92 immigration cards (collected and published by the U.S. Department of Commerce) that foreign travelers are required to fill in before entering the U.S., this section introduces both the parametric and probabilistic framework. Results are discussed and compared against the available empirical studies and reports. The last section concludes the paper with policy implications and potential future research.

FREEDOMS OF THE AIR

In 1944, several countries of the world entered into multilateral treaties with respect to scheduled international air travel at the Convention on International Civil Aviation[4] (also known as Chicago Convention) that allowed airlines of sovereign countries to enter into each others' territories. Altogether, the treaties provided nine freedom rights, of which the first five are considered officially recognized. Figure 1 illustrates the types of freedom and their implications.

Figure 1: Freedoms of the Air



Source: U.S. Government Accountability Office (GAO) (2004)

With the implementation of the OAA, all the bilateral agreements between the U.S. and individual European countries have been replaced, including the restrictive Bermuda II treaty. Bermuda II was a bilateral agreement in 1977 between the U.S. and the United Kingdom (U.K.)

that was originally signed in 1946. Under the Bermuda II (with the latest revision taking place in 1995), "dual designation" of airlines was agreed upon, under which two U.K. airlines (British Airways and Virgin Atlantic) and two U.S. airlines (United and American Airlines) were assigned as "flag carriers" on the transatlantic routes. Under this treaty, the selected U.S. and U.K. carriers had access to secondary airports beyond the gateways without fifth freedom rights. Under the present OAA, however, the liberalization of the Bermuda II will remove some of the regulatory restrictions, including (Oxera 2007):

a. Removing the "two carriers from each side" stipulation for Heathrow Airport that limits the number of competitors from Heathrow to the U.S. In particular, by enabling free access between Heathrow and the U.S. for British Midland Airline (BMI) and other U.K. carriers, relaxation of the Bermuda II constraints would likely have a substantial benefit for other bilateral agreements, where the U.K. Government's policy of restricting transatlantic flights for foreign carriers has been a hindrance to more liberal agreements.
b. Removing the capacity limitations that currently restrict annual growth to a level of annual "creep." Services in excess of this limit have to be agreed to or upon by both sides.
c. Removing the sum-of-sectors policy, which artificially raises the prices of journeys involving a connecting point by insisting on a match with the sum-of-charges levied on the component sectors.

In addition to removing the remaining constraints under Bermuda II, the broader framework of the OAA aims for expansive liberalization in the first stage (Source: Hasan 2008; see also European Commission 2007) including the following:

- Unlimited third, fourth and fifth freedom rights
- Unlimited code sharing for both sides
- Acceptance of the *community air carrier* concept for EU carriers by the U.S. Any airline that is registered and possesses operational certificate from one member country is also allowed to operate within the greater community, i.e. EU27. The acceptance of this community air carrier has been one of the major demands of the EU in OAA.
- Free pricing, except the limitation that U.S. carriers cannot lead prices (e.g., predatory pricing) on intra-EU routes
- New opportunities for EU airlines to provide aircraft with crew (or wet leasing) to U.S. airlines on international routes
- Access for EU airlines to certain *FLY America* traffic. The *FLY America* law requires U.S. federal employees and their dependents, consultants, contractors, grantees, and others performing U.S. government financed foreign air travel to travel by U.S. flag air carriers.
- EU airlines qualify for antitrust immunity
- Right to limit U.S. investments in EU airlines reciprocally to 25% voting equity
- Guarantees concerning permissible percentage ownership by EU nationals, including possibility to exceed 50% of total equity, also guarantees of fair and expeditious consideration of transactions involving EU investment in U.S. airlines
- Acceptance by U.S. of any EU airline owned or controlled by EU or European Common Aviation Area (ECAA) citizens
- Unilateral acceptance by U.S. of EU ownership and control of any airline in the European Economic Area (EEA), ECAA, and 18 African countries
- Both sides will cooperate in the regulatory sector especially in the sector of security, safety, competition, government subsidies and environment
- Commitment to cooperate in the application of competition regimes to agreements that have an impact on the transatlantic market
- Recognition that government subsidies and support may affect fair and equal opportunity of airlines to compete

In addition to improving the scope of the open aviation area, the OAA is expected to foster the concept of a community air carrier enabling consolidation in the industry and encouraging competition on the majority (75%) of services from London by other European carriers. Removal of these restrictions is expected to rationalize capacity, foster greater competition and provide greater benefit to the economies involved. In the next section, empirical literature is reviewed that provides evidence of the magnitude of these benefits facilitated by the liberalization in air transportation.

LITERATURE REVIEW AND EMPIRICAL EVIDENCE

InterVISTAS-ga[2] (2006) conducted an elaborate study of countries where aviation liberalization has taken place. These five case studies included the U.S.-U.K., Intra-European Union, United Arab Emirates (UAE)-Germany, Australia-New Zealand (Trans-Tasman), and Malaysia-Thailand markets. The overall empirical evidence demonstrated a strong causal link between air service liberalization, traffic growth, and economic development. In each case, InterVISTAS-ga examined the background of the bilateral relationship, the history of traffic growth, and its relationship to benchmark parameters such as gross domestic product (GDP) growth.

In all the cases studied, the analysis found that there was substantial incremental passenger traffic and economic growth after air service agreements between the countries had been liberalized. The magnitude of these benefits depended on the size and development of the economies. For example, the liberalizations from the Bermuda-II agreement, however limited, enhanced carrier choice and led to robust traffic growth. During the years of 1990–2005, traffic between the U.S. and U.K. demonstrated an annual growth of 4.1%. It is noteworthy to mention that Bermuda-II retained strict limits on designations and operations between the U.S. and the two principal U.K. airports, London Heathrow (LHR) and Gatwick (LGW). Furthermore, the historical growth had been slower due to capacity constraints at LHR.

Where the capacity constraints were not so stringent, in intra-European markets for example, liberalization led to a dramatic increase in air travel. The legislation in 1992 that created the Single European Aviation Market between the 12 member states of the European community resulted in 44 million additional passengers, representing an increase of 33%.

The liberalization of Germany-UAE in 1986, on the other hand, led to multiple designations of airports and the lifting of limits on frequencies, capacity, choice of aircraft-type, and schedules. Despite the fact that only a limited number of German airports could be served by UAE air carriers, the liberalization prompted a market expansion of almost 167,000 passengers (approximately a 20% increase compared to no liberalization).

The Australia-New Zealand Open Skies agreement was negotiated in 2000 and became fully effective in 2002. The agreement lifted all earlier restrictions and served as the catalyst for a true open skies agreement. Consequently, Trans-Tasman traffic increased by 1.7 million passengers annually (or 56%) by 2005 compared to traffic in those years without liberalization.

Finally, Malaysia-Thailand's agreement showed similar evidence. Although somewhat restrictive (i.e. Bermuda-II type), several memorandums of understanding relaxed restrictions gradually. Of the total 1.3 million passengers that traveled between Thailand and Malaysia in 2005, 370,000 – market expansion of 37% – can be attributed to the combination of the liberalized air service regime and entry of a new low cost carrier (Air Asia from Malaysia).

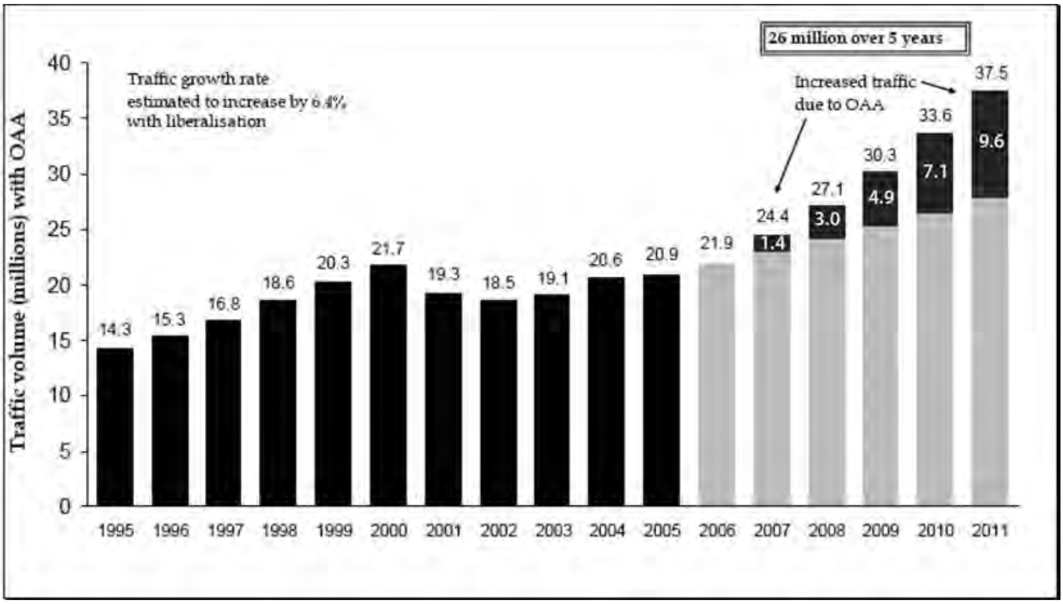
Using these five case studies, InterVISTAS-ga formalized the quantitative relationships between liberalization of air travel regime and the impact on air travel by constructing a time series analysis and cross-sectional analysis of the data from these case histories. While the case histories highlighted recent and dissimilar instances of air service liberalization, the cross-sectional model offered a formal and rigorous framework that can be universally applied. Such a framework can be used for other arbitrary country-pairs with appropriate accounting of individual markets and other attributes. The cross-sectional modeling approach demonstrated that economic fundamentals such as gross domestic product (GDP), the level of trade in services, and geographical variables are by far the most important determinants of traffic between any country-pair. The passenger model, using cross-sectional data, related traffic to the scale of economic activity and the constraints posed by air service agreements. Using 800 country-pair observations, the model quantified the total number of passengers traveling between any country-pair, including those for which no traffic data was available. Since the model included information about the bilateral agreements, it can also estimate the increases in traffic resulting from liberalization. The study used the quantitative estimates to validate the causal findings reported above.

In a similar vein, two earlier reports commissioned by the European Commission, one by the Brattle Group (2002) and the other by Booz Allen Hamilton (2007), found that liberalization on the transatlantic markets will lead to significant positive benefits. The report by the Brattle Group, entitled *An Analysis of the Economic Impacts of an EU-US Open Aviation Area,* projected that the U.S.-EU OAA will result in a drop in fares leading to a surge in air travel. Using estimated relationships between fares and passenger responses (i.e. elasticity) and their lower and upper bounds, the Brattle Group estimated that transatlantic travel would increase by 4.1 million to 11 million passengers a year, representing an increase of 9% to 24% respectively, following the establishment of the OAA. Furthermore, the study suggested that intra-EU travel will observe an additional increase of 13.6 million to 35.7 million passengers a year, an increase of 5% to 14% a year. Aggregating all these benefits (i.e. fare drops, increased market service, passenger air travel), the report estimated that transatlantic OAA would create about $5.2 billion a year in consumer benefits. More than half of these benefits are expected to benefit the transatlantic passengers. In terms of indirect economic benefits, the OAA will increase economic output by $3.6 billion to $8.1 billion a year.

Booz Allen Hamilton's report, entitled *The Economic Impact of an Open Aviation Area between the EU and the US*, was an update of the Brattle study. It found that over 26 million passengers will be added over the next five years (see Figure 2), which can be directly attributed to the OAA. The cargo market will also experience an increase, and transatlantic passengers will be offered numerous new routes. Subsequently, 80,000 new jobs will be created, more or less equally divided between the U.S. and the EU (See Hasan 2008; see also Micco and Serebrisky 2006 for an analysis of the impact of OAA on air cargo).

In its report to the U.S. Congress, entitled *Transatlantic Aviation: Effects of Easing Restrictions on US-European Markets*, the U.S. Government Accountability Office (GAO 2004) observed that U.S. airlines would gain substantial legal access to EU markets if the rights available to both U.S. and EU airlines under the current 15 bilateral agreements were extended to the entire EU (see also Campos and Cosmas 2007). Removal of the nationality clause restrictions would mean that the U.S. would recognize all EU airlines as common "European Community" airlines, i.e. introduction of the community air carrier. Under the community air carrier concept, all EU airlines would gain the right to operate in the U.S. from EU airports irrespective of their home country or operations base status. It is likely that EU-based airlines would be able to move their operations to other EU member states and still be able to provide service to the U.S., a new freedom that was not permitted under earlier bilateral agreements. Clearly, this provides an impetus for EU airlines to merge or consolidate or move an existing base of operations to somewhat cheaper or less congested airports and still have access to the U.S. markets. While this may translate to significant benefits for both the airlines and passengers, it also raises issues about which nation's legal and regulatory system would apply, particularly regarding safety, security, and labor law. Furthermore, the process of shifting operations to relatively cheaper or less congested airports takes time.

Figure 2: Predicted Increase in Traffic Volume (Passengers) Due to OAA



Source: Booz Allen Hamilton (2007)

Consequently, the benefits from the OAA liberalization would be significantly limited by capacity constraints and restrictions at a number of key airports, including London Heathrow, according to the report. In the absence of relaxation on those constraints in the short run, the benefits of the OAA may have greater impact on cargo carriers than on passenger airlines. Unlike the earlier two reports, the GAO indicated that the benefits of the OAA may not be realized for quite a few years and will depend in part on the business strategies that the U.S. and EU airlines choose (see also Jonsson 1991; U.S. DOT 1999).

Not only are these benefits expected to take longer, they may also have diminishing returns over the number of markets served. Button and Taylor (2000) argued that international air transportation is of considerable significance as an input to a rapidly growing international and global economy. However, when a large number of international markets are already served, wider benefits from further liberalization in air transportation will be exhausted. The authors examined some of the benefits that U.S. air transportation enjoys from liberal international air transportation and the potential gains from further liberalization. The authors used standard methods of regression to determine parameters for a non-linear model linking the overall new employment in a region to a set of parameters that included the availability of European air services and their utilization. Europe, in the context of this research, was taken to be the 15 EU nations together with Norway and Switzerland. These 17 nations provided the majority of the transatlantic traffic and a significant business base. Both the range of destinations served and the scale of services offered by airports were used to capture the effects of international air transportation on the economy. The authors found diminishing returns to the local economic base, including the number of onboard passengers and the new economy-wide jobs created. For example, as liberalization of international air transportation increased and EU destinations went up from three to four, the number of onboard passengers increased from about 120,000 to 160,000 and created an additional 2,900 economy-wide jobs in the region. However, as services increased from nine to 10 EU destinations, the number of onboard passengers increased from 250,000 to 270,000 and 955 new jobs created within the economy. When the number of EU destinations rose from 20 to 21, the number of onboard passengers increased from 360,000 to 370,000 and employment rose by only 440 jobs. Clearly, there is a fairly strong link between the number of EU destinations served and the onboard passengers carried, but the increases exhibited diminishing returns. In terms of the U.S.-EU OAA, this means that the benefits of a full liberalization is expected to be limited and depends on the current state of liberalization.

U.S. and European airlines have gone through major changes in their corporate strategies and internal structures in order to adapt to regulatory changes such as the OAA that are designed to create greater competition. Staniland (1996) explored the interactions between international aviation policies and corporate strategies on both sides of the Atlantic. The author argued that in reality, OAAs are subject to two restrictions that impede substantive internationalization; one preventing domestic operation by foreign carriers and the other requiring 75% of the voting stock of a U.S. airline to be owned by U.S. citizens. Given that these restrictions limit the true benefit of OAAs, Button (1998) argued that the U.S. Congress should grant foreign-owned carriers the right to provide domestic air services in the U.S., as well as foreign ownership of majority voting stock. He concluded that further opening the U.S. skies would inject fresh capital and competition into the U.S. aviation market and the consumers will benefit from the lower fares and improved service.

In a paper that evaluated the effects of regulatory reform on performance in air passenger transport, Gonenc and Nicoletti (2000) demonstrated that improving the regulatory environment affects air transportation significantly. An econometric analysis was performed using a cross-sectional analysis of 27 countries in the Organisation for Economic Cooperation and Development (OECD) for 100 major international routes during the 1996-1997 air travel season. Data Envelopment Analysis (DEA) was used to measure the air transport efficiency in OECD countries. The inputs included total personnel, capacity, fleet, fuel, and average stage length, while outputs included total passengers transported and total passenger-kilometers. A production possibilities frontier was constructed by the best performing countries (U.S., U.K. and Japan). Using this framework, Gonenc and Nicoletti (2000) found that deregulation through OAA that enhances competition should increase the number of passengers transported and the number of total passenger-kilometers, as well as reduce airfare. In order to explore the relationship between industry efficiency and the regulatory and market environments, a reduced form multivariate model was estimated on the cross-section of countries. Using these empirical frameworks, the market and regulatory environments were found to have a significant impact on industry efficiency — the more deregulated markets were found to be more competitive and more efficient. Improving efficiency through deregulation will thus lead to lower low-cost carrier discount-fares, while no significant independent effects were found on the network carriers' business and economy fares. This is because, as the authors argued, the increasing role of airline alliances on the route dampens those price effects. In time-sensitive market segments, inefficiencies in the infrastructure related to airport dominance and congestion, as well as government control over route carrier, increased air fares. However, in the case of non time-sensitive market segments, government control can actually improve efficiency in aircraft use and moderate prices.

The effect of the OAA is not limited to only air travel. Button and Drexler (2006) argued that OAA have not only removed restrictions governing rates and fares, market entry, and the ways revenues are allocated, but they have also permitted the emergence of various forms of business alliances. As a result, market expansions have been significant from 1985 to 2000, though disrupted by September 11, 2001 (9/11), but once again an outward shift in the demand is expected. It is important to note that not everyone has gained, because some services have been lost, airlines have gone bankrupt, and fares for some classes of passengers have increased. Overall, there is more variety of services, cheaper flights, and higher employment in the newly created air transportation value chain, and the positive impacts outweigh the negatives.

Goetz and Graham (2004) looked at the linkages between sustainability and liberalization and their implications on policies. The paper argued that setting aside the short-term effects of the post-9/11 crisis, projected growth rates for air transport over 5% per annum (leading to a doubling of air traffic around 2018) are not sustainable. This is due to the realization that infinite mobility is not attainable. The issue of sustainability is viewed more closely in addition to the focus on the effects of liberalization, competition, and the impacts of globalization. The paper further argued that one result of liberalization and privatization is that while air transport is almost entirely a derived demand; its provision is now overrun with the interests of private or quasi-private sector air transportation companies. The policy agenda should, therefore, aim to maintain sustainability by not allowing air traffic to increase at a rate greater than its demand. The paper concludes that the interpretation of liberalization and globalization resulting in excessive air traffic growth and wasteful competition is more plausible than more efficient operation (i.e. an economic outcome). Thus, according to the authors, the U.S.-EU OAA may open the door too wide, resulting in excess traffic.

FRAMEWORK OF OAA AND CURRENT ENVIRONMENT

Enhanced traffic between the EU and the U.S. is likely, as the present OAA replaces all earlier bilateral treaties that the U.S. had with the countries from the EU: Austria (1995), Belgium (1995), Czech Republic (1995), Denmark (1995), Finland (1995), France (2001), Germany (1996), Italy (1998), Luxembourg (1995), Malta (1996), the Netherlands (1993), Poland (2001), Portugal (1999), and Sweden (1995). In addition, the United Kingdom (U.K.) (including Northern Ireland) had a somewhat limited bilateral agreement (i.e. Bermuda II) with the U.S. The 12 countries that are entering into the OAA without prior bilateral treaties with the U.S. are Bulgaria, Cyprus, Estonia, Greece, Hungary, Ireland, Latvia, Lithuania, Romania, Slovakia, Slovenia, and Spain. Figure 3 provides the scope of the OAA in the EU. Countries under the OAA have been marked by black-white-gray colored squares.

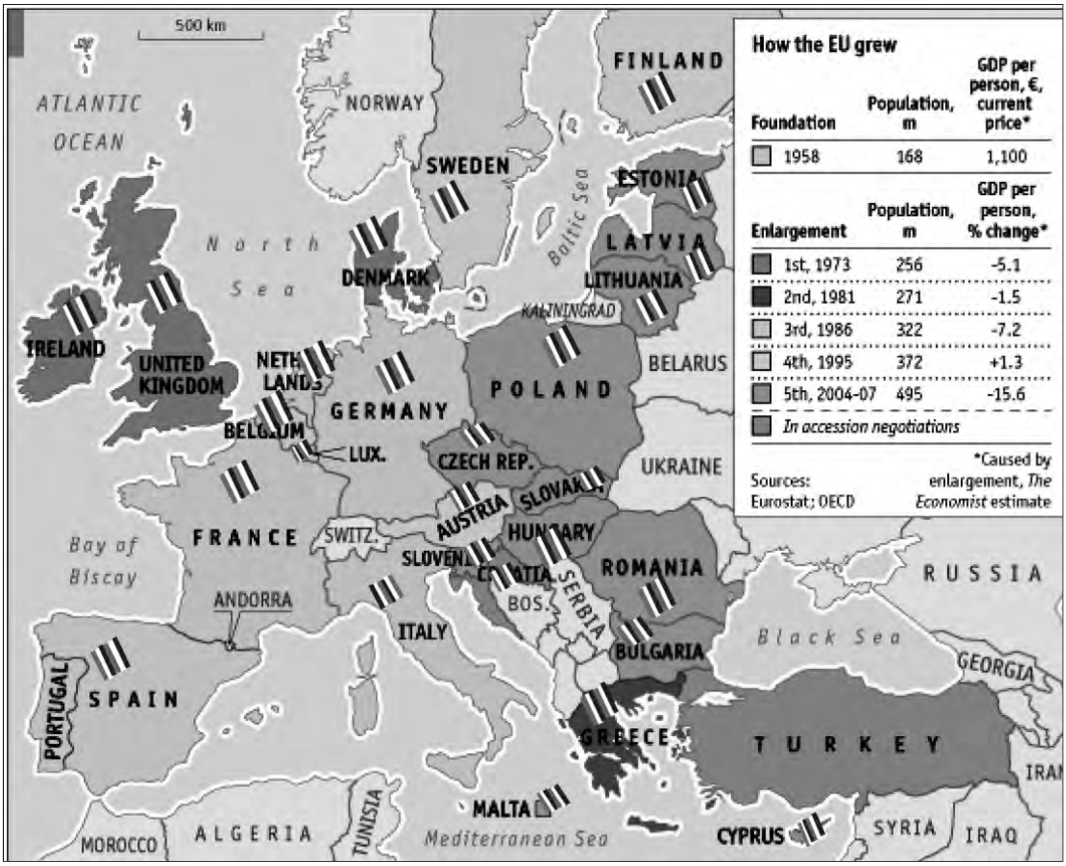
Despite the stricter Bermuda II agreement, the U.S.-U.K. traffic was the largest in 2006. According to I-92 data, the U.S.-U.K. and Northern Ireland flow of traffic accounted for more than a quarter of the total passenger flow between the U.S. and EU. In addition to London's importance in the global economy, Heathrow airport plays a critical role in international hubbing for traffic eastbound to different parts of Asia. Furthermore, London Heathrow is a key transfer point for intra-European traffic. Of those countries that had bilateral treaties with the U.S., France, Germany and the Netherlands have the largest traffic flows after the U.K. Not surprisingly, all these countries are represented by large hubs and dominated by relatively larger airlines: Lufthansa at Frankfurt (FRA) in Germany, Air France-KLM at both Charles de Gaulle (CDG) in France and Amsterdam (AMS) in the Netherlands.

Now that all 27 countries of the EU are contractual parties to the broad OAA, it is anticipated that some restructuring in traffic flow may occur. However, much of this restructuring would depend upon success of the second stage agreement. According to Article Number 21 of the OAA agreement, the second stage negotiations were to begin within 60 days of the implementation of the first stage, i.e. June 1, 2008. Within 18 months of the implementation of the first stage, i.e. October 2009, all parties are expected to review progress of the second stage negotiations. Two particular issues that are keys to successful negotiations of the second stage are ownership rights of the U.S. airlines by EU members (presently capped at 25%) and cabotage within the U.S. In return, the EU is expected to make London Heathrow accessible to those interested in entering into these markets. If the goals of the OAA have not been achieved, the EU can re-implement some restrictions, including postponing the terms. However, such postponement will not occur until September, 2012.[5]

NETWORK OF ALLIANCES

In the evolving world of air travel, U.S.-EU in particular, the network of airline alliances will continue to play an important role. The scale and scope of the markets within the present regulatory framework will be determined, to a large extent, by the strength of the networks. At present, there are three international alliances that facilitate interline air travel in the international markets. These are: Star, One World and Sky Team.[6]

Figure 3: Open Aviation Area Reach in European Union



Based on: The Economist; May 29, 2008, issue.

Table 1: International Airline Alliances: Statistics for 2007

Feature	One World	Sky Team	Star Alliance
Countries	142	149	155
Destinations	692	728	855
Market share	13.5	20.7	23.6
Passengers (million)	319.7	372.9	413
Fleet	2,453	2,081	2,831
Employees	266,426	286,958	351,000
Daily departures	9,190	14,615	16,000+

Source: Tiernan, Rhoades and Waguespack (2008).

The above alliances will continue to play an important role in deepening the benefits of the OAA (InterVISTAS-ga[2] 2007). First and foremost, the EU carriers (either direct or via network alliances) will have complete access to the large markets of the U.S. because of the reciprocity arrangement underlying OAA. While the EU carriers do not have the right of cabotage in the U.S. markets, nor do U.S. carriers in EU member states. It is important to note, however, that the air carriers from the EU countries have been granted unlimited 7th freedom rights for cargo operations. Furthermore, EU carriers will enjoy 7th freedom rights between the U.S. and European Common Aviation Area (ECAA) countries (including Norway, Iceland, Croatia, and Serbia). No such rights have been granted to the U.S. carriers under the OAA agreement. Additional regulatory support from the U.S., e.g., anti-trust immunity to Sky Team partners in May 2008 and likely immunity for One World partners this year or early next year, may further deepen the benefits of OAA via stronger alliance-based U.S.-EU travel. Closer cooperation in aviation security, as a direct result of these strengthening partnerships, may also be forthcoming in the near future (see Toh 1998 for a discussion on the nature of domestic deregulations and rational overflow of those policies into international air travel).

As the restrictive arrangement of Bermuda II fades away, the OAA will likely put British Airways (BA) under tremendous pressure. As noted earlier, London Heathrow is a key destination hub for both eastbound and intra-Europe transition traffic, estimated to be around 70 million passengers a year. Effective implementation of the OAA means that carriers operating North Atlantic services from Heathrow can pick up large numbers of additional traffic. Recently, Continental Airlines bought two peak hour slots at the cost of £50 million each, an indirect evidence of U.S. carriers' interests at London Heathrow. If this competition trend continues, BA is likely to lose business. Analysts at Deutsche Bank calculated that more than £400 million ($780 million) of BA revenue could be at risk, since BA earns more than half of its operating profits from flights crossing the Atlantic (*Economist*, August 3, 2007).

The ultimate goal of the OAA is to create competition. The airline industry, on both sides of the Atlantic, has already started to evolve due to the implementation of the first-phase agreement. Many European carriers are considering setting up operations in cities other than their home base. Furthermore, interest in mergers has grown: recent merger of Delta and Northwest Airlines in the U.S.; the recent acquisition of 19% stake in jetBlue by Lufthansa; Air France-KLM's offer of $300 million to Delta-Northwest; Lufthansa's acquisition of 80% stake at British Midland, an airline with second highest slots (after BA) at London Heathrow; Texas Pacific Group (a giant private-equity firm) interest (together with BA) in a bid for Spain's Iberia; and Air France-KLM's minority stake interest in Alitalia are all evidences that the OAA has intensified the competition in the industry.

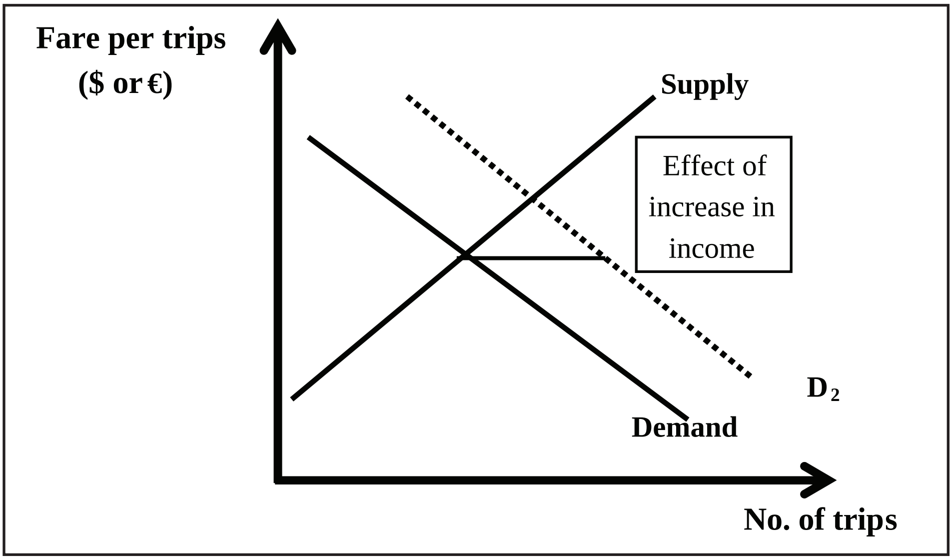
Unlike the mainline air carriers, the competitive response by the LCCs to the OAA is not so clear yet. Ryanair, Europe's biggest low-cost carrier, announced plans on April 12, 2007, to offer flights to Baltimore, Rhode Island and New York for as little as €10 to €12 each way (*Times* Online 2007). Southwest Airlines is also said to be considering going international, while jetBlue, another U.S. low-cost airline, has strengthened its code-sharing with both Lufthansa and Aer Lingus. Like in domestic markets, these LCCs can bring further competition in U.S.-EU markets by offering low fares and a much wider choice of service. Although there are certain advantages of the low-cost model, such as higher utilization rates and in-flight service charges, they are unlikely to work that well on longer haul trips (Hasan 2008).

EMPIRICAL FRAMEWORK AND RESULTS

In this section, a simple generalized analytical framework is offered to capture the empirical drivers for estimating the effect of OAA. Air travelers, like buyers of any other commodities, respond to fare increases by buying less. Hence a typical demand curve is negatively sloped (see InterVISTAS-ga[2] 2007; Gillen et al. 2002 for empirical estimates). On the other hand, as a country progresses and its income improves, it has been observed (see ICAO 1997 for multi-country studies) that travelers prefer to fly rather than using alternative transportation. From the point of view of development economics, this makes sense, as a country's economic development is often synonymous with rising income. As wages increase, the opportunity cost of time increases. Hence, it is likely that travelers would prefer to use aviation, *ceteris paribus*, with rising income (i.e. a shift in demand curve, from

Demand to D_2), as shown in Figure 4. Consequently, air travel, as captured by number of trips, would increase given the same price.

Figure 4: Relationship Between Air Travel and Increasing Income



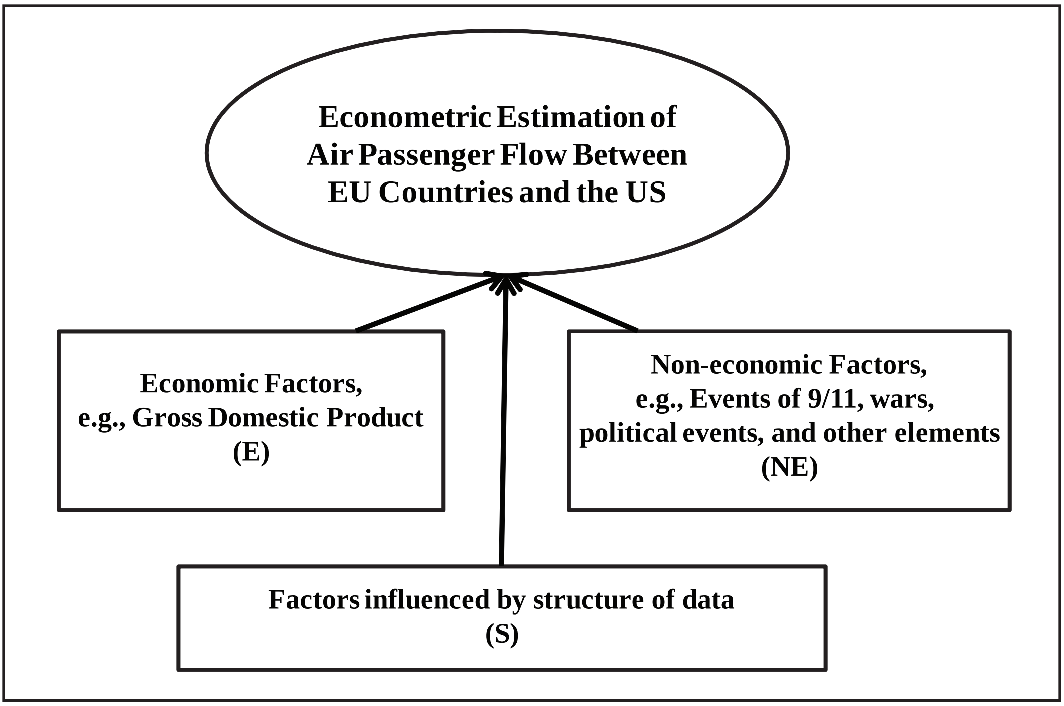
Since all incomes add up to the national income, or GDP (a broader measure for national income), a relationship is hypothesized to exist between aviation demand and GDP. In order to explore the economically plausible relationship between GDP and aviation demand, economists often choose econometric methodology. Trend projections using graphical extrapolations or statistical estimation do not allow one to understand the *causality* between the dependent (e.g., aviation demand) and independent variables (income, other external factors). That is, there is no economic logic underlying trend projections. Thus, trends are incapable of explaining behavior beyond a simple time factor. Econometric methodologies are preferred because they embody: (i) an underlying economic logic or intuition (either deduced from behavior or induced from data) relating the dependent variable with a set of independent variables; (ii) a mathematical formulation of that logic; and (iii) statistical estimation (see ICAO 1997).

It is often the case that economic variables alone cannot explain the demand for aviation. Following the events of 9/11, air travel demand, in particular U.S.-EU travel, has been impacted quite significantly by non-economic factors. A review of historical passenger demand indicates that non-economic factors are important in explaining the "unevenness" or "spikes"[7] that are observed periodically, especially in the short run. This spike is expected to be most pronounced in air travel soon after 9/11. While higher income or rising GDP may explain the rising trend in medium- to long-term aviation demand, non-economic factors are as important in explaining uneven spikes characterizing the short-run demand for air transportation.

Based on these observations, the proposed econometric framework (Figure 5) was expanded to accommodate the following non-economic factors that played crucial roles in affecting U.S.-EU travel:

a. The events of 9/11 and the period afterwards
b. Wars in Afghanistan (2002) and Iraq (2003)

Figure 5: Estimation Framework



Framework for Econometric Estimation

In order to econometrically estimate the above model, the first step is to specify the correct mathematical model. Computational ease and standard properties were the two criteria by which the model was selected.

One model for which both criteria are fulfilled is the standard Cobb-Douglas functional form that can be specified as follows:

(1) $(\text{Number of Passengers})_{ij,t} = a\,(E)_{ij,t}^{\alpha}\quad(E)_{ij,t}^{\beta}$

where i = EU countries[8] (i = 1, 2, …, 14); j = US; t = year

I-92 data for the period of 1991-2006 was used to estimate the model. To save the computational time and to derive standard properties more easily, the model was then log-linearized:

(2) $\log(pax_{ij,t}) = C + \alpha\text{*}\log(\text{GDPindex}) + \beta_1\text{*}\log(\text{realyield}) + \beta_2\text{*bilateral dummy}$
$+ \beta_3\text{*post 9/11 dummy} + \varepsilon_{ij}$

where pax $_{ij,,t}$ = total passengers between the EU (i) and the US (j) in year (t); and C = a constant;

GDPindex is a weighted index of GDP of the U.S. and the countries from the EU. Instead of using GDPs of countries separately, an index of GDPs (U.S. vis-à-vis country from EU) has been constructed. EU countries are relatively smaller in economic size in comparison to the U.S. Thus, the weighting scheme was devised in order to find the appropriate weights of the country's economy, noting the fact that the U.S. economy is overwhelmingly larger than its counterparts in the EU. In order to avoid this bias, an index combining GDP of two countries (U.S. and EU countries) was constructed. In order to construct and assign appropriate weights, nine different weights were defined from the highest weight to the U.S. GDP (0.9) and correspondingly lowest weight (0.1) to the GDP of the EU countries and the vice versa (i.e. with 0.1 weight to the U.S. GDP and 0.9 weight to the EU country's GDP). Based on statistical properties of the estimated model (i.e. Adj. R^2, DW statistic and values and significance of the estimated parameters), values of these weights were then assigned. It is expected that GDPindex will positively impact the dependent variable; thus, it is anticipated that estimated α will have positive value.

Real yield = nominal fare per mile (or, yield) adjusted for inflation (year = 2006) is expected to have a negative impact on the dependent variable; bilateral dummy = a binary variable, noting the period when the U.S. entered into the treaty with the particular country and its lingering impact. We assume that this impact will continue for four years.[9] Thus, Austria will have a value of 1 in 1995 and four years onward, since the U.S. and Austria entered into bilateral treaty in 1995. Post-9/11 dummy = a binary variable to capture the massive transformations that went into effect in the years after 9/11. It is important to recognize that the dummy is set to capture many more effects that are well beyond the events of 9/11/2001. Beginning with 9/11, the airline industry has been experiencing quite a few changes, both external and internal, that have made the period of post 9/11 unique. While the wars in Afghanistan and Iraq are some of those external factors, the post 9/11 years have also experienced a series of internal transformations, e.g., Internet expansion in ticket booking, massive cost-restructuring of U.S. carriers via bankruptcies, mergers, and significant low-cost carrier expansion. In order to capture combined effects of all these factors, the post 9/11 dummy takes a value of 0 until 2001 and 1 afterwards. While many of the events have had negative impacts on international air travel (e.g., wars), some of them have been positive (e.g., cost restructuring), and therefore the sign of this dummy variable is unknown a priori. Finally, log is natural log; ε_{ij} (i.e. error or noise in data) is distributed normally with $\varepsilon_{ij} \sim N(0, \sigma^2)$, i.e. distributed normally with mean = 0 and a constant variance = σ^2; and α, β_1, β_2, and, β_3 are the coefficients that will be estimated from individual equations with anticipated signs discussed earlier.

The log linear format allows derivation of the following relationship, an often referred estimated coefficient in empirical aviation demand literature (i.e. income elasticity):

$$\alpha = \text{elasticity of demand with respect to GDP}$$

$$(3) \qquad = \frac{\%\ \text{change in number of passengers}}{\%\ \text{change in GDP}}$$

Equation 2 is the estimating equation. This equation is estimated for 14 countries separately. These 14 countries form the U.S.-EU travel under bilateral treaties, and therefore have had enough data to evaluate the effects of bilateral agreements on air travel. Estimated parameters from these 14 equations provide, a priori, information about the EU27 as a block and can be used to forecast and simulate the effects of OAA on U.S.-EU air travel.

Estimated Model and the Role of Uncertainty

Uncertainty plays critical roles in demand forecasts (Bhadra and Schaufele 2008), especially under volatile supply situations like the one being experienced currently. Forecasts and associated errors are a product of many elements.[10] First, there are errors that are caused by incorrect specification of relationships and/or capturing perhaps an inexact or implausible relationship through parametric relations. Second, variables that are used to explain the explanatory variables may themselves contain errors. This is particularly true for an economy's GDP. As the economies of the U.S. and EU enter into recessions, GDP forecasts have been modified almost every quarter, thus making use of any particular forecast rather tricky. Third, the estimated parameters from a parametric model themselves may be random in nature. A large body of literature has evolved where distribution of parameter randomness, stability and its impact on forecasts are studied (see Andrews 1993). Fourth, parametric relationships contain implicit error terms. These residuals and their distributions may have critical impact on the nature of the forecasts themselves (for a detailed discussion on these issues, see Bhadra and Schaufele 2008).

Nevertheless, the 14 specified equations with 10 degrees of freedom, once estimated, provide estimates of parameters of equation (2) and the distribution around those parameters. In other words, these estimated parameters and their distribution provide a menu from which to choose future outcomes. These estimated parameters and their distributions embody information that is essential and provides bounds on the possible future values. In order to formalize this relationship, the forecast series are postulated to have come from the following generalized relationship:

Y_{t+1} = [model output combined with opinion and errors], $Y_{t....t-n}$

or,

(4) $= f[\gamma \,;\, Y_{t...t-n}]$

where Y is the annual growth rate series and t-n,….,t,….t+1 represent time periods of the past, present and future, respectively. It is important to note here that the forecasts can be derived either from the growth rates or the levels of the series. In this exposition, growth rates are used. However, the explanation is identical for the discussion on levels of the series.

In reality, the "true γ" linking past to future values nor its distribution are known. However, what is known is that a series of forecasted annual growth rates and distribution around them (i.e. forecasts at each point in time) captures or approximates the true value of γ. Thus, instead of using a single γ, like in structural parametric estimation, forecasts that follow in the discussion below make use of all values defining γ and its distribution, thus leading to a probabilistic forecast as opposed to a single point forecast. This is the point of departure for this paper from a point forecast methodology to probabilistic methodology.

Figure 6: Point Estimate for the Netherlands Using Econometric Model and Uncertainty

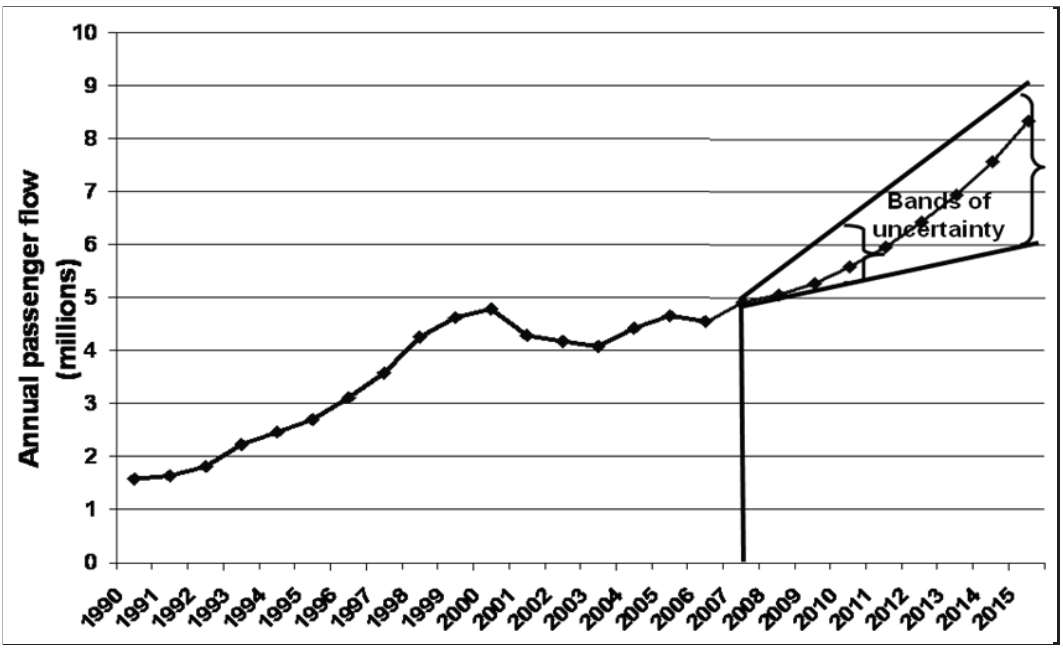


Figure 6 demonstrates the basic difference of the proposed methodology from the standard forecasts using the Netherlands as an example. Combined with pre-determined or forecast values of the exogenous variables, estimated values of equation (2) provide the foundation for benchmark forecasting a U.S.-Netherlands air travel that is represented by the middle line, i.e. point forecasts. Two bands around the point forecast provide the notional bands of uncertainty. Standard confidence intervals, usually set at 90% values and above, are often drawn to mark the boundaries on the benchmark point forecasts. While this approach provides a statistically relevant range (90% and above) of estimated parameters, it does not truly reveal the entire domain of the plausible outcomes. Forecasting in uncertain times requires knowledge of the entire distribution around those estimated parameters, as opposed to only statistically relevant ranges.

In such circumstances, two approaches have been used. In absence of any knowledge of the distribution of γs, one would be inclined to use a non-parametric Bootstrapping method. With this technique, original data (i.e. growth rate or γ) are sampled with replacement to generate possible outcomes. Instead of making any assumptions about the distribution of the data, Bootstrapping allows one to experiment repeatedly through replacement (by drawing k sub-samples from a population of n) so that the underlying distribution of the population can be approximated through sub-sampling as the sample size gets larger. Clearly, if the sub-samples come from the same population distribution, then repeated sampling ought to discover the "true" distribution of γ. Consequently, confidence intervals and other properties of probabilistic outcomes can be easily established.

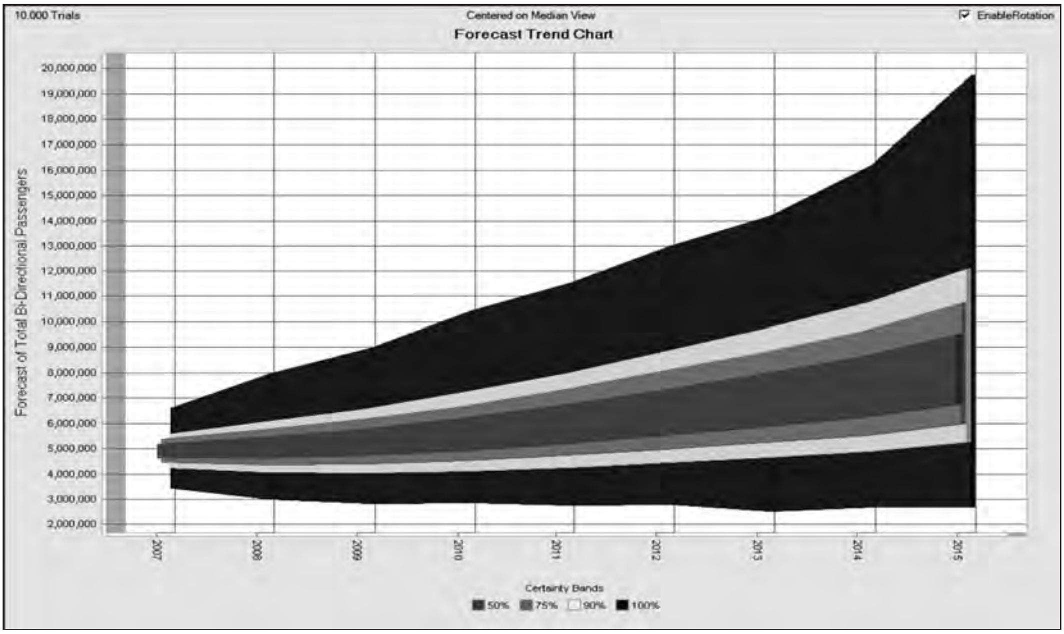
However, Bootstrapping is inappropriate in the approach employed in this paper because of the knowledge of estimated properties of γs from equation (2). Using 14 equations, γs are computed from the estimated equation (2) for each EU country-U.S. pair. Furthermore, every γ is different and is not representative of the same population due to its associated country and time element, even though they all represent annual growth rates. Due to the knowledge of computed γs and their differences across samples, a Monte Carlo (MC) method seems more appropriate for simulating likely possible growth rates, beginning with computed γs and their distributions.

Unlike Bootstrapping, MC is a parametric method where simulation is performed on data that generates possible outcomes by sampling from a theoretical distribution with predefined parameters defining spread, location and distribution of γs, thus making it parametric. The MC is a tool that combines distributions, thus propagating more than summary statistics. Although summary statistics provide useful information, it is clear that combining more than two distributions in an analytic solution is extremely difficult. Therefore, computer simulation using random numbers has become extremely popular with the use of high-speed computers. There are quite a few user-friendly software packages that are available to perform such calculations. Crystal Ball® was used because of its relatively low cost and user friendliness for such applications.

MC has quite a few advantages. Unlike non-parametric estimation that allows a specified functional form to fit the underlying data, and thus yielding no meaningful associated parameters, distributional assumptions under parametric specification, or MC, allow data to be represented most compactly. Parameters defining location, spread, and shape of distributions can summarize the data. Using these parameters, statistical bands, as well as the entire area under the probability density function, can be identified by increasing the number of simulations; that is, the higher the number of simulations, the denser the area under the distribution curves. Second, parametric assumptions also allow data to be generated outside the range of historically observed data. This may embody useful information, especially when simulated results use "extreme events" (i.e. outside the observed data range). In times of great uncertainty and acknowledging that extreme events do impact demand forecasts (e.g., 9/11; wars; high fuel prices), this is a useful property. Third, distributional assumptions smooth out the jagged edges of raw data. This smoothing represents, in most circumstances, the nature of continuity in a physical system, including the expansion and contraction of traffic at an airport over a long period of time. Finally, distributional assumption and its use may also shed some light on the underlying model structure and any systematic bias (Bhadra and Schaufele 2008 for more details).

Given the estimated properties of γs, the choice of parametric distributions is pre-determined. Crystal Ball® software is used for both identifying and measuring the goodness of fit. In Figure 7, results of MC simulations using estimated γs and their entire distribution have been reported. The Netherlands is used as an example.[11]

Figure 7: Simulation Using Point Estimate for the Netherlands

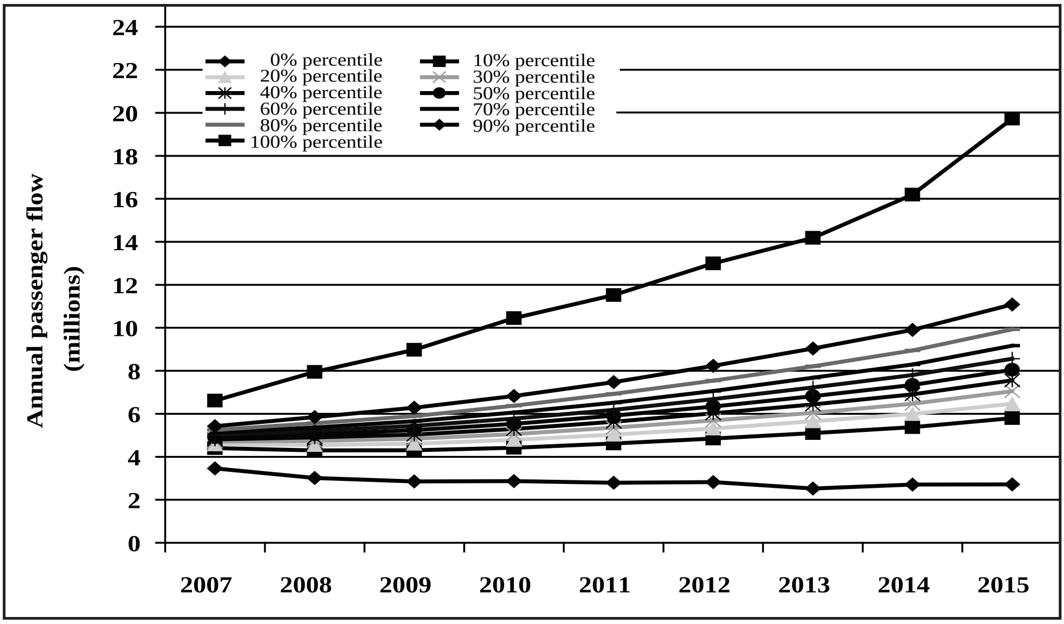


Following the procedure laid out above, simulations reveal the entire range of outcomes, as captured by different shades in Figure 7. This is in sharp contrast with standard forecasting with base (point) and usually two confidence intervals. 10,000 simulations were run for each estimated γs for each year, which generated 90,000 data points (10,000 simulations times nine years, covering the period of 2007–2015) that define the entire domain of future possibilities in Figure 7.

Too much information may also overwhelm or confuse those using forecasts. Thus, there is a need for summarizing these 90,000 data points in different categories, or bins. This is where probabilistic ranges become useful. Figure 8 summarizes the 90,000 data points in different probabilistic ranges from 0–100%. As evident in Figure 7, the 0% and 100% ranges usually capture extreme cases and may not necessarily convey useful information; however, they too have been reported below. Using categories or bins for every 10th percentile (e.g. 0–10%, 11–19%, 20–29%, etc.). Figure 8 shows the entire area for the traffic distribution, ranging from slightly below four million (0%) to approximately 20 million (100%) passengers traveling between U.S.-Netherlands in 2015. In 2006, traffic between U.S.-Netherlands has been reported to be 4.55 million. Alternatively, one can call these two extreme possibilities as highly pessimistic to highly optimistic scenarios.

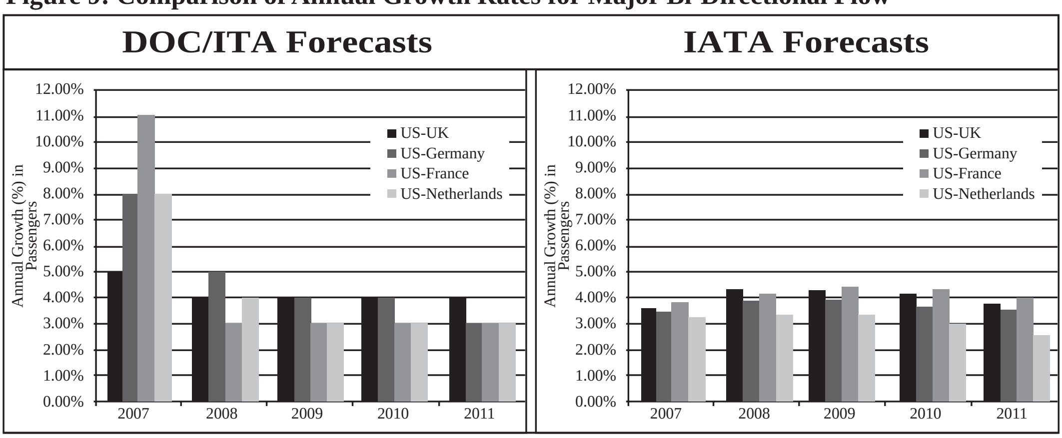
Figure 8 illustrates that U.S.-Netherlands passenger flow was estimated somewhere between 3.5 million (0% percentile bin) to over 6.6 million (100% percentile) in 2007. As noted earlier, these two data points are usually extreme in nature and tend to capture somewhat outlying information. The maximum traffic level (100% percentile) stood at around 1.9 times the minimum traffic level (0 % percentile) in 2007. However, as time passes uncertainties are expected to widen. Thus, the ratio between maximum and minimum is calculated to be over four in 2011 and almost six in 2015. In comparison, the ratio between 10%–90% data stood at 1.2 in 2007 while growing to 1.8 times by 2015.

Figure 8: Summary of Simulation Results in Percentile Bins (Netherlands)



Notice that for 14 countries, parameters and their distributions have been estimated. These are used for individual country-U.S. pair traffic simulations. Furthermore, these estimated parameters and their distributions provide a range of possibilities for other countries (13) that began liberalized air travel with the U.S., starting with the OAA. Estimated parameters and their distributions to simulate air traffic scenarios for the country pairs between the remaining 13 and the U.S. are used. Replicating this procedure, forecasts for all 27 EU member countries were generated. The mean of the simulated data provides the average traffic flow. From these numbers, average growth rates were computed, which are compared against two industry-accepted growth projections – one from the U.S. Department of Commerce's International Travel Agency (DOC/ITA) and one from the International Air Transport Association (IATA). These forecasts are reported in Figure 9.

Figure 9: Comparison of Annual Growth Rates for Major Bi-Directional Flow

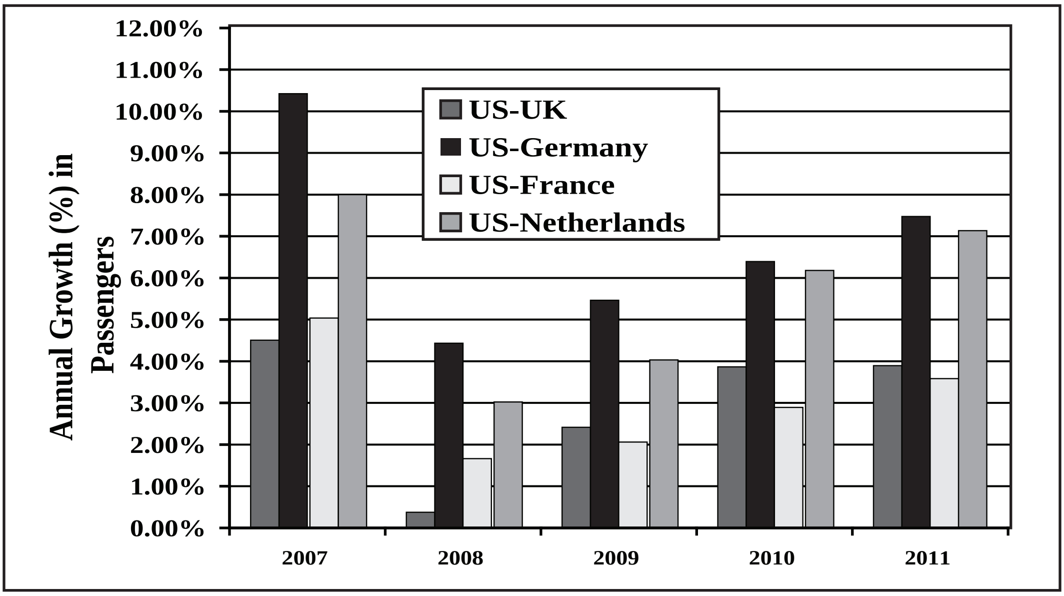


Source: DOC/ITA (2007)

Source: DOC/ITA (2007)

In Figure 9, growth rates for major countries as projected by DOC/ITA and IATA are provided.[12] The forecasts are similar except for 2007. Generally speaking, the above forecasts project annual growth rates in the range of 3%-4 %. DOC/ITA forecasts that the U.S.-U.K. and U.S.-Germany would grow at a higher rate of 4% annually, while IATA forecasts that U.S.-U.K., U.S.-Germany, and U.S.-France would also grow at this similar rate. U.S.-Netherlands traffic flow is expected to grow around 3% annually under both projections.

Figure 10: Forecasts Using Probabilistic Method



In comparison, the probabilistic forecast method that is developed in this paper forecasts a much higher growth rate in the initial year (2007), in the range of 5%-10%, followed by a drop in the growth rate in 2008. In particular, very little growth in 2008 is projected, less than 0.5% for the U.S.-U.K. traffic, followed by a little less than 2% growth in U.S.-France traffic. U.S.-Germany traffic is expected to grow at an annual rate of 4%, and U.S.-Netherlands traffic will likely experience around 3% growth rate this year. The economic slowdown of the U.S. and EU is largely responsible for a slower growth rate in GDP and hence the air traffic growth this year and into the next.

Going forward, the probabilistic method forecasts that the highest growth would occur in the U.S.-Germany traffic, followed by the U.S.-Netherlands traffic. They are both likely to grow over 5% annually. The economic growth along with available capacity and fare competition will be the primary reasons fostering such growth. On the other hand, the U.S.-U.K. traffic appears to have a longer-term trend of 4%, while U.S.-France is likely to experience around 3%-4% annual growth. It is evident from the comparison above that probabilistic method-based bi-directional country models may yield forecasts that are different from the presently available forecasts. This demonstrates both the need for country-specific models and incorporating uncertainty in forecasting methodologies. This is particularly important in a traffic environment that is fraught with economic, market, and industry-wide uncertainties.

Table 2 provides the base traffic flow in 2006 and average annual projected growth rates for the EU27 countries. Notice that for some countries annual average projected growth rates are not available (N/A) because there was no historical data available to build the series. Despite this, the base passenger flow between U.S. and EU27 countries in 2006 was calculated to be around 47 million. The average annual growth rates for this total traffic flow are projected to be around 2.84%

in 2007 followed by 0.9% in 2008, 1.53% in 2009, 3.2% and 3.9% for 2010 and 2011, respectively. For the longer term, i.e. 2012-2015, the average rate is calculated to be around 4.25%.

Table 2: U.S.-EU Traffic Growth Projections

	EU27 Countries	Base Passenger Flow in 2006	Annual Average Projected Growth Rates 2007	2008	2009	2010	2011	2012-2015
1	Austria	338,955	-0.49%	1.00%	2.10%	2.60%	2.80%	3.30%
2	Belgium	726,115	-3.50%	-2.00%	1.50%	2.00%	2.00%	3.00%
3	Bulgaria	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	Cyprus	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5	Czech Republic	145,339	-8.00%	-3.00%	1.50%	2.80%	3.30%	3.00%
6	Denmark	701,875	3.00%	-1.80%	-1.00%	2.30%	3.00%	3.20%
7	Estonia	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	Finland	134,586	-0.98%	-1.00%	2.30%	3.80%	4.20%	4.50%
9	France	6,323,960	5.00%	1.73%	2.00%	2.98%	3.45%	3.50%
10	Germany	8,831,538	10.20%	4.40%	5.40%	6.30%	7.40%	7.50%
11	Greece	314,131	4.99%	2.80%	1.50%	2.80%	3.40%	4.50%
12	Hungary	132,282	3.30%	1.60%	1.80%	2.80%	3.50%	3.90%
13	Ireland	1,978,944	6.30%	3.80%	-0.50%	1.20%	3.20%	4.50%
14	Italy	2,626,265	1.60%	-1.80%	-2.00%	1.00%	1.50%	1.80%
15	Latvia	19,781	7.30%	3.20%	2.10%	5.60%	7.20%	8.00%
16	Lithuania	N/A	N/A	N/A	N/A	N/A	N/A	N/A
17	Luxembourg	0	N/A	N/A	N/A	N/A	N/A	N/A
18	Malta	0	N/A	N/A	N/A	N/A	N/A	N/A
19	Netherlands	4,551,720	8.00%	3.00%	4.00%	6.03%	7.01%	6.30%
20	Poland	434,299	1.60%	0.80%	2.30%	4.60%	5.80%	6.30%
21	Portugal	289,951	2.30%	1.02%	2.02%	3.70%	4.20%	4.80%
22	Romania	0	N/A	N/A	N/A	N/A	N/A	N/A
23	Slovakia	N/A	N/A	N/A	N/A	N/A	N/A	N/A
24	Slovenia	0	N/A	N/A	N/A	N/A	N/A	N/A
25	Spain	1,723,092	3.78%	1.10%	0.50%	1.80%	1.90%	2.02%
26	Sweden	422,568	2.30%	1.02%	-0.50%	1.30%	2.30%	2.60%
27	U.K	17,012,243	4.50%	0.38%	2.45%	3.98%	3.97%	3.75%
	Total	**46,707,644**	**2.84%**	**0.90%**	**1.53%**	**3.20%**	**3.90%**	**4.25%**

Starting from a low-base and recently granted visa-waiver by the U.S., Latvia has the highest projected growth rates, followed by Germany, Netherlands, and Poland. It is anticipated that Poland will be granted visa waiver by the U.S. in the near future as well.

SUMMARY, POLICY AND OTHER IMPACTS

In this paper, the background of the OAA leading to the successful implementation in March, 2008 was reviewed. In particular, the international framework governing air travel freedoms have been reviewed, as well as the types of freedoms that are facilitated by the introduction of the OAA. Following that discussion, relevant empirical evidences of air service liberalizations and their impact on passenger travel was reviewed, with special attention to the OAA. The importance of network alliances has also been noted.

Following this discussion, a bi-directional U.S.-EU country model was developed together with its analytical underpinnings. These bi-directional models were statistically estimated for each U.S.-EU country pair for the period where earlier bilateral agreements were in effect. Noting that the uncertainty plays a critical role in forecasting, key estimated parameters were used to simulate probabilistic ranges around the forecasts. Monte Carlo simulation was used in order to generate probabilistic forecasts for U.S.-EU country pairs. The probabilistic forecasts are different, both in methodology and in results, than the standard DOC/ITA and IATA forecasts.

Like any other forecasts, the probabilistic forecasts are also dependent upon the underlying historical factors that played a key role in determining estimated parameters and their distribution. Thus, certain risks are worth mentioning.

First and foremost, the oil price hike and its subsequent decline, accompanied with its volatility may change the structure of international air travel in significant ways. The airline industry, on both sides of the Atlantic, has never experienced oil prices exceeding $140/barrel at any time in history. The anticipated increase in fare to cover these additional costs may significantly jeopardize the industry's growth in the future.

Second, consolidation and mergers may also affect the balance in the industry. Domestic effects from such mergers through capacity rationalization may spill over into international air travel.

Third, London's Heathrow remains a key airport for realizing true OAA benefits, at least in the short-run. However, Heathrow is severely restricted in terms of its capacity and its short-run outlook is not favorable. Despite the addition of terminal 5 (T5) that facilitates British Airway's operations at Heathrow, runway capacity remains severely limited. Consequently, huge costs are likely (i.e. administrative measures capping airport landing/departures leading to high slot costs, as well as delay costs) and may constrain the benefits of the OAA. However, such constraints are likely to be relieved as other airports in the EU become more and more integrated with the operations enhanced by the OAA.

Fourth, 2008-2009 looks extremely vulnerable in terms of economic growth. All signs from the overall economy, on both sides of the Atlantic, suggest that economies will be subject to recession and perhaps for a longer duration. The changing economic circumstances will slow down the likely growth in transatlantic traffic growth.

Despite these limitations, the results of the probabilistic forecasts of OAA provide strategic planners and policy-makers with an effective tool in these uncertain times. An understanding of the lower and upper bounds corresponding to each forecast may provide the information necessary to minimize the risks associated with future plans. The procedure offered in this paper can be improved upon in numerous ways, including incorporating many more exogenous variables and applying them to understand the nature of traffic in other regions. This is one area of future research that may be pursued.

Endnotes

1. An earlier version of the paper was presented at the 33rd Annual FAA Forecast Conference, Washington, D.C., March 11, 2008. We thank those who attended the presentation and provided valuable comments. The presentation can be accessed at: www faa.gov/news/conferences_events/aviation_forecast_2008/agenda_presentation/media/dipasis_bhadra.pdf. We greatly appreciate research assistance provided by Tony Dziepak and Simon Tsao of The MITRE Corporation's Center for Advanced Aviation System Development (CAASD). Most of the research underlying this paper was completed when the first author was a principal economist at the MITRE/CAASD. Finally, we would like to thank two anonymous referees and the General Editor of this *Journal* for suggestions and comments that significantly improved the paper.

2. Authors are, respectively, a senior quantitative economist and manager, Statistics and Forecasting division at the Office of Aviation Policy and Plans (APO), U.S. Federal Aviation Administration (FAA). Corresponding author: dipasis.bhadra@faa.gov

3. See www.eu2008.si/ for more details on this summit.

4. See www.icao.int/icaonet/dcs/7300 html for more on this Convention.

5. This is because coordination of airlines with IATA published schedules will not be completed until September 2012, if the present term of the OAA is postponed in 2010.

6. Star alliance consists of the following major airlines and their respective codeshare partners: Air Canada, Air China, Air New Zealand, ANA All Nippon, Asiana, Austrian, BMI, LOT Polish, Lufthansa, Scandinavian, Shanghai, Singapore, South Africa, Spanair, Swiss, TAP Portugal, Thai, Turkey, United, and USAirways. One World consists of the following major airlines and their respective codeshare partners: American Airlines, British Airways, Cathay Pacific, Finnair, Iberia, Japan Airlines, LAN (Peru, Argentina, and Ecuador), Malev (Hungary), Qantas, and Royal Jordanian. Sky Team consists of the following major airlines together with their respective codeshare partners: Aeroflot, Aeromexico, Air France/KLM, Alitalia, China Southern, Continental, Czech, Delta, Korean, and Northwest.

7. "Unevenness" or "spikes" are defined as sporadic jumps in data. There are two types of "unevenness" or "spikes" that are common: routine (e.g. holiday travel) and random (e.g. 9/11). Looking at data for air passengers to and from the U.S., we observed both types of spikes.

8. These are the 13 countries from the EU with whom the U.S. has had bilateral treaties before joining into the OAA. The U.S. also had a somewhat restrictive bilateral with the U.K. Thus, a total of 13 new countries and the U.K. are entering into the OAA. See the next section for more details.

9. This decision was purely data-driven. Examining the data suggests that secular trend in travel is restored within four years after a parametric shift buoyed by a bilateral treaty.

10. Over the last few decades, a very rich empirical literature has evolved in econometrics and forecasting that discuss the nature of these errors in detail. Our discussion in this paper is structured around those as laid out in, for example, Pindyck and Rubinfeld (1991) and SAS (1993).

11. However, all other fits and experiments for every year are available from the authors upon request.

12. Since the initial publication of these forecasts, IATA has adjusted its forecast a couple of times this year in view of the economic slowdown and increasing fuel prices.

References

Andrews, Donald W. K. "Tests for Parameter Instability and Structural Change with Unknown Change Point." *Econometrica 61(4)*, (1993); 821-856.

Bhadra, D. and R. Schaufele. "Probabilistic Forecasts for Aviation Traffic at FAA's Commercial Terminals: A Suggested Methodology and an Example." *Transportation Research Record: Journal of the Transportation Research Board* (2007): 37-46.

Booz Allen Hamilton Ltd. *The Economic Impact of an Open Aviation Area Between the EU and the US,* 2007. Available at: http://ec.europa.eu/transport/air_portal/international/pillars/global_partners/doc/us/final_report_bah.pdf, Retrieved on October 20, 2007.

Brattle Group. *The Economic Impact of an EU-US Open Aviation Area*, 2002. Report prepared for the European Commission Directorate General Energy and Transport Commission, Final report available at: http://www.brattle.com/_documents/UploadLibrary/ArticleReport2198.pdf.; Retrieved on October 20, 2007.

Button, K. J. and S. Taylor. "International Air Transportation and Economic Development." *Journal of Air Transport Management 6*, (2000): 209–222.

Button, K. and J. Drexler. "The Implications of Economic Performance in Europe of Further Liberalization of the Transatlantic Air Market." *International Journal of Transport Economics 33(2)*, (2006), 169-192.

Button, K. J. "Opening US Skies to Global Airline Competition." Center for Trade Policy Studies, CATO Institute, November 24, 1998 (5), 1-17.

Campos, N. and A. Cosmas. "Air Transportation Regulatory Environment: Ownership Liberalization and Open Skies," presentation at the MIT Global Airline Industry Program, October, 2007.

European Commission. "Information Note: Air Transport Agreement between the EU and US." Directorate-General for Energy and Transport, Brussels, 2007.

Gillen D. W., W. G. Morrison, and C. Stewart. *Air Travel Demand Elasticities: Concepts Issues and Measurement*. Department of Finance, Canada, 2002. Available at: http://www.fin.gc.ca/consultresp/Airtravel/airtravStdy_e html; Retrieved on December 7, 2007.

Goetz A. R. and B. Graham. "Air Transport Globalization, Liberalization, and Sustainability: Post-2001 Policy Dynamics in the United States and Europe." *Journal of Transport Geography 12*, (2004): 265–276.

Gonenc, R. and G. Nicoletti. "Regulation, Market Structure and Performance in Air Passenger Transportation." *Organisation for Economic Cooperation and Development*, Economics Department Working Papers No. 254, 2000.

Hasan, M. (2008). "Transatlantic Open Aviation Area: A Template for a Globalised Civil Aviation Industry?" 2008. Available at: http:://www.aerlines.nl/issue40/40_Hasan_Atlantic_Open_Aviation_Area.pdf; Retrieved on May 5, 2008.

International Civil Aviation Organization (ICAO). *Manual on Air Traffic Forecasting*, Second Edition, Doc. 8991-AT/722/2, 1997.

InterVISTAS-ga[2]. "Estimating Air Travel Demand Elasticities." 2007. Available at: http://www.iata.org/NR/rdonlyres/0E7F6834-2506-498B-9CB9-8DCA198FA3BC/0/Intervistas_Elasticity_Study_2007.pdf; Retrieved on May 5, 2008.

InterVISTAS-ga[2]. "The Economic Impact of Air Service Liberalization." 2006. Available at: http://www.intervistas.com/4/reports/2006-06 07_EconomicImpactOfAirServiceLiberalization_FinalReport.pdf; Retrieved on May 28, 2008.

Jonsson, C. "Sphere of Flying: The Politics of International Aviation." *International Organisation 35(2)*, (1991): 273-302.

Micco, A. and T. Serebrisky. "Competition Regimes and Air Transport Costs: The Effects of Open Skies Agreements." *Journal of International Economics 70,* (2006): 25–51.

Oxera Investment. "Slots Trading Under Open Skies: The Implications for Allocating Capacity." Available at: http://www.oxera.com/main.aspx?id=6200, August, 2007; Retrieved on February 10, 2008.

Pindyck, R.S. and D.L. Rubinfeld. *Econometric Models and Economic Forecasts*, 3rd Edition. McGraw-Hill, Inc., New York, 1991.

SAS/ETS Software. *Applications Guide 2: Econometric Modeling, Simulation, and Forecasting*. Version 6, First Edition, SAS Institute, 1993.

Staniland, M. "Open Skies – Fewer Planes? Public Policy and Corporate Strategy in EU-US Aviation Relations." *European Policy Paper Series 3*, (1996).

The Economist. *EU Enlargement: In the Nick of Time.* May 29, 2008. Available at: http://www.economist.com/specialreports/displaystory.cfm?story_id=11436623; Retrieved on January 20, 2008.

Tiernan, T., D. Rhoades, and B. Waguespack. "Airline Alliance Service Quality Performance – An Analysis of US and EU Member Airlines." *Journal of Air Transport Management* March, (2008): 99-102.

Times Online. "Transatlantic Dogfight Looms as Ryanair Promises £7 fare to US." Available at: http://business.timesonline.co.uk/tol/business/industry_sectors/transport/article1647610.ece (28/07/2007); Retrieved on January 20, 2008.

Toh, R. "Toward an International Open Skies Regime: Advances, Impediments, and Impact." *Journal of Air Transportation World Wide 3*, (1998): 61-71.

U.S. Department of Commerce. TI News: *An Information Service from Office of Travel & Tourism Industries (OTTI): U.S. Commerce Department Forecasts Record Arrivals from Travelers to the United States,* October, 2007.

U.S. Department of Transportation. *International Aviation Developments: Global Deregulation Takes Off (First Report)*, Washington, D.C., 1999.

U.S. Government Accountability Office. *TransAtlantic Aviation: Effects of Easing Restrictions on U.S.-European Markets*, GAO Report No. GAO-04-835, Washington, D.C., 2004.

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