Estimating the Gains from Liberalizing Services Trade: The Case of Passenger Aviation[*]

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Abstract:

Little is known about the effects of liberalizing services trade. Detailed data on services flows are rare and identifying changes in regulatory regimes can be difficult. This paper overcomes these difficulties by exploiting detailed transactions data from an important service sector – passenger aviation – and the signing of 87 bilateral "Open Skies Agreements" over a 16 year period. We use a price-setting game with free entry and imperfect information about rival's costs to model how restrictions on route offerings and their subsequent liberalization affects entry, costs and the distribution of markups, and predict differential effects across city types. We then empirically examine particular channels through which liberalization reshapes aviation services trade using difference-in-difference estimators. Liberalizing countries see expansions in route offerings, reductions in prices, and large increases in quantities traded conditional on prices. However, these effects are not uniform. Carriers previously constrained by regulations re-orient capacity away from highly contested routes and toward routes with little competition; entry leads to price reductions and exit leads to price increases. We estimate that the combined effect of these changes yields a 31 percent reduction in quality- and variety-adjusted prices for liberalized markets relative to those who remain regulated.

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1. Introduction

Services represent a large (20 percent) and growing share of world trade, but the exact reasons for that growth are not immediately clear. Growth in services trade may simply reflect the rising share of services in employment and output worldwide, or be due to trade facilitating improvements in information technology and telecommunications.[2] It may also be that a sustained focus on liberalizing services trade at the multilateral level through the WTO General Agreement on Trade in Services (GATS) and through bilateral agreements have succeeded in eroding regulatory barriers to entry.

While the literature features many papers on the effects of merchandise trade liberalization, careful empirical work on services trade liberalization is scarce.[3] The difference in research emphasis is largely due to the paucity of detailed data on international service transactions. Feenstra et al. (2010) note that "value data for imports and exports of services are too aggregated and their valuation questionable, while price data are almost non-existent".[4] Making matters worse, it can be challenging to identify changes associated with service liberalization events. Service liberalizations are infrequent, and often target domestic market regulations (e.g., privatization, permitting foreign investment), as part of complex national reforms. This stands in stark contrast to manufacturing trade, where tariffs provide an exact measure of the price wedges imposed by policy intervention, and liberalization efforts correspond to well-defined reductions in these wedges.

This paper focuses on a traded service sector, passenger aviation, where these data limitations can be overcome. Trade in passenger aviation services is important: it represents $190billion of trade for the US and EU; it is an important input into exports of manufactures (Poole, 2010; Cristea 2011), knowledge flows across countries (Hovhannisyan and Keller 2011), and flows of other services, especially Mode 2 (consumption of services abroad, e.g. tourism), and Mode 4 (presence of natural persons abroad, e.g. forms of business services). Critically, and unlike many other forms of services trade, the unit of output and its price is well defined. We draw on two datasets that contain carrier-specific data on the quantity of passengers and ticket prices for every city pair for international flights originating or terminating in the US from 1993-2008. Figure 1 displays passenger traffic and ticket prices in our data between 1992 and

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[2] Freund and Weinhold (2002) empirical evidence for the impact of internet on the growth of services trade. Also, Ariu and Mion (2011) find that an increase in computer use or analytical tasks increases the number of service-trading firms.

[3] The few exceptions are Fink et al. (2003), who investigate the impact of telecommunication reforms on output and productivity in a panel of developing countries, and Arnold et al. (2011), who bring evidence from Czech Republic for the productivity effects of services liberalization on downstream manufacturing firms. See Hoekman et al. (2007) for a discussion on the state of services trade negotiations, and Francois and Hoekman (2010) for an excellent survey on the advances in services trade.

[4] It is only very recent that firm level studies on services trade have surfaced. See for example Hanson and Xiang (2011), Breinlich and Criscuolo (2011), Ariu and Mion (2011).

2008. In this period we see a doubling of US international passenger traffic, and a 20-30 percent decline in ticket prices. What caused these changes?

As we further detail in Section 2, the airline industry is global in scope yet remains tightly regulated through a series of bilateral Air Services Agreements. Between 1993 and 2008, the US began liberalizing this market, signing 87 bilateral "Open Skies Agreements" (OSA) that removed barriers to trade in passenger aviation. While OSA's altered aviation regulations in multiple ways, we focus on several aspects that appear particularly relevant. Existing Air Service Agreements imposed limits on the number of foreign carriers who could enter, restricted service offerings to include only a limited number of "international gateway" cities into which carriers could fly, and allowed for cooperative agreements including codeshares and alliances between domestic and foreign carriers.

In Section 3 we model these restrictions formally, using a stylized hub-and-spoke network game with *N* carriers competing to offer service between two countries. Our model builds upon the approach of Hendricks, Piccione, and Tan (1997, 1999), who examine a two-stage entry/network configuration and price setting game. Each domestic carrier has monopoly power in its own domestic hub cities, but they are not permitted to route international passenger traffic into these hubs unless they first fly through an international gateway city. In the first stage, carriers decide whether to pay a fixed cost to enter an international gateway city. In the second stage, carriers realize a random shock to costs, and set prices.

A key insight of Hendricks, Piccione, and Tan (1997, 1999) is that, because Bertrand competition drives prices to marginal costs, competing hub-and-spoke networks do not arise in equilibrium. That is, only one carrier would enter each gateway city. Our model assumes that in setting prices, carriers have private information regarding the realization of their costs. This leads to equilibria in which there are multiple competing carriers earning profits, and where the mean and variance of prices are falling in the number of competitors.

In this game, the combination of economies of route density and restrictions on route entry has important competitive effects which can be seen by examining entry and prices pre/post liberalization for gateway cities and for non-gateway hubs. Prior to liberalization, all traffic must be routed through a small number of international gateways, and no carrier faces international competition into their hub. (Foreign carriers are not permitted to engage in cabotage, offering service between two domestic cities). This means that there is an "excess" of entry on gateway routes – domestic carriers will enter past the point where they are losing money on the gateway route itself because they more than make up the difference by channeling passengers into domestic hubs.

The model predicts several effects of liberalization. One, there is an increase in the number of cities with direct international connections, as newly permitted under the OSA. Two, there is net entry of carriers on these routes, as foreign carriers can now fly directly to domestic hubs. Three, the ability to fly direct lowers marginal costs, and the increased competition lowers markups, leading to an unambiguous decline in prices on non-gateway hub routes. Four, gateway cities may experience exit of carriers and increases in prices. Carriers no longer need to route passengers through the gateway to reach domestic hubs, and are no longer willing to "subsidize" the fixed cost of gateway entry using profits from those hubs. The aggregate effect on consumer welfare depends on which effects dominate: net entry and price reductions in domestic hubs, or net exit and price increases in the gateways. In extensions of the model, we incorporate additional features of OSA's, including lifting direct restrictions on the number of carriers competing (which makes gateway exit less likely), and allowing for cooperative agreements between domestic and foreign carriers (which lower marginal costs of services, but lower entry).

In summary, liberalization need not improve consumer welfare. It is therefore an empirical question what effects Open Skies Agreements have had on international passenger aviation markets in the US. We describe our data in Section 4, and our econometric exercises in Section 5.

Because OSAs come into force discretely and sequentially, we can test for the effects of liberalization using difference-in-difference strategies. That is, we measure pre/post agreement changes in quantities, prices, and route offerings for a given country-pair or city-pair in comparison to pairs that have not yet liberalized. This allows us to control for changes in technology, input cost shocks, and exogenous changes in aviation demand to see whether liberalizing countries experience differential growth in variables. We can also look at the distribution of effects across city-pair markets to see if the core predictions of the model (entry and price drops for non-gateway cities, exit and price increases for gateways) can be found in the data.

We find evidence for significant gains associated with opening aviation markets to foreign competition. Five or more years after the signing of an Open Skies Agreement, outbound air traffic is 18 percent higher in liberalized markets compared to regulated markets. 40 percent of this increase is explained by the introduction of new non-stop routes to the liberalized foreign country, and the remaining 60 percent is attributed to air traffic growth along previously offered routes. This is consistent with the view that pre-OSA gateway restrictions significantly reduced the desired route offerings of carriers.

Looking at prices and quantities for each route, we find that the introduction of Open Skies Agreements leads to a 2-4 percent average drop in air fares (controlling for trip characteristics). These effects are larger on inbound markets, and on routes with net entry of carriers. Routes that experience net exit of carriers see price increases. The empirics also highlight an additional feature of OSAs – "beyond market rights" -- not incorporated in our theory model. When the US signs an OSA with country B, carriers can offer continuing service onto a third country C. We find large price drops for ticket prices that terminate in country C, provided that the itinerary routes through an OSA partner country.

In the model, OSA's expand quantities by lowering prices. It is possible that OSAs may have additional effects on quantities if carriers increase flight frequency, offer better connections, more direct service, or otherwise improve consumer's perceived quality of service. Alternatively, increased congestion or decreased service quality aboard planes may lower consumer demand. We find that OSAs lead to a 6-16 percent rise in quantities conditional on prices, consistent with consumers perceiving a quality change on these routes. This quality effect translates into the equivalent of an additional 4.8 to 12.8 percent drop in prices.

Finally, we combine the variety, efficiency and quality effects in an overall air service price index adapted from Feenstra (1994). This index is interpreted as the price equivalent measure of air services liberalization. In implementing the consumer welfare calculations, we infer the elasticity of substitution among air transport service from the observed changes in product market share. Combining the price, quality, and net routes effect we find the Open Skies Agreements lower prices by 32 percent relative to regulated markets.

The liberalization of air transport services has been the focus of few recent studies. Micco and Serebrisky (2006) estimate the effect of Open Skies Agreements on air cargo freight rates available from U.S. data on merchandise imports. Using a shorter panel than ours, and unit value type data, they find that air services liberalization reduces freight rates by 9 percent. Piermartini and Rousova (2009) estimate the impact of air services liberalization on the bilateral volume of air passenger flows using a cross-section sample of worldwide country-pairs, and an index of air services liberalization. While both studies find significant price, respectively quantity effects associated with air transport liberalization, neither one employs data of sufficient level of detail in order to implement the quantitative methods and to estimate the post-liberalization industry responses that we document in this paper.

Several industrial organization studies employ the same datasets that we use here to investigate the price effects of the inter-airline strategic alliances, which are granted by U.S. authorities conditional on market liberalization (Brueckner and Whalen, 2000; Brueckner, 2003; Whalen, 2007; Bilotkach, 2007). These studies find that airline alliances reduce airfares, which is consistent with our price results as Open Skies Agreements facilitate the formation of airline alliances.[5]

[5] Whalen (2007) goes beyond strategic alliances to focus on OSAs generally, using similar data sources but a substantially different sample. He finds that OSAs have a positive significant effect on air fares and no effect on passenger volumes once controlling for market competition and strategic alliances. We model and estimate changes in competition and alliances as an endogenous outcome.

2. Liberalization in International Air Transport Services

Historically, the provision of international air services has been severely restricted by a complex web of regulations set on a bilateral basis.[6] [7] A standard bilateral aviation agreement specifies a limited set of points/airports to be serviced by a restricted number of designated airlines (typically one or two carriers from each country). It also delineates the traffic rights granted to operating carriers, the capacity that can be supplied in each origin-destination city pair (with exact rules for sharing capacity), and the air fares to be charged on each route (with both countries' approval required before they can enter into effect). The prices agreed upon in the agreements frequently correspond to the fixed rates set by IATA during periodic air fare conferences (Doganis, 2006).[8] As an example of the restrictiveness of standard bilateral air transport agreements, the U.S. -- China Aviation Treaty (1980) restricts market access to two designated airlines per country, who can operate at most two round-trip flights per week each on routes connecting four U.S. points (New York, San Francisco, Los Angeles, Honolulu) to two Chinese cities (Shanghai, Beijing). Tokyo is the only third country location from where service to either country's designated airports can be operated. Prices charged on all routes must be submitted to government authorities two months in advance for double approval. In addition, both countries can take 'appropriate' action to ensure that traffic is 'reasonably balanced' and mutually beneficial to all designated airlines.

Similar restrictions imposed on US domestic aviation caused a variety of distortions in these markets. Studies of the U.S. domestic airline industry have shown that the inability of airlines to compete in prices forced them to invest in service enhancements such as lower density seating or more flight attendants (Borenstein and Rose, 1998). Limitations in route and capacity choices increased operating costs by restraining airlines' ability to optimize their network structure, size and traffic density (Baltagi et. al, 1995). To the extent that similar forces are at work in international aviation, deregulation may result in pronounced changes in prices, service quality, and passengers served.

In 1980, the United States passed the International Air Transportation Competition Act, which set the stage for opening international aviation markets. The liberalization efforts debuted with the

[6] As Doganis (2006) puts it "the airline industry is a paradox. In terms of its operations it is the most international of industries, yet in terms of ownership and control it is almost exclusively national."

[7] Efforts to set a flexible regulatory framework go back to the Chicago Convention of 1944 when the International Civil Aviation Organization (ICAO) was established under the auspices of the United Nations. Apart from safety and technical rules, the Convention failed to reach common grounds among participating countries in terms of key economic provisions such as traffic rights, market access, price and capacity decisions, leaving their negotiations to be settled on a bilateral basis. Bilateralism (or regionalism as in the case of the EU) remains the norm, and international air transport services are left outside of the General Agreement on Trade in Services (GATS).

[8] IATA (International Air Transport Association) is the trade association of international airlines and one of its main tasks has been to fix prices on most international city-pair routes. Because IATA prices have to be agreed upon by all member airlines, they tend to be high enough to cover the costs of the least efficient carrier (Brueckner, 2003).

renegotiation of many U.S. bilateral aviation agreements during the 1980s -- the "open markets" phase. The main focus of these treaty renewals was to relax market access and capacity restrictions by extending the number of designated airlines, the pre-defined points of service, and the flight frequencies. Some agreements also granted a partial relaxation of pricing provisions and beyond traffic rights (i.e., the right to fly passengers between two pre-approved foreign points on the way to/from a carrier's home country).

Over the period 1993-2008 the U.S. signed 87 bilateral Open Skies Agreements.[9] These agreements grant unlimited market access to any carrier for service between any two points in the signatory countries, full flexibility in setting prices, unconstrained capacity choice and flight frequencies, unlimited access to third country markets, and a commitment to approve inter-airline commercial agreements (e.g., code-share, strategic alliances). The timing and complete list of partner countries is reported in the Appendix Table A1.[10] Apart from the completely liberalized intra-EU aviation market, US efforts to de-regulate international aviation in this period are atypical. While some air service agreements have been amended to relax regulatory provisions, overall the global aviation market remains fairly closed to trade. Piermartini and Rousova (2009) provide a comprehensive description of all bilateral aviation treaties and conclude that 70 percent of bilateral agreements worldwide are still highly restrictive.

While OSAs have many provisions, we focus our attention on few features that appear particularly relevant for consumer welfare. We begin by modeling how route restrictions affect airline network structure, entry and pricing, and how relaxing these restrictions reshapes competition. We then extend the model to incorporate the possibility that pre-OSA constraints on prices, the number of carriers, or flight frequency were binding, and also to account for the possibility of post-OSA cooperative agreements between carriers. In the empirical work, we examine the direct implications of the model, but extend the analysis to incorporate other possible dimensions of response including changes in consumer's perception of service quality, as reflected in changes in demand conditional on prices.

3. Model

We consider a stylized hub-and-spoke network game with N carriers and two countries, A and B. Our model builds upon the approach of Hendricks, Piccione, and Tan (1997, 1999), who examine a two-stage entry/network configuration and price setting game. A key insight of Hendricks, Piccione, and Tan (1997, 1999) is that competing hub-and-spoke networks do not arise in equilibrium. This is clearly

[9] While the focus in the last two decades has been on achieving complete liberalization through OSAs, in this period the U.S. continued to engage in bilateral negotiations that resulted in a partial relaxation of existing agreements. Sometimes these partial liberalization served as a short transitory stage before signing Open Skies Agreements, but often countries maintained or gradually raised their degree of partial liberalization. We address these partial liberalization efforts in our empirical work.

[10] We address selection into these agreements in the empirical section.

inconsistent with patterns we see in the data, in which multiple carriers compete on international routes, and route offerings change in response to liberalization efforts. To capture these effects, we assume that in the final stage Bertrand competition the carriers have private information regarding their costs (as in Spulber 1995).[11] As a result, there exist equilibria that feature multiple competing carriers with a distribution of prices on a given route. Further, the number of carriers and price distributions that result depend on liberalization and also on multi-market interactions between carriers. That is, decisions to enter one route affect competitors on that route and on competing routes.[12]

The basic model is described as follows. N_A carriers have hubs in country A, and N_B carriers have hubs in country B. There are two types of cities: (i) gateway cities which may serve as an international hub both pre- and post-OSA and (ii) non-gateway cities that have a high enough traffic flow that they could profitably serve as an international hub, but can only be used for this purpose post-OSA. Each non-gateway city also serves as a domestic hub for one domestic carrier.[13]

While the approach we employ can be adapted to allow for more complex hub-and-spoke network structures, we examine a simple prototypical domestic network structure to highlight key features. (Extensions to more general networks, and general functional forms are found in the appendix.) Country A is a large country with a single gateway city and $N_A > 1$ non-gateway high traffic cities. To ensure symmetry we assume there is one non-gateway domestic hub for each of the N_A carriers in country A. Country B is a small country consisting of only a gateway city. Let g_i denote the gateway city in country $i = A, B$; index an arbitrary carrier by j and let h_j denote carrier j's non-gateway hub. Figure 2 illustrates the carriers' domestic networks for one gateway and two hubs.

In the first stage of the game, each carrier chooses whether to provide nonstop service between its hub and each city in the other country. Providing direct service for an international city pair includes hiring station and ground crews for international long-haul aircraft with fixed entry costs of f, which are independent of the total number of international travelers serviced by the carrier.

In the second stage of the game the carriers observe the international networks chosen in stage 1, observe their private per unit cost of providing international service, and simultaneously choose prices for travel between international city pairs. (The prices and quantities in the domestic airline service market are exogenous in our model.) The per unit cost of providing round-trip service between the hub and the

[11] For an application of Bertrand competition with incomplete information, see Lofaro (2002).
[12] If the fixed cost of maintaining an international hub is nonsunk, equivalently the entry/network configuration and price setting decisions occur simultaneously, then multiple competing carriers also arise in equilibrium.
[13] The assumption of monopoly domestic hubs can be replaced by the weaker assumption that the hub and spoke networks give rise to heterogeneous marginal costs for each of the flight segments.

gateway $\{h, g\}$ is c_d. While domestic unit costs are constant, international costs are a carrier-specific random draw, c_j from a distribution G, which we simplify here to uniform on [0,1]. Similar to Spulber (1995), we assume that each carrier experiences its own private shock to the opportunity cost of providing international service and this shock may be city-pair specific. These cost shocks could reflect changes in input prices, including fuel, insurance, ground or air crew. They could also be interpreted as a capacity constraint on long-haul aircraft combined with demand uncertainty in the domestic network.[14]

We represent demand in the hub market as $D_h(p) = 1 - p$ and demand in the gateway as $D_g(p) = \alpha(1 - p)$, for $\alpha \geq 1$, which has a finite choke price at $p = 1$. We treat passenger aviation as homogeneous so consumers will choose whichever carrier announces the lowest price in that period. If two or more carriers announce the same lowest price, then we assume that each of the lowest price carriers receive an equal share of the total quantity demanded. Finally, we assume that when consumers prefer a direct flight to an indirect flight regardless of the difference in price.[15]

For the sake of tractability, we make several additional simplifying assumptions along the lines of Hendricks, Piccione, and Tan (1999). First, we initially assume that carriers cannot share a passenger's international itinerary, which rules out both interline ticketing and codesharing. Second, we impose the restriction that prices must be the same in each direction, and focus on the total quantity of round-trip travel demanded on a given route at a given price. Third, we assume that carriers do not face hard capacity constraints. Fourth, we assume that there is no substitutability in demand across international city-pair markets. That is, travelers in a non-international-hub city h1 cannot buy a separate domestic ticket to hub h2, and then an international ticket originating in the hub city.[16]

3.2 Equilibrium

This is a two-stage game with observable actions and incomplete information, and the equilibrium concept used is perfect Bayesian equilibrium (PBE). We characterize the unique PBE in which for each route the stage-two pricing strategy is symmetric among the active carriers offering a

[14] That is, shocks to demand in the domestic network affect the opportunity cost of employing crew or planes on international routes. Although the planes used to provide international travel generally differ from those used for domestic travel, e.g. seating configurations etc, it is not uncommon for domestic airlines to use such planes on long-haul domestic routes such as New York to L.A.

[15] Relaxing this assumption does not qualitatively change our main results. Furthermore, our current setup appears to be the more empirically relevant case.

[16] It is possible to relax this last assumption, but, as domestic route prices are exogenous in our model, it does not add anything meaningful to the analysis.

direct connection on the route. A PBE consists of a stage-one entry decision for each of the carriers, a stage-two pricing strategy for each of the active carriers, and beliefs about the realizations of the stage-two private costs.

3.2.1 Pre-OSA

We begin in the final stage of the pre-OSA game, and then move back through the game tree. In the final stage, the set of active carriers is observable. As the active country A carriers have, pre-OSA, a monopoly over the connection between their domestic non-gateway city and the foreign gateway city (henceforth denoted as player j's $h-g$ route), they can always charge the monopoly price for round-trip service on this route. For each carrier j we define the $h-g$ monopoly profits from the indirect route, net of fixed costs, as $\pi_h^{ind}(c_j)$, where

$$\pi_h^{ind}(c_j) \equiv \left[max_{p_{j,h}}(p_{j,h} - c_d - c_j)D_h(p_{j,h})\right].$$

Note that costs here include both an international segment and a domestic segment. Given the assumptions on demand, $\pi_h^{ind}(c_j)$ is symmetric across $j \in \mathcal{A}$.

Next we discuss the strategic pricing decisions of each carrier on the gateway routes. Recall, the lowest price carrier receives all the demand in a period, but a carrier does not know its competitors cost draws. As a result each active carrier chooses a price $p_{j,g}(c_j)$ on the gateway-to-gateway route as a function of their cost draw, and the number of competitors with which it competes. If the $g-g$ route has a total of $\widehat{N}_g > 1$ active carriers, then the total expected payoff to each active carrier $j \in \mathcal{A}$ from the arbitrary pricing strategy $p_{j,g}(c_j)$, given that each of the other active carriers are using the symmetric pricing strategy $p_g(c)$, is given by

$$\pi_j(p_{j,g}|c_j) \equiv \left[1 - G\left(p_g^{-}\left(p_{j,g}(c_j)\right)\right)\right]^{(\widehat{N}_g - 1)} \psi_g(p_{j,g}(c_j)|c_j) + \pi_h^{ind}(c_j) - f$$

Breaking this expression down, the first (square brackets) term expresses the probability that carrier j wins the pricing competition at the gateway, which depends on its cost draw, and the number of competitors.[17] The term $\psi_g(p|c) \equiv (p-c)D_g(p)$ expresses profits per unit earned on the gateway route, multiplied by the quantity demanded. Establishing an international gateway allows the carrier to

[17] Note that the generalized inverse of the pricing function is denoted by $p_{j,g}^{-}(p) = \sup\{c \epsilon [\underline{c}, \overline{c}] | p < p_{j,g}(c)\}$.

earn profits on passengers flying between the gateways, but also on passengers continuing on through the gateway to the carrier's domestic hub. These profits, $\pi_h^{ind}(c_j)$ are not multiplied by a probability of success because, as the only carrier offering service through to the domestic hub, the carrier can bank these profits with certainty. Finally, net profits from the gateway and hub passengers are offset by the fixed cost f of establishing the gateway.

There is a similar expression for carriers in country B, with the exception that they are not allowed to engage in "cabotage", that is, offer passenger service between country A's gateway and any other domestic hub. This implies $\pi_h^{ind}(c_j) = 0$, so profits of entering the gateway are

(1) $$\pi_B(p_{B,g}|c_B) \equiv \left[1 - G\left(p_g^{-}\left(p_{B,g}(c_B)\right)\right)\right]^{(\hat{N}_g-1)} \psi_g(p_{B,g}(c_B)|c_B) - f$$

Standard arguments can be used to show that in any equilibrium the symmetric pricing strategy $p_g(c)$ is strictly increasing in costs. We can then write the first order conditions for any active carrier, and assuming symmetry across active carriers we have the following differentiation equation

(2) $$p_g'(c) = \left[\frac{(\hat{N}_g-1)G'(c)}{1-G(c)}\right]\left[\frac{\psi_g(p_g(c)|c)}{\psi_g'(p_g(c)|c)}\right]$$

This equation holds for general forms of the demand function and the distribution of cost shocks. Given the specific assumptions above, we can rewrite prices charged by carrier j as a function of the number of entrants and j's cost draw.

(3) $$p_g^*(c_j) = \frac{1+\hat{N}_g c_j}{1+\hat{N}_g}$$

The first period expected profits on the gateway to gateway connection are

(4) $$E(\pi_g|\hat{N}_g) = \frac{\hat{N}_g \alpha}{(1+\hat{N}_g)^2(2+\hat{N}_g)}$$

which are strictly decreasing in $\hat{N}_g$ (where $\hat{N}_g \geq 2$). Monopoly profits on the non-gateway routes are

(5) $$E(\pi_h^{ind}) = \frac{2\left(\frac{1-c_d}{2}\right)^3}{3}$$

We next turn to the first stage of the game and examine the number of firms who will enter the gateway market, focusing on the case where at least two country A carriers enter. There are N_A Country A carriers, and $\widehat{N}_g \leq N_A$ will enter up to the point where net profits cover fixed costs. That is, $\widehat{N}_g$ is the largest number of entrants such that $E(\pi_g|\widehat{N}_g) + E(\pi_h^{ind}) \geq f$.

We have assumed that country B carriers are symmetric, except for the lack of a domestic hub. This implies that country B carriers will only be able to enter in two cases. The first case is that the market is large enough to accommodate all country A carriers, $\widehat{N}_g = N_A$, and an additional country B carrier, $E(\pi_g|N_A + 1) \geq f$. The second case is that country B is willing to subsidize its carriers in an amount equal to country A carriers' expected profits on indirect routes, $E(\pi_h^{ind})$. With the subsidy, carriers from A and B are symmetric with respect to costs and profitability. More formally,

Proposition 1: In the absence of a subsidy for the country B carrier, the country B carrier makes the gateway-to-gateway connection if and only if $E(\pi_g|N_A + 1) \geq f$. If $E(\pi_g|N_A + 1) < f$, then only country A carriers make the gateway to gateway connection, and the number of country A carriers that make the connection is the largest $\widehat{N}_g \leq N_A$ such that $E(\pi_g|\widehat{N}_g) + E(\pi_h^{ind}) \geq f$.

In any given period, carriers in the gateway-to-gateway market charge a price given by equation (3). At a single point in time, only one carrier wins this pricing competition. Our data includes multiple carriers operating multiple flights on the same route over the span of one quarter. To reconcile this, think of cost draws as being realized at high frequencies, perhaps day by day, and the data is the resolution of many draws occurring over many days. The expected market price on the gateway-to-gateway route is then the lowest order statistic, that is, the lowest prevailing price on any given day.

Letting $G^*(p)$ denote the equilibrium distribution of prices for each active carrier on the gateway-to-gateway route, the pre OSA probability function for the minimum of the prices is

$$f(p_g) = \widehat{N}_g[1 - G^*(p_g)]^{(\widehat{N}_g - 1)}$$

and so the expected market price is

$$E(p_g) = \int_{\frac{1}{1+\widehat{N}_g}}^{1} p\widehat{N}_g \left[\frac{1-p}{1 - \frac{1}{1+\widehat{N}_g}}\right]^{(\widehat{N}_g - 1)} \frac{1}{1 - \frac{1}{1+\widehat{N}_g}} dp$$

which is decreasing in the number of active carriers, $\widehat{N}_g$.

For each non-gateway hub city j in which the associated carrier $j \in \mathcal{A}$ is active in stage two, carrier j provides service between the non-gateway hub and the foreign gateway if and only if $c_j < 1 - c_d$. (otherwise profits would be negative). This occurs with probability $1 - c_d$, and in such cases the monopoly price is given by $(1 + c_d + c_j)/2$, with expected price (conditional on offering service) $E(p_h) = (1 - c_d)^2/4$.

3.2.2 Post-OSA

In moving to the post-OSA game, country A carriers now have the option to stay out of the market, offer indirect service through the gateway, or offer service directly from their hub to the foreign gateway. Country B carriers can now offer direct service to both gateways and hubs. This creates a larger number of stage-two pricing subgames, and it is necessary to evaluate all these subgames to identify equilibria. The payoffs for each of the possible subgames are characterized in the Appendix. Given these payoffs, the perfect Bayesian Nash equilibrium first-period entry decisions are characterized as follows. Let $E(\pi_{B,h_j}|\iota_{j,h_j}, \iota_{B,h_j})$ denote player B's expected payoff on the $h_j - g$ route given the stage-one entry decisions ι_{j,h_j} *and* ι_{B,h_j}, where

$$E\left(\pi_{B,h_j}|0,1\right) = E\left(max_{p_{h_j}}(p_{h_j} - c)D_h(p_{h_j})\right)$$

Proposition 2: If $E(\pi_{B,h}|0,1) < f$, then any equilibrium of the post-OSA game is also an equilibrium of the pre-OSA game, and thus, satisfies the conditions in Proposition 1. If $E(\pi_{B,h}|0,1) > f$, then in any equilibrium of the post-OSA game the expected equilibrium price on the $g - g$ route is higher and the expected equilibrium prices on the (active) $h_j - g$ routes are lower than in the pre-OSA game. And, the number of $h_j - g$ routes that are offered is at least as high if not higher.

The proof of Proposition 2 is contained in the Appendix. The following corollary is a direct consequence of Proposition 2.

Corollary 1: All consumers traveling on a $h_j - g$ route are at least as well off in the post-OSA game, but consumers traveling on the $g - g$ route may be worse off.

3.2.3 Simulation

To fix ideas, we present a particular parameterization of the model, and simulate equilibrium values for the number of carriers who will choose to make a gateway connection, and the distribution of prices pre/post OSA. Figure 3 graphs the number of firms who will enter the gateway against the fixed costs of entering. Expected net profits from entering depend on the number of entrants, and entry is dictated by $E\left(\pi_g|\widehat{N}_g\right) + E\left(\pi_h^{ind}\right) \geq f$, or

$$(6) \qquad \frac{\widehat{N}_g \alpha}{\left(1+\widehat{N}_g\right)^2\left(2+\widehat{N}_g\right)} = f - \frac{2\left(\frac{1-c_d}{2}\right)^3}{3}$$

Entry continues until expected net profits on the gateway route equal fixed entry costs, f less profits from pulling passengers through the gateway and into the hubs. At higher levels of f, the number of entrants must fall.

Exit has a straightforward effect on prices. The price a particular firm will charge depends on the number of entrants and its particular realization of the cost draw, as shown in equation (3). Since the costs are drawn from [0,1], the minimum price a firm will charge $p_g^*(c) = \frac{1}{1+\widehat{N}_g}$ is decreasing in the number of entrants. This can be seen in Figure 4, where the minimum support of the price distribution drops as the number of entrants increases.

Additionally, entry leads to more mass in the left tail of the price distribution. For example, with $\widehat{N}_g = 2$, $p > 0.4$ more than 80% of the time, whereas with $\widehat{N}_g = 4$, $p > 0.4$, only 30% of the time, and so on. Note that the number of entrants does not change the underlying distribution of costs, but it does change the likelihood that at least one firm will receive a very low cost draw. Since carriers do not know what cost draw their competitors will receive, and the lowest price wins, carriers respond to entry by sharply limiting markups they would charge when they themselves receive low cost draws. In a monopoly setting, given a cost draw of zero, the optimal price is 0.5. With four competitors, the optimal price given the same zero cost draw is 0.2.

This same logic can be applied to the non-gateway prices in Figure 5. Here we have two effects. The ability to fly directly from the foreign gateway to the domestic hub lowers the unit cost of service. Costs fall from $c + c_d$ to c. In addition, foreign entry increases the number of competitors on this route, lowering prices through the same mechanism.

Critically, entry on the non-gateway hub has equilibrium effects on entry in the gateway. Because carriers can offer direct international service from their hubs, carriers no longer earn returns from funneling passengers through the gateway and into their hub city, $E(\pi_h^{ind}) = 0$. The entry equation is determined by $E(\pi_g|\hat{N}_g) \geq f$, or

(7) $$\frac{\hat{N}_g \alpha}{(1+\hat{N}_g)^2(2+\hat{N}_g)} = f$$

Put simply, traffic terminating in the gateway must generate sufficient profitability to cover fixed costs. Contrasting the number of firms that solve pre-OSA equation (6) and post-OSA equation (7), it must be the case that the OSA induces exit in the gateway.[18] Following the linkage between number of entrants and prices shown in Figure 4, if exit occurs in the gateway, prices will rise.

3.3. Extensions: Constraints on Carriers and Capacity

(to be added)

4. Data Sources and Description

We draw on two rich datasets that cover international travel to and from the United States at quarterly frequencies over the period 1993-2008. The *Databank 1B (DB1B) Origin and Destination Passenger Survey* represents a 10 percent sample of airline tickets drawn from airport-pair routes with at least one end-point in the U.S. Each airline ticket purchase recorded in the data contains information on the complete trip itinerary including airports, air carriers marketing the ticket and operating each flight segment, the total air fare, distance traveled split by flight segments, ticket class type, as well as other segment level flight characteristics. We focus on international economy-class airline tickets, and employ some additional filters described in the appendix. We restrict attention to foreign countries with at least one city-pair route serviced continuously over the time period. The resulting sample includes 50,000 origin-destination airport pairs, with an average of 12 observations per pair. The summary statistics for the variables of interest are provided in the Appendix Table A3.

One limitation of the DB1B data is that foreign carriers that are not part of immunity alliances are not required to file ticket sales information to the U.S. Department of Transportation.[19] This is less of an issue for "outbound" tickets rather than "inbound" tickets. Tickets whose first segment originates in the

[18] Note, however, that the Figure is drawn for fractional numbers of firms. Were we to impose an integer constraint on the number of firms (so that, for example, a change from 4.4 to 4.2 firms became 4 firms in each case), the pre/post change might reduce the profitability of the gateway without inducing exit.

[19] Immunity alliances represent strategic alliances between domestic and foreign airlines with granted antitrust immunity from the U.S. Department of Transportation. Immunity grants allow carriers to behave as if they were merged, cooperating in setting prices and capacity on all joint international route to and from the U.S.

US are more likely to be sold by US carriers and therefore appear in the data. Accordingly, we focus primarily on outbound ticket data. In addition, we augment the empirical analysis with an alternative dataset that offers complete coverage of passenger traffic. The *T100 International Segment* database provides information on capacity and air traffic volumes on all U.S. non-stop international flight segments (defined at airport-pair level), distinguished by the direction of travel, and operated by both domestic and foreign carriers. The data is collected at monthly frequencies and reports for each carrier-route pair the number of departures scheduled and operated, seats supplied, onboard passengers, segment distance and airborne time.[20] The disadvantage to the T-100 data is two-fold. They do not include prices, and they do not provide complete origin-destination itineraries, reporting only segments that cross the US border.

Table 1 summarizes regional growth in passenger traffic on non-stop segments, and regional growth in the share of traffic covered by OSAs, during the sample period 1993-2008. Figure 1 shows the annual time series aggregated over regions. By any measure of industry performance - passenger volumes, number of non-stop international routes or annual departures performed (unreported) - international air traffic has grown rapidly during this period of deregulation. By 2008, 62 percent of total U.S. international air passenger traffic passed through a foreign gateway airport located in an Open Skies country.

5. Econometric Analysis

We examine how international passenger aviation changes in the wake of trade liberalization efforts, focusing on change along three dimensions. First, we use a difference in difference methodology to compare growth in passenger traffic pre/post liberalization to growth in the same period for non-liberalization countries. Second, we decompose aggregate changes into growth in traffic along "new" and existing routes. Growth in new routes is potentially important given that prior regulations on passenger aviation strictly limited market access to a pre-defined set of city pairs. Third, we examine price and quantity effects separately to see the channels through which OSA liberalization effects passenger aviation, and also examine whether these effects are asymmetric across gateway and non-gateway cities as predicted by the theory. Finally, we combine these estimate into a variety- and quality-adjusted price index to measure consumer welfare gains from liberalization.

[20] However, the T100 Segment data does not easily match to the true Origin and Destination Passenger data, since passengers with very different start and end point itineraries get lumped together in a single observation in the T100 Segment dataset if their cross-border flight segment is the same. Unlike goods, which feature a one-to-one relation between a product and its producer, international air travel often involves the service of more than one airline. This is why firm- and product-level air travel datasets are imperfectly compatible.

5.1. International Passenger Traffic: Methodology and Results

We begin by examining traffic growth using the T-100 International segment data. We observe passenger traffic for every carrier c and route r, corresponding to a US city – Foreign City pair. Total air passenger traffic between the United States and country j at time t is the sum of traffic across all routes r and carriers c.

$$Q_{jt} = \sum_r Q_{r\in j,t} = \sum_r \sum_c Q_{c,r\in j,t}$$

We are interested in aggregate traffic growth with country j, as well as a decomposition of that growth into new routes and old routes. For this decomposition, we treat each city-pair route within country j as a distinct traded 'variety', but aggregate over carriers. That is, we count Chicago-Paris as distinct from Atlanta-Paris, but do not distinguish whether that service was operated by United Airlines or Air France. This approach assumes consumers regard flights into Chicago and Atlanta distinct goods, but carriers as differentiated.[21]

One simple decomposition of Q_{jt} is to count the number of routes offered N_{jt} and the average passenger volume per route at a given point in time:

$$Q_{jt} \equiv \sum_r Q_{rjt} = N_{jt} * \overline{Q}_{jt} \tag{8}$$

A drawback of this approach is that it treats all air services as having equal value weights in the total consumption of international travel. Alternatively, we can assess the importance of each aviation route using its share of passenger shares for country j. Similar to the extensive margin calculation in Feenstra (1994) and the decomposition method in Hummels and Klenow (2005), we denote by I_{jt} the set of all routes offered between the US and country j in period t, and by I_j the subset of routes operated between the US and country j in both the reference period t_0 and current period t, i.e., $I_j \subseteq \left(I_{jt} \cap I_{jt_o}\right)$.[22] Then the total bilateral volume of air passengers can be decomposed as follows:

[21] Retaining carrier specific traffic information is difficult as carriers frequently enter/exit particular routes, change names, merge, and go out of business. In instances where it is possible to track longer time series for multiple carriers on the same route, we can estimate elasticities of substitution between carriers. We find elasticities of substitution between carriers on a given route almost an order of magnitude larger than elasticities across routes.

[22] In the empirical exercises, we will define the common variety set I_j to include those varieties that are have been available in the current year as well as there years before. This ensures that experimental or temporary aviation routes are excluded from I_j. We also experiment with a common variety set including routes offered both currently and in the previous year.

(9) $$Q_{jt} = \left(\sum_{r \in I_j} Q_{rjt}\right)\left(\lambda_{jt}\right)^{-1}, \quad \text{where} \quad \lambda_{jt} = \frac{\sum_{r \in I_j} Q_{rjt}}{\sum_{r \in I_{jt}} Q_{rjt}}$$

The first term of the decomposition -- the intensive margin -- measures the volume of air traffic accounted by aviation routes that are available in both the current and reference periods. The lambda term represents the (passenger-share) weighted count of aviation routes to country *j* available in both time periods. Alternatively, the lambda term can be viewed as one minus the passenger-share weighted count of aviation routes that are "new" relative to the reference period.[23]

It is useful to express total air traffic in terms of annual growth rates. Equation (9) then becomes:

(10) $$\frac{Q_{jt}}{Q_{jt-1}} = \left(\frac{\sum_{r \in I_j} Q_{rjt}}{\sum_{r \in I_j} Q_{rjt-1}}\right)\left(\frac{\lambda_{jt}}{\lambda_{jt-1}}\right)^{-1}$$

In this formulation, the first bracketed term captures the growth in air passenger traffic on "common" service varieties (routes), while the second bracketed term measures the *net* change in route offerings between two consecutive years. A lambda-ratio greater (less) than one implies a gain (loss) in service varieties. The benefit of expressing the extensive margin as a net measure is that in this way it accounts not only for new route additions, but also for any disappearing routes since the reference period. However, if adding or withdrawing city-pair routes are discrete, less frequent events, then cumulative (rather than annual) growth rates are a better way to decompose growth. Summing equation (10) over time periods until current year, we get an expression for the cumulative air traffic growth relative to the first sample year 1993:

(11) $$\Delta Q_{j,t}^{93} = \Delta IM_{j,t}^{93} * \Delta EM_{j,t}^{93}, \quad \text{where} \quad \Delta Z_{j,t}^{93} = \prod_{y=1994}^{t} \frac{Z_{jt}}{Z_{jt-1}}$$

and $Z \in \{Q, IM, EM\}$, with each element defined as in equation (9). We normalize $Z_{j,93}^{93}$ to one.

To estimate the impact of liberalization on air passenger transport, we rely on the time dimension of the T100 International Segment data. Our identification strategy compares the change in passenger volumes within a country pair before and after the introduction of the Open Skies Agreements with the

[23] If all routes carried the same traffic volume (i.e., they have equal weights), then the lambda term would correspond to the fraction of routes from the total number currently offered, that were already available in the reference period. If traffic on new routes is non-negligible, then the inverse of lambda - the extensive margin - is large, having an important contribution towards the total bilateral air traffic flow.

corresponding value calculated for countries that maintain restrictive aviation policies (control group). In using this difference-in-difference estimation method we consider the following regression model:

$$\ln \Delta Z_{jqt}^{93} = \beta_1 OSA_{jqt} + \beta_2 \ln \Delta \left(Y / L \right)_{jt}^{93} + \beta_3 \ln \Delta L_{jt}^{93} + X\beta + \alpha_{jq} + \alpha_t + \varepsilon_{jqt} \quad (12)$$

where *j, q* and *t* index the country, quarter and year respectively, and $Z \in \{Q_{jqt}, IM_{jqt}, EM_{jqt}\}$ takes in turn each variable, expressed as cumulative growth rates. The variable of interest OSA_{jqt} is an indicator variable that equals 1 for all the years when an Open Skies Agreement exists between the U.S. and country *j*. *Y/L* and *L* denote the per-capita income and population of the foreign country respectively, and represent the standard factors determining the demand for air travel; *X* denotes a vector of additional control variables, such as a *Partial Liberalization* indicator for non-OSA countries with more relaxed air transport agreements, a *9/11* control variable, and its interaction with a Visa Waiver Program (*VWP*) indicator to capture any differential response to the tightened security post 9/11 (Neiman and Swagel, 2009)[24], as well as selected region and country trend variables. Finally, α_{jq} and α_t represent country-quarter and year fixed effects.[25] Since all our data involve US bilateral flows, the year effects eliminate any time-varying changes that are specific to the US, which could include incomes, inflation, changes in input prices or technology.

Endogeneity of Open Skies Agreements

One complication in policy evaluation comes from the potential endogeneity between the change in policy and the outcome variable(s) of interest. In our case, a primary concern is that some omitted variable affects the scale or expected future growth of aviation traffic with country j and this omitted variable is correlated with the likelihood and/or timing of an Open Skies Agreement. Countries differ substantially in the size and income of the market, the quality of aviation infrastructure, the dependence on aviation for trade, migration, or tourism, and the strength or political connections of their domestic airlines. The US may be more likely to sign agreements, or sign them earlier, when the benefits of signing are greater and the political opposition to signing is less.

As an initial look at this problem, we inspect the timing of agreements provided in appendix Table A1. What we see is that there is no clear pattern to the timing of the agreements. After The Netherlands signs the first agreement in 1992, 8 OECD European countries sign in 1995. But the rest of

[24] Very few countries change Visa Waiver Program Status during our sample period, so including the VWP variable independently in the regression has no effect on the estimates.
[25] Since the air transport data is for the U.S., the year fixed effects also account for any US specific time varying factors, such as size or income level

Europe is spread throughout the sample, with one each in 1996, 1998, 1999, 2001, and then a final group in 2007. Many Latin American countries sign in 1997, and other signings occur over the next 8 years. Similar partners are found for East Asia, South Asia, Central Europe, and Africa. Table 1 has the percentage of its region that signs at each of three points in time, and again there is no clear pattern. By the end of the period, all of OECD Europe is in, but other regions all have a mix of signers and non-signers. Appendix Table A2 examines the timing of signing and its correlates, including levels and growth rates of population, GDP, GDP per capita, exports, distance, and tariffs. None are statistically significant (though if we enter a "high income" indicator with no other controls it is marginally significant). We also explored characteristics of air traffic routes prior to signing agreements including the country's number of departures worldwide, carrier concentration on routes, and the restrictiveness of existing agreements, including whether they included restrictions on routes, carriers, price setting, or capacity restrictions. Of these, only the existence of capacity restrictions is correlated with early signing, and so we include the degree of partial liberalization as a control in the regressions. We have explored similar regressions in which the dependent variable is binary (sign/don't sign) and these show similar lack of correlation, with the exception of a weak positive correlation with per capita income, driven by OECD Europe. It appears that there is no obvious pattern to which countries sign agreements.

Nevertheless, there could be some more subtle explanation for why countries sign that is correlated with dependent variables of interest. We deal with this concern by transforming the data. First, we express variables in growth rates relative to a base year. To the extent that the selection into Open Skies Agreements depends on any initial condition that affects the level of traffic across countries, expressing traffic in growth rates eliminates this variation. (Many existing studies of services liberalization rely entirely on cross-sectional identification, and in these cases, exploring differential growth rates is not viable.) It may also be that countries in which air traffic will grow faster over time for other reasons are more likely to sign agreements. By incorporating country-quarter fixed effects we allow for different growth rates across countries, and so the effects are identified off of pre/post signing changes in these growth rates. Here differences in the timing of OSAs help us, as some countries sign early and some sign later, and so we can distinguish changes that happened in the year after an OSA was signed, whether that occurred in 1995 or 2005, and separate liberalization from common shocks that occur in a particular year.

A third possibility is that there are changes in growth rates that happen to coincide with signing OSAs. To rule this out we interact the OSA dummy with a vector of time dummies corresponding to t-4 through t+5, where t is the date of signing. This enables us to see whether aviation traffic was already growing prior to the OSA signing or whether changes in growth rates correspond to the date agreements were signed. We will come back to this point in a short while, and discuss the results from the data exercises.

Estimation Results

Moving to the estimation results, Table 2 reports the coefficients from the regression model in equation (12) estimated using the cumulative growth rate decomposition in equation (11). From the aggregate effects reported in Column 1, we find that countries who liberalize their international aviation markets receive on average 7.9 percent (i.e., exp(0.076)-1) more air passenger traffic from the U.S. conditional on demand side factors such as per-capita income, country size, bilateral distance, seasonality, or post-September 11 effects (differentiated by countries' visa regime).

This observed increase in the volume of international air travel is explained in part by the net expansion of international aviation routes. Countries that sign OSAs see a 10.7 percent faster growth in the number of routes, as measured by a simple count. When using weighted counts to measure the extensive margin, liberalization corresponds to an increase in the extensive margin between 3.9 percent (Column 4) and 2.4 percent (Column 6), depending on whether the reference year is based on one or three years lag. Weighted counts of the extensive margin yield smaller elasticities, which indicates that new routes correspond, on average, to smaller passenger counts. By weighting by passenger counts we appropriately account for the economic importance of these new routes.

Liberalization also affects the cumulative passenger growth along routes previously offered. The intensive margin effects range between 3.7 percent (Column 5) and 5.3 percent (Column 7). Given the log-additive property of the components of the air traffic decomposition, the estimated intensive margin effects are equivalent to the difference between total air traffic and extensive margin coefficients.

The simple OSA indicator specification assumes that there is a one-time level change in growth rates after signing. But aviation markets may take time to adjust to new policies, as carriers experiment with new markets and route networks, and consumers learn of new opportunities. To account for this we interact the OSA indicator with a vector of time dummies corresponding to t-1 through t+5, where t is the date of signing. This enables us to see whether increases in traffic growth accumulate over time.

Table 3 reports the regression results. Two points emerge from these estimates. First, for all three dependent variables, the impact of air services liberalization increases monotonically over time. Focusing on the long run effects, we find that the cumulative growth of air passenger travel after five or more years since an Open Skies Agreement is 20 percent. Of this increase, 37 percent (i.e., 7 percentage points) is the result of a net gain in new aviation routes, and the remaining 63 percent (i.e., 12.2 percentage points) is explained by passenger growth along previously offered routes. These numbers correspond to estimates in columns (2) and (3). A more frequent (year-on-year) updating of the "common" variety set implies that the newly introduced routes start to be accounted as previously available varieties within one year. As a consequence, any rapid increases or deteriorations in the market share of new services in their first few years of activity are going to be captured in the intensive margin. This explains the much lower (larger) extensive (intensive) margin estimates reported in Column 4 (Column 5).

This approach also allows us to address a final concern regarding endogeneity of OSAs. Recall that we have already accounted for differences in the level of traffic, and differences in the growth rates of traffic that are specific to each country. The final concern is that some variable induces a change in growth rates, and this change in growth rates induces the country to sign. To address this, we incorporate a full set of t-4 through t+5 year dummies, where t is the time of signing, interacted with the OSA indicator.

We plot these coefficients in Figure 6. The first panel traces the changes in the cumulative air traffic growth rate for several years before and after liberalization, after controlling for the same determinants of air traffic as in regression equation (12). Similar time series plots are done for the intensive and extensive margins of air transport, respectively. Each plot makes clear that in the years prior to signing of the Open Skies Agreements there are no statistically significant differences in the growth of air transport between signers and non-signers, but that growth after signing is significant. For this to be driven by some factor other than the OSA it would have to be the case that the omitted variable changed in the same year that the OSA was signed. Further, since we have 87 different signings over a 15 year period, this omitted variable would have to coincidentally change at the same time as the OSA signing in every market, but in a different year for every country. This seems unlikely.

To summarize, signing Open Skies Agreements corresponds to acceleration in passenger traffic growth in signatories relative to non-signatories. Moreover, a significant fraction of this growth occurs through the expansion of new routes. This is particularly relevant since strict limits on the number of international gateway cities was of those most restrictive aspects of pre-OSA regimes. We turn next to the impact on prices and service quality

5.2. Entry and Exit of Carriers

Our model suggests that Open Skies Agreements lead to two distinct kinds of entry / exit patterns. Relaxing restrictions on routes leads to an expansion of routes, as clearly shown in the last section.

However, removing route restrictions can lead to changes in the equilibrium patterns of entry and exit by carriers. On non-gateway "hub" routes, foreign carriers cannot enter prior to OSAs because direct flights are prohibited, as is "cabotage", in which the foreign carriers transits a US gateway and continues onto the non-gateway city. Relaxing these restrictions should lead to entry on these routes. In addition, our model predicts exit from gateways after signing. Domestic carriers who, pre-OSA, were forced to offer service through gateways to attract international passengers into their hub routes can, post-OSA, offer direct service and forego the fixed cost of establishing a gateway presence.

We examine these conjectures in Figure 7. We begin by counting the number of carriers competing on each route pre-OSA, and organizing these into 8 equal size bins from fewest competitors (at left) to most competitors. We then examine the log change in the number of carriers pre/post OSA. This is represented by the vertical bars in Figure 7. Routes with the fewest carriers see the most entry (on average, a 20 percent rise in the number of carriers), and routes with the most carriers see exit (for bins 6 and 7, a 25 percent decline in the number of carriers). This is consistent with the view from the model, that existing regulations force an "excess" of entry into a few gateway cities. These gateways enjoy intense competition, while remaining routes have few competitors. Post-OSA, not only is there entry on the off-gateway routes, but the ability to offer direct service causes exit on the gateways. The unregulated market results in a different, and less concentrated, distribution of capacity.

5.3. Price and Quality Effects of Open Skies Agreements

Our model suggests several ways in which OSAs could affect aviation prices. On non-gateway hubs, flying more direct routes reduces the marginal cost of providing service, and entry into previously monopolized routes could lower markups. In contrast, carriers who no longer need to transit through gateways may exit, raising markups on gateway routes. There may be several additional channels, outside our model that would affect prices. Regulated prices might be higher or lower than prices in the unregulated equilibrium. Low cost carriers, restricted by capacity limits, might enter and push down prices. Alliances could either allow carriers to specialize on "comparative advantage" segments, or allow cooperating carriers to collude in setting prices or market shares. Market liberalization may also push up costs due to increased competition for scarce factors (e.g., gate-space) or lower capacity utilization on shorter, thinner routes (Morrison and Winston, 1990). In short, it is not obvious whether on net OSAs will affect prices or in which direction.

Similarly, in the model, OSAs only affect quantities demanded by changing prices. More generally, we could see passenger demand changing because OSAs affect consumers' valuation of international flight. It is possible that OSAs lead unregulated airlines to lower service quality, as occurred in the domestic US context. Alternatively, more dense aviation markets after an OSA might improve flight frequency, connectivity, or the ability to get non-stop flights. If consumers value these attributes then the OSA might increase consumer demand conditional on prices.

To address pricing we turn to the airline ticket database, Databank 1B (DB1B). As described in the data section, the DB1B data includes detailed information on prices, service characteristics and full itinerary captured at airport detail. Knowing the complete itinerary of travelers provides several advantages. First, we can account for the true origin and destination of the traveler, rather than relying on the international segment that is captured in the T-100 data. This allows us to properly account for demand shifters specific to each country. It also allows us to account for third country effects implied by the bilateral policy change, such as the extent to which air services liberalization generates new traffic (trade creation) or just reallocates transit passengers across international routes covered by Open Skies Agreements (trade diversion). Second, by observing the itinerary we can see whether OSAs lead to changes in flight characteristics such as the number of connections, that affect consumer valuation.

To introduce the estimating equations, we consider a simple set-up that describes a city-pair (origin-destination) international aviation market. At this point, for estimation purposes, we depart from the much simplified theory framework (i.e., linear demand, constant domestic cost), and assume more flexible reduced form demand and cost specifications.

To characterize the demand side, we start by assuming that the representative U.S. consumer derives utility from all available city-pair routes *r* reaching all destination countries *j*, formalized through an asymmetric CES utility function. Straightforward utility maximization subject to the budget constraint gives the demand function for air travel on route *r*. Summing the individual demands by direction of travel in each city pair market leads to the following route specific air travel demand:

$$Q_{rjt} = \alpha_{rjt}\left[p_{rjt}(.)\right]^{-\sigma}\left(\frac{\mu Y_t}{P_t}\right) \tag{13}$$

Where α_{rjt} denotes any route specific attributes that are valuable to the traveler and are not captured by the level of air fare p_{rjt} , σ is the own-price elasticity of demand (which in a CES framework also defines the elasticity of substitution across routes); μ is the constant expenditure share of international travel in total U.S. income Y_t; and P_t is the CES price index for air transport services.

The demand shifter α_{rjt} is assumed to depend on a multiplicative term of observable trip characteristics Z_{rj} (such as distance, average number of connections, direction of travel: outbound vs. inbound, etc.), and unobservable service quality attributes that become effective with the Open Skies Agreements. In log form, we express the quality shifter as:

(14) $$\ln \alpha_{rjt} = g(OSA_{jt}) + \ln Z_{rjt}$$

A similar equation as can be written for the demand arising from country *j* consumers for travel on the same route *r*. Under symmetric technologies, the only difference comes from the inclusion of foreign country expenditures instead of those for the U.S.. Summing the two demand equations we get the expression for the total air travel demand at city-pair level. We further refine this aggregate demand by decomposing total expenditures into population and per capita income at origin and destination. Taking logs, and substituting out α_{rjt} using equation (14), we obtain the following reduced form estimating equation for the (city-pair) total air passenger traffic:

(15) $$\ln Q_{rjt} = \beta_0 \ln p_{rjt}(.) + \beta_1 OSA_{jt} + \beta_2 \ln Z_{rjt} + \beta_3 \ln L_{st} + \beta_4 \ln\left(\frac{Y/L}{P}\right)_{st} + \\ + \beta_5 \ln L_{jt} + \beta_6 \ln\left(\frac{Y/L}{P}\right)_{jt} + \alpha_t + \alpha_{rj} + \varepsilon_{rjt}$$

where *s* indexes the US state associated with the aviation route *r*, and α_t, α_{rj} represent year and (city-pair) route fixed effects, respectively. The vector Z_{rjt} of demand shifting itinerary characteristics includes flight distance, average segments per trip (i.e., connections), the fraction of outbound traffic (i.e., passengers that begin their journey in the US), and the fraction of direct traffic.

In characterizing the supply side of an aviation market we employ a reduced form approach where the average air fare on the international route *r*, p_{rjt}, depends multiplicatively on the marginal cost MC_{rjt} and the price cost mark-up γ_{rjt}.[26] Open Skies Agreements may affect airfares through changes in mark-ups and/or changes in marginal costs. We write the expression for prices as:

(16) $$\ln p_{rjt} = h(OSA_{jt}) + \ln MC_{rjt} + \ln \gamma_{rj}$$

where we impose a time invariant route specific mark-up, net of the competitive effects of liberalization. We further assume that the marginal cost is a log-linear function of traffic density at origin (Q_{st}) and destination (Q_{jt}), of input prices w_t (e.g., fuel, aircraft insurance costs), and of cost-related travel characteristics Λ_{rj} (e.g., distance, one-way trip, number of segments per trip, direction of travel, etc.).

Embedding the marginal cost assumptions in the prices equation given by (9), we arrive at the following reduced-form price regression:

[26] With a small number of air carriers in each city-pair route, mark-ups fall with entry even in the presence of constant elasticity demand. See for example Feenstra and Ma (2007).

(17) $$\ln p_{rjt} = \gamma_1 OSA_{jt} + \gamma_2 \ln Q_{st} + \gamma_3 \ln Q_{jt} + \gamma_4 \Lambda_{rjt} + \gamma_5 \ln(Dist_{rjt} * Fuel_t) + \sum_{i=6}^{n} \gamma_i (\ln Insur_t * D_i^{geo}) + \alpha_t + \alpha_{rj} + \varepsilon_{rjt}$$

where α_t and α_{rj} are year and origin-destination city-pair fixed effects. In the data, we measure traffic density (Q_{st}, Q_{jt}) using population size and number of destination cities reached from each origin city.

Figure 8 displays trends in input costs over this period. Many input costs will vary only over time, and therefore be absorbed into year effects. However, some inputs vary across time and geography in a way that is useful for identifying cost effects. For example, takeoff/landing intensively uses fuel, so fuel represents a larger percentage of costs on short haul flights. Changes in fuel costs over time will then represent a larger percentage change for short versus medium length flights. Accordingly, we interact fuel costs with flight distances. Similarly, aircraft insurance costs changed markedly in this period, with sharp declines prior to a 9/11 related increase. But these insurance rates were not uniform across markets, presumably reflecting a belief that risks differed by destination. We interact changes in insurance costs with indicator variables for different geographic regions. These latter variables will also serve as excluded instruments for prices when estimating demand.

The demand estimation model in (15) and the price equation in (17) are estimated using the DB1B ticket level dataset. Both models include time and route-specific fixed effects, so identification relies entirely on time variation within each origin-destination city pair.[27] Additional control variables not mentioned before include an indicator variable for post-September 11 period, interactions with a time trend, and a country indicator for Partial Liberalization.

We begin with the estimation of the price equation and report the results in Table 4. Column 1 includes the benchmark estimates. We find that the impact of Open Skies Agreements on airfares is close to zero and insignificant. We suspect however that this small effect is the outcome of a miss-specified control group. In particular, suppose that the benefits of the bilateral Open Skies Agreements may accrue not only to passengers ending their trip in liberalized countries, but also to those that fly some segments of their itineraries along routes covered by Open Skies Agreements. If that is the case, then not separating out both itinerary types -- which are directly affected by Open Skies Agreements -- from the reference group of fully regulated air travel flows, makes it difficult to identify the actual effects of liberalization.

Accordingly, we construct another liberalization variable: *OSA Connect*Share of distance*, measuring the distance share of an itinerary not involving OSA partners, that is traveled along connections covered by Open Skies Agreements. More exactly, *OSA Connect* equals 1 if a trip *r* to/from country *j*, where *j* has no Open Skies Agreement, transits via an airport hub *h* located in a fully liberalized

[27] Figure 3 shows graphically the average change in route level prices and quantities over the sample period using the DB1B dataset.

market; and *Share of distance* measures the fraction that the connection between hub h and a point in the U.S. takes in total flight distance.[28] Column 2 reports the results including this additional liberalization variable, and both the direct and the network effects of Open Skies Agreement are negative and significant. The direct effect of liberalization indicates an average 1.5 percent drop in air fares conditional on other itinerary characteristics. Such fare reductions generated by international air service liberalization may be explained by factors such as increased competition and cost synergies via carrier alliance formation.

Interestingly, the network price effect of Open Skies Agreements (which affects air traffic connecting via liberalized countries) is larger in magnitude than the direct price effect whenever the distance share flown on OSA segments increases by at least 14 percent (i.e., -0.105*0.14 = -0.015) for transit itineraries. One potential explanation for this latter result lies in the development of strategic airline alliances, which are directly tied to Open Skies Agreements. They are shown to bring significant price reductions on inter-airline routes (Brueckner and Whalen, 2003), and to have an extensive network coverage that includes non-OSA countries. To understand whether the liberalization effects differ between U.S. outbound and inbound flows, next we interact the OSA dummy with the fraction of passengers that originate their trip in the U.S. (i.e., outbound traffic). The results reported in Column 3 point out to significant differences in the effect of Open Skies Agreements on outbound versus inbound air traffic. While incoming travelers to the U.S. see a 4 percent decrease in air fares as a result of market liberalization, the OSA price effect for passengers originating their trip in the U.S. is insignificant and close to zero (when evaluated at the sample average share of outbound passengers per route). Furthermore, separating the average treaty effect into immediate impact (first three years since the signing of the treaty) and longer-term effects (three or more years after the treaty is in effect) does not change previous findings. The results reported in Column 4 of Table 4 reinforces the differential impact of the agreement on inbound and outbound traffic, while highlighting the time lag necessary for the market liberalization benefits to affect transit passengers to third countries.

We turn next to the estimation of the air travel demand equation at route level. Table 5 reports the results. Column 1 includes the OLS estimates from the benchmark model with route and year fixed effects, and column 2 allows for separate effects of the Open Skies Agreements on transit versus final destination traffic. Because the consumption benefits from connecting flights in fully liberalized countries have more to do with the increased convenience of using those hubs than with the fraction of the total

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[28] Formally, we construct the following variable at ticket level: $\sum_{i\in\omega}\left\{I(OSA_{i\omega}=1)\frac{dist_{i\omega}}{\sum_i dist_{i\omega}}\right\}$, where i denotes a flight segment of an airline ticket ω; *I(.)* is an indicator function equal to 1 whenever the flight segment i crossing the US border is covered by an Open Skies Agreement.

distance traveled to get to those hubs, this time *OSA Connect* is constructed slightly different. It reflects the OSA transit intensity of travel in a city-pair market *r* involving a strictly regulated foreign country *j*. More exactly, *OSA Connect* is an indicator variable equal to 1 if at least 10 percent of travelers in a city-pair market involving a non-liberalized country do connect through an OSA hub.[29] The pattern of results that we find is consistent with the price regression results. That is, separating out the direct and the network effects of Open Skies Agreements reveals a sizeable and significant impact of liberalization on route level traffic. In column 3 we distinguish between the quality effects of OSA on U.S. outbound versus inbound traffic flows, and the pattern of results is reversed compared to the price effects. This time, it is the outbound passengers that benefit more from the liberalization of air services.

One issue with the OLS estimates reported in the first three columns is that they do not account for the fact that, in theory, prices are endogenous in a demand equation. To deal with this econometric problem, we re-estimate the demand model by two stage least squares (2SLS) and rely on the price equation to identify cost shifters that can be used as exogenous instruments for airfares. In particular, we exploit the time variation in fuel prices (interacted with average trip distance) and the variation in insurance cost shocks (interacted with world geographical region dummies) to identify the price elasticity of demand. Figure 8 shows the time trends for various cost components constructed using IATA data.

Column 4 reports the two-stage least squares estimates. Several points emerge. First, the estimated price elasticity of demand increases in absolute value relative to the OLS estimate, as was expected, and now it conforms to other estimates from the literature.[30] Second, route level traffic originating in the U.S. and terminating in countries signatories of Open Skies Agreements increases on average by 11.3 percent relative to traffic with similar itinerary characteristics but operated on restricted aviation routes.[31] Such significant traffic growth generated by trade liberalization *net* of price effects can be attributed to improvements in service quality (e.g., flight frequency, better coordinated schedules and gate proximity, broader coverage of frequent flier programs, etc.). Third, the impact of market liberalization on traffic incoming to the U.S. falls to zero and becomes insignificant, once correctly accounting for the OSA effect on inbound airfares. However, when decomposing the average effects into immediate impact (first three years since the signing of the treaty) and longer term effects (three or more

[29] Experimenting with higher cutoff shares, such as 20% of total route level traffic, decreases the magnitude of the estimates but not their significance level. Yet, raising too much the cutoff share comes with the risk of ignoring economically important effects of OSA on connecting air traffic. This is because it is reasonable to expect carriers operating direct or alternative hub services on non-OSA routes to respond to competitive pressure from OSA connecting services in order to avoid large loses in traffic shares.

[30] Brons et al. (2001) provide a meta-analysis of price elasticities of demand for passenger air travel and report a mean estimate of -1.146 (st.dev. 0.619) based on a set of 204 elasticities from 37 studies.

[31] Note also that the quantity effect of air trade liberalization is in the ballpark of the traffic growth values obtained from the T100 Segment dataset (reported in Table 2), although the T100 traffic data combines both true origin-destination and connecting traffic across non-stop international flight segments.

years into the treaty), as seen in Column (5), there is evidence that liberalization has positive and significant quantity effects for inbound traffic. Fourth, the gains from liberalization enjoyed by travelers transiting an OSA hub are larger than the direct effects estimated for traffic whose final destination are the OSA countries. The volume of international passengers who connect in airport hubs covered by Open Skies Agreements but do not terminate their itineraries in liberalized destination markets is larger on average by 8.6 percent relative to the reference group. Again, this may suggest that quality gains in air transport service may be more important in thin, poorly accessible, non-gateway international routes. All the other variables in the model have the expected sign and are generally significant.

The price and quantity effects of air services liberalization are estimated as an average effect over heterogeneous origin-destination city-pair routes. One dimension on which aviation routes may differ is market competition. Market liberalization presumably brings significant entry and exit of carriers across routes. Using a subsample of gateway-to-gateway routes of direct or one-stop round tickets matched to corresponding cross-border flight segments in the T100 dataset, we identify the city-pair routes that saw a net increase in air carriers three years into OSA from city-pairs that saw no change or even a net decrease in operating air carriers. Focusing on outbound traffic only, Table 6 reports the results from estimating the impact of OSA on air fares using this subsample of city-pair routes. Column 1 reports the average effects over all route types, and the insignificant coefficient reinforces the findings in Table 4. However, Columns 2 and 3 provide the explanation for this result: the overall OSA effect averages out the counteracting impact of liberalization on routes with net entry versus routes with net exit. That is, market liberalization leads to 2.3 percent lower air fares on routes with intensified completion, but increases average air fares by 4.3 percent on routes witnessing firm exits. This pattern is persistent in the longer run, as shown by the phase-in effects estimated in Columns 4 to 6.

Table 7 provides the same data exercise for the net entry/exit subsample but focusing instead on quantity effects. All estimates are obtained by 2SLS using as excluded instruments the same cost shifters as in Table 5. Consistent with our expectation, city-pair routes with net exit of carriers see no increase in air traffic post liberalization, even after accounting for their higher average prices. This is in contrast to the estimated 14 percent increase in traffic on routes enjoying net entry of carriers after OSA.

To test the sensitivity of our findings to the estimation sample, as a robustness exercise we re-estimate the demand and price regressions on two separate subsamples. One subsample selects only routes involving the main US airports for each state, with the large states represented by the top three airports in terms of traffic, while medium and small states counted with two or one airports respectively (see Appendix Table A6 for the list of selected airports). This subsample eliminates all the unusual and infrequent trip itineraries while still covering all three types of airport sizes in relatively equal shares (by count). The second subsample includes only behind-to-gateway and behind-to-beyond aviation markets, which have the advantage of being representative of actual traffic volumes even if they tend to be on average much thinner markets. Table 8 reports the estimation results using the same sets of instruments as previously described. Overall, the estimates are quite similar both across the two subsamples and with the estimates from the full sample in spite of differences in the composition of routes and of airline tickets per route.

5.4. Consumer Welfare Calculations

To summarize all our empirical findings in one statistic on consumer welfare, we combine the variety, efficiency and quality effects in an overall air price index following a methodology adapted from Feenstra (1994). Our goal is to assess the price equivalent measure of air services liberalization, in the same way we evaluate the liberalization of goods by a reduction in the price wedge between exporters and importers.

In a seminal paper, Feenstra (1994) provides a methodology to calculate price indexes in the presence of new varieties, as follows:

$$\pi_t \equiv P_t \left(\frac{\lambda_t}{\lambda_{t-1}} \right)^{1/(\sigma-1)} \tag{18}$$

where π_t represents the variety-adjusted price index, $P_t \equiv \prod_i \left(\frac{p_{it}}{p_{it-1}} \right)^{w_{it}}$ represents the exact price index computed over a common set of varieties available in periods t and $t\text{-}1$, and $\lambda_r = \left[\frac{\sum_{i \in I} p_{ir} x_{ir}}{\sum_{i \in I_r} p_{ir} x_{ir}} \right]$, r=t, t-1 represents the variety adjustment.

Our empirical results suggest that OSAs affect the variety-adjusted price index π_t both via price and variety effects. With regards to the price effects, OSA's affect p_{it} both directly, through changes in costs or price mark-ups, and also indirectly, through quality changes.

In what follows, we describe the calculation of each of these price index components, as they change in response to OSAs. We do this separately for inbound and outbound traffic. We use long run estimates (3+ years since OSA) and an elasticity of substitution between air services, σ = 1.250, suggested by the price elasticity of demand estimated in column 5 of Table 5. The results from our calculation of changes in price indexes are reported in Table 9.

To illustrate the steps undertaken in the computation of the price equivalent measure of air services liberalization, let us focus on the case of US inbound traffic for passengers beginning their trip in OSA countries (i.e., not OSA connect traffic). The calculations for all the other categories of travel flows reported in Table 9 are performed in exactly the same way.

For inbound traffic, the direct effect of OSA on prices p_{it} relative to equivalent routes in regulated markets is equal to -0.026 (column 4 in Table 4). However, conditional on prices, OSAs also have an effect on the quantity of travel, a demand shift that we interpret as quality effects. Using a price elasticity of demand of -1.250, we can express quality effects in price equivalent units as: $\beta^{OSA}/\sigma = 0.048/-1.250 = -0.038$. Adding together the efficiency and quality effects, it follows that the change in the quality-adjusted price index attributed to OSA is -0.064 (i.e., $P^{OSA}/P^{regulated} = 0.936$). These price effects are reported in the first three lines of column 2 in Table 9.

To compute the variety adjustment, recall from equation (9) that the extensive margin we have used in our earlier estimations is in fact the inverse of the λ-ratio from equation (18). Thus, using the long run OSA estimate (+5 years) reporter in column 2 of Table 3, the λ-ratio for OSA relative to regulated markets is given by: (1 - 0.068)^(1/(1.250-1) = 0.755. This is reported in line 4 of column 2 in Table 9.

Multiplying together the quality-adjusted price index with the variety-adjusted price as indicated in equation (18), we obtain a variety and quality adjusted price index for OSA markets relative to regulated ones of 0.706. This implies that the price equivalent of the Open Skies Agreements is a drop in the price index of 29.41percent.

Table 9 reports similar calculations for outbound travel, as well as for traffic transiting via OSA hubs. The results are quite similar in magnitude, with slightly large price drops for OSA connect traffic. This points to spillover effects in consumer welfare triggered by air service liberalization.

6. Conclusions

Services is large and growing fast, but we know relatively little about the importance of policy barriers to services trade, or the kinds of effects that are likely to result from liberalization. Recent US efforts to liberalize passenger aviation via Open Skies Agreements led to sweeping changes in the regulatory structure facing domestic and foreign carriers. But as we show in the accompanying model, the net effect of these changes on entry, pricing, and welfare is not obvious.

We draw on services data at the level of individual transactions (passenger tickets) combined with differences in the timing of liberalization across partner countries to identify the effect of Open Skies Agreements. We find that, compared to non-signatory countries, OSA signatories experienced 18 percent higher growth in traffic five years after signing. More than a third of this growth is accounted for by growth in new routes. This is channel is especially relevant since existing Air Services Agreements explicitly restricted the number of entry routes, and signatories see much more rapid growth in new routes than non-signatories.

Removing route restrictions also leads to changes in the equilibrium patterns of entry and exit by carriers. On non-gateway "hub" routes, foreign carriers cannot enter prior to OSAs because direct flights are prohibited, as is "cabotage", in which the foreign carriers transits a US gateway and continues onto the non-gateway city. Relaxing these restrictions led to carrier entry on these routes, but it also led to exit from gateways. Domestic carriers are no longer forced to offer service through gateways to attract international passengers into their hub routes, and these carriers exit. The unregulated market reallocates capacity across routes leading to a greater uniformity of competition.

Exploiting ticket-level data for thousands of true origin-destination aviation markets we find that Opens Skies Agreements are associated with a decrease in average airfares, and conditional on prices, an increase in the demand for international air traffic at route level. However, price effects are not uniform, as gateways routes with exiting carriers see prices increase. The rise in quantity conditional on prices suggests that OSAs lead to air service quality improvements such as more frequent departures and greater flexibility in scheduling, or more direct connections, all of which consumers value highly. Additionally, the estimated price and quality gains associated with the liberalization are enjoyed not only by consumers traveling to a liberalized market, but also by transit passengers connecting through gateway airports located in Open Skies Agreement countries. This suggests an important but unusual policy spillover: Open Skies Agreements are so powerful they benefit even countries unwilling to sign them.

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Data Appendix

The *Databank 1B (DB1B) Origin and Destination Passenger Survey* represents a 10 percent sample of airline tickets drawn from airport-pair routes with at least one end-point in the U.S. Each airline ticket purchase recorded in the data contains information on the complete trip itinerary at airport level of detail, the air carriers marketing the ticket and operating each flight segment, the total air fare, distance traveled split by flight segments, ticket class type, as well as other segment level flight characteristics. Even though more than one air carrier may operate the travel itinerary, the responsibility to report the complete flight information to the DOT falls on the marketing carrier, which is also the one setting the air fare.

We apply several filters to the original DB1B dataset before using it for the empirical analysis. First, we keep only international airline tickets, dropping all domestic itineraries and all international trips transiting only the U.S. Second, we remove circuitous itineraries and keep only tickets that have a single trip break point used in identifying the final destination of the traveler. Third, to limit heterogeneity and coding errors in ticket prices, we further drop the following observations: a). business and first class tickets; b). tickets flagged by the Department of Transportation during data assembly as having unreasonably high fares; c). tickets with fares below $100 or above $9,999; d). tickets with more than four flight connections per direction of travel; e). tickets that involve land segments longer than 35 miles (i.e., transfers between two airports of the same city would not be dropped). Using the resulting sample, we construct a few additional ticket-level variables such as indicators for one-way trip, for direct service, and for the U.S. outbound itinerary. For round trip tickets we replace the fare level and ticket distance with half their values, to be directly comparable with one-way tickets. All observations for the same origin-destination pair are collapsed across all quarters within a given year using passenger-share weights to obtain route level annual aggregates. Finally, for reasons dictated by our traffic decomposition methods and described later on, we restrict attention to foreign countries with at least one city-pair route serviced continuously over we remove the very thin and infrequent aviation routes to be able to exploit in the empirics within city-pair variation.[32] The resulting restricted sample is going to be used for the estimation exercises. It includes about 50,000 origin-destination airport pairs, with an average of 12 observations per pair. The summary statistics for the variables of interest are provided in the Appendix Table A3.

[32] To do this, we drop the bottom 10% city-pairs in terms of sample frequency across all quarters and years, the bottom 5% state-country pairs in terms of sample frequency across all quarters and years and with and we also drop the bottom 10% city-pairs in terms of number of sampled passengers across all time periods. While we end up dropping 27% of origin-destination-time observations, they represent only 2 percent of the observed international air passenger flows. Note that eliminating infrequent state-country pairs as opposed to infrequent foreign countries has the benefit of maintaining international routes between gateway airports, for example New York City to Dakar, Senegal, while removing barely sampled routes such as Indianapolis to Dakar.

One limitation of the DB1B data is that foreign carriers that are not part of immunity alliances are not required to file ticket sales information to the U.S. Department of Transportation.[33] This implies that itineraries along routes with a U.S. gateway airport end-point (i.e., US gateway-to-foreign gateway and US gateway-to-beyond foreign gateway routes) are under-represented in the estimation sample. However, information about foreign operated flights does appear in the DB1B dataset provided at least one segment of the tickets is operated by a US carrier. In fact, since international air traffic on routes involving non-gateway U.S. airports always requires a U.S. air carrier to provide service on the domestic spoke, then these sampled itineraries are representative for the population. Appendix Table A4 summarizes the distribution of international air traffic by route categories. The most frequently sampled route category is the U.S. behind-to-gateway routes, which reflects the extensive coverage of the U.S. domestic network. However, when factoring in traffic densities, 70 percent of the observed international air passenger traffic represents gateway-to-gateway trips.[34] In fact, there is significant difference in average traffic densities across route categories. Therefore, the trade-off between representativity and relevance of the estimation sample is serious. If we were to consider a representative sample and only focus on behind-to-gateway and behind-to-beyond routes, we would essentially omit at least 77 percent of international traffic. So instead of doing that, we keep all sampled ticket itineraries in the sample and augment the empirical analysis with an alternative air travel dataset, which is more aggregated but offers complete coverage.

A second dataset we use in this paper is *T100 International Segment*. This is a firm level dataset that provides information on capacity and air traffic volumes on all U.S. non-stop international flight segments (defined at airport-pair level), distinguished by the direction of travel, and operated by both domestic and foreign carriers. The data is collected at monthly frequencies and reports for each carrier-route pair the number of departures scheduled and operated, seats supplied, onboard passengers, segment distance and airborne time. A more detailed description of the data and sample construction is included in the Data Appendix. One important advantage of the T100 Segment dataset is that it provides an exhaustive account of all U.S. cross-border air passenger traffic by operating carrier and airport-pair route.[35] Appendix Table A5 summarizes the aggregate market share of U.S. and foreign air carriers in total international air passenger transport, with the foreign airlines distinguished based on participation in antitrust immunity alliances. Two aspects are worth pointing out. First, the market share of US carriers

[33] Immunity alliances represent strategic alliances between domestic and foreign airlines with granted antitrust immunity from the U.S. Department of Transportation. Immunity grants allow carriers to behave as if they were merged, cooperating in setting prices and capacity on all joint international route to and from the U.S.

[34] This is a lower estimate of the true value given the unobserved number of travelers flying on foreign carries.

[35] However, the T100 Segment data does not easily match to the true Origin and Destination Passenger data, since passengers with very different start and end point itineraries get lumped together in a single observation in the T100 Segment dataset if their cross-border flight segment is the same. Unlike goods, which feature a one-to-one relation between a product and its producer, international air travel often involves the service of more than one airline. This is why firm- and product-level air travel datasets are imperfectly compatible.

has constantly dropped in the first half of the sample -- consistent with on-going efforts towards openness in air services trade -- although this downward trend reversed after 2001. Second, the fraction of international traffic operated by non-immunized foreign carriers is on average 36 percent. A fraction of these passenger flows (those having *all* flight segments operated by foreign air carriers) are omitted from the DB1B ticket level dataset.[36]

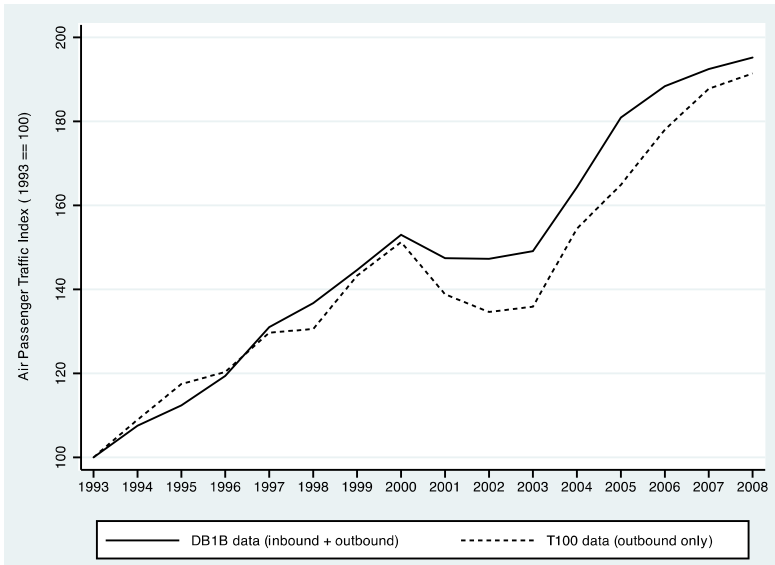
To complete the data description, Table 1 provides a summary of the evolution of international traffic on non-stop segments during the sample period 1993-2008. By any measure of industry performance - passenger volumes, number of non-stop international routes or annual departures performed (unreported) - international air traffic has grown at remarkable rates.[37] This period of expansion in international air travel has overlapped with a time of "global deregulation" (DOT, 1999). In fact, by 2008, as much as 62 percent of total U.S. international air passenger traffic passed through a foreign gateway airport located in an Open Skies country. Table 1 reports for each world geographic region the passenger share accounted for by OSA countries. Variations in the extent of air services liberalization across the globe reflect not only differences in countries' participation in liberalization policies but also differences in the timing of these decisions.

[36] Because only U.S. carriers can operate domestic routes, all international passengers that enter (exit) the U.S. on foreign carriers, yet fly an extra domestic leg to (from) their final (starting) point of their itinerary, have the same likelihood of being sampled in the DB1B dataset through reports prepared by the domestic carrier.

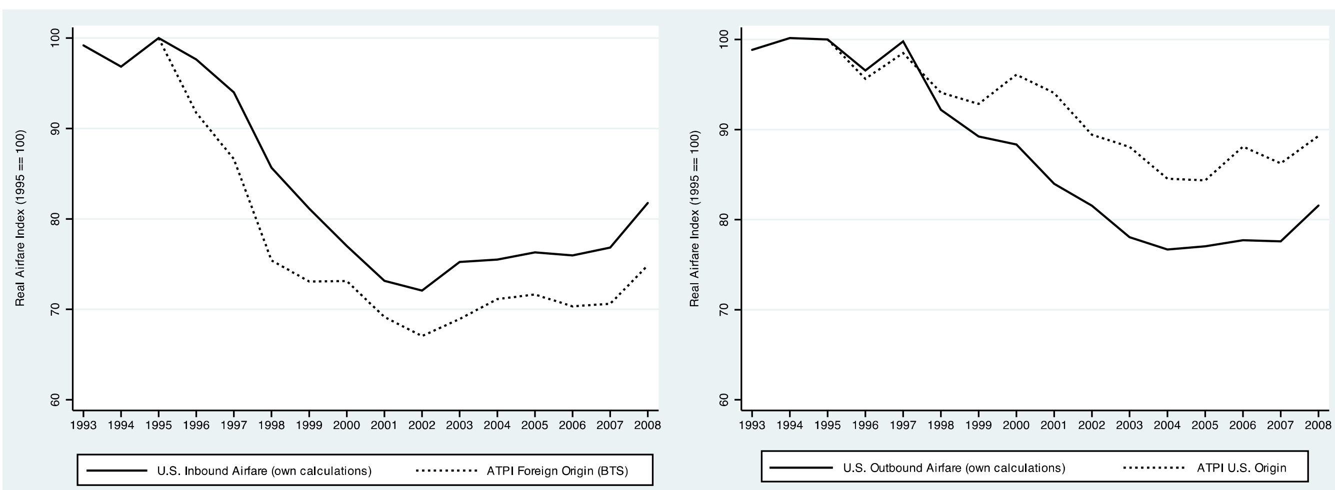
[37] The September 11 terrorist attracts, followed by other disrupting events like the Iraq war and SARS, have significantly affected the international aviation industry curbing its ascending trend. However these shocks were temporary, so traffic growth rates picked up again.

Figure 1: The Evolution of Air Travel using True Origin-Destination Data (DB1B)

1A: Air Passenger Traffic Trend



1B: Average Inbound and Outbound Airfare Trend

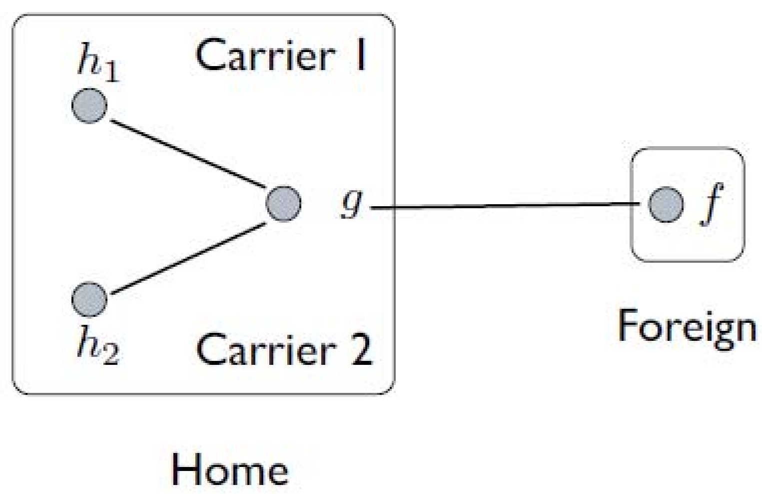


Notes:

1. The series based on DB1B data represent the year intercepts from regressions with origin-destination city pair fixed effects. Economy class airfare values represent averages over inbound and outbound tickets within a route, and are first normalized using U.S. CPI values.
2. The Air Travel Price Index (ATPI) is a price index series provided by the Bureau of Transport Statistics starting from 1995. It is constructed based on the Fisher formula, separately for inbound and outbound travel flows.

Figure 2: Network Structure

Pre-OSA



Post-OSA

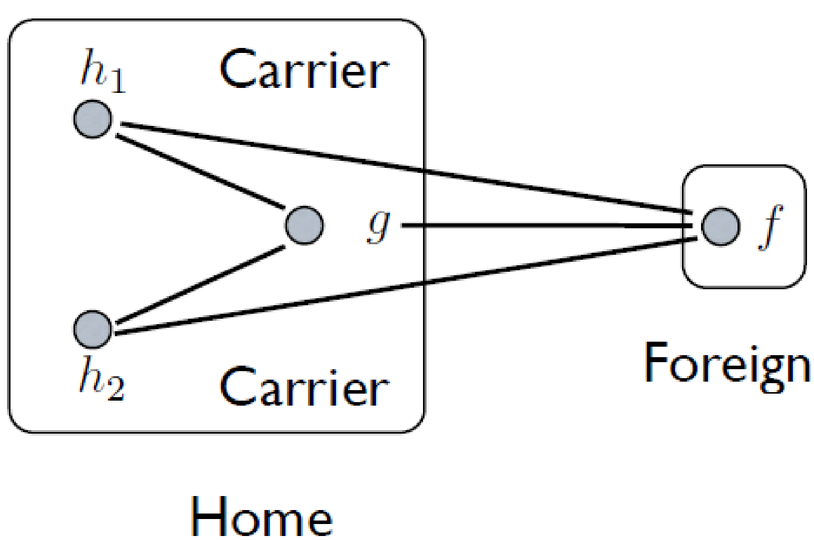


Figure 3: Entry Into Gateway

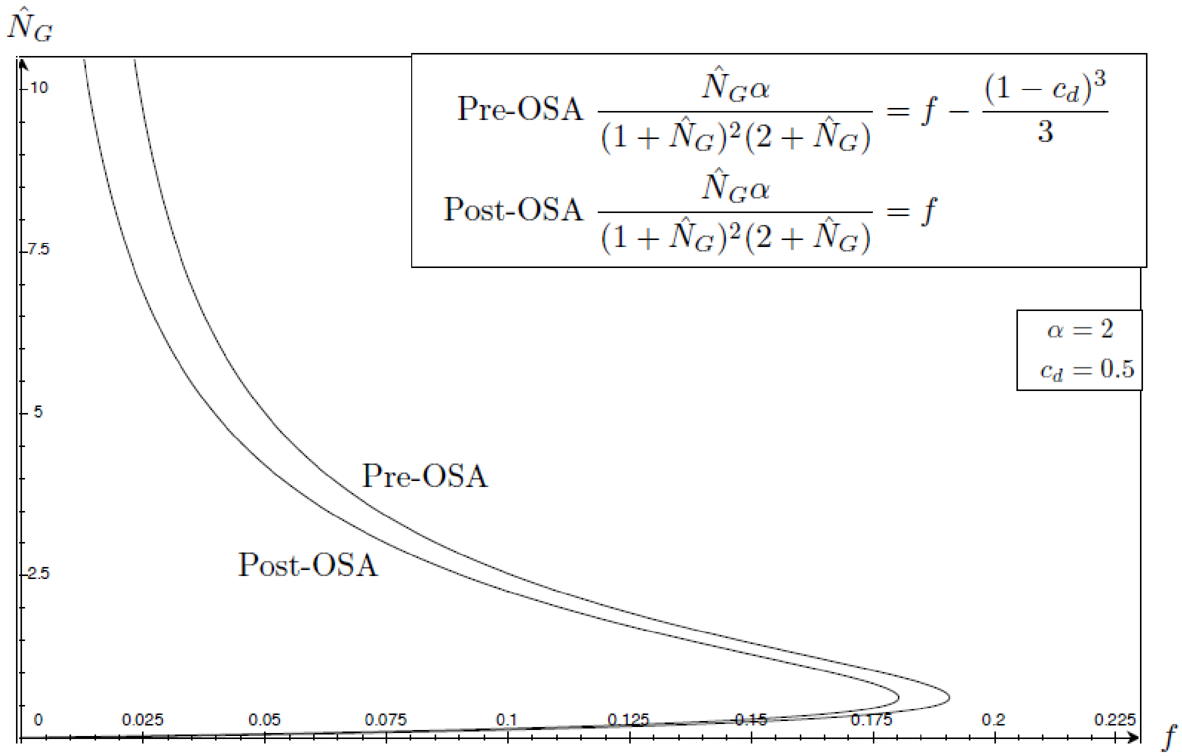


Figure 4: CDF of Gateway Price

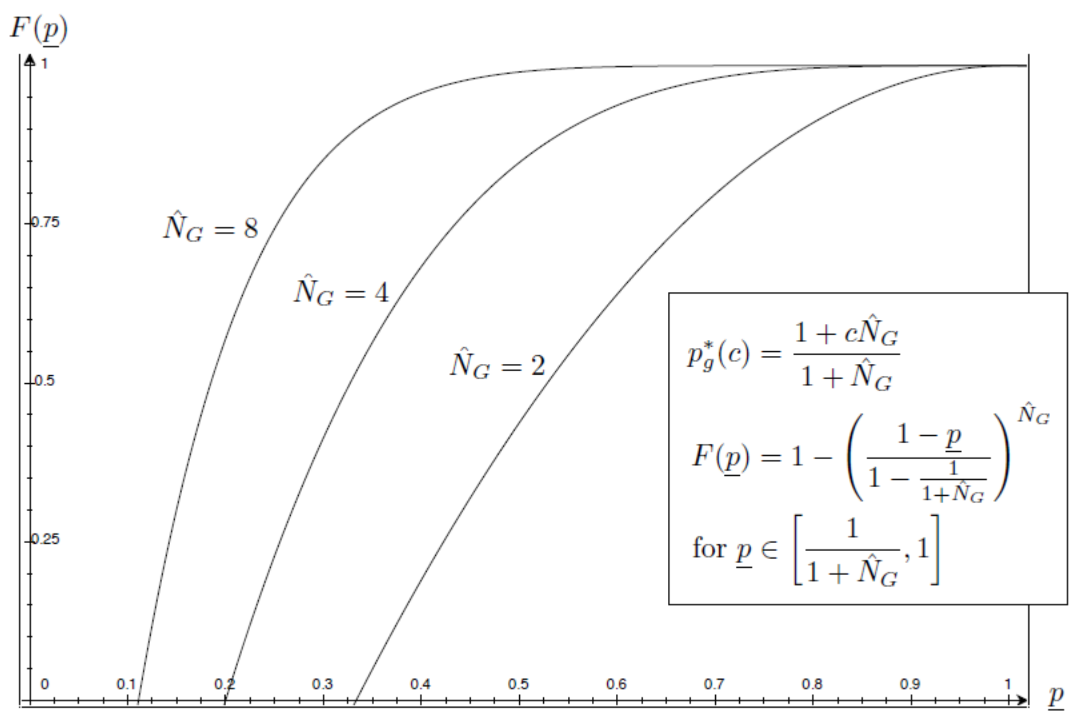


Figure 5: CDF for Non-Gateway Prices

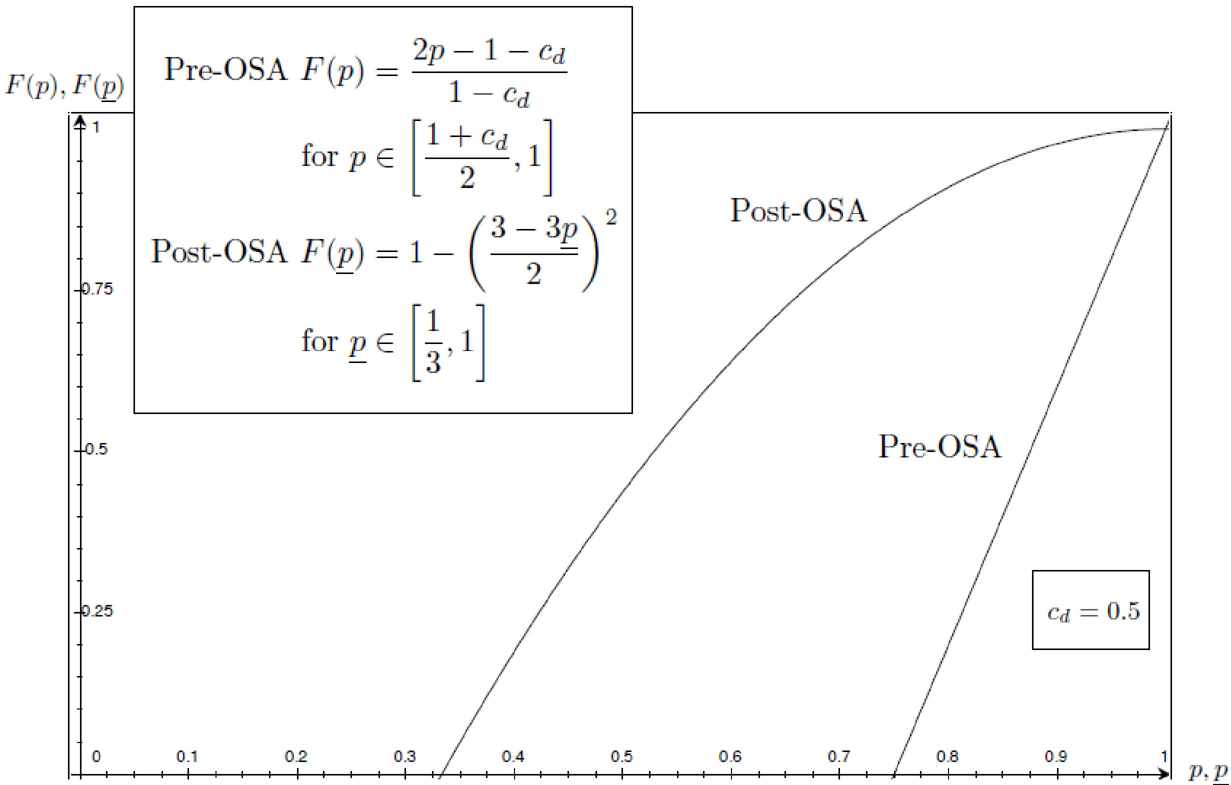
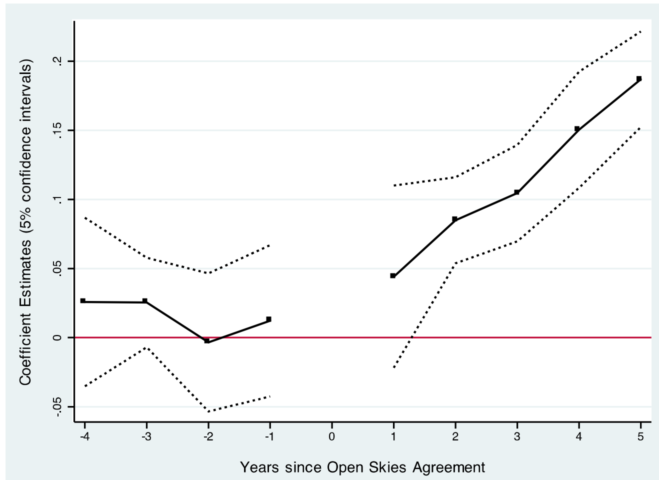
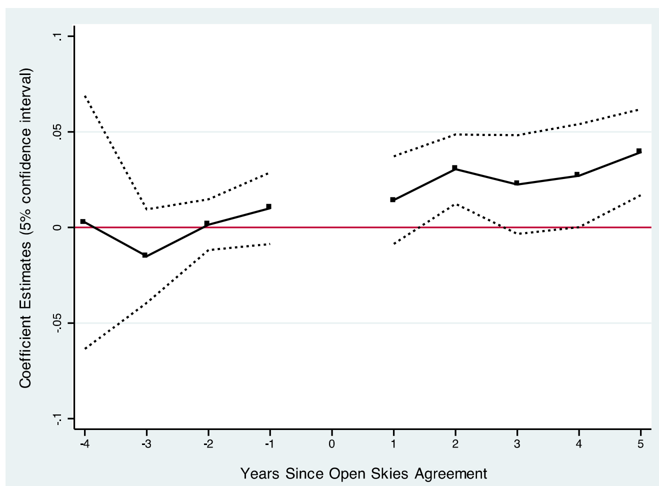


Figure 6: Trends in Air Traffic Before and After the Policy Change

A. Total Air Traffic



B. Extensive Margin: Cumulative Net Route Changes



C. Intensive Margin: Traffic on Common Routes

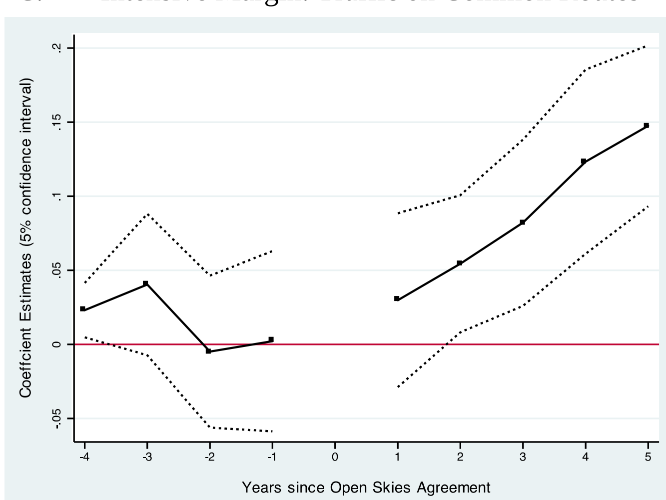


Figure 7: Net Entry and Exit of Carriers across Routes after Liberalization

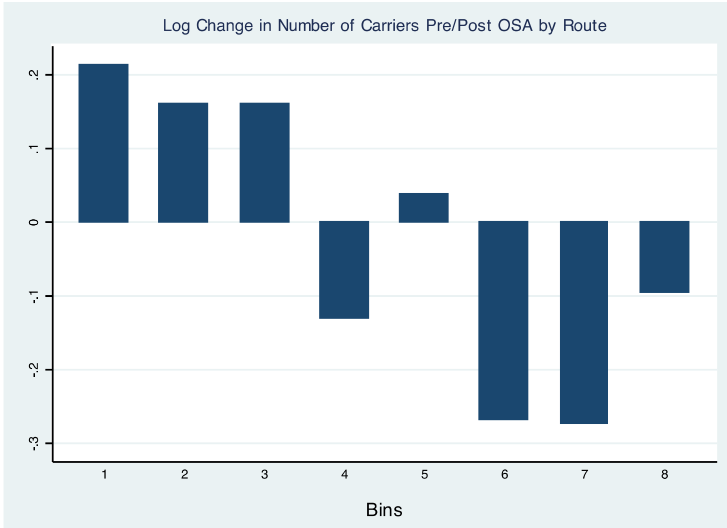
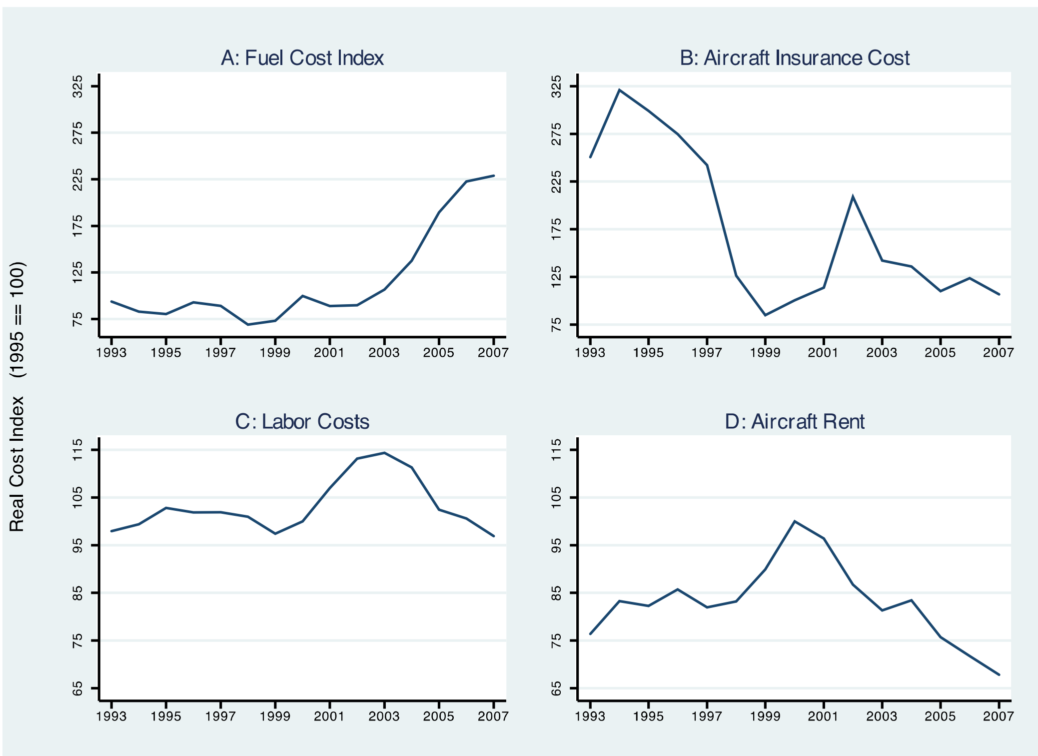


Figure 8: Aircraft Cost Indexes by Category



Notes:

Cost index series are taken from IATA. Each cost series is normalized using the CPI for the US and is scaled relative to year 2000 values.Insurance costs are expressed as a percentage of hull net value. Labor costs represent wages per full time employee. Aircraft rent costs are expressed in dollars per operating seat.

Table 1: Summary of U.S. International Air Passenger Transport

	1993	2000	2008	Cumulative Percent Change 1993-2000	2000-2008
Total Passengers ('000), T100 Data					
NAFTA	10189	15821	20631	55.3	30.4
Latin America & Caribbean	8771	12903	17003	47.1	31.8
OECD Europe	14398	24454	25335	69.8	3.6
Europe & Central Asia	247	589	852	138.7	44.6
Southeast Asia & Pacific	8926	13029	12385	46.0	-4.9
Middle East & North Africa	423	734	856	73.5	16.5
TOTAL	*42953*	*67530*	*77061*	*57.2*	*14.1*
Non-Stop Routes, T100 data					
NAFTA	266	410	592	54.1	44.4
Latin America & Caribbean	235	312	436	32.8	39.7
OECD Europe	234	266	263	13.7	-1.1
Europe & Central Asia	13	18	20	38.5	11.1
Southeast Asia & Pacific	110	118	119	7.3	0.8
Middle East & North Africa	12	14	14	16.7	0.0
TOTAL	*870*	*1138*	*1444*	*30.8*	*26.9*
True Origin-Destination Markets, DB1B data					
NAFTA	6460	8077	8242	25.0	2.0
Latin America & Caribbean	4929	7658	6942	55.4	-9.3
OECD Europe	8969	12306	12241	37.2	-0.5
Europe & Central Asia	849	2260	2593	166.2	14.7
Southeast Asia & Pacific	5048	7113	7542	40.9	6.0
Middle East & North Africa	1177	1482	1160	25.9	-21.7
Sub-Saharan Africa	528	890	1104	68.6	24.0
TOTAL	*27960*	*39786*	*39824*	*42.3*	*0.1*
Traffic Share Covered by OSA, T100 data					
NAFTA	0	0.0	53.2	0.0	53.2
Latin America & Caribbean	0	28.5	41.0	28.5	12.5
OECD Europe	7.7	43.3	100.0	35.6	56.7
Europe & Central Asia	0	37.0	60.4	37.0	23.5
Southeast Asia & Pacific	0	22.2	32.6	22.2	10.4
Middle East & North Africa	0	8.9	7.1	8.9	-1.9

[a] In the case of traffic share accounted for by OSA, the values reported in columns 3 and 4 represent absolute percent differences rather than cumulative percentage changes.

Notes:

1. Data comes from the T100 Segment sample and includes only US outbound traffic in order to avoid double-counting of round-trip travelers.
2. All the reported values for total passengers, number of departures and non-stop routes are annual.
3. The number of non-stop routes represents a simple count of distinct origin-destination airport pairs within a year. So, if a route is serviced only in one quarter out of the full year, it counts the same as a route serviced in all four quarters. Results look quite different if quarter-origin-destination pairs are counted in the total number of routes because thick routes tend to receive more weight. Thus frequently traveled regions such as OECD Europe and Southeast Asia & Pacific would have small but positive growth rates until 2000, suggesting that the drop in routes comes from highly seasonal origin-destination pair

Table 2: Impact of Air Trade Liberalization on Country Level Passenger Transport

	Total Air Traffic	Cumulative Margins of Adjustment (log): Simple Route Count		Common routes defined relative to T-3		Common routes defined relative to T-1	
		Extensive	***Intensive***	***Extensive***	***Intensive***	***Extensive***	***Intensive***
OSA	*0.076***	*0.107****	*-0.031*	*0.038***	*0.037*	*0.024*	*0.052**
	[0.031]	*[0.016]*	*[0.016]*	*[0.016]*	*[0.028]*	*[0.015]*	*[0.029]*
Ln Per Capita GDP (t/93)	0.334***	0.036	0.298***	0.011	0.323***	0.021	0.313***
	[0.056]	[0.038]	[0.038]	[0.028]	[0.055]	[0.028]	[0.054]
Ln Population (t/93)	0.001	1.510***	-1.509**	0.580***	-0.579	0.408***	-0.407
	[0.370]	[0.087]	[0.303]	[0.124]	[0.363]	[0.133]	[0.374]
11-Sep	-0.180***	-0.042	-0.139**	-0.018	-0.162***	-0.031**	-0.150***
	[0.027]	[0.051]	[0.040]	[0.016]	[0.026]	[0.014]	[0.025]
Sept 11*Visa Waiver	-0.098**	-0.016	-0.082**	0.004	-0.103**	0.033**	-0.132***
	[0.044]	[0.011]	[0.023]	[0.017]	[0.042]	[0.016]	[0.040]
Asia Crisis	-0.000**	-0.000*	0.000	-0.000	-0.000	-0.000	-0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Caribbean Trend	0.000	0.013***	-0.013***	0.004***	-0.003**	0.004***	-0.004*
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.001]	[0.002]
Partial Liberalization	0.046	0.098**	-0.051	0.049***	-0.003	0.029*	0.018
	[0.030]	[0.018]	[0.027]	[0.015]	[0.027]	[0.015]	[0.028]
Constant	0.037	-22.944***	31.054***	-0.072***	0.109***	-0.066**	0.104**
	[0.038]	[1.425]	[4.753]	[0.027]	[0.041]	[0.031]	[0.047]
Observations	4036	4036	4036	4,036	4,036	4,036	4,036
R-squared	0.506	0.303	0.223	0.299	0.339	0.288	0.368

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in brackets. All specifications include a constant, year and quarter-country fixed effects.

Notes:

1. The table reports the estimates from the regression models described by equation (5) in the text using as dependent variables each component from the decomposition in (4). The estimation sample is constructed from the T100 dataset and includes only non-stop flight segments originating in the US (i.e., outbound traffic).
2. *Total Air Traffic* is the total number of US outbound travelers to a given country in a quarter and year. The *Intensive Margin* measures air traffic on routes that are operated in the same quarter of both the reference year and year *t* (i.e., *common* services). The *Extensive Margin* (the *lambda*-term formalized in the text) represents the (passenger share weighted) count of routes that are new in quarter *q* and year *t* relative to the same quarter of the reference year (i.e, *new* services). *OSA* is a country-year indicator equal to one for all years when a bilateral Open Skies Agreement is in effect. All the other control variables are described in the text.

Table 3: Lagged Effects of Air Trade Liberalization on Country Level Passenger Transport

	Total Air Traffic	Cumulative Margins of Adjustment (log): Common routes defined relative to T-3 — Extensive	Intensive	Common routes defined relative to T-1 — Extensive	Intensive
D (age_OSA == -1)	0.034	-0.000	0.034	0.002	0.032
	[0.022]	[0.013]	[0.023]	[0.010]	[0.022]
D (age_OSA == 0)	0.008	-0.001	0.009	-0.001	0.009
	[0.034]	[0.018]	[0.032]	[0.016]	[0.031]
D (age_OSA == 1)	0.048	0.018	0.030	0.016	0.032
	[0.031]	[0.018]	[0.030]	[0.015]	[0.030]
D (age_OSA == 2)	0.078**	0.046**	0.033	0.031*	0.047
	[0.036]	[0.020]	[0.034]	[0.018]	[0.035]
D (age_OSA == 3)	0.093**	0.046**	0.047	0.026	0.067*
	[0.042]	[0.021]	[0.038]	[0.020]	[0.040]
D (age_OSA == 4)	0.099*	0.056**	0.043	0.031	0.068
	[0.053]	[0.022]	[0.052]	[0.021]	[0.054]
D (age_OSA == 5+)	0.183***	0.068***	0.115**	0.044**	0.140***
	[0.053]	[0.023]	[0.049]	[0.022]	[0.050]
Ln Per Capita GDP (t/93)	0.337***	0.014	0.323***	0.023	0.314***
	[0.056]	[0.028]	[0.055]	[0.028]	[0.055]
Ln Population (t/93)	0.025	0.590***	-0.565	0.414***	-0.389
	[0.372]	[0.124]	[0.365]	[0.132]	[0.377]
11-Sep	-0.172***	-0.015	-0.157***	-0.029**	-0.143***
	[0.027]	[0.016]	[0.026]	[0.014]	[0.025]
Partial Liberalization	0.055*	0.051***	0.004	0.030**	0.025
	[0.030]	[0.015]	[0.028]	[0.015]	[0.029]
Observations	4,036	4,036	4,036	4,036	4,036
R-squared	0.513	0.303	0.343	0.290	0.374

Notes:

1. The table reports the estimates from the regression models described by equation (5) in the text using as dependent variables each component from the decomposition in (4). The estimation sample is constructed from the T100 International Segment dataset and includes only non-stop flight segments originating in the US (i.e., outbound traffic).
2. *D(age_OSA == n)* is an indicator variable equal to one for the n^{th} year since the introduction of an Open Skies Agreement. The control variables used in the estimation are the same as in Table 2. For conciseness, several estimates have not been reported in Table 3 (i.e., Sept 11* Visa Waiver, Caribbean Trend, dummy for Asian Crisis), but their sign and significance is as expected.

Table 4: Price Regressions: True Origin-Destination Air Travel (DB1B Sample)

	Dependent variable: Economy Class Airfare (log)				
	(1)	(2)	(3)	(4)	
				First 3 Years	*Past 3 Years*
OSA	0.004	-0.015***	-0.040***	-0.045***	-0.026***
	[0.005]	[0.005]	[0.006]	[0.007]	[0.009]
OSA Connect * Distance Share		-0.105***	-0.105***	0.020*	-0.119***
		[0.009]	[0.009]	[0.011]	[0.009]
OSA * Share US Origin (Outbound)			0.042***	0.047***	0.038***
			[0.007]	[0.008]	[0.008]
Ticket Distance (log)	0.176***	0.184***	0.183***	0.180***	
	[0.018]	[0.018]	[0.018]	[0.018]	
US State Population (log)	0.062*	0.069*	0.077**	0.070**	
	[0.036]	[0.036]	[0.036]	[0.036]	
US Airport Network Size (log)	0.039***	0.038***	0.038***	0.038***	
	[0.008]	[0.008]	[0.008]	[0.008]	
Foreign Country Population (log)	-0.347***	-0.335***	-0.337***	-0.347***	
	[0.039]	[0.039]	[0.039]	[0.039]	
Foreign Airport Network Size (log)	-0.122***	-0.122***	-0.122***	-0.119***	
	[0.006]	[0.006]	[0.006]	[0.006]	
No. Segments (log)	0.238***	0.243***	0.244***	0.243***	
	[0.008]	[0.008]	[0.008]	[0.008]	
Share US Origin	0.030***	0.030***	0.017***	0.017***	
	[0.004]	[0.004]	[0.005]	[0.005]	
Share One-way	0.395***	0.395***	0.394***	0.394***	
	[0.005]	[0.005]	[0.005]	[0.005]	
No. US Direct Routes (log)	-0.002	-0.002	-0.002	-0.002	
	[0.002]	[0.002]	[0.002]	[0.002]	
Fuel * Log Ticket Distance (log)	0.232***	0.228***	0.228***	0.219***	
	[0.068]	[0.067]	[0.067]	[0.066]	
Fuel * (Log Ticket Distance)^2	-0.015***	-0.015***	-0.015***	-0.014***	
	[0.004]	[0.004]	[0.004]	[0.004]	
Insurance*Lat. Am. & Caribbean	-0.060***	-0.059***	-0.059***	-0.045***	
	[0.006]	[0.006]	[0.006]	[0.006]	
Insurance*Mid East & North Africa	-0.021***	-0.024***	-0.026***	-0.021***	
	[0.007]	[0.007]	[0.007]	[0.007]	
Insurance*NAFTA	-0.086***	-0.084***	-0.085***	-0.072***	
	[0.006]	[0.006]	[0.006]	[0.006]	
Insurance*OECD Europe	-0.006	-0.005	-0.006	0.006	
	[0.005]	[0.005]	[0.005]	[0.005]	
Insurance*SE Asia/Pacific	-0.037***	-0.039***	-0.040***	-0.026***	
	[0.006]	[0.006]	[0.006]	[0.006]	
Insurance*Sub-Saharan Africa	0.031***	0.033***	0.032***	0.038***	
	[0.007]	[0.007]	[0.007]	[0.007]	
Partial Liberalization	-0.013**	-0.016***	-0.018***	-0.018***	
	[0.005]	[0.005]	[0.005]	[0.005]	
Observations	599533	599533	599533	599533	
R-squared	0.203	0.204	0.204	0.204	

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in brackets clustered by state-country pair.

Notes:

1. The table reports the estimates from the price regression described by the system of demand and supply equations in the text. The estimation sample comes from the DB1B dataset and includes only economy-class travel, inbound and outbound flows combined.
2. All specifications include year and city-pair fixed effects, as well as time trends for the Caribbean and Asian Crisis period.
3. *OSA Connect*Distance Share* is variable computed at city-pair level for routes that terminate in non-Open Skies countries, i.e., which have OSA indicator equal to zero. It measures the (passenger-weighted) average fraction of total trip distance that is flown on international segments involving an Open Skies airport hub (OSA connection).

Table 5: Quantity Regressions: True Origin-Destination Air Travel (DB1B Sample)

	Dependent variable: Number of Air Passengers (log)					
	OLS			2SLS	2SLS	
	(1)	(2)	(3)	(4)	(5)	
					First 3 Yrs.	*Past 3 Yrs.*
Economy Class Airfare (log)	-0.068***	-0.067***	-0.067***	-1.412***	-1.250***	
	[0.007]	[0.007]	[0.007]	[0.113]	[0.115]	
OSA	0.048***	0.088***	0.073***	0.002	0.019	0.048***
	[0.012]	[0.013]	[0.015]	[0.015]	[0.017]	[0.018]
OSA Connect		0.099***	0.099***	0.083***	0.108***	0.127***
		[0.008]	[0.008]	[0.009]	[0.009]	[0.010]
OSA*Share US Origin (Outbound)			0.024**	0.107***	0.069***	0.119***
			[0.012]	[0.015]	[0.018]	[0.017]
Ticket Distance (log)	-0.489***	-0.497***	-0.498***	--	--	
	[0.055]	[0.056]	[0.056]			
No. Segments (log)	-1.255***	-1.269***	-1.269***	-0.930***	-0.991***	
	[0.033]	[0.033]	[0.033]	[0.049]	[0.049]	
Share US Origin	-0.052***	-0.052***	-0.060***	-0.091***	-0.089***	
	[0.006]	[0.006]	[0.007]	[0.009]	[0.008]	
US State Per Capita Income (log)	-0.101	-0.103	-0.101	0.020	0.008	
	[0.123]	[0.124]	[0.124]	[0.108]	[0.104]	
US State Population (log)	0.678***	0.668***	0.672***	0.783***	0.782***	
	[0.128]	[0.129]	[0.128]	[0.094]	[0.092]	
Bilateral Exports (log)	0.026***	0.027***	0.027***	0.033***	0.031***	
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	
Foreign Per Capita GDP (log)	0.573***	0.575***	0.575***	0.335***	0.388***	
	[0.047]	[0.048]	[0.048]	[0.052]	[0.050]	
Foreign Country Population (log)	0.739***	0.716***	0.715***	0.242**	0.304***	
	[0.092]	[0.092]	[0.092]	[0.102]	[0.099]	
No. US Direct Routes (log)	0.066***	0.066***	0.066***	0.065***	0.065***	
	[0.006]	[0.006]	[0.006]	[0.006]	[0.006]	
Asia Crisis Trend	-0.000**	-0.000***	-0.000***	-0.000***	-0.000***	
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	
Caribbean*Trend	0.019***	0.020***	0.020***	0.034***	0.035***	
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	
Partial Liberalization	0.010	0.017	0.017	-0.009	-0.007	
	[0.012]	[0.012]	[0.012]	[0.013]	[0.013]	
Observations	599,533	599,533	599,533	599,520	599,520	
R-squared	0.218	0.219	0.219	n.a.	n.a.	
First Stage Statistics:						
Instruments	Distance; Fuel*Distance; Fuel*Distance^2; Insurance*Regions					
Partial R-squared				0.0112	0.0101	
F-Test of ivs				108.2	97.85	
Hansen's j stat				126.6	139.1	

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in brackets clustered by foreign country. Year and airport-pair fixed effects included.

Notes:

1. The table reports the estimates from the quantity regression described by the system of demand and supply equations in the text. The sample comes from the DB1B dataset and includes only economy-class travel, inbound and outbound flows combined.
2. *OSA Connect* is an indicator variable equal to 1 if on a given route not belonging to an Open Skies country-pair the market share of travelers arriving at the destination via connection in an Open Skies hub airport is at least 10 percent. The list of exogenous instruments includes also interaction terms between fuel costs and route distance, and between insurance costs and seven world geographical regions.
3. In column (5), *First 3* refers to the first 3 years since OSA signing, while *Past 3* refers to the period 3 years or more into the treaty. These immediate and longer run effects of OSA are estimated in the same regressions.

Table 6: Price Effect of Liberalization in Markets with Net Entry or Exit (outbound flows)

	Dependent variable: Economy Class Airfare (log)					
	All Routes	*Net Exit*	*Net Entry*	*All Routes*	*Net Exit*	*Net Entry*
	(1)	(2)	(3)	(4)	(5)	(6)
OSA	-0.001	0.043***	-0.023***			
	[0.007]	[0.008]	[0.007]			
OSA First3 (Years 0, 1, 2)				-0.010	0.015*	-0.031***
				[0.006]	[0.008]	[0.007]
OSA Past3 (Years +3)				0.005	0.062***	-0.020**
				[0.008]	[0.010]	[0.009]
Partial Liberalization	-0.054***	-0.041***	-0.054***	-0.054***	-0.040***	-0.054***
	[0.009]	[0.009]	[0.010]	[0.009]	[0.009]	[0.010]
Direct	0.065***	0.052***	0.054***	0.065***	0.052***	0.054***
	[0.014]	[0.015]	[0.015]	[0.014]	[0.015]	[0.015]
US State Population (log)	0.021	0.049	0.043	0.020	0.049	0.043
	[0.048]	[0.055]	[0.051]	[0.047]	[0.055]	[0.051]
Foreign Country Population (log)	0.032	0.154	0.034	0.030	0.163*	0.033
	[0.073]	[0.094]	[0.075]	[0.073]	[0.095]	[0.075]
Ticket Distance (log)	-0.081***	-0.089***	-0.072***	-0.080***	-0.088***	-0.072***
	[0.019]	[0.022]	[0.021]	[0.019]	[0.022]	[0.021]
Fuel*Distance (log)	-0.291***	-0.292***	-0.283***	-0.292***	-0.286***	-0.284***
	[0.061]	[0.063]	[0.058]	[0.060]	[0.062]	[0.058]
Fuel* (Log Distance)^2	0.020***	0.020***	0.019***	0.020***	0.019***	0.019***
	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]	[0.004]
Insurance*Europe & Central Asia	-0.042***	-0.031***	-0.026**	-0.040***	-0.028***	-0.024**
	[0.007]	[0.007]	[0.012]	[0.007]	[0.007]	[0.012]
Insurance*Lat. Am. & Caribbean	-0.084***	-0.100***	-0.084***	-0.083***	-0.099***	-0.083***
	[0.009]	[0.011]	[0.009]	[0.009]	[0.011]	[0.009]
Insurance*Mid. East & North Africa	-0.097***	-0.091***	-0.090***	-0.096***	-0.090***	-0.090***
	[0.009]	[0.010]	[0.010]	[0.009]	[0.010]	[0.010]
Insurance*NAFTA	-0.129***	-0.124***	-0.119***	-0.129***	-0.123***	-0.119***
	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]	[0.007]
Insurance*OECD Europe	-0.052***	-0.053***	-0.050***	-0.051***	-0.050***	-0.050***
	[0.005]	[0.005]	[0.006]	[0.005]	[0.005]	[0.006]
Asia Crisis Trend	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Caribbean*Trend	0.002***	0.002***	0.002***	0.002***	0.002***	0.002***
	[0.000]	[0.001]	[0.000]	[0.000]	[0.001]	[0.000]
Observations	545,345	433,592	480,365	545,345	433,592	480,365
R-squared	0.063	0.063	0.058	0.063	0.063	0.058

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in brackets clustered by state-country pair.

Notes:

1. The table reports the estimates from the quantity regression described by the system of demand and supply equations in the text. This is a subsample of the DB1B ticket dataset that includes only round trip, economy-class, outbound travel, with at most one connection per direction of flight. For each of these tickets, the cross-border segment of the trip was matched to the corresponding segment in the T100 dataset.
2. A route is defined as having *net entry* if 3 years after OSA the number of carriers operating in that market is greater relative to 3 years prior to OSA. If the number of carriers post-liberalization remains constant or even decreases, then these routes are defined as having *net exit.*
3. Only city-pair markets that are active throughout the sample are used in this estimation, because only for these markets we can observe competition prior to liberalization. Similarly, countries that sign OSA too early or too late in the sample are also separately controlled for, since we again cannot observe changes in competition +/- 3 years since OSA.

Table 7: Quantity Effect of Liberalization in Markets with Net Entry or Exit (outbound)

	Dependent variable: Number of Air Passengers (log)					
	All Routes	*Net Exit*	*Net Entry*	*All Routes*	*Net Exit*	*Net Entry*
	(1)	(2)	(3)	(4)	(5)	(6)
OSA	0.077***	0.026	0.133***			
	[0.019]	[0.031]	[0.021]			
OSA First3 (Years 0, 1, 2)				0.023	-0.052	0.080***
				[0.019]	[0.033]	[0.021]
OSA Past3 (Years +3)				0.117***	0.064*	0.167***
				[0.021]	[0.033]	[0.023]
Economy Class Airfare (log)	-1.884***	-1.480***	-1.329***	-1.766***	-1.391***	-1.248***
	[0.195]	[0.196]	[0.182]	[0.187]	[0.190]	[0.179]
Partial Liberalization	-0.083***	-0.066***	-0.079***	-0.072***	-0.061***	-0.070***
	[0.021]	[0.019]	[0.020]	[0.020]	[0.019]	[0.019]
Direct	3.541***	3.596***	3.545***	3.532***	3.590***	3.539***
	[0.118]	[0.126]	[0.123]	[0.117]	[0.125]	[0.122]
US State Population (log)	0.490***	0.450***	0.435***	0.486***	0.442***	0.433***
	[0.146]	[0.154]	[0.145]	[0.140]	[0.150]	[0.141]
US State Per Capita Income (log)	0.577***	0.555***	0.488***	0.569***	0.539***	0.485***
	[0.158]	[0.159]	[0.145]	[0.151]	[0.155]	[0.141]
Foreign Country Population (log)	2.465***	2.379***	2.342***	2.459***	2.378***	2.328***
	[0.172]	[0.230]	[0.178]	[0.166]	[0.229]	[0.174]
Foreign Per Capita GDP (log)	0.333***	0.260***	0.280***	0.337***	0.251***	0.290***
	[0.049]	[0.051]	[0.048]	[0.048]	[0.050]	[0.048]
Bilateral Exports (log)	0.008	-0.005	0.005	0.005	-0.006	0.003
	[0.008]	[0.009]	[0.008]	[0.007]	[0.008]	[0.008]
Nominal Exchange Rate (log)	0.059**	0.054*	0.098***	0.066**	0.061**	0.101***
	[0.028]	[0.028]	[0.030]	[0.027]	[0.028]	[0.029]
Asia Crisis Trend	0.000*	0.000***	-0.000***	0.000**	0.000***	-0.000***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Caribbean*Trend	0.010***	0.008***	0.008***	0.010***	0.008***	0.008***
	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]	[0.001]
Observations	538,042	427,852	473,543	538,042	427,852	473,543
R-squared	-0.152	-0.011	0.021	-0.109	0.014	0.042
First Stage Statistics:						
Instruments	Fuel*Distance; Fuel*Distance^2; Insurance*Regions					
Partial R-squared	0.00581	0.00624	0.00566	0.00602	0.00644	0.00584
F-Test of ivs	45.07	41.36	44.51	48.41	43.90	48.71
Hansen's j stat	132.2	80.92	101.8	139.6	82.54	105.1

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in brackets clustered by state-country pair.

Notes:

1. The table reports the estimates from the quantity regression described by the system of demand and supply equations in the text. This is a subsample of the DB1B ticket dataset that includes only round trip, economy-class, outbound travel, with at most one connection per direction of flight. For each of these tickets, the cross-border segment of the trip was matched to the corresponding segment in the T100 dataset.
2. A route is defined as having *net entry* if 3 years after OSA the number of carriers operating in that market is greater relative to 3 years prior to OSA. If the number of carriers post-liberalization remains constant or even decreases, then these routes are defined as having *net exit*.
3. Only city-pair markets that are active throughout the sample are used in this estimation, because only for these markets we can observe competition prior to liberalization. Similarly, countries that sign OSA too early or too late in the sample are also separately controlled for, since we again cannot observe changes in competition +/- 3 years since OSA

Table 8: Sample Sensitivity Analysis: Instrumental Variables Estimations

Dependent variable:	**Airfare Coach (log)**		**Number Air Passengers (log)**	
	Major State Airports	Behind Markets	Major State Airports	Behind Markets
Economy Class Airfare (log)			-1.584***	-1.221***
			[0.141]	[0.101]
OSA	-0.047***	-0.037***	0.004	-0.004
	[0.007]	[0.007]	[0.022]	[0.015]
OSA Connect	-0.115***	-0.098***	0.073***	0.097***
	[0.011]	[0.009]	[0.011]	[0.009]
OSA * Share US Origin (Outbound)	0.047***	0.041***	0.141***	0.103***
	[0.009]	[0.007]	[0.023]	[0.014]
Ticket Disrance (log)	0.193***	0.150***		
	[0.021]	[0.020]		
No. Segments (log)	0.246***	0.244***	-1.100***	-0.766***
	[0.010]	[0.010]	[0.066]	[0.042]
Share US Origin	0.047***	0.001	-0.099***	-0.070***
	[0.006]	[0.005]	[0.014]	[0.009]
No. US Direct Routes (log)	-0.007	-0.003*	0.059***	0.060***
	[0.004]	[0.002]	[0.011]	[0.006]
US State Population (log)	0.019	0.117***	0.998***	0.325***
	[0.039]	[0.042]	[0.120]	[0.097]
Foreign Country Population (log)	-0.316***	-0.350***	0.228*	0.289***
	[0.041]	[0.041]	[0.135]	[0.101]
US State Per Capita Income (log)			-0.374***	0.124
			[0.143]	[0.105]
Bilateral Exports (log)			0.032***	0.034***
			[0.005]	[0.004]
Foreign Per Capita GDP (log)			0.347***	0.334***
			[0.068]	[0.050]
Share One-way	0.402***	0.387***		
	[0.006]	[0.006]		
US Airport Network Size (log)	0.156***	0.016**		
	[0.027]	[0.008]		
Foreign Airport Network Size (log)	-0.101***	-0.172***		
	[0.006]	[0.008]		
Fuel*Log Distance	0.301***	0.237***		
	[0.076]	[0.066]		
Fuel* $(\text{Log Distance})^2$	-0.019***	-0.015***		
	[0.005]	[0.004]		
Insurance*Lat. Am. & Caribbean	-0.040***	-0.069***		
	[0.006]	[0.006]		
Insurance*Mid East & North Africa	-0.018**	-0.026***		
	[0.008]	[0.008]		
Insurance*NAFTA	-0.069***	-0.089***		
	[0.006]	[0.006]		
Insurance*OECD Europe	-0.007	-0.005		
	[0.005]	[0.005]		
Insurance*SE Asia & Pacific	-0.041***	-0.034***		
	[0.006]	[0.006]		
Insurance*Sub-Saharan Africa	0.037***	0.030***		
	[0.008]	[0.009]		
Partial Liberalization	-0.022***	-0.014***	-0.004	-0.004
	[0.006]	[0.005]	[0.017]	[0.012]
Observations	311,784	403,774	311,775	402,533
R-squared	0.232	0.187	n.a.	n.a.
First Stage Statistics:				
Partial R-squared			0.00981	0.0116
F-Test of ivs			94.67	88.26
Hansen's j stat			99.56	125.2

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in brackets clustered by foreign country.

Table 9: Welfare Calculations

	OSA direct		OSA connect	
Sigma* == *1.25	*outbound*	*inbound*	*outbound*	*inbound*
D Airfare (price effect)	0.000	-0.026	-0.060	-0.053
D Quality (quantity effect net of prices)	-0.098	-0.038	-0.102	-0.102
D *Quality Adjusted* Price Index	**0.902**	**0.936**	**0.839**	**0.846**
D Lambda-ratio Variety Index	0.755	0.755	0.755	0.755
D *Variety Adjusted* Price Index	**0.681**	**0.706**	**0.633**	**0.638**
Drop in Price Index due to OSA (%)	**31.91%**	**29.41%**	**36.70%**	**36.18%**

Notes:

1. The welfare calculation assumed that the extensive margin effect estimated in the T100 data sample affects travelers in the same way no matter whether they connect and terminate their travel in the liberalized country. That is, the variety index enters in the same way the welfare calculations for direct and connect traffic.

2. The average price and quantity effects estimated using the DB1B data sample are assumed not to differ across routes that are offered continuously (i.e., common varieties) versus routes that are newly introduced.

Appendix Tables

Table A1: List of Countries and Years when Open Skies Agreements were signed

Year OSA	Country	Region	Population 1993	Pop. Growth 1993-2008	Per-capita Income 1993	Income Growth 1993-2008
1992	Netherlands	OECD Europe	16.54	4.68	9.88	4.95
1995	Austria	OECD Europe	15.89	4.66	9.89	4.92
1995	Belgium	OECD Europe	16.13	4.66	9.85	4.88
1995	Denmark	OECD Europe	15.46	4.66	10.11	4.88
1995	Finland	OECD Europe	15.44	4.65	9.78	5.10
1995	Iceland	OECD Europe	12.48	4.79	10.13	5.02
1995	Norway	OECD Europe	15.28	4.71	10.30	4.96
1995	Sweden	OECD Europe	15.98	4.66	10.00	4.98
1995	Switzerland	OECD Europe	15.75	4.70	10.37	4.78
1995	Czech Republic	Europe & Central Asia	16.15	4.61	8.46	5.09
1996	Germany	OECD Europe	18.21	4.62	9.91	4.84
1996	Jordan	Middle East & North Africa	15.18	5.02	7.41	5.01
1997	Chile	Latin America & Caribbean	16.45	4.79	8.23	5.11
1997	Costa Rica	Latin America & Caribbean	15.01	4.92	8.15	5.01
1997	El Salvador	Latin America & Caribbean	15.53	4.70	7.49	5.00
1997	Guatemala	Latin America & Caribbean	16.07	4.97	7.33	4.83
1997	Honduras	Latin America & Caribbean	15.49	4.92	7.02	4.85
1997	Malaysia	East Asia & Pacific	16.79	4.93	8.06	5.09
1997	New Zealand	East Asia & Pacific	15.09	4.78	9.34	4.90
1997	Nicaragua	Latin America & Caribbean	15.31	4.85	6.45	4.96
1997	Panama	Latin America & Caribbean	14.76	4.89	8.15	5.11
1997	Singapore	East Asia & Pacific	15.01	4.98	9.74	5.17
1998	Italy	OECD Europe	17.86	4.66	9.73	4.76
1998	Korea	East Asia & Pacific	17.60	4.70	9.02	5.23
1998	Peru	Latin America & Caribbean	16.95	4.83	7.42	5.17
1998	Romania	Europe & Central Asia	16.94	4.55	7.35	5.21
1999	Bahrain	Middle East & North Africa	13.21	4.96	9.34	5.00
1999	Pakistan	South Asia	18.57	4.96	6.21	4.87
1999	Portugal	OECD Europe	16.12	4.67	9.08	4.88
1999	Tanzania	Sub-Saharan Africa	17.15	5.02	5.53	4.97
1999	UAE*	Middle East & North Africa	14.60	9.99	9.99	4.78
2000	Ghana	Sub-Saharan Africa	16.61	4.97	5.44	4.96
2000	Malta and Gozo*	Europe & Central Asia	12.82	8.92	8.92	4.95
2000	Morocco	Middle East & North Africa	17.08	4.80	7.04	5.03
2000	Nigeria	Sub-Saharan Africa	18.47	4.97	5.90	4.90
2000	Senegal	Sub-Saharan Africa	15.92	5.00	6.10	4.79
2000	The Gambia*	Sub-Saharan Africa	13.82	5.81	5.81	4.69
2000	Turkey	Europe & Central Asia	17.90	4.83	8.19	4.95
2001	France	OECD Europe	17.87	4.69	9.87	4.83
2001	Oman*	Middle East & North Africa	14.53	8.93	8.93	4.86
2001	Poland	Europe & Central Asia	17.47	4.60	8.02	5.32
2001	Sri Lanka	South Asia	16.69	4.74	6.47	5.22
2002	Jamaica	Latin America & Caribbean	14.71	4.70	8.19	4.65
2002	Uganda	Sub-Saharan Africa	16.79	5.08	5.27	5.18
2003	Albania	Europe & Central Asia	14.98	4.58	6.57	5.53
2004	Indonesia	East Asia & Pacific	19.04	4.80	6.60	5.00
2004	Uruguay	Latin America & Caribbean	14.97	4.66	8.72	4.96
2005	India	South Asia	20.62	4.84	5.82	5.36
2005	Mali	Sub-Saharan Africa	16.03	4.93	5.25	5.05
2005	Paraguay	Latin America & Caribbean	15.34	4.91	7.26	4.67

2005	Thailand	East Asia & Pacific	17.89	4.74	7.45	5.04
2006	Cameroon	Sub-Saharan Africa	16.41	4.97	6.39	4.77
2007	Bulgaria	Europe & Central Asia	15.95	4.50	7.30	5.16
2007	Canada	NAFTA	17.18	4.75	9.85	4.94
2007	Cyprus	Europe & Central Asia	13.47	4.80	9.18	4.99
2007	Greece	OECD Europe	16.16	4.67	9.18	5.05
2007	Hungary	Europe & Central Asia	16.15	4.57	8.19	5.15
2007	Ireland	OECD Europe	15.09	4.82	9.60	5.34
2007	Liberia	Sub-Saharan Africa	14.48	5.27	4.42	5.18
2007	Spain	OECD Europe	17.48	4.76	9.35	4.95
2007	United Kingdom	OECD Europe	17.87	4.67	9.91	4.97
2008	Australia	East Asia & Pacific	16.69	4.80	9.78	4.96
2008	Kenya	Sub-Saharan Africa	17.07	5.01	6.02	4.70
2008	Laos	East Asia & Pacific	15.33	4.91	5.49	5.27

* Growth rates are for the period 1993-2007.
Note: The following 16 countries have signed an Open Skies Agreement with the U.S. but there is missing data on either population or income for the period of interest: Armenia (2008), Aruba (1997), Bosnia-Hercegovina (2007), Croatia (2008), Estonia (2007), Georgia (2007), Kuwait (2006), Latvia (2006), Lithuania (2007), Luxembourg (1995), Quatar (2001), Slovakia (2000), Slovenia (2007), Tonga (2003), Uzbekistan (1998), Western Samoa (2002).

Table A2: Testing for Endogeneity in the Timing of Open Skies Agreements

	Dependent Variable: (Year OSA - 1992)					
	(1)	(2)	(3)	(4)	(5)	(6)
Log Population 1993	0.504				0.180	0.501
	[0.307]				[0.412]	[0.513]
Log Population Growth ‘93-‘08	3.413				-1.041	-7.399
	[3.422]				[4.363]	[5.509]
Log GDP 1993		-0.154				
		[0.310]				
Log GDP Growth ‘93-‘08		3.635				
		[2.506]				
Log Per-Capita GDP 1993			-0.501		-0.470	-0.173
			[0.513]		[0.692]	[1.062]
Log Per Capita GDP Growth ‘93-‘08			3.292		2.452	-2.564
			[2.758]		[3.561]	[3.892]
Log Exports 1993				-0.279		
				[0.214]		
Log Export Growth ‘93-‘08				-0.838	-0.420	-0.175
				[0.688]	[0.615]	[1.062]
Log Distance					1.499	
					[1.697]	
Log Average Tariffs (year 2001)						0.683
						[0.858]
High & Upper Middle Income Dummy			-1.299	-1.868	-1.568	-2.124
			[1.611]	[1.205]	[1.661]	[1.849]
Constant	-16.101	-6.729	-3.277	19.862***	-8.113	51.420
	[18.107]	[17.785]	[15.610]	[6.570]	[34.723]	[47.141]
Observations	64	64	64	64	64	41
R-squared	0.039	0.048	0.124	0.105	0.160	0.171

*** p<0.01, ** p<0.05, * p<0.1; Robust standard errors in brackets

Table A3: Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Air Traffic Indicators					
Econ Passengers	599533	63.18	422.87	1	39572
Econ Airfare	599533	619.94	393.28	50	9238
OSA	599533	0.31	0.46	0	1
OSA connect	599533	0.13	0.34	0	1
OSA connect* Dist. Share	599533	0.06	0.17	0	0.97
US Direct Routes	523740	31.04	35.71	1	186
Itinerary Characteristics					
Direct	599533	0.01	0.09	0	1
Segments	599533	2.72	0.56	1	4
Share One-Way	599533	0.17	0.25	0	1
Share US Origin	599533	0.62	0.34	0	1
Ticket Distance	599533	4886.73	2684.15	37	17818
EU Indicator	599533	0.35	0.48	0	1
NAFTA indicator	599533	0.21	0.40	0	1
Caribbean Indicator (incl. Mexico)	599533	0.16	0.37	0	1
Cost Indexes					
Fuel Cost Index	599533	130.62	66.83	69.10	290.21
Insurance Cost Index	599533	163.40	76.71	79.29	320.91
Demand Shifters					
State Population (log)	599533	15.85	0.99	13.07	17.42
US State Income (log)	599533	5.65	0.15	5.21	60.26
Country Population (log)	599533	17.16	1.75	10.60	21.00
Per Capita GDP (log)	599533	9.04	1.26	4.42	11.19
Real Exports (log)	599533	18.73	2.66	7.84	24.80

Table A4: Distribution of Route Categories in the DB1B Dataset

	US Gateway-to-Foreign Gateway	US Gateway-to-Foreign Beyond	US Behind-to-Foreign Gateway	US Behind-to-Foreign Beyond
Routes	57,396	138,363	249,505	154,269
Fraction of Total Routes (%)	10.26	24.73	44.59	27.57
Avg. Passengers per Route	447.05	18.44	33.08	5.77
Fraction of Total Int'l Traffic (%)	69.69	7.68	20.07	2.56

Notes:

1. The reported values are annual.
2. The U.S. gateways are defined as airports that offer at least one international flight per business day per direction of travel. Similarly, foreign gateways are defined as airports that offer at least one flight per business day anywhere in the US per direction of travel. The number of departures performed by sampled airports is provided in the T100 Segment dataset, which is the source of data used in constructing the gateway indicator.
3. The distribution of routes and passengers by route categories is calculated on the restricted DB1B sample. See the text for details on sample construction.

Table A5: Airline Market Shares at Route Level in the T100 Segment Data

	Share of Total International Air Passenger Traffic Supplied by:		
	U.S. Domestic Carriers (%)	*Foreign Carriers with Immunity (%)*	*Foreign Carriers No Immunity (%)*
1993	54.48	1.61	43.91
1994	53.37	1.55	45.08
1995	52.01	1.47	46.52
1996	51.01	6.76	42.22
1997	49.55	11.15	39.29
1998	48.99	11.38	39.63
1999	48.37	12.60	39.03
2000	48.29	12.49	39.22
2001	49.36	13.38	37.25
2002	50.41	16.30	33.29
2003	51.03	16.84	32.12
2004	52.14	15.78	32.07
2005	53.71	15.76	30.54
2006	54.89	14.74	30.37
2007	55.66	15.65	28.68
2008	56.09	15.40	28.50
Entire sample	*51.96*	*12.19*	*35.85*

Note: The list of foreign carriers with and the year in which they have been granted antitrust immunity is provided online by the US Department of Transportation at http://ostpxweb.dot.gov/aviation/X-50 Role_files/All Immunized Alliances.pdf

Table A6: List of Major Airports by State

No.	US State	City	Airport	FAA Hub Type	FAA Rank
1	AL	Birmingham	Birmingham International	Small	71
2	AR	Little Rock	Adams Field	Small	80
3	AZ	Tucson	Tucson International	Medium	66
4	AZ	Phoenix	Phoenix Sky Harbor International	Large	5
5	CA	San Francisco	San Francisco International	Large	8
6	CA	Los Angeles	Los Angeles International	Large	3
7	CA	San Diego	San Diego International-Lindbergh Field	Large	30
8	CO	Denver	Denver International	Large	6
9	CT	Windsor Locks	Bradley International	Medium	48
10	DC	Arlington	Ronald Reagan Washington National	Medium	32
11	DC	Chantilly	Washington Dulles International	Large	27
12	FL	Orlando	Orlando International	Large	15
13	FL	Miami	Miami International	Large	13
14	FL	Tampa	Tampa International	Large	29
15	GA	Atlanta	Hartsfield Atlanta International	Large	1
16	IA	Des Moines	Des Moines International	Small	89
17	ID	Boise	Boise Air Terminal/Gowen Field	Small	75
18	IL	Chicago	Chicago O'Hare International	Large	2
19	IN	Indianapolis	Indianapolis International	Medium	46
20	KS	Wichita	Wichita Mid-Continent	Small	104
21	KY	Louisville	Louisville International-Standiford Field	Medium	64
22	LA	New Orleans	New Orleans International/Moisant Field	Medium	40
23	MA	Boston	Logan International	Large	18
24	MD	Baltimore	Baltimore-Washington International	Large	22
25	ME	Portland	Portland International Jetport	Small	98
26	MI	Detroit	Detroit Metropolitan Wayne County	Large	11
27	MN	Minneapolis	Minneapolis-St Paul International	Large	10
28	MO	Kansas City	Kansas City International	Medium	36
29	MO	St. Louis	Lambert-St Louis International	Large	16
30	MS	Jackson	Jackson International	Small	97
31	MT	Billings	Billings Logan International	Small	134
32	NC	Charlotte	Charlotte/Douglas International	Large	20
33	NC	Raleigh/Durham	Raleigh-Durham International	Medium	39
34	ND	Fargo	Hector International	Non-primary	162
35	NE	Omaha	Eppley Airfield	Medium	65
36	NH	Manchester	Manchester	Small	69
37	NJ	Atlantic City	Atlantic City International	Small	123
38	NM	Albuquerque	Albuquerque International Sunport	Medium	53
39	NV	Las Vegas	Mc Carran International	Large	7
40	NY	New York	John F Kennedy International	Large	14
41	NY	Newark	Newark International	Large	12
42	NY	New York	La Guardia	Large	21
43	OH	Cincinnati, Oh	Cincinnati/Northern Kentucky International	Large	26
44	OH	Columbus	Port Columbus International	Medium	51
45	OH	Cleveland	Cleveland-Hopkins International	Medium	35
46	OK	Tulsa	Tulsa International	Small	68
47	OK	Oklahoma City	Will Rogers World	Medium	67
48	OR	Portland	Portland International	Medium	33
49	PA	Pittsburgh	Pittsburgh International	Large	23
50	PA	Philadelphia	Philadelphia International	Large	19
51	RI	Providence	Theodore Francis Green State	Medium	57
52	SC	Greer	Greenville-Spartanburg International	Small	93
53	SC	Charleston	Charleston AFB/International	Small	90
54	SD	Sioux Falls	Joe Foss Field	Small	136
55	TN	Memphis	Memphis International	Medium	38
56	TN	Nashville	Nashville International	Medium	42
57	TX	Fort Worth	Dallas/Fort Worth International	Large	4
58	TX	Houston	George Bush Intercontinental	Large	9
59	UT	Salt Lake City	Salt Lake City International	Large	25
60	VA	Norfolk	Norfolk International	Small	73
61	VT	Burlington	Burlington International	Small	108
62	WA	Seattle	Seattle-Tacoma International	Large	17
63	WI	Milwaukee	General Mitchell International	Medium	55
64	WV	Charleston	Yeager	Non-primary	156
65	WY	Jackson	Jackson Hole	Non-primary	183