Simulating the Dynamic Effects of Horizontal Mergers: U.S. Airlines*

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This version: August 2008

Abstract

We propose a new method for studying the medium and long run dynamic effects of horizontal mergers. Our method builds on the two-step estimator of Bajari, Benkard, and Levin (2007). Policy functions are estimated on historical pre-merger data, and then future industry outcomes are simulated both with and without the proposed merger. Using data for 2003-2007, we apply our model to two recently proposed airline mergers. In our airline entry model, an airline's entry/exit decisions are made jointly across routes, and depend on features of its own route network as well as the networks of the other airlines. The model allows for city-specific profitability shocks that affect all routes out of a given city, as well as route-specific shocks. We find that the model fits the data very well. Empirical conclusions in the paper are preliminary.

PLEASE NOTE: This paper is preliminary and incomplete. Empirical work does not yet include data for regional airlines operating routes for major carriers. Results may change when these are added.

*This draft is a very rough first effort – not even really a complete paper yet. We thank Steve Berry, Severin Borenstein, Phil Haile, and Darin Lee for several useful discussions. Correspondence: lanierb@stanford.edu; acreed@stanford.edu; lazarev_john@gsb.stanford.edu

1 Introduction

In the past, empirical analysis of horizontal mergers has relied almost exclusively on static analyses. The simplest methods compute pre- and post-merger concentration measures, assuming no post-merger changes in market shares. Large increases in concentration are presumed to be bad or illegal (Shapiro (1996),of Justice (1997)). More sophisticated methods (Berry and Pakes (1993),Berry, Levinsohn, and Pakes (1995),Nevo (2000)) have been developed recently for analyzing mergers in markets with differentiated products, where competition between firms depends critically on the precise characteristics each firm's array of products. These methods can more fully account for changes in post-merger prices and market shares, but still rely on a static model that holds fixed the set of incumbent firms and products in the market.

There are many reasons to believe that dynamics may be important for merger analysis. The most obvious one, mentioned in the merger guidelines, is that entry can mitigate the anticompetitive effects of a merger. If entry costs are low, then we should expect approximately the same number of firms in long run equilibrium regardless of whether mergers occur or not. This is clearly an important issue for the airline industry, where entry costs at the individual route level are thought to be low. In addition, the static models do not account for post-merger changes in firms' behavior. By changing firms' incentives, a merger might lead to different levels of entry, exit, investment, and pricing than occured pre-merger, in both merging and nonmerging firms (Berry and Pakes (1993),Gowrisankaran (1999)). Lastly, several papers have shown that dynamics can weaken the link between market structure and performance (Pakes and McGuire (1994),Ericson and Pakes (1995),Gowrisankaran (1999),Fershtman and Pakes (2000).Benkard (2004)), making the pre-/post-merger snapshot of market concentration and markups less relevant to medium and long run welfare implications.

All of this suggests a need for empirical techniques for analyzing the potential dynamic effects of a merger. We would like to know, for example, how long important increases in concentration are likely to persist, as well as their effects on prices and investment in the medium and long run. This paper provides a simple set of techniques for doing this, and applies these techniques to two recently proposed mergers in the airline industry.

We begin with the general framework of Ericson and Pakes (1995), which models a dynamic industry in Markov perfect equilibrium (MPE). In this model, it is not possible to characterize equilibria analytically, so they must be computed numerically on a computer. In general, inserting mergers into this framework would require a detailed model of how mergers occur (see Gowrisankaran (1999)), resulting in a complex model that may be difficult to compute and to apply to data. Analyzing specific mergers would in general require further computation.

We propose to simplify both estimation and merger analysis in these models using methods in the spirit of Bajari, Benkard, and Levin (2007) (hereafter BBL). Specifically, as in BBL, our first estimation step is to estimate firms' equilibrium strategy functions. The estimated strategy functions represent our best estimates of past equilibrium play in the dynamic game between firms.

We then employ an important simplifying assumption: we assume that the equilibrium being played does not change after the merger. For example, this might be the case if mergers are a standard occurence in equilibrium. Alternatively, it might happen if mergers are very rare, so that equilibrium play is not strongly affected by the likelihood of future mergers (whether or not the merger in question happens).

On the other hand, the assumption would not hold in the event that allowing the proposed merger would represent a substantive change in antitrust policy. In that case, the fact that the merger is allowed to go through might change firms' beliefs about future play, changing their behavior. This limits somewhat the applicability of our methods, but the benefit is that our methods are vastly simpler than the alternative of computing a new post-merger equilibrium to the game.

To analyze the dynamic effects of a proposed merger, we use BBL's forward-simulation procedure to simulate the distribution of future industry outcomes both with and without the merger. This allows us to compare many statistics: investment, entry, exit, prices, markups, etc in the medium and longer terms both with and without the merger.

Note that our methods are not intended to replace traditional antitrust analyses, described in Shapiro (1996) and Nevo (2000), which seek to measure the short run effects of a proposed merger on prices, market shares, and consumer welfare. On the contrary, our methods are complementary to these existing approaches, and when used together both sets of methods become more powerful. When used in isolation, our methods generate predictions about the medium and long term effects of a merger on industry structure through entry, exit, investment, and product turnover. However, without an accompanying model of consumer demand and market supply, it would be impossible to evaluate the overall effect of these things on consumer welfare. Similarly, as we have already noted above, if all that is available is a static model of demand and supply then it is impossible to say how industry structure might respond to a proposed merger. Thus, in our opinion, merger analyses should include both of these tools.

We apply our techniques to two recently proposed mergers in the U.S. airline industry: United-USAir and Delta-Northwest. The United-USAir merger was proposed in 2000 and eventually rejected by anti-trust authorities (see below for more details). The Delta-Northwest merger was proposed in 2008 and recently cleared and finalized. At this time, our empirical analyses are preliminary as our data does not yet include regional airlines operating routes for the major carriers. However, our preliminary findings suggest that both of these two mergers would prompt the other major carriers to increase entry relative to a world where the mergers did not occur. This increased entry somewhat, but not completely, mitigates the short run increases in concentration caused by the mergers.

2 Literature Review

Literature review not yet written (sorry!). Here are some relevant papers:

Berry (1992), Borenstein (1989), Borenstein (1990), Borenstein (1991), Borenstein (1992), Borenstein and Rose (1994), Borenstein and Rose (1995), Borenstein and Rose (2007), Brueckner and Spiller (1994), Kim and Singal (1993), Morrison and Winston (1995), Ciliberto and Williams (2007), Berry and Jia (2008), Gayle (2006), Boguslaski, Ito, and Lee (2004), Ito and Lee (2007), Morrison and Winston (1990), Sinclair (1995), Ciliberto and Tamer (2007), Whinston (1992), Reiss and Spiller (1989), Hurdle, Werden, Joskow, Johnson, and Williams (1989)

Berry and Pakes (1993), Nevo (2000), Gowrisankaran (1999),

Shapiro (1996), Willig, Salop, and Scherer (1991)

Collard-Wexler (2009), Stahl (2009),

3 Model/Methodology

We start with a general model of dynamic competition between oligopolistic competitors. The purpose of the general model is to show how our approach would work in general contexts. We develop a more detailed model for airlines below. Our general model closely follows BBL, and is a generalization of the Ericson and Pakes (1995) model. The defining feature of the model is that actions taken in a given period may affect both current profits and, by influencing a set of commonly observed state variables, future strategic interaction. In this way, the model can permit aspects of dynamic competition such as entry and exit decisions, mergers, dynamic pricing or bidding, etc.

There are N firms, denoted $i = 1, ..., N$, who make decisions at times $t = 1, 2, ..., \infty$. Conditions at time t are summarized by a commonly observed vector of state variables $\mathbf{s}_t \in S \subset \mathbb{R}^L$. Depending on the application, relevant state variables might include the firms' production capacities, their technological progress up to time t, the current market shares, stocks of consumer loyalty, or simply the set of incumbent firms.

Given the state $\mathbf{s}_t$, firms choose actions simultaneously. These actions might include decisions about whether to enter or exit the market, investment or advertising levels, or choices about prices and quantities. Let $a_{it} \in A_i$ denote firm i's action at time t, and $\mathbf{a}_t = (a_{1t}, \dots, a_{Nt}) \in A$ the vector of time t actions.

We assume that before choosing its action, each firm i receives a private shock ν_{it}, drawn independently across agents and over time from a distribution $G_i(\cdot|\mathbf{s}_t)$ with support $\mathcal{V}_i \subset \mathbb{R}^M$. The private shock might derive from variability in marginal costs of production, due for instance to the need for plant maintenance, or from variability in sunk costs of entry or exit. We denote the vector of private shocks as $\nu_t = (\nu_{1t}, ..., \nu_{Nt})$.

Note that at present the assumption that the private shocks are independent over time is required for estimation. It is nevertheless a troublesome assumption as in many empirical applications it would be reasonable to expect serial correlation in these shocks. Our hope is that present and future work (add cites) will allow this important assumption to be relaxed.

Each firm's profits at time t can depend on the state, the actions of all the firms, and the firm's private shock. We denote firm i's profits by $\pi_i(\mathbf{a}_t, \mathbf{s}_t, \nu_{it})$. Profits include variable returns as well as fixed or sunk costs incurred at date t, such as entry costs or the sell-off value of an exiting firm. We assume firms share a common discount factor $\beta < 1$.

Given a current state $\mathbf{s}_t$, firm i's expected future profit, evaluated prior to realization of the private shock, is

$$\mathbb{E}\left[\sum_{\tau=t}^{\infty} \beta^{\tau-t} \pi_i(\mathbf{a}_\tau, \mathbf{s}_\tau, \nu_{i\tau}) \middle| \mathbf{s}_t \right].$$

The expectation is over i's private shock and the firms' actions in the current period, as well as future values of the state variables, actions and private shocks.

The final aspect of the model is the transition between states. We assume that the state at date $t+1$, denoted $\mathbf{s}_{t+1}$, is drawn from a probability distribution $P(\mathbf{s}_{t+1}|\mathbf{a}_t, \mathbf{s}_t)$. The dependence of $P(\cdot|\mathbf{a}_t, \mathbf{s}_t)$ on the firms' actions $\mathbf{a}_t$ means that time t behavior, such as entry/exit decisions or long-term investments, may affect the future strategic environment. Not all state variables necessarily are influenced by past actions; for instance, one component of the state could be an i.i.d. shock to market demand.

To analyze equilibrium behavior, we focus on pure strategy Markov perfect equilibria (MPE). In an MPE, each firm's behavior depends only on the current state and its current private shock.

Formally, a Markov strategy for firm i is a function $\sigma_i : S \times \mathcal{V}_i \rightarrow A_i$. A profile of Markov strategies is a vector, $\sigma = (\sigma_1, ..., \sigma_n)$, where $\sigma : S \times \mathcal{V}_1 \times ... \times \mathcal{V}_N \rightarrow A$.

If behavior is given by a Markov strategy profile σ, firm i's expected profit given a state s can be written recursively:

$$V_i(\mathbf{s};\sigma) = \mathbb{E}_\nu \left[\pi_i(\sigma(\mathbf{s},\nu),\mathbf{s},\nu_i) + \beta \int V_i(\mathbf{s}';\sigma) dP(\mathbf{s}'|\sigma(\mathbf{s},\nu),\mathbf{s}) \middle| \mathbf{s} \right].$$

Here V_i is firm i's ex ante value function in that it reflects expected profits at the beginning of a period before private shocks are realized. We will assume that V_i is bounded for any Markov strategy profile σ.

The profile σ is a Markov perfect equilibrium if, given the opponent profile σ_{-i}, each firm i prefers its strategy σ_i to all alternative Markov strategies σ_i'. That is, σ is a MPE if for all firms i, states s, and Markov strategies σ_i',

$$V_i(\mathbf{s};\sigma) \geq V_i(\mathbf{s};\sigma_i',\sigma_{-i}) = \mathbb{E}_\nu \left[\begin{array}{c} \pi_i\left(\sigma_i'(\mathbf{s},\nu_i),\sigma_{-i}(\mathbf{s},\nu_{-i}),\mathbf{s},\nu_i\right) + \\ \beta \int V_i(\mathbf{s}';\sigma_i',\ \ \sigma_{-i}) dP\left(\mathbf{s}'|\sigma_i'(\mathbf{s},\nu_i),\sigma_{-i}(\mathbf{s},\nu_{-i}),\mathbf{s}\right) \end{array} \middle| \mathbf{s} \right].$$

Doraszelski and Satterthwaite (2007) provide conditions for equilibrium existence in a closely related model. Here, we simply assume that an MPE exists, noting that there could be many such equilibria.

The structural parameters of the model are the discount factor β, the profit functions $\pi_1, ..., \pi_N$, the transition probabilities P, and the distributions of the private shocks $G_1, ..., G_N$. We assume the profit functions and the private shock distributions are known functions indexed by a finite parameter vector θ: $\pi_i(\mathbf{a}, \mathbf{s}, \nu_i; \theta)$ and $G_i(\nu_i|\mathbf{s};\theta)$.

3.1 The Method and The Key Assumption

As in BBL, assuming that actions and states are observed, the model above can be estimated in two steps. In the first step of BBL, agents' strategy functions (σ) and the state transition function $Pr(\mathbf{s}_{t+1}|\mathbf{a}_t, \mathbf{s}_t)$ are estimated from observations on actions and states. In a second step, the profit function parameters, θ, are estimated.

There is an important but subtle difference between the approach we propose and the approach used in BBL. The second step of the BBL estimation requires complete knowledge of the strategy functions, σ, as a function of the common states, s, and the private shocks ν_i in order to simulate the future distribution of profits, so the complete strategy functions must be estimated in the first step of BBL. Here we require only knowledge of the "reduced form" distribution of actions given states, $P(a_{it}|\mathbf{s}_t)$, for all agents i and at each state $\mathbf{s}_t$. Thus, the main difference in our approach relative to BBL is that in our first step where BBL would estimate σ, we instead estimate these choice distributions.

While it may in some cases require a large amount of data to estimate the choice distributions flexibly, our approach has the advantage that in principle the reduced form choice distributions are always identified. Estimation becomes only an empirical problem. The problem with estimating the strategy functions is that identification of σ can be difficult, and would typically require that the private shock ν_i be single dimensional. For example, you could model a cost shock or a demand shock but typically not both. Our approach has the advantage of being consistent with a more general class of models. In principle, the private shocks inducing $Pr(a_{it}|\mathbf{s}_t)$ could be high dimensional and it would not matter.

We consider how to measure the dynamic effects of a specific proposed merger in this model between two firms at a particular observed value of the state, s. Of course, in general many modelling details will depend critically on the application being considered, and below we consider mergers in a specific application: the airline market. However, more generally, we employ a simplifying assumption that allows for a general approach to evaluating mergers in any model of this type.

Assumption 1 The same Markov perfect equilibrium profile, σ, is played for all t whether or not the merger of interest takes place.

This assumption would hold sometimes and not others. For example, it would hold any time that mergers represent equilibrium play in the game, so long as the primitives of the model and the policy environment remain constant. In that case, mergers would also need to be represented in the strategy function σ, and the first stage estimation would need to include estimates of the probability of each merger taking place.

Alternatively, it could be that mergers are rare enough that the potential for future mergers is not likely to significantly impact firm behavior. That is, even though a merger is proposed at present, the expectation of future mergers does not influence equilibrium play. Moreover, the fact that there has been one merger does not change equilibrium play. In this case there is no need to model mergers in the first step estimation (and they would not exist in the data either, with the exception of the merger under consideration). We argue below that that the airline market might reasonably fit into the latter category.

The importance of this assumption is that it means that the choice distributions recovered from the data in the first step of estimation are relevant whether or not the merger being evaluated takes place. In that case, the first stage estimates completely determine the future distribution of actions and states conditional on the current state,

$$P((\mathbf{a}_{t+1}, \mathbf{s}_{t+1}), ..., (\mathbf{a}_{t+r}, \mathbf{s}_{t+r})|\mathbf{a}_t, \mathbf{s}_t), \text{ for all } r, \tag{3.1}$$

whether or not the merger takes place. The effect of the merger is to change the initial state of the industry, s_t. Of course the future distribution of market outcomes will change with the initial state, but in a way that we can easily evaluate since we know the stategy functions and transition probabilities generating them.

In practice, once the first step estimates have been obtained, we can use the BBL forward simulation procedure to simulate the distribution of future market outcomes both with and without the merger. The great benefit of assumption 1 is that we do not require the ability to compute a new equilibrium to the game, which may be very difficult in many cases.[1] As a result, for many markets, our proposed methods may be economical enough to be useful to policy makers such as the DOJ and the FTC.

On the other hand, the assumption would be presumed to fail in the event of a policy change at the time of the merger. For example, if the merger under consideration is one that would never have been allowed under the previous policy regime, then allowing the merger might lead to increased merger activity in the future. In that case, the choice distributions estimated in the past may not accurately describe future industry dynamics if the merger were to take place. Any other contemporaneous policy change would lead to a similar problem. The only way that we know of to evaluate such a policy change would be to compute a new MPE strategy profile under the new policy, a much more difficult approach than the one we consider here.

[1] Cite computational references here.

In general, policy makers are interested in the effects of a merger on competition, prices, quantities, and ultimately consumer and producer surplus. Once estimates are obtained for the choice distributions and for the one period transition probabilities, we are able to construct/simulate the implied probability distribution of actions and states (3.1) at every point in time for both the merger and no merger cases. Knowing these distributions may already be enough to evaluate the medium and long run competitive effects of a merger.

Note that the model does not necessarily imply that the equilibrium Markov process of industry states be ergodic. However, if it is ergodic then the effects of any specific merger will always be transient. That is, in the very long run, the distribution of industry states will be the same regardless of whether the merger takes place or not. However, even in that case there may still be important medium term effects of a merger.

Knowledge of the future distributions of actions and states given today's state typically would not provide enough information to calculate the expected welfare implications of a proposed merger. To do that we would also need to know something about period demand and supply in order to calculate the prevailing prices and consumer and producer surplus. This would typically require an additional set of estimates, for example, from a Berry, Levinsohn, and Pakes (1995)-like model.

On the other hand, for most statistics of interest we would not require estimates of sunk costs (e.g., the BBL second stage). All relevant information about sunk costs is contained in the choice distributions. The only thing we would need sunk costs estimates for would be to compute producer surplus net of sunk costs. For example, we may want to compute the level of sunk costs being paid in an industry if we believed that the industry had excess entry, and that a merger might exacerbate this phenomenon.

4 Airline Mergers: Recent Experience

Figure 1 shows a graphical timeline of recent airline mergers and code share agreements in the U.S. airline industry. The history of mergers within the airline industry over the last decade could be characterized as the combination of distressed assets to form larger conglomerates that all too soon become financially troubled in turn. Many policy makers feared that the commercial airline industry could become overly concentrated in the wake of the Airline Deregulation Act of 1978 and the closure of the Civil Aeronautics Board in 1985. Therefore, mergers between airlines on the verge of collapse were approved under the auspices of maintaining competition, while mergers between fiscally healthy airlines were generally prevented.

This logic was expressed quite cleanly in the approval of the merger between ValuJet and AirTran Airways in 1997. After a series of safety problems culminating in the May 11, 1996 crash of ValuJet flight 592 in the Florida Everglades, the Federal Aviation Administration (FAA) grounded the ValuJet fleet for three months. In addition to the harm done to ValuJet's reputation, the financial burden of the grounding forced ValuJet to seek a buyer to salvage the value of its assets. The merger was completed on November 17, 1997 with the joint company retaining the AirTran name with little reference to ValuJet's checkered past.

In 1999, Northwest Airlines (NWA) and Continental Airlines formed an alliance that, although falling short of a full merger, was designed to provide many of the practical benefits thereof. The alliance involved code-sharing and joint marketing of flights so that Continental and Northwest agents could provide passengers tickets on either Continental or NWA flights. This significantly expanded the hub and spoke networks the airlines could provide, which is thought to be a major benefit to the lucrative business-class market. The alliance provided NWA with control of 51%

of the Continental voting shares, which allowed NWA to veto any mergers or other significant business activity on the part of Continental. The Department of Justice (DoJ) filed suit over this arrangement with the final result that NWA sold back the controlling share of Continental prior to a final legal judgment being rendered.

In April 2001 Trans World Airlines (TWA) was acquired by American Airlines (AA). In 1996, TWA flight 800 exploded in the airspace outside of New York City, an event that prompted TWA to commence a major program of fleet renewal to forestall the sort of negative publicity that ruined ValuJet. This involved the purchase of large numbers of new aircraft and a refocusing on domestic service. However, the economic downturn starting at the end of the decade wreaked significant financial hardship on the airline. TWA declared bankruptcy the day after AA agreed to acquire its assets and assume its debt obligations.

On May 5, 2000 United Airlines and USAir announced an agreement to seek a merger of their assets. Neither airline was in formal financial distress at this point. The merger was opposed by the DoJ, which prompted the airlines to design the merger so that significant USAir assets would be purchased by AA in order to alleviate concerns over competition on select routes. An entirely new airline, DCAir, was proposed to introduce added competition to the highly profitable Washington, D.C. - New York City - Boston traffic corridor heavily served by both United and USAir. One potential motivation for the merger was to enable United and AA to form dominant positions in markets within the northeastern United States where industry experts believe entry to be difficult. United announced opposition to the merger July 2, 2001, primarily due to the DoJ's insistence on significant sales of the rights to existing United and USAir hubs and other conditions for the deal to be approved.

In September 2005, US Airways emerged from bankruptcy to a form a merger with America

West. Given that US Airways primarily serviced the eastern United States and America West the western states, the airlines had hoped to leverage complementarities in their regional networks to form a low cost carrier that could effectively compete with Southwest airlines. The primary objectors to the merger were the US Airways labor unions, which worried about the effects of combining two heterogeneous labor forces on the union's ability to effectively bargain with the firm. This merger is historically significant in that America West was not in financial distress at the time, although the pre-merger airlines did not provide significantly overlapping service and therefore the merger represented a lesser risk to competition.

In 2006 US Airways made an unsolicited takeover offer to Delta while Delta was in chapter 11 bankruptcy hearings. The offer was rejected by the unsecured creditors responsible for guiding the Delta reorganization through the bankruptcy hearings. Delta CEO Gerald Grinstein was quoted in the July 29, 2006 Wall Street Journal as expressing doubt that any US Airways - Delta merger would be acceptable to regulators since the two airlines have competing hubs in the southeastern United States. In addition, the merger was opposed by US Airways labor unions still in disarray from the US Airways - America West merger. US Airways abandoned their hostile takeover efforts in early 2007.

At the end of 2006, United Airlines and Continental airlines were actively discussing potential merger options. As news of a possible United-Continental deal circulated, rumors mounted of possible mergers between Northwest and other major airlines and that United had also expressed interest in merging with Delta. Several industry sources (Wall Street Journal, December 13, 2006) have suggested that the possibility of a US Airways - Delta merger prompted the merger talks under the assumption that size leads to a stronger competitive position within the industry. Although none of these merger options have yet sought regulatory approvable, if any were consummated it would yield one of the largest airlines in the world with a significant presence in many domestic and international routes.

In April 2008, Delta announced that it would be merging with Northwest Airlines. Domestically, the Delta and Northwestern route networks do not overlap significantly, which could limit any anti-competitive effects of the potential merger. Internationally, Delta and Northwestern would become the largest U.S. carrier on profitable routes between the U.S. and many regions of the world. The expanded international network was emphasized by Delta officials as the principal benefit of the merger on the day it was announced (April 15, 2008), although cost savings and improved aircraft utilization were also cited as benefits of the merger.

Below, we analyze the potential medium and long term effects of two recently proposed mergers: Delta-Northwest, which was cleared in late 2008, and United-USAir, which was blocked in mid 2000.

In lieu of merging, many airlines have formed alliances or marketing agreements to engage in code-sharing. Code-sharing is the practice of a group of airlines providing the right to other members of the group to sell tickets on each others flights. This can effectively extend the flight offerings of each member airline greatly. Code-sharing agreements have been a prominent feature of international travel for many years since countries often restrict the service foreign airlines can provide. In the United States, code-sharing between regional airlines and national airlines allows the regional airlines to provide service from isolated airports to hub locations, which has allowed the national airlines to extend their route network.

Code-sharing between major airlines along domestic routes has exploded within the last decade as regulators have more readily approved these alliances than full mergers. American Airlines and Alaska Airlines formed a domestic code-sharing agreement in 1998. Delta and Alaska Airlines initiated a separate code-sharing agreement in 2005. Both of these alliances allowed Alaska Airlines to provide service to customers throughout the United States even though Alaska's network is focused almost entirely on routes within Alaska and the western United States.

As part of their equity alliance, Northwestern Airlines and Continental formed a code-sharing alliance. The extension of the code-sharing agreement to include Delta Airlines was approved by regulators in January 2003. The approval included conditions designed to preserve competition such as limits on the total number of flights that could be included in the code-sharing agreement and demands to relinquish gates at certain hubs.

United and US Airways launched a code-sharing agreement in 2003. Since both of these airlines offer service in many of the major domestic markets, it is not surprising that the agreement was approved with conditions by the Transportation Department. These conditions included mandating independent schedule and price planning as well as forbidding code-sharing on routes in which both airlines offered non-stop service. Without these conditions, code-sharing agreements could become de facto mergers from a consumer competition stand point.

5 A Model of the U.S. Airline Industry

Consider an air transportation network connecting a finite number, K, of cities. A nonstop flight between any pair of cities is called a *route* (or segment). We index routes by $j \in \{1, ..., J\}$ and note that $J = K * (K - 1)/2$, though of course not all possible routes may be serviced at any given time.

There are a fixed number, A, of airlines, including both incumbent airlines and potential entrants. Each airline i has a network of routes defined by a J dimensional vector, n_i. The jth element of n_i equals one if airline i currently flies route j, and is zero otherwise. Let the $J \times A$ matrix N be the matrix obtained by setting the network variables for each airline next to each other. We call N the *route network*.

In order to travel between two cities, consumers are not required to take a nonstop flight, but might instead travel via one or more other cities along the way. Thus, we define the market for travel between two cities broadly to include any itinerary connecting the two cities. Below we will argue that itineraries involving more than one stop are rarely flown in practice, and will restrict the relevant market to include only nonstop and one-stop flights. Markets are indexed by $m \in \{1, ..., J\}$.

5.1 Period Profits

Airlines earn profits from each market that they serve. Profits depend on city pair characteristics, z_m, as well as the strength of competition in the market, and are given by a function,

$$\pi_{im}(z_{mt}, N_t) + \epsilon_{imt},$$

where ϵ_{imt} is an unobserved random market and airline specific profit shifter. Later we will make more specific assumptions about ϵ_{imt}, but for now we will only assume that it is independent over time. It would be nice to relax this assumption, but this would be difficult empirically, so for now any serial correlation in profits will have to be captured by z_{mt}. Though we will require further simplifying assumptions, in principle, we can allow ϵ_{im} to be correlated across markets or airlines.

Note that π_{im} is a reduced form that is derived from underlying demand and cost functions and a static equilibrium in prices/quantities. For example, while we will not elaborate this further, it may be that (suppressing the t subscript)

$$\pi_{im}(z_m, N) = q_{im}(z_m, N, \mathbf{p}_m) * p_{im} - C(z_m, q_{im}),$$

where $\mathbf{p}_m$ is a vector of prices charged by each airline to fly market m, $C(z_m, 0) = 0$ and prices are set in static Nash equilibrium. Of course here we are ignoring price discrimination and assume that each airline charges a single price in each market, but note that this is not a required assumption for the reduced above.

We assume that $\pi_{im} = 0$ for any market m that is not served by airline i. Total profits in a given period across all markets for airline i are

$$\sum_{m=1}^{J} (\pi_{im}(z_m, N) + \epsilon_{im}).$$

5.2 Sunk Costs and Route Network Dynamics

We will assume that decisions are made in discrete time at yearly intervals. Each year, t, an airline can make entry and exit decisions that will be reflected in the network in the next year, N_{t+1}. Changing the firm's network, however, involves some costs. Let D be a $J \times K$ matrix where each column d_k contains a vector of zeros and ones such that $d_{jk} = 1$ if route j has city k as one of its end points, and otherwise $d_{jk} = 0$. Then airline i's cost of changing its network is given by,

(5.1)

$$S_{it}(n_i^t, n_i^{t+1}) = \Big\{\sum_{j=1}^{J} n_{ij}^t > 0\Big\}\Big\{\sum_{j=1}^{J} n_{ij}^{t+1} = 0\Big\}\Phi_{it} - \Big\{\sum_{j=1}^{J} n_{ij}^t = 0\Big\}\Big\{\sum_{j=1}^{J} n_{ij}^{t+1} > 0\Big\}\Xi_{it} +$$

$$\sum_k \left(\Big\{\sum_j d_{jk} n_{ij}^t > 0\Big\}\Big\{\sum_j d_{jk} n_{ij}^{t+1} = 0\Big\}\Phi_{ikt} - \Big\{\sum_j d_{jk} n_{ij}^t = 0\Big\}\Big\{\sum_j d_{jk} n_{ij}^{t+1} > 0\Big\}\Xi_{ikt}\right) +$$

$$\sum_{j=1}^{J} \left(\{n_{ij}^{t+1} < n_{ij}^t\} * \phi_{ijt} - \{n_{ij}^{t+1} > n_{ij}^t\} * \kappa_{ijt}\right)$$

where the notation $\{\ldots\}$ refers to an indicator function, Φ_{it} is a random scrap value obtained from shutting down an airline entirely (for example the value from selling off the brand name), Ξ_{it} is a random setup cost paid when opening a new airline (for example, the cost of regulatory approval), Φ_{ikt} is a random scrap value obtained from closing operations at airport k, Ξ_{ikt} is a random cost of opening operations at airport k, ϕ_{ijt} is a random route specific scrap value from closing a route, and κ_{ijt} is a random route specific setup cost. Let ω_{it} be a vector consisting of all the random cost shocks for firm i at time t, $\omega_{it} = (\Phi_{it}, \Xi_{it}, \Phi_{i1t}, ..., \Phi_{iKt}, \Xi_{i1t}, ..., \Xi_{iKt}, \phi_{i1t}, ..., \phi_{iJt}, \kappa_{i1t}, ..., \kappa_{iJt})$. Then we can write

$$S_{it}(n_i^t, n_i^{t+1}) \equiv S(n_i^t, n_i^{t+1}, \omega_{it}).$$

Each period, each airline chooses it's next period's network so as to maximize the expected discounted value of profits, where the discount factor β is assumed constant across firms and time. Let Z_t be a matrix consisting of the variables z_m for all m in period t and assume that Z_t is Markov.[2]

[2]Note that our notation does not rule out Z_t containing aggregate variables that are relevant to all markets.

Written recursively, the firm's problem is:

$$(5.2)\quad V_i(N_t, Z_t) = \int \max_{n_i^{t+1}} \Big\{ \sum_{m=1}^{J} (\pi_{im}(z_{mt}, N_t) + \epsilon_{imt}) - S(n_i^t, n_i^{t+1}, \omega_{it}) + \beta \int V_i(N_{t+1}, Z_{t+1}) dP(Z_{t+1}|Z_t) dP(N_{-i,t+1}|N_t, Z_t) \Big\} dF(\omega_{imt}, \epsilon_{it})$$

where $P(N_{-i,t+1}|N_t)$ represents airline i's beliefs about the entry and exit behavior of competing airlines. (In equilibrium, i will have correct beliefs.) This choice problem will lead to a set of strategy functions of the form:

$$n_i^{t+1}(N_t, Z_t, \omega_{it}, \epsilon_{it}).$$

Assuming symmetry, these functions would have the property that permuting the order of airlines in N_t (and correctly updating the index i) would not change the value of the function. However, while symmetry is commonly assumed in many applications of dynamic games, here complete symmetry may not be a good assumption as there are at least two kinds of airlines: hubbing carriers, and point-to-point (or "low cost") carriers that appear to act differently in their entry decisions. This is something that can be explored empirically.

Note that, in a market where mergers have an important influence on the industry structure, we would also want to model mergers. In that case there would also be a choice of whether to merge and who to merge with, and an associated strategy function. Because mergers between financially healthy carriers have been so rare in the airline industry, we exclude mergers from the model. With so few historical mergers, it would be also be difficult to extract a merger strategy function from the data without adding substantially more modelling structure and assumptions.

The model above will result in the following set of behavioral probability distributions for each airline:

$$Pr(n_i^{t+1}|N_t, Z_t) \tag{5.3}$$

If we knew π_m (up to a vector of parameters to be estimated) and we could compute V_i, then we could derive these probabilities by doing the integral on the right hand side of (5.2). However, in our problem computing an equilibrium, V_i, is most definitely out of the question, and furthermore there are almost surely going to be many equilbria (with associated V_i's and behavioral probabilities). Alternatively, we will follow the approach of Bajari, Benkard, and Levin (2007) and attempt to recover the behavioral probabilities directly from the data.

6 Data

The principle data source was the Bureau of Transportation Statistics (BTS) T-100 Domestic Segment Data set for the years 2003-2007. Much more historical data is readily available. However, due to the large impact of the events of 9/11/2001 on the airline industry, we view 2001 and 2002 as not representative of the current industry, so we dropped those from our sample. We did not use data from years prior either because our model requires us to use a period where airlines' entry/exit strategy functions are constant, and we felt that this was not likely to be true over longer time horizons due to changes in policy, technology, etc. However, we note that we have tried extending all of our estimations back all the way to 1993, and achieved very similar results.

The T-100 segment data set presents quarterly data on enplaned passengers for each route segment flown by each airline in the U.S. The data defines a segment to be an airport to airport flight by an airline. A one-stop passenger ticket would therefore involve two flight segments. We use data for the segments connecting the 75 largest airports, where size is defined by enplaned passenger traffic. The data was then aggregated to the Composite Statistical Area (CSA) where possible and to the metropolitan statistical area when this was not possible. The end result was segment data connecting 60 demographic areas (CSA's). Appendix A.1 contains the list of airports included in each demographic area and our precise definition of entry, exit, and market presence.

Although the airline strategy function is defined over the route segment entry decisions, we also allow airlines to carry passengers between a pair of CSAs using one-stop itineraries. The combination of non-stop and one-stop service between two CSAs is denoted the "market" between the CSAs. An airline is defined as present in a market if either (1) the airline provides service on the route segment connecting the two CSAs OR (2) the airline provides service on two route segments that connect the CSAs and the flight distance of the two segments is less than or equal to 1.6 times the geodesic distance between the CSAs. Itineraries that use 2 or more stops are extremely rare in the airline ticket database (DB1B), so we exclude this possibility from our analysis. Note that in certain places we supplement the T100S data with data from the T100M "market" database, the DB1B ticket database, and the Household Transportation Survey (tourism data).

Please note: at this point our data for major carriers does not include those routes flown by regional partners (Mesa, etc). We are working on adding these to the data for the next draft of the paper. Note that any of our results below could change when we do this.

Table 1 lists some summary statistics for route and market presence for this data. Southwest has the most routes, followed by the three major carriers: American, United, and Delta. Because the majors have hub and spoke networks, as compared with Southwest's point-to-point network, they are present in as many or more markets as Southwest despite flying fewer routes. Southwest and Jet Blue are expanding during this period, while American, Delta, and US Air are contracting. Turnover varies quite a bit, but averages about four percent across airlines.

Table 2 lists some summary statistics for the airline's networks across city pairs. The top half of the table is measured across the 1770 city pairs in our data. We interact the populations of the two endpoint cities, representing a measure of the potential number of trips between the two cities (Berry (1992)). The largest fraction of city pairs are between 500 and 1500 miles apart. Consistent with the model above, the competition variables are computed for the market (including one-stops), not the route segment.

One of the most important variables is one that measures passenger density (enplanements) on the market in 1993. This variable is designed to capture many of the unobservable aspects of market demand that are peculiar to a given city pair, but is chosen to be from a point in the past in order to avoid endogeneity problems.[3] The "percent tourist" variable measures the percentage of passengers travelling in each market who report that their travel was for the purpose of tourism.

The bottom half of the table is measured at the airline-route level, so there are 12*1770 observations. For each carrier-route, it lists measures of own market presence and competitor presence.

6.1 Competition in the U.S. Airline Network and the Two Proposed Mergers

Tables 3-5 describe the amount of overlap that currently exists in the U.S. airline network. Table 3 shows that approximately half of nonstop route segments flown by United, American, US Air, and Alaska are also flown by Southwest, which flies by far the most nonstop routes of any airline. Reflecting their shared hubs at Chicago and San Francisco, American and United overlap about

[3] We currently use 1993 because we wanted a point before the data starts and we were experimenting with different data periods. Now that we are using 2003-2007, we will update this to 2002.

30% of each other's routes. Neither shares many nonstop routes in common with Delta, Continental, and Northwest. Delta and Northwest appear the most isolated from nonstop competition from other majors, while both also do not overlap much with Southwest. Continental overlaps most heavily with Southwest and Jet Blue. When we include one-stop flights, there is much more competition in general. American and United overlap Delta, Continental, and Northwest much more heavily, for example.

Table 4 shows that Southwest and Northwest are the most isolated from competition in the sense that they have by far the most monopoly and duopoly markets. In the event of a Delta-Northwest merger or United-US Air merger, the merged carriers would also have a significant number of markets isolated from competition.

Looking more closely at these potential mergers, we see that Delta and Northwest have very little overlap in nonstop routes, but fly about 70% of the same markets. In all of these markets there will be one fewer carrier post-merger. United and US Air have more nonstop routes in common (about 15% of their networks) but about the same overlap in markets served.

Table 5 shows that there are no nonstop routes where Delta and Northwest are the only two carriers and only one route where they are the only two carriers with a single third airline. There are two markets where they are the only two carriers and 16 where they are the only two carriers with a third airline. These markets, and particularly the two where Delta and Northwest are a duopoly, will likely see a significant short-run increase in price after the merger. United and US Air, meanwhile, are the only two carriers on two nonstop routes, but only one market. They share traffic with a third carrier in four nonstop routes, and 18 markets overall. Again, these markets would likely see post-merger price increases assuming no entry takes place.

Table 6 shows the most affected individual market segments for the two mergers in terms of increase in the HHI. For Delta-Northwest, these are routes between Atlanta, Detroit, and Minneapolis-St Paul. For United-US Air the worst affected routes are two out of Denver and three out of Philadelphia.

There is some evidence (Borenstein (1989)) that, due to frequent flyer mile accumulation, market concentration out of a city as a whole is also an important determinant of market power. Table 7 shows the worst affected cities in terms of HHI increase across all flights from the city. For Delta-Northwest, the worst markets are Hartford and Memphis. For United-US Air, the worst affected cities are Washington DC and Philadelphia. In the latter case, concentration at these two cities was cited as the main reason that the United-US Air merger was blocked.

7 Estimation and Results

The results above provide a short run snapshot of the increase in concentration that would result from the two proposed mergers. In this section, we use our model to simulate medium and longer term market outcomes.

The primary difficulty with estimating the airlines model above is that, in their raw form, the choice probalities in (5.3) are very high dimensional and would be identified only by variation in the data over time. Variation across airlines could also be used if we were to assume some symmetry across carriers. However, given that there are two types of carriers: hub carriers and low cost carriers, we do not want to assume symmetry across all carriers. Furthermore, given that have only 10 carriers and 5 years, that still only leaves 50 observations to determine a very high dimensional set of probabilities.

Therefore, to estimate these probabilities we will require some simplifying assumptions. Most notably, we will need to use the variation in the data across routes to identify the strategy functions. Our approach will be to start with a fairly simple model and then add complexity until we exhaust the information in the data. In principle, all routes in the whole system are chosen jointly, and we would like our model to reflect that. That said, it seems unlikely that the entry decisions are very closely related for routes that are geographically distant and not connected in the network.

The simplest model we can think of would allow the entry decisions across routes to be correlated only through observable features of the market, so we will begin with this model. For the base model, we assume that there are only route level shocks (no city specific shocks) and that these shocks are independent across routes. We model route entry and exit decisions as a probit.

Our main probit results are shown in table 8. The first panel of coefficients are demand shifters: population, passenger density, and tourist travel on the route in question. The "Dens New Markets" variable compares an airline's route network both with and without the route in question, and adds up the total amount of new passenger density (in 1993) if the route in question is included in the airline's network relative to if the route is excluded from the network.

The second panel of coefficients are route distance dummies; the third panel of coefficients are competition variables; the fourth panel are network variables; the fifth panel are presence variables. The variables "Non Stops Conns (Small and Large)" reflect the number of nonstop connections available at each end of the route in question. The variable for presence in market but not segment reflects one-stop service on the city pair in question. All of the probits also include city and year dummies.

Note that in a model of this type, with entry on one side and competition on the other, we might typically expect to get the wrong sign on the competition variables due to there being serially correlated unobserved demand shifters. In markets with serially high demand shocks, there would be a lot of entry, and thus strong competition may appear favorable to entry in the regression. One way to solve this problem is to have very good measures of underlying demand. We believe that in our case the route passenger density variable largely solves this problem by giving us a very good measure of the underlying demand on each route. Of course it would not necessarily completely solve the problem to the extent if underlying demand conditions on a route change over time in a persistent way, but it seems to alleviate it considerably.

As a result, all of the coefficients come out as we would expect except for two: the variables for present at one airport and present at both airports, which are consistently negative in every specification we have ever run (though not always statistically significant). Note that the excluded variable is no presence and therefore the probit results are telling us that, all other things equal, entry is more likely in markets with no presence than it is in markets with presence at one end. We do not believe this result and we are currently trying to figure out what is driving it. There are zero entry occurences in our data for a route where the airline has no market presence at either end. There are a few entries on routes where there is presence at only one end, and most entries of course occur on routes where there is presence at both ends. Therefore, in principle our data do not identify a nonparametric lower bound on the profitability of entering a route where there is no market presence (which would translate to there being no upper bound on the two presence coefficients). Thus, it must be that the negative coefficients obtained here are due to functional form restrictions imposed in the probit, such as the normally distributed error terms. Obviously these coefficients may adversely affect our merger simulations. However, we also note that for the major airlines there are very few airports where they are not present, so any affect of these coefficients on the simulations will be small.

Table 9 shows the model fit for the pooled probits. For “stayers” (first panel), the fit is very good. For switchers (second panel) it is not as good if you look at the entry/year combination. However, if instead we try to predict what entries/exits would have happened over the four year sample period, without regard for exactly which year they occur (the third panel of the table), the fit is much better. We would even argue that it is exceptional. The fit of the model improves even more if we use separate probits for each airline (see table 10). Ignoring the actual year of entry/exit, we are able to consistently predict entry/exit with more than 50% accuracy.

We have also estimated a more generalization of this entry model that allows for city specific random profitability shocks (results not currently reported). So far we have found that this additional level of generality does not add much to the model empirically. In part this is because the model above fits well enough that there is not much variation in the data left to explain. However, we are still working on this aspect of the estimation problem and will likely report results from this model in a future draft of the paper.

8 Merger Simulations

Tables 11-22 show simulation results when the pooled model above is used to simluate the U.S. airline route network for the top 60 CSA's over the next 10 years. We run three simulations. One in which there are no mergers. One where Delta and Northwest merge, and one where United and US Air merge. For the simulations we use the average value of the year fixed effects so essentially we are assuming flat demand over the period.

In the base case simulation there are few major changes to the route network. The biggest change is that we forecast that Jet Blue will continue to expand, such that in 10 years it will be nearly twice its current size. This would put it on par with Continental. Essentially, our model is saying that Jet Blue has been acting over the last few years as if it is quite profitable. If that is the case, then there are many additional profitable routes for it to enter in the next 10 years. The only other significant change in the base case simulations is that our model forecasts that Northwest will shrink by about 20%. We have yet to investigate exactly why this latter effect occurs.

In both cases, when there is a major merger we find that the other major carriers respond by increasing entry. For example, in both cases American airlines adds about 15 nonstop routes relative to the base case. Results are similar for the other majors. Interestingly, the merged carriers also expand relative to what they would have done in the base case. The result is more competition in many areas of the route network.

Looking at the most involved cities shows that these two effects are typically still present. Service levels by all carriers are higher at Bradley, Memphis, DC, and Philadelphia with a merger than they would have been without a merger. That said, concentration in the merger simulations is typically persistently higher than it would have been in the base case. That is, the short run increase in concentration persists. It diminishes over time in many cities, but persists through the 10 year simulations.

This set of results presents a tradeoff. Many cities are clearly better off after the merger due to increased service levels, without much of an increase in concentration. Even the most involved cities have higher service levels post-merger. There is also another possible benefit of the mergers which is that consumers in some cities can reach many more destinations on a single carrier than they could without the merger. However, these consumers also experience higher concentration, which would likely lead to higher prices. How this tradeoff impacts welfare is ambiguous, and we would not be able to quantify it without having a model of short run demand and supply in these markets.

9 Conclusions

[to be written]

A Data Appendix

As an example of the CSA aggregation, the CSA containing San Francisco contains the Oakland International Airport (OAK), the San Francisco International Airport (SFO), and the Mineta San Jose International Airport (SJC). Once the data was aggregated, passengers from all three airports in the San Francisco Bay Area CSA were treated as originating from the CSA as opposed to the individual airports within the CSA. This aggregation captures the fact that these airports are substitutes both for passenger traffic and for airline entry decisions.

The portion of the T100 data set that we use contains quarterly data on passenger enplanments for each airline on segments connecting between the 60 demographic areas of interest for our study. The segment data is in principle so accurate that if a NY-LA flight is diverted to San Diego due to weather, then it shows up in the data as having flown to San Diego. This leads to there being a fair amount of "phantom" entry occurrences in the raw data. To weed out these one-off flights, an airline is defined to have entered a segment that it had not previously served if it sends 9000 or more enplaned passengers on the segment per quarter for four successive quarters. The level chosen is roughly equivalent to running one daily nonstop flight on the segment, a very low level of service for a regularly scheduled flight. For example, if airline X sends at least 9000 passengers per quarter along segment Y from the third quarter of 1995 through the second quarter of 1996 (inclusively), then it is defined to have entered segment Y in the third quarter of 1995. If an airline entered a route in any quarter of a given year, then it is said to have entered during that year. Once an airline has entered a segment, it is considered present on that segment until an exit even has occurred. We define exit event symmetrically with our entry definition. If an airline is defined to be "In" on a segment, four successive quarters with fewer than 9000 passengers enplaned on the segment defines an exit event. Therefore, if airline X had been in on segment Y in quarter 2 of 1995, but from quarter 3 of 1995 through quarter 2 of 1996 the airline had fewer than 9000 enplanned passengers, the airline is noted as having exited segment Y in quarter 3 of 1995. Once an airline has entered a segment, it is defined as present on that segment until an exit even occurs for that airline on that segment. Similarly, once an airline has exited a segment, it is defined as not present on the segment until an entry event occurs. The data on segment presence is initialized by defining an airline as present if it had 9000 or more enplaned passengers on a segment in quarter 1 of 1993 and not present otherwise.

A.1 Variable Definitions

Data Point: A single data point is an airline-year-route segment triple. Given 60 CSAs, this yields 1770 route segments and 10 airports, for a net data set of 17700 data points per year.

Dependent Variable: Segment Presence - This is defined as per the previous section

Independent Variables: Population 1 x Population 2 on Segment: Product of the population of the CSAs on the terminal points of the segment. If one assumes a uniform probability of an individual in each CSA desiring travel to visit an individual in the other CSA, this represents the expected demand for air travel. The population values are taken from the 1990 census.

Route Distance greater than 500/1000/1500/2000/2500/3000 miles: Set of dummy variables where a value of "1" indicates the geodesic distance of the route segment is greater than the respective mileage.

Num Big 3 Competitors: This is the number of "Big 3" airlines (American Airlines, United Airlines, and Delta Airlines) present in the market in the prior year.

Num Other Major Competitors: Number of other major airlines (Continental Airlines, Northwest Airlines, USAirways, America West, and Alaskan Airlines) present in the market in the prior year.

Southwest Competitor: Dummy variable set to 1 if Southwest was present in the market in the prior year.

Number Other Low Cost Competitors: Number of other low cost carriers (Jet Blue, Other Low Cost Carriers) present in the market in the prior year

Number Other Competitors: Dummy variable set to “1” if the other carriers are present in the market in the prior year.

Present at One Airport: Service to a CSA is defined as presence in any route segments originating at a CSA. “Present at One Airport” is a dummy variable set to “1” if the airline provided service to exactly one of the CSAs on the route segment in the prior year.

Present at Both Airports: Dummy variable set to 1 if the airline provided service to both of the CSAs in the route segment in the prior year.

One Airport a Hub: Dummy variable set to 1 if one of the CSAs contains a hub for the airport. See Appendix XXX for a definition of the hub airports.

Both Airports Hubs: Dummy variable set to one if both CSAs contain hub airports.

HHI (for top 10 airlines): Computes the HHI in terms of enplaned passengers for the top 10 airlines for the market between the two CSAs connected by the route segment. This variable was constructed from the T-100 Market data set and is unlagged.

Log Passenger Density on New Markets: The sum of the densities on markets that would be entered if the route segment is entered. Densities are drawn from the 1993 T-100 Market data set on passenger enplanments.

Percent Tourist: Derived from the 1995 American Travel Survey. “Percent Tourist” is the percentage of passengers flying between the CSAs based on coded value of the survey variable “Vacation.”

Non-Stop Small City: The number of segments served from the smaller CSA. Size in this context is determined by the number of segments served from the CSA.

Non-Stop Large City: The number of segments served from the larger CSA. ¡Carrier Dummy¿ x 1993 Passenger Density: The total number of passengers enplaned on the segment in 1993. This is interacted with a dummy variable for each carrier, which allows carrier specific density effects.

A.2 Hub Definitions by CSA

American: Dallas, TX; Los Angeles, CA; Ft. Lauderdale, FL; Chicago, IL; San Francisco, CA

United: Denver, CO; Chicago, IL; San Francisco, CA

Delta: Atlanta, GA; Cincinnati, OH; Salt Lake City, UT

Continental: Cleveland, OH; New York, NY; Houston, TX

Northwest: Detroit, MI; Minneapolis/St. Paul, MN

USAIrways: Charlotte, NC; Washington, D.C.; Philadelphia, PA; Pittsburgh, PA

JetBlue: Boston, MA; New York, NY

American West: Las Vegas, NV; Phoenix, AZ

Alaska: Seattle, WA; Portland, OR

A.3 CSA Airport Correspondences

CSA code	CSA name	Pop 2000	ΔPop 90-00	Median Inc.	# pass (mark, 2000)	# seats 2000	# deps 2000
12	BUR, LAX, ONT, SNA	16373645	0.127	52069	63366291	95110864	651974
32	MDW, ORD	9312255	0.111	54421	62343200	93061401	699212
22	EWR, JFK, LGA	21361797	0.084	56978	58882013	87383247	689529
4	ATL	4548344	0.371	52957	55337406	77332404	499976
37	OAK, SFO, SJC	7092596	0.128	66657	51131131	73829347	503844
18	DAL, DFW	5346119	0.292	49146	49770836	74224719	580463
13	BWI, DCA, IAD	7538385	0.131	67752	42311686	66378939	514799
45	PHX	3251876	0.453	48124	33102813	51514967	367510
26	HOU, IAH	4815122	0.249	46480	31547559	47808782	388080
19	DEN	2449054	0.306	55149	31311309	44588701	300264
29	LAS	1408250	0.855	49171	31081307	44419188	299968
10	BOS, MHT, PVD	1582997	0.048	51310	29349066	45857416	360982
23	FLL, MIA	5007564	0.235	43091	29309146	40084680	275868
57	STL	2698687	0.046	48361	25674940	40224228	303880
31	MCO	1697906	0.351	43952	25459140	33480480	236478
20	DTW	5357538	0.051	50471	25396816	37249268	280110
35	MSP	3271888	0.164	58459	25124724	37320932	267797
53	SEA	3604165	0.198	53900	22497342	32091595	238320
44	PHL	5833585	0.047	53266	18812458	29843849	241778
55	SLC	1454259	0.258	50357	16205369	23114414	148173
15	CLT	1897034	0.263	44402	16052317	24729706	198542
17	CVG	2050175	0.09	48022	15283486	23324344	197718
50	SAN	2813833	0.126	56335	15118565	21053644	163921
58	TPA	2395997	0.159	41852	14373207	20164000	144221
46	PIT	2525730	-0.015	41648	13979823	22121531	182791
43	PDX	1927881	0.265	49227	12134527	18358819	150319
30	MCI	1901070	0.121	50179	11320857	19311614	151568
14	CLE	2945831	0.03	44049	10842047	17271912	192681
25	HNL	876156	0.048	60485	10320878	13752318	71179
36	MSY	1360436	0.04	39479	9497691	14448813	108138
47	RDU	1314589	0.379	49449	9221253	13581120	137888
33	MEM	1205204	0.129	41065	8651773	13275247	118131
8	BNA	1381287	0.252	45194	8552027	14876691	120258
56	SMF	1930149	0.216	54071	7728952	10678264	80867
54	SJU	2509007	0.08	19403	7067099	9554899	51241
6	BDL	1257709	0.026	59912	6963738	10343661	84986
5	AUS	1249763	0.477	50484	6950039	10582687	82864
27	IND	1843588	0.156	48399	6885666	10835665	93134
51	SAT	1711703	0.216	43263	6624018	10208034	77632
16	CMH	1835189	0.137	47075	6163317	10011432	89701
1	ABQ	729649	0.217	43070	5871686	9651914	71116
34	MKE	1689572	0.051	47799	5445851	8942034	90630
42	PBI	5007564	0.235	43091	5376385	7211271	51452
48	RNO	342885	0.333	48974	5294211	8244183	61475
28	JAX	1122750	0.214	47323	4955361	7583714	60860
38	OGG	128094	0.276	57573	4840509	7243806	49519
49	RSW	2395997	0.159	41852	4629297	5863665	42883
11	BUF	1170111	-0.016	41947	3770970	5985579	54207
52	SDF	1292482	0.097	42943	3702821	6206637	57119
40	OMA	803201	0.115	48826	3585827	5700776	49920
60	TUS	843746	0.265	41521	3500323	5361525	39440
39	OKC	1160942	0.127	39743	3367555	5729173	53260
59	TUL	908528	0.123	40512	3253687	5872280	53582
21	ELP	679622	0.149	30968	3142143	6053912	47032
24	GEG	417939	0.157	41667	2933340	4516389	42947
7	BHM	1129721	0.103	43290	2884829	5070829	43839
9	BOI	464840	0.454	46960	2667242	4473475	41537
41	ORF	234403	-0.03	31815	2577507	3992287	39326
2	ALB	825875	2.03	50828	2438339	3758965	37108
3	ANC	319605	0.201	60180	2293263	3424582	21837

B Gibbs Sampler for Random City Effect Model

Econometric model We want to estimate a behavioral strategy of a given airline. The data we observe are as follows: (y_t, x_t, y_{t-1}) where $y_{ij,t}$ is the *indicator of firm being active* on the market ij (i and j denote the corresponding cities or airports, $i < j$) at time $t+1$, $x_{ij,t}$ is the vector of the "explanatory variables".

Suppose that the airline is active at time t. Then the behavioral strategy prescribes the firm to stay on the market for the next period (i.e., $t+1$) if

$$x'_{ij,t}\beta + \xi_{i,t} + \xi_{j,t} + \varepsilon_{ij,t} > -\gamma,$$

where $\xi_{i,t}$ are city specific shocks drawn from $N(0, \tau^2)$ independently across time and cities, $\varepsilon_{ij,t}$ are i.i.d. market specific shocks drawn from $N(0, \sigma^2)$ independently of the city specific shocks $\xi_{i,t}$, and $(-\gamma)$ is some threshold. If the inequality does not hold, then the airline will exit the market. The probability of any tie is zero.

The same strategy is assumed to be true if the airline is instead a potential entrant. The only difference is the entry threshold, which in this case is normalized to zero.

Thus, we observe the following data generating process:

$$y_{ij,t} = 1\left\{x'_{ij,t}\beta + \gamma y_{ij,t-1} + \xi_{i,t} + \xi_{j,t} + \varepsilon_{ij,t} > 0\right\}$$

In order to simplify notations, denote $\theta = (\beta', \gamma)'$ and $\tilde{x}_{ij,t} = \left(x'_{ij,t}, y_{ij,t-1}\right)'$. Therefore, the model can be described as follows.

$$\begin{aligned} \mathbf{z}_t|\tilde{\mathbf{x}}'_{\mathbf{t}} &\sim N\left(\tilde{\mathbf{x}}'_{\mathbf{t}}\theta, \mathbf{\Sigma}\right), \\ y_{ij,t} &= 1\left\{z_{ij,t} > 0\right\} \end{aligned}$$

where

$$\mathbf{\Sigma}_{ij,kl} = \begin{cases} 2\tau^2 + \sigma^2, \text{ if } i = k \text{ and } j = l, \\ \tau^2, \text{if } i = k \text{ or } j = l \text{ but not both}, \\ 0, \text{ otherwise.} \end{cases}.$$

Combining the observations for all periods $t = 1, ..., T$ we can write

$$\begin{bmatrix} \mathbf{z}_1 \\ \vdots \\ \mathbf{z}_T \end{bmatrix} = \begin{bmatrix} \tilde{\mathbf{x}}_1 \\ \vdots \\ \tilde{\mathbf{x}}_T \end{bmatrix} \theta + \begin{bmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_T \end{bmatrix}$$

or

$$\mathbf{Z} = \tilde{\mathbf{X}}\theta + \varepsilon,$$

where ε is distributed $N(0, \Omega = I_T \otimes \mathbf{\Sigma})$.

Normalization So far, we normalized γ (in ML estimation). It appears to me that it may be better to normalize one of the variances and τ^2 may be a better choice. So, the algorithm described below takes $\tau^2 \equiv 1$.

Prior distributions We need to specify prior distributions of θ and σ^2. The easiest way is to choose a conjugate distribution. For θ it is normal, i.e.

$$\theta \sim N\left(\bar{\theta}, A^{-1}\right).$$

A conjugate distribution for σ^2 is not available. So, as a prior distribution, let us use the inverse gamma distribution with parameters (b, c). This distribution is given by

$$\pi\left(\sigma^2\right) = \frac{c^b}{\Gamma(b)}\left(\sigma^2\right)^{-(b+1)} e^{-\frac{c}{\sigma^2}} 1\left\{\sigma^2 > 0\right\}.$$

The prior is less informative for smaller b and bigger c.

Bayesian estimation The parameters to estimate are (θ, σ^2).

The algorithm goes as follows.

1. Start with initial values, $\mathbf{Z}_0$, θ_0, σ_0^2. Set $k = 1$.
2. Draw $\mathbf{Z}_k|\theta_{k-1}, \sigma_{k-1}^2, \mathbf{y}, \tilde{\mathbf{X}}$ from

$$\begin{aligned} & N\left(\tilde{\mathbf{X}}\theta_{k-1}, I_T \otimes \mathbf{\Sigma}\left(\sigma_{k-1}^2\right)\right) \text{ truncated so that} \\ z_{ij,t} &< 0 \text{ whenever } y_{ij,t} = 0 \text{ and } z_{ij,t} \geq 0 \text{ whenever } y_{ij,t} = 1. \end{aligned}$$

This step can be done dimension-by-dimension with draws from corresponding conditional distributions. Namely, for each $ij = 1, ..., n$ and $t = 1, ...T$:

$$\begin{aligned} z_{ij,t,k} &\sim N\left(E\left(z_{ij,t,k}|z_{-ij,t,k-1}\right), Var(z_{ij,t,k}|z_{-ij,t,k-1})\right) \text{ truncated so that} \\ z_{ij,t,k} &< 0 \text{ if } y_{ij,t} = 0 \text{ and } z_{ij,t,k} \geq 0 \text{ if } y_{ij,t} = 1, \end{aligned}$$

where

$$\begin{aligned} E\left(z_{ij,t,k}|z_{-ij,t,k-1}\right) &= \tilde{x}_{ij,t}\theta_{k-1} + \Sigma_{12}\left(\sigma_{k-1}^2\right)\Sigma_{22}^{-1}\left(\sigma_{k-1}^2\right)\left(z_{-ij,t,k-1} - x_{-ij,t}\theta_{k-1}\right), \\ Var\left(z_{ij,t,k}|z_{-ij,t,k-1}\right) &= 2 + \sigma_{k-1}^2 - \Sigma_{12}\left(\sigma_{k-1}^2\right)\Sigma_{22}^{-1}\left(\sigma_{k-1}^2\right)\Sigma_{21}\left(\sigma_{k-1}^2\right). \end{aligned}$$

Here is the algorithm of drawing x from a normal with mean μ and variance σ^2 truncated at $a \leq x \leq b$:

(i) Draw u from uniform distribution on $[0, 1]$;

(ii) Set $x = \mu + \sigma\Phi^{-1}\left(\Phi\left(\frac{a-\mu}{\sigma}\right) + u\left(\Phi\left(\frac{b-\mu}{\sigma}\right) - \Phi\left(\frac{a-\mu}{\sigma}\right)\right)\right)$ where $\Phi(\cdot)$ is standard normal cdf.

3. Draw $\theta_k | \mathbf{Z}_k, \sigma^2_{k-1}, \mathbf{y}, \tilde{\mathbf{X}}$ from $N\left(\tilde{\theta}, V\right)$, where

$$
\begin{aligned}
V &= \left(\tilde{\mathbf{X}}^{*\prime}\tilde{\mathbf{X}}^{*} + A\right)^{-1}, \\
\tilde{\theta} &= V\left(\tilde{X}^{*\prime}\mathbf{Z}^{*}_{k} + A\bar{\theta}\right), \\
\Sigma_0^{-1}\left(\sigma^2_{k-1}\right) &= C'C, \\
\tilde{\mathbf{x}}^{*}_{t} &= C'\tilde{\mathbf{x}}_t, \\
\mathbf{z}^{*}_{t,k} &= C'\mathbf{z}_{t,k}, \\
\tilde{\mathbf{X}}^{*} &= \begin{bmatrix} \tilde{\mathbf{x}}^{*}_{1} \\ \vdots \\ \tilde{\mathbf{x}}^{*}_{T} \end{bmatrix}
\end{aligned}
$$

4. Draw $\sigma^2_k | \mathbf{Z}_k, \theta_k, \mathbf{y}, \tilde{\mathbf{X}}$ from a density proportional to:

$$
\pi\left(\sigma^2\right)\left|\Omega\left(\sigma^2\right)\right|^{-1/2}\exp\left\{-\frac{1}{2}\left(\mathbf{Z}_k - \tilde{\mathbf{X}}\theta_k\right)'\Omega^{-1}\left(\sigma^2\right)\left(\mathbf{Z}_k - \tilde{\mathbf{X}}\theta_k\right)\right\}.
$$

Note that $\Omega^{-1}\left(\sigma^2\right) = I_T \otimes \mathbf{\Sigma}^{-1}\left(\sigma^2_{k-1}\right)$ and $\left|\Omega\left(\sigma^2\right)\right| = \det\left(\mathbf{\Sigma}\left(\sigma^2_{k-1}\right)\right)^{-1}$.To draw from this distribution, we use a Metropolis-Hastings algorithm, which is described in what follows:

(i) Draw $\tilde{\sigma}^2$ from $N\left(\sigma^2_{k-1}, v^2\right)$.

(ii) Calculate:

$$
\begin{aligned}
r &= \min\left\{\frac{\pi\left(\tilde{\sigma}^2\right)\left|\Omega\left(\tilde{\sigma}^2\right)\right|^{-1/2}\exp\left\{-\frac{1}{2}\left(\mathbf{Z}_k - \tilde{\mathbf{X}}\theta_k\right)'\Omega^{-1}\left(\tilde{\sigma}^2\right)\left(\mathbf{Z}_k - \tilde{\mathbf{X}}\theta_k\right)\right\}}{\pi\left(\sigma^2_{k-1}\right)\left|\Omega\left(\sigma^2_{k-1}\right)\right|^{-1/2}\exp\left\{-\frac{1}{2}\left(\mathbf{Z}_k - \tilde{\mathbf{X}}\theta_k\right)'\Omega^{-1}\left(\sigma^2_{k-1}\right)\left(\mathbf{Z}_k - \tilde{\mathbf{X}}\theta_k\right)\right\}}, 1\right\} = \\
&= \min\left\{\begin{array}{c} \left(\frac{\sigma^2_{k-1}}{\tilde{\sigma}^2}\right)^{(b+1)}\left(\frac{\det\left(\mathbf{\Sigma}\left(\sigma^2_{k-1}\right)\right)}{\det\left(\mathbf{\Sigma}\left(\tilde{\sigma}^2\right)\right)}\right)^{1/2} \times \\ \times \exp\left\{-\frac{1}{2}\left(\mathbf{Z}_k - \tilde{\mathbf{X}}\theta_k\right)'\left(I_T \otimes \left[\mathbf{\Sigma}^{-1}\left(\tilde{\sigma}^2\right) - \mathbf{\Sigma}^{-1}\left(\sigma^2_{k-1}\right)\right]\right)\left(\mathbf{Z}_k - \tilde{\mathbf{X}}\theta_k\right) - \frac{c}{\tilde{\sigma}^2} + \frac{c}{\sigma^2_{k-1}} \end{array}\right.
\end{aligned}
$$

(iii) Set

$$
\sigma^2_k = \begin{cases} \tilde{\sigma}^2, & \text{with probability } r, \\ \sigma^2_{k-1}, & \text{with probability } 1 - r. \end{cases}
$$

5. Update $k = k + 1$, then go to step 2.

Note that for our data, $\Sigma_2 2^{-1}$ is of dimension 1769, and we must compute this inverse 1770 times per Gibbs iteration in step 2. Obviously, this is not computationally feasible. However, since Σ is sparse and has a very particular structure to it, if we smartly reorder the routes so that the current route under consideration is always "1-2" (that is reorder the cities and routes such that route i becomes route 1 and route j becomes route 2) for each of the 1770 routes in step 2, then

Σ_{22} is always exactly the same matrix (since there is a route from each city i to each city j in the matrix). Thus, we only need invert it once per Gibbs iteration, still computationally heavy, but at least possible.

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C Tables and Figures

Table 1: Airline Route and Market Statistics, 2003-2007

	Routes						Markets		
Carrier	Avg	Min	Max	Avg Entry	Avg Exit	Turnover	Avg	Min	Max
American	163	152	185	15	53	4.2%	923	886	990
United	131	131	132	9	10	1.5%	882	867	889
Southwest	304	271	325	72	16	2.9%	958	834	1039
Delta	149	140	163	31	59	6.0%	1124	1101	1158
Continental	95	93	97	4	9	1.2%	739	697	798
Northwest	131	128	136	17	14	2.4%	1040	1001	1080
USAirways	102	92	112	21	41	6.1%	481	436	540
JetBlue	35	17	51	36	1	10.5%	140	67	224
America West	64	63	67	13	13	4.0%	447	406	492
Alaska	31	29	32	11	1	3.9%	99	90	102
Other	356	276	396	255	77	9.3%	1107	1005	1164
Other Low Cost	224	194	235	120	49	7.6%	932	848	979

Note: Turnover is computed as (average entry plus average exit over two) over average route presence.

Table 2: Airline Route and Market Statistics, 2003-2007

Regressor	Avg	SD	Min	25%	50%	75%	MAX
Pop1*Pop2 (*1e-15)	0.00846	0.0176	0.00003	0.00149	0.00340	0.00830	0.350
Distance >500	0.837	0.369	0	1	1	1	1
Distance >1000	0.574	0.495	0	0	1	1	1
Distance >1500	0.372	0.483	0	0	0	1	1
Distance >2000	0.222	0.415	0	0	0	0	1
Distance >2500	0.114	0.317	0	0	0	0	1
Distance >3000	0.074	0.262	0	0	0	0	1
HHI (for top 10 airlines)	6313	3630	0	4012	6856	9976	10000
Log 1993 Pass. Density	5.51	5.24	0	0	4.95	10.8	14.6
Percent Tourist	0.372	0.353	0	0	0.33	0.67	1
Num Big 3 Comps.	1.69	0.999	0	1	2	2	3
Num Other Major Comps.	1.46	1.10	0	1	1	2	5
Southwest Comp.	0.335	0.472	0	0	0	1	1
Num Other Low Cost Comps.	0.299	0.494	0	0	0	1	2
Num Other Comps.	0.602	0.489	0	0	1	1	1
Present in Market	0.323	0.468	0	0	0	1	1
Present at one airport	0.252	0.434	0	0	0	1	1
Present at both airports	0.569	0.495	0	0	1	1	1
One airport a hub	0.070	0.256	0	0	0	0	1
Both airports hubs	0.00153	0.0390	0	0	0	0	1
Non-Stop Small City	1.54	2.48	0	0	1	2	47
Non Stop Large City	6.37	9.99	0	1	3	6	55

Table 3: Airline Route Network Overlap A

This table lists in each cell the percentage of routes/markets flown by the row airline, that are also flown by the column airline. The diagonal is the total number of routes flown by the row airline.

	2007: routes	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Other	401	32	12	15	28	15	6	11	12	4	2	24	24
2	Other low cost	51	247	17	24	32	18	17	17	23	8	2	33	42
3	American (AA)	32	28	152	31	38	16	11	7	9	11	3	22	36
4	United (UA)	45	46	36	131	47	11	7	5	18	9	9	15	100
5	Southwest (WN)	35	24	18	19	325	6	7	3	23	3	5	8	37
6	Delta (DL)	43	32	18	11	13	141	13	4	8	15	1	100	18
7	Continental (CO)	26	44	18	10	26	19	93	6	8	27	2	25	16
8	Northwest (NW)	34	32	8	5	7	5	5	128	6	0	0	100	11
9	US Airways (US)	31	37	8	16	50	7	5	5	153	8	3	12	100
10	JetBlue (B6)	29	37	33	24	18	41	49	0	24	51	4	41	39
11	Alaska (AS)	25	16	16	38	47	3	6	0	13	6	32	3	50
12	DL + NW	37	31	13	8	10	54	9	49	7	8	0	263	14
13	UA + US	37	40	21	50	46	10	6	5	59	8	6	14	260

	2007: markets	1	2	3	4	5	6	7	8	9	10	11	12	13
1	Other	1191	68	47	50	63	59	36	58	47	11	5	77	66
2	Other low cost	81	993	59	55	64	70	48	66	61	17	5	85	75
3	American (AA)	63	66	886	61	67	74	66	63	55	18	5	82	71
4	United (UA)	67	61	61	895	62	70	52	71	67	19	10	86	100
5	Southwest (WN)	72	61	57	54	1039	64	48	59	54	15	7	77	71
6	Delta (DL)	64	64	60	57	60	1101	51	67	59	20	8	100	72
7	Continental (CO)	61	69	84	67	72	82	692	69	62	28	6	87	79
8	Northwest (NW)	69	66	56	64	61	74	48	1000	59	20	6	100	76
9	US Airways (US)	65	70	56	69	64	76	49	68	866	22	10	87	100
10	JetBlue (B6)	56	77	70	74	68	96	86	89	83	226	12	97	94
11	Alaska (AS)	55	45	41	85	68	83	41	55	81	27	103	84	89
12	DL + NW	67	62	53	56	59	81	44	73	55	16	6	1365	71
13	UA + US	68	64	54	77	63	69	47	65	75	18	8	83	1162

Table 4: Airline Route Network Overlap B

This table lists the total number of routes/markets flown by each airline, followed by the number of routes where they are the only carrier, where there is one additional carrier, etc.

	Year	Total	with number of competitors equal to										
	2007: routes		0	1	2	3	4	5	6	7	8	9	10
1	Other	401	123	123	83	45	17	7	3	0	0	0	0
2	Other low cost	247	15	67	86	54	14	8	3	0	0	0	0
3	American (AA)	152	31	43	28	27	15	6	2	0	0	0	0
4	United (UA)	131	11	24	41	31	15	6	3	0	0	0	0
5	Southwest (WN)	325	89	95	81	41	14	4	1	0	0	0	0
6	Delta (DL)	141	42	33	32	20	9	3	2	0	0	0	0
7	Continental (CO)	93	21	22	19	19	6	4	2	0	0	0	0
8	Northwest (NW)	128	52	43	20	9	1	1	2	0	0	0	0
9	US Airways (US)	153	30	41	45	27	5	3	2	0	0	0	0
10	JetBlue (B6)	51	3	9	10	20	3	5	1	0	0	0	0
11	Alaska (AS)	32	7	8	8	7	1	1	0	0	0	0	0
12	DL + NW	263	94	77	53	23	11	3	2	0	0	0	0
13	UA + US	260	43	65	89	39	16	7	1	0	0	0	0

	Year	Total	with number of competitors equal to										
	2007: markets		0	1	2	3	4	5	6	7	8	9	10
1	Other	1191	42	74	162	196	167	148	141	118	93	38	12
2	Other low cost	993	2	12	91	142	134	135	166	154	101	44	12
3	American (AA)	886	6	23	66	104	111	125	153	145	96	45	12
4	United (UA)	895	9	28	52	103	120	125	152	144	105	45	12
5	Southwest (WN)	1039	19	46	99	143	170	133	152	127	97	41	12
6	Delta (DL)	1101	2	43	92	163	162	146	172	157	107	45	12
7	Continental (CO)	692	0	5	32	42	79	92	141	138	106	45	12
8	Northwest (NW)	1000	11	38	64	131	148	126	167	155	103	45	12
9	US Airways (US)	866	1	13	63	95	132	106	154	143	102	45	12
10	JetBlue (B6)	226	0	0	0	7	14	14	40	53	46	40	12
11	Alaska (AS)	103	2	2	8	10	18	14	11	2	7	17	12
12	DL + NW	1365	15	93	197	245	213	224	192	125	49	12	0
13	UA + US	1162	11	57	122	180	192	193	200	143	52	12	0

Note: the 12 markets that are served by ALL 11 carriers are as follows:
BOS-LAX, BOS-LAS, BOS-SFO, BOS-PHX, LAX-BWI, SFO-FLL, LAX MCO, BWI-LAS, BWI-SFO, BWI-SAN, FLL-SFO, MCO-SFO

Table 5: Airline Route Network Overlap C

This table lists in its upper triangle the number of routes/markets where the row and column carriers are the only two carriers. In its lower triangle it lists the number of routes/markets which the row and column carriers serve with any third carrier.

	2007: routes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Other	--	22	7	5	33	20	1	25	8	2	0	46	13
2	Other low cost	44	--	2	5	6	7	9	13	3	0	0	20	9
3	American (AA)	11	7	--	6	17	2	0	2	5	1	1	4	11
4	United (UA)	17	17	10	--	2	0	0	0	2	1	3	0	0
5	Southwest (WN)	39	29	14	21	--	3	7	2	23	0	2	5	28
6	Delta (DL)	21	17	5	4	9	--	0	0	0	1	0	0	0
7	Continental (CO)	4	11	3	1	12	1	--	1	0	3	1	1	0
8	Northwest (NW)	7	16	3	1	4	1	1	--	0	0	0	0	0
9	US Airways (US)	18	27	1	4	25	3	2	7	--	0	0	0	0
10	JetBlue (B6)	1	2	2	3	4	3	3	0	2	--	1	1	1
11	Alaska (AS)	4	2	0	4	5	0	0	0	1	0	--	0	3
12	DL + NW	29	36	8	5	13	0	2	0	10	3	0	--	0
13	UA + US	38	48	13	0	50	7	3	8	0	6	5	0	--

	2007: markets	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
1	Other	--	5	5	4	17	15	0	25	3	0	0	46	7
2	Other low cost	71	--	2	0	1	4	0	0	0	0	0	5	0
3	American (AA)	24	10	--	4	8	2	1	1	0	0	0	8	8
4	United (UA)	28	4	6	--	3	9	0	7	1	0	0	17	0
5	Southwest (WN)	69	19	28	11	--	8	3	1	5	0	0	10	8
6	Delta (DL)	57	26	19	15	27	--	0	2	2	0	1	0	13
7	Continental (CO)	5	2	31	2	13	10	--	0	0	0	1	1	0
8	Northwest (NW)	37	23	7	19	8	16	1	--	2	0	0	0	21
9	US Airways (US)	27	27	7	18	17	13	0	16	--	0	0	5	0
10	JetBlue (B6)	0	0	0	0	0	0	0	0	0	--	0	0	0
11	Alaska (AS)	6	0	0	1	6	1	0	1	1	0	--	1	0
12	DL + NW	127	85	32	44	54	0	12	0	37	1	2	--	0
13	UA + US	66	32	17	0	42	52	2	26	0	0	7	0	--

Table 6: Top 5 Markets by HHI Increase, Passengers Enplaned

		Num Carriers	HHI Passengers			HHI Departures		
DL-NW								
CSA1	CSA2	pre	pre	post	chng	pre	post	chng
ATL	DTW	4	2960	5068	2108	2713	4155	1441
MSP	SLC	3	4434	6301	1866	4021	5159	1139
ATL	MSP	4	2604	4011	1407	2671	3563	892
ATL	MEM	4	2829	3699	870	2715	3461	746
BUR, LAX, ONT, SNA	HNL	7	1811	1949	137	1746	1869	123
US-UA								
		Num Carriers	HHI Passengers			HHI Departures		
CSA1	CSA2	pre	pre	post	chng	pre	post	chng
DEN	PIT	2	5345	10000	4655	5560	10000	4440
CLT	DEN	2	5437	10000	4563	5223	10000	4777
OAK, SFO, SJC	PHL	3	4179	7728	3549	3825	7124	3299
BUR, LAX, ONT, SNA	PHL	3	4178	7381	3203	3593	6357	2764
DEN	PHL	3	3912	6672	2760	3715	6229	2514

Table 7: Top 10 Cities by HHI Increase, Passengers Enplaned

DL-NW													
	Num Carriers	HHI Routes			HHI Markets			HHI Passengers			HHI Departures		
CSA	pre	pre	post	chng	pre	post	chng	pre	post	chng	pre	post	chng
BDL	9	1483	1687	205	1145	1302	157	1553	1871	318	2023	2184	161
MEM	5	3955	4094	139	2109	2728	619	4110	4415	305	3733	3875	142
RSW	10	1505	1576	71	1070	1212	142	1281	1484	204	1345	1467	122
ATL	8	2842	2974	132	1368	1591	223	4447	4643	197	3209	3388	179
TPA	10	1964	2085	121	1104	1247	143	1446	1634	187	1464	1576	112
DTW	9	2880	3043	163	1155	1317	162	4479	4659	180	3612	3737	125
MCO	11	1574	1659	85	1024	1146	121	1230	1400	170	1339	1437	98
MSP	8	3365	3511	146	1353	1546	193	5000	5159	159	3937	4051	114
HNL	8	1528	1834	306	1355	1574	218	2430	2587	157	3251	3325	74
ANC	6	1944	2222	278	2064	2601	537	4273	4427	154	4582	4673	91
UA-US													
	Num Carriers	HHI Routes			HHI Markets			HHI Passengers			HHI Departures		
CSA	pre	pre	post	chng	pre	post	chng	pre	post	chng	pre	post	chng
BWI, DCA, IAD	11	1552	1813	261	990	1100	110	1370	1823	453	1543	1785	242
PHL	9	2118	2287	169	1161	1301	140	2435	2886	451	2403	2638	235
LAS	11	2091	2262	171	1031	1156	125	2244	2589	346	2616	2917	301
PHX	11	2417	2571	154	1071	1208	137	2604	2922	318	2748	2990	243
OAK, SFO, SJC	11	1351	1523	171	1001	1119	118	1861	2144	282	1889	2095	205
BOS, MHT, PVD	11	1244	1343	99	965	1074	108	1111	1385	274	1465	1625	160
DEN	11	2136	2293	157	1110	1241	131	2899	3162	263	2477	2673	196
PIT	9	2502	2669	166	1171	1332	160	2249	2505	256	3182	3271	90
CLT	8	2988	3139	151	1389	1598	208	4678	4888	211	3421	3561	140
BDL	9	1483	1605	122	1145	1298	154	1553	1754	201	2023	2120	97

Table 8: Probits for Entry/Exit/Stay, Hub Carriers Pooled

	Hub Carriers		Southwest		Jet Blue		Alaska	
Variable	Beta	SE	Beta	SE	Beta	SE	Beta	SE
Pop1*Pop2 (*1e-15)	0.245	1.511	0.384	9.104	-3.271	5.864	3.221	19.79
Log (1993 Pass Dens)	0.039	0.011	0.086	0.023	0.040	0.055	0.041	0.127
Log (Dens New Markets)	0.003	0.009	-0.012	0.018	-0.043	0.037	-0.141	0.088
% Tourist	0.263	0.111	0.536	0.230	-0.064	0.427	0.341	2.138
Distance > 500	0.173	0.107	-0.460	0.271	-0.037	0.654	-0.530	1.341
Distance > 1000	0.209	0.102	-0.078	0.220	0.755	0.575	-1.475	2.281
Distance > 1500	0.186	0.114	-0.126	0.251	-0.519	0.584	-1.914	2.653
Distance > 2000	0.121	0.122	0.000	0.292	0.817	0.711	-1.015	1.922
Distance > 2500	0.031	0.158	0.032	0.633	-0.415	0.592	1.990	1.947
Distance > 3000	-0.903	0.223	-1.625	2109	-3.124	112	-3.535	8.963
Comp: Big 3	-0.147	0.046	-0.174	0.129	-0.179	0.294	-0.349	0.745
Comp: Oth Maj	-0.124	0.041	0.107	0.111	0.173	0.260	0.707	0.871
Comp: Southwest	-0.018	0.104			-0.650	0.528	-0.084	1.667
Comp: Oth Low Cost	0.027	0.064	-0.079	0.152	0.544	0.471	0.197	0.991
Comp: Oth	-0.024	0.078	0.178	0.159	-0.194	0.466	-1.013	1.124
HHI (Top 10)	-0.079	0.112	-0.008	0.280	-0.858	0.611	-0.967	1.329
One End a Hub	0.543	0.103						
Both Ends Hubs	2.411	20.024						
Non Stops Conns (Small)	0.098	0.021	-0.108	0.030	-0.033	0.235	-1.373	0.673
Non Stops Conns (Large)	0.044	0.004	-0.003	0.026	0.179	0.082	0.247	0.383
Present One Airport	-1.316	0.310	-1.021	0.648	-0.673	0.644	-2.018	2.530
Present Both Airports	-1.053	0.292	-1.285	0.974	-0.766	0.963	-1.334	3.030
Present Market (not Seg)	0.219	0.121	0.466	0.316	-1.180	0.561	1.664	1.255
Present Segment	3.582	0.140	5.192	0.380	3.437	0.642	5.078	1.309
Note: all probits have year and city dummies (and no constant term).								

Table 9: Measures of Fit by Airline: Pooled Probits

	Actual Last Period Status				Full Sample Simulated	
	Stay		Switch		Switchers, Whole Period	
Airline	In	Out	In	Out	In	Out
American (15,53)	0.954	0.997	0.038	0.204	0.218	0.769
United (9,10)	0.970	0.998	0.045	0.080	0.152	0.294
Southwest (72,16)	0.994	0.992	0.223	0.114	0.466	0.468
Delta (31,59)	0.957	0.998	0.048	0.208	0.260	0.666
Continental (4,7)	0.968	0.999	0.073	0.056	0.220	0.588
Northwest (17.14)	0.958	0.999	0.020	0.137	0.005	0.637
US Air (21,41)	0.942	0.998	0.021	0.155	0.138	0.509
Jet Blue (36,1)	0.993	0.997	0.413	0.010	0.801	NA
America West (13,13)	0.983	0.999	0.063	0.093	0.436	0.568
Alaska (11,1)	0.993	0.9997	0.299	0.113	0.688	0.890
Note: table lists actual entries/exits in parentheses.						

Table 10: Measures of Fit by Airline: Separate Probits

	Actual Last Period Status				Full Sample Simulated	
	Stay		Switch		Switchers, Whole Period	
Airline	In	Out	In	Out	In	Out
American (15,53)	0.971	0.999	0.073	0.472	0.458	0.879
United (9,10)	0.989	0.999	0.076	0.167	0.553	0.684
Southwest (72,16)	0.994	0.992	0.223	0.114	0.466	0.468
Delta (31,59)	0.961	0.998	0.142	0.382	0.609	0.821
Continental (4,7)	0.993	0.9999	0.543	0.383	1.000	0.793
Northwest (17.14)	0.985	0.999	0.189	0.273	0.405	0.927
US Air (21,41)	0.952	0.998	0.089	0.325	0.299	0.575
Jet Blue (36,1)	0.993	0.997	0.413	0.010	0.801	NA
America West (13,13)	0.986	0.999	0.352	0.490	0.777	0.621
Alaska (11,1)	0.993	0.9997	0.299	0.113	0.688	0.890
Note: table lists actual entries/exits in parentheses.						

Table 11: Airline Network Simulations: Next 10 years, Routes

Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

Median number of routes served by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**152**	149	148	147	147	147	147	148	149	151	152
	United (UA)	**131**	131	131	131	131	131	131	131	131	131	131
	Southwest (WN)	**325**	328	330	332	333	335	336	338	339	340	341
	Delta (DL)	**141**	138	136	133	131	129	127	125	123	122	120
	Continental (CO)	**93**	92	92	91	90	90	89	88	88	87	86
	Northwest (NW)	**128**	125	121	118	115	112	109	106	104	101	99
	US Airways (US)	**153**	152	151	151	150	150	150	150	150	150	151
	JetBlue (B6)	**51**	56	66	77	81	83	85	87	89	91	95
	Alaska (AS)	**32**	32	33	33	33	34	34	34	34	34	35
DL-NW merger	American (AA)	**152**	151	151	152	153	155	157	160	162	165	168
	United (UA)	**131**	132	133	134	135	136	137	138	139	139	140
	Southwest (WN)	**325**	327	328	329	330	332	332	333	334	335	336
	DL+NW	**263**	267	271	275	280	285	291	298	306	314	324
	Continental (CO)	**93**	93	93	93	93	93	93	92	92	92	92
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**153**	154	155	156	157	158	159	161	162	164	166
	JetBlue (B6)	**51**	55	62	73	79	81	82	83	84	84	86
	Alaska (AS)	**32**	32	32	32	32	33	33	33	33	33	33
UA-US merger	American (AA)	**152**	151	151	151	153	155	157	159	162	165	168
	UA+US	**260**	264	269	275	282	290	298	307	317	328	339
	Southwest (WN)	**325**	326	328	329	330	331	332	332	333	334	335
	Delta (DL)	**141**	139	138	136	135	134	133	132	132	131	130
	Continental (CO)	**93**	93	93	93	92	92	92	92	91	91	90
	Northwest (NW)	**128**	126	123	120	118	115	113	111	109	107	105
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**51**	55	64	75	79	81	82	83	84	84	86
	Alaska (AS)	**32**	32	32	31	31	31	31	31	31	31	31

Table 12: Airline Network Simulations: Next 10 years, Markets

Median number of markets served by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**886**	869	851	833	817	802	788	777	767	760	755
	United (UA)	**895**	886	876	868	862	855	849	845	841	838	835
	Southwest (WN)	**1039**	1046	1053	1058	1063	1067	1070	1073	1075	1077	1079
	Delta (DL)	**1101**	1089	1075	1063	1054	1046	1040	1034	1027	1022	1017
	Continental (CO)	**692**	682	668	657	646	636	627	618	610	603	597
	Northwest (NW)	**1000**	971	942	915	891	868	848	829	811	793	776
	US Airways (US)	**866**	848	827	807	788	773	760	750	742	737	735
	JetBlue (B6)	**226**	277	384	568	678	717	732	734	735	736	737
	Alaska (AS)	**103**	103	103	104	104	105	106	107	107	108	109
DL-NW merger	American (AA)	**886**	873	858	844	831	821	813	808	805	804	807
	United (UA)	**895**	889	882	877	872	869	866	865	865	864	865
	Southwest (WN)	**1039**	1045	1051	1056	1060	1064	1067	1070	1072	1074	1076
	DL+NW	**1370**	1355	1336	1320	1306	1294	1285	1280	1274	1272	1271
	Continental (CO)	**692**	686	673	664	657	649	643	637	633	628	624
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**866**	853	836	820	807	796	789	784	782	782	786
	JetBlue (B6)	**226**	267	347	507	643	698	730	732	734	734	735
	Alaska (AS)	**103**	103	103	103	104	104	104	105	105	105	105
UA-US merger	American (AA)	**886**	872	858	844	831	821	813	807	803	801	803
	UA+US	**1168**	1155	1143	1137	1136	1140	1147	1157	1170	1183	1199
	Southwest (WN)	**1039**	1045	1050	1055	1059	1062	1065	1068	1071	1073	1075
	Delta (DL)	**1101**	1092	1080	1071	1064	1058	1053	1048	1044	1040	1036
	Continental (CO)	**692**	684	672	662	654	646	639	631	626	621	617
	Northwest (NW)	**1000**	974	947	922	900	880	863	845	829	813	797
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**226**	271	366	543	663	700	730	732	733	734	735
	Alaska (AS)	**103**	103	103	103	103	103	104	104	104	104	105

Table 13: Airline Network Simulations: Distribution in Year 10

Number of simulations: M = 10,000 Horizon: effect in 10 year

		Number of **Routes** Served								Number of **Markets** Served							
		base	mean	std	min	max	q 0.25	med	q 0.75	mean	std	min	max	q 0.25	med	q 0.75	**base**
NOT approved	American (AA)	152	152	13	106	206	143	152	161	755	94	411	1079	692	755	820	886
	United (UA)	131	131	10	98	167	124	131	137	835	91	505	1204	773	835	896	895
	Southwest (WN)	325	341	5	322	360	337	341	344	1079	9	1044	1133	1073	1079	1085	1039
	Delta (DL)	141	120	9	87	152	114	120	126	1011	79	592	1223	961	1017	1067	1101
	Continental (CO)	93	86	7	61	112	81	86	91	597	86	303	897	539	597	655	692
	Northwest (NW)	128	99	8	67	127	94	99	104	774	86	403	1033	716	776	835	1000
	US Airways (US)	153	151	12	109	202	142	151	159	735	80	432	1035	681	735	789	866
	JetBlue (B6)	51	99	14	75	133	87	95	110	738	6	682	773	735	737	742	226
	Alaska (AS)	32	35	2	28	45	33	35	36	111	8	89	208	105	109	114	103
DL-NW merger	American (AA)	152	168	13	121	218	159	168	178	807	93	455	1115	743	807	870	886
	United (UA)	131	140	10	101	182	134	140	147	865	90	515	1237	805	865	924	895
	Southwest (WN)	325	336	5	319	357	332	336	339	1076	10	1039	1134	1070	1076	1083	1039
	DL+NW	263	325	22	245	419	309	324	339	1268	62	1002	1468	1228	1271	1311	1370
	Continental (CO)	93	92	7	64	119	87	92	97	625	85	357	957	567	624	682	692
	--merged--	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	153	166	13	125	214	157	166	174	786	80	508	1112	731	786	842	866
	JetBlue (B6)	51	88	10	73	131	82	86	91	734	7	677	770	733	735	737	226
	Alaska (AS)	32	33	2	27	39	32	33	34	106	5	83	137	104	105	108	103
UA-US merger	American (AA)	152	168	13	121	219	159	168	177	804	91	482	1102	742	803	865	886
	UA+US	260	339	20	266	422	326	339	352	1198	68	940	1437	1153	1199	1246	1168
	Southwest (WN)	325	335	5	318	356	331	335	338	1075	9	1042	1132	1068	1075	1081	1039
	Delta (DL)	141	131	10	95	170	124	130	137	1031	76	695	1246	984	1036	1086	1101
	Continental (CO)	93	90	7	65	118	85	90	95	616	85	332	939	558	617	674	692
	Northwest (NW)	128	105	8	73	135	100	105	110	794	85	423	1056	737	797	853	1000
	--merged--	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	51	89	11	74	131	82	86	92	734	7	677	770	732	735	737	226
	Alaska (AS)	32	31	2	26	39	30	31	33	105	5	83	161	103	105	107	103

Table 14: Aggregate Concentration Measures: Distribution in Year 10

Number of simulations: M = 10,000 Horizon: effect in 10 year

	Number of…	base	mean	std	min	max	q 0.25	med	q 0.75
NOT approved	markets with 0 carriers	**73**	97.534	10.417	64	139	90	97	104
	markets with 1 carriers	**197**	222.81	22.514	149	316	207	222	237
	markets with 2 carriers	**291**	290.62	21.604	212	378	276	290	305
	markets with 3 carriers	**276**	271.07	20.148	194	343	257.5	271	284
	markets with 4 carriers	**253**	251.44	20.175	175	331	238	251	265
	markets with 5 carriers	**243**	204.78	20.868	135	285	191	205	219
	markets with 6 carriers	**188**	162.54	18.45	97	233	150	162	175
	markets with 7 carriers	**168**	154.24	17.946	89	221	142	154	166
	markets with 8 carriers	**59**	91.834	13.706	43	142	83	92	101
	markets with 9 carriers	**22**	22.274	3.3993	10	43	20	22	24
DL-NW merger	markets with 0 carriers	**71**	91.508	10.374	54	129	84	91	99
	markets with 1 carriers	**240**	219.46	22.95	143	340	204	219	235
	markets with 2 carriers	**301**	301.8	22.791	216	403	286	302	317
	markets with 3 carriers	**309**	288.71	23.391	190	376	273	288	304
	markets with 4 carriers	**324**	278.98	23.196	197	372	264	278	295
	markets with 5 carriers	**249**	236.16	23.133	156	324	221	236	251
	markets with 6 carriers	**187**	204.65	22.163	131	282	189	204	219
	markets with 7 carriers	**67**	123.68	15.979	54	185	113	124	134
	markets with 8 carriers	**22**	23.838	3.8049	8	40	21	24	26
	markets with 9 carriers	**0**	1.1983	1.2959	0	10	0	1	2
UA-US merger	markets with 0 carriers	**73**	88.734	9.6826	58	131	82	88	95
	markets with 1 carriers	**197**	198.88	20.278	134	285	185	198	212
	markets with 2 carriers	**339**	294.36	22.624	218	399	279	294	309
	markets with 3 carriers	**312**	305.65	23.005	219	400	290	305	321
	markets with 4 carriers	**280**	288.79	24.014	197	376	272	289	305
	markets with 5 carriers	**257**	228.83	25.232	137	343	212	228	246
	markets with 6 carriers	**207**	209.75	22.402	128	296	194	209	225
	markets with 7 carriers	**83**	131.32	15.904	68	195	121	131	142
	markets with 8 carriers	**22**	22.428	3.4223	8	37	20	22	25
	markets with 9 carriers	0	1.2622	1.3746	0	11	0	1	2

Table 15: City Simulations: Bradley, Routes

Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

CSA = 6 (BDL)

Median number of **routes** served from CSA and HHI by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**3**	3	3	3	3	3	3	3	3	3	3
	United (UA)	**2**	2	2	2	2	3	3	3	3	3	3
	Southwest (WN)	**7**	7	7	7	8	8	8	8	8	8	8
	Delta (DL)	**7**	6	6	5	5	4	4	4	3	3	3
	Continental (CO)	**2**	2	2	2	2	2	2	2	2	2	2
	Northwest (NW)	**2**	2	2	2	2	2	2	2	2	2	2
	US Airways (US)	**4**	4	4	4	4	4	4	4	4	4	4
	JetBlue (B6)	**0**	0	0	1	1	1	1	1	1	2	2
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**1852**	1824	1797	1736	1715	1717	1733	1736	1742	1748	1758
DL-NW merger	American (AA)	**3**	3	3	3	3	3	4	4	4	4	4
	United (UA)	**2**	2	2	2	3	3	3	3	3	3	3
	Southwest (WN)	**7**	7	7	7	7	7	8	8	8	8	8
	DL+NW	**9**	9	9	10	10	10	11	11	12	12	13
	Continental (CO)	**2**	2	2	2	2	2	2	2	2	2	2
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**4**	4	4	4	4	4	4	4	5	5	5
	JetBlue (B6)	**0**	0	0	1	1	1	1	1	1	1	1
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**2236**	2236	2200	2143	2111	2114	2129	2149	2176	2213	2250
UA-US merger	American (AA)	**3**	3	3	3	3	3	4	4	4	4	4
	UA+US	**5**	5	6	6	7	7	8	8	8	9	9
	Southwest (WN)	**7**	7	7	7	7	8	8	8	8	8	8
	Delta (DL)	**7**	7	6	6	5	5	5	4	4	4	4
	Continental (CO)	**2**	2	2	2	2	2	2	2	2	2	2
	Northwest (NW)	**2**	2	2	2	2	2	2	2	2	2	2
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**0**	0	0	1	1	1	1	1	1	1	1
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**2071**	2067	2041	1986	1962	1982	2000	2029	2050	2081	2111

Table 16: City Simulations: Bradley, Markets

Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

CSA = 6 (BDL)

Median number of **markets** served from CSA and HHI by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**27**	27	26	26	26	26	26	27	28	29	30
	United (UA)	**34**	34	34	34	34	34	34	33	33	33	33
	Southwest (WN)	**42**	42	43	43	43	44	44	44	44	45	45
	Delta (DL)	**40**	39	39	38	38	38	38	37	37	37	37
	Continental (CO)	**28**	27	27	27	28	37	38	38	39	39	39
	Northwest (NW)	**43**	43	42	42	41	41	40	40	39	39	38
	US Airways (US)	**41**	40	39	38	38	37	37	37	37	37	37
	JetBlue (B6)	**0**	0	0	52	55	57	57	57	57	58	58
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**1471**	1473	1467	1317	1318	1321	1322	1322	1322	1321	1321
DL-NW merger	American (AA)	**27**	27	27	26	26	27	27	29	31	32	32
	United (UA)	**34**	34	34	34	35	34	34	34	34	34	34
	Southwest (WN)	**42**	42	43	43	43	43	44	44	44	44	44
	DL+NW	**48**	48	48	48	48	48	48	48	48	49	49
	Continental (CO)	**28**	28	27	27	28	38	39	39	40	40	41
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**41**	40	39	39	38	38	38	38	38	39	39
	JetBlue (B6)	**0**	0	0	47	55	56	57	57	57	57	57
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**1739**	1742	1734	1527	1513	1514	1513	1511	1508	1505	1501
UA-US merger	American (AA)	**27**	27	27	27	27	27	29	31	32	32	33
	UA+US	**46**	46	46	46	46	46	46	46	47	47	47
	Southwest (WN)	**42**	42	43	43	43	43	44	44	44	44	44
	Delta (DL)	**40**	39	39	39	38	38	38	38	38	38	38
	Continental (CO)	**28**	27	27	27	28	37	38	39	39	40	40
	Northwest (NW)	**43**	43	42	42	41	41	40	40	40	39	39
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**0**	0	0	50	55	56	57	57	57	57	57
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**1731**	1733	1720	1511	1499	1500	1499	1497	1494	1490	1487

Table 17: City Simulations: Memphis, Routes

Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

CSA = 33 (MEM)

Median number of **routes** served from CSA and HHI by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**1**	1	1	1	2	2	2	2	2	3	3
	United (UA)	**0**	0	0	0	0	0	0	1	1	1	1
	Southwest (WN)	**0**	0	0	0	0	0	0	0	0	0	0
	Delta (DL)	**1**	1	1	1	1	1	1	1	2	2	2
	Continental (CO)	**0**	0	0	0	0	0	0	0	1	1	1
	Northwest (NW)	**27**	24	22	19	17	15	13	11	10	8	7
	US Airways (US)	**0**	0	0	0	0	0	0	0	0	1	1
	JetBlue (B6)	**0**	0	1	1	1	1	1	1	1	1	1
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**8692**	8036	7339	6512	5833	5225	4600	4062	3580	3156	2813
DL-NW merger	American (AA)	**1**	1	1	2	2	2	2	3	3	3	3
	United (UA)	**0**	0	0	0	0	0	0	1	1	1	1
	Southwest (WN)	**0**	0	0	0	0	0	0	0	0	0	0
	DL+NW	**27**	27	27	26	25	25	24	24	23	23	23
	Continental (CO)	**0**	0	0	0	0	0	0	1	1	1	1
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**0**	0	0	0	0	0	1	1	1	1	1
	JetBlue (B6)	**0**	0	0	1	1	1	1	1	1	1	1
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**9311**	8772	8310	7759	7336	6980	6686	6389	6131	5923	5713
UA-US merger	American (AA)	**1**	1	1	2	2	2	2	2	3	3	3
	UA+US	**0**	0	0	0	1	1	2	2	3	3	4
	Southwest (WN)	**0**	0	0	0	0	0	0	0	0	0	0
	Delta (DL)	**1**	1	1	1	1	1	1	2	2	2	2
	Continental (CO)	**0**	0	0	0	0	0	0	0	1	1	1
	Northwest (NW)	**27**	24	22	19	17	15	13	11	10	9	8
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**0**	0	1	1	1	1	1	1	1	1	1
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**8692**	8074	7339	6512	5800	5123	4464	3906	3424	3075	2810

Table 18: City Simulations: Memphis, Markets

Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

CSA = 33 (MEM)

Median number of **markets** served from CSA and HHI by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**22**	22	21	21	21	21	21	22	22	23	23
	United (UA)	**0**	0	0	0	0	0	0	10	16	17	17
	Southwest (WN)	**0**	0	0	0	0	0	0	0	0	0	0
	Delta (DL)	**34**	34	34	34	34	35	35	35	35	35	35
	Continental (CO)	**0**	0	0	0	0	0	0	0	6	6	7
	Northwest (NW)	**45**	42	40	37	35	34	32	31	30	29	29
	US Airways (US)	**0**	0	0	0	0	0	0	0	0	8	9
	JetBlue (B6)	**0**	0	4	8	10	11	12	12	12	12	12
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**3593**	3522	3112	2728	2460	2315	2249	2203	2164	2061	2008
DL-NW merger	American (AA)	**22**	22	21	21	21	21	22	22	23	24	25
	United (UA)	**0**	0	0	0	0	0	0	10	16	17	17
	Southwest (WN)	**0**	0	0	0	0	0	0	0	0	0	0
	DL+NW	**53**	51	49	48	47	46	45	45	44	44	43
	Continental (CO)	**0**	0	0	0	0	0	0	6	7	7	8
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**0**	0	0	0	0	0	4	9	10	11	12
	JetBlue (B6)	**0**	0	0	7	10	11	12	12	12	12	12
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**5854**	5723	4860	4048	3484	3189	3032	2889	2723	2626	2541
UA-US merger	American (AA)	**22**	22	22	21	21	21	22	22	23	24	25
	UA+US	**0**	0	0	0	11	15	18	22	29	31	31
	Southwest (WN)	**0**	0	0	0	0	0	0	0	0	0	0
	Delta (DL)	**34**	34	34	35	35	35	35	35	35	35	35
	Continental (CO)	**0**	0	0	0	0	0	0	0	6	7	7
	Northwest (NW)	**45**	42	40	38	36	34	33	32	31	30	29
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**0**	0	2	8	10	11	12	12	12	12	12
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**3593**	3530	3126	2760	2434	2305	2247	2214	2187	2172	2105

Table 19: City Simulations: DC, Routes

Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

CSA = 13 (DC)

Median number of **routes** served from CSA and HHI by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**6**	6	6	6	7	7	7	7	7	8	8
	United (UA)	**19**	18	18	17	17	16	16	16	15	15	15
	Southwest (WN)	**34**	34	34	34	34	34	35	35	35	35	35
	Delta (DL)	**4**	4	4	5	5	5	5	5	5	6	6
	Continental (CO)	**3**	3	3	3	3	4	4	4	4	4	4
	Northwest (NW)	**3**	3	3	3	3	3	3	3	3	3	3
	US Airways (US)	**18**	20	21	23	24	26	28	29	31	32	34
	JetBlue (B6)	**6**	6	6	6	6	5	5	5	5	5	5
	Alaska (AS)	**2**	2	2	2	2	2	2	2	2	2	2
	HHI	**2162**	2136	2125	2118	2116	2123	2134	2146	2164	2184	2205
DL-NW merger	American (AA)	**6**	6	6	7	7	7	8	8	8	8	9
	United (UA)	**19**	19	18	18	18	17	17	17	16	16	16
	Southwest (WN)	**34**	34	34	34	34	34	34	34	34	34	34
	DL+NW	**7**	8	9	10	12	13	15	17	18	20	21
	Continental (CO)	**3**	3	3	3	4	4	4	4	4	4	4
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**18**	20	22	24	26	28	30	32	33	35	37
	JetBlue (B6)	**6**	6	6	6	5	5	5	5	5	4	4
	Alaska (AS)	**2**	2	2	2	2	2	2	2	2	2	2
	HHI	**2188**	2151	2119	2094	2076	2065	2059	2057	2060	2067	2075
UA-US merger	American (AA)	**6**	6	6	7	7	7	8	8	8	9	9
	UA+US	**28**	29	29	30	31	32	33	34	35	36	37
	Southwest (WN)	**34**	34	34	34	34	34	34	34	34	34	34
	Delta (DL)	**4**	4	5	5	5	6	6	6	6	7	7
	Continental (CO)	**3**	3	3	3	4	4	4	4	4	4	4
	Northwest (NW)	**3**	3	3	3	4	4	4	4	4	4	4
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**6**	6	6	6	5	5	5	5	4	4	4
	Alaska (AS)	**2**	2	2	2	2	2	2	2	2	2	2
	HHI	**2772**	2738	2714	2690	2672	2658	2647	2640	2634	2634	2632

Table 20: City Simulations: DC, Markets

Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

CSA = 13 (DC)

Median number of **markets** served from CSA and HHI by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**32**	32	32	32	32	32	32	32	32	32	32
	United (UA)	**35**	35	34	34	34	34	33	33	33	33	33
	Southwest (WN)	**46**	46	46	46	46	46	46	47	47	47	47
	Delta (DL)	**43**	42	42	41	41	41	40	40	40	40	39
	Continental (CO)	**36**	36	36	36	36	36	36	36	36	36	36
	Northwest (NW)	**34**	34	34	33	33	32	32	31	31	31	30
	US Airways (US)	**42**	42	41	41	41	40	40	40	41	41	41
	JetBlue (B6)	**25**	29	36	44	47	48	48	48	48	48	48
	Alaska (AS)	**11**	11	11	11	11	11	11	11	11	11	11
	HHI	**1209**	1200	1194	1198	1202	1205	1207	1208	1210	1211	1212
DL-NW merger	American (AA)	**32**	32	32	32	32	32	33	33	33	33	33
	United (UA)	**35**	35	35	34	34	34	34	34	33	33	33
	Southwest (WN)	**46**	46	46	46	46	46	46	47	47	47	47
	DL+NW	**48**	48	48	48	48	48	47	47	47	47	48
	Continental (CO)	**36**	36	36	36	36	36	37	37	37	37	37
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**42**	42	41	41	41	41	41	42	42	42	43
	JetBlue (B6)	**25**	28	34	42	46	47	48	48	48	48	48
	Alaska (AS)	**11**	11	11	11	11	11	11	11	11	11	11
	HHI	**1385**	1376	1367	1364	1368	1370	1372	1372	1373	1374	1374
UA-US merger	American (AA)	**32**	32	32	32	32	33	33	33	33	33	33
	UA+US	**47**	47	47	46	47	47	47	47	48	48	49
	Southwest (WN)	**46**	46	46	46	46	46	46	46	46	46	46
	Delta (DL)	**43**	43	42	41	41	41	41	40	40	40	40
	Continental (CO)	**36**	36	36	36	36	36	36	36	37	37	37
	Northwest (NW)	**34**	34	34	33	33	33	32	32	32	31	31
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**25**	28	35	43	46	47	48	48	48	48	48
	Alaska (AS)	**11**	11	11	11	11	11	11	11	11	11	11
	HHI	**1385**	1374	1364	1364	1368	1371	1373	1375	1376	1378	1379

Table 21: City Simulations: Philadelphia, Routes

Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

CSA = 44 (PHL)

Median number of **routes** served from CSA and HHI by year

	Year	0	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**4**	4	4	4	4	4	4	4	4	4	4
	United (UA)	**4**	4	4	4	4	4	3	3	3	3	3
	Southwest (WN)	**18**	18	18	18	18	19	19	19	19	19	19
	Delta (DL)	**3**	3	3	2	2	2	2	2	2	2	2
	Continental (CO)	**1**	1	1	1	1	1	1	1	1	1	1
	Northwest (NW)	**3**	3	3	3	2	2	2	2	2	2	2
	US Airways (US)	**28**	27	26	26	25	24	24	23	22	22	21
	JetBlue (B6)	**0**	0	0	0	1	1	1	1	1	1	1
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**3115**	3115	3115	3099	3049	3044	3038	3033	3026	3015	3006
DL-NW merger	American (AA)	**4**	4	4	4	4	4	4	4	4	4	4
	United (UA)	**4**	4	4	4	4	4	4	4	4	4	3
	Southwest (WN)	**18**	18	18	18	18	18	19	19	19	19	19
	DL+NW	**6**	6	6	6	6	6	6	6	6	6	6
	Continental (CO)	**1**	1	1	1	1	1	1	1	1	1	2
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**28**	27	27	26	26	25	25	24	24	23	23
	JetBlue (B6)	**0**	0	0	0	1	1	1	1	1	1	1
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**3163**	3145	3115	3072	2997	2954	2932	2908	2889	2865	2846
UA-US merger	American (AA)	**4**	4	4	4	4	4	4	4	4	4	4
	UA+US	**28**	26	25	23	22	21	20	20	19	19	18
	Southwest (WN)	**18**	18	18	18	18	18	18	18	18	18	18
	Delta (DL)	**3**	3	3	2	2	2	2	2	2	2	2
	Continental (CO)	**1**	1	1	1	1	1	1	1	1	1	1
	Northwest (NW)	**3**	3	3	3	2	2	2	2	2	2	2
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**0**	0	0	0	1	1	1	1	1	1	1
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**3518**	3469	3422	3368	3273	3240	3219	3205	3195	3185	3176

Table 22: City Simulations: Philadelphia, Markets

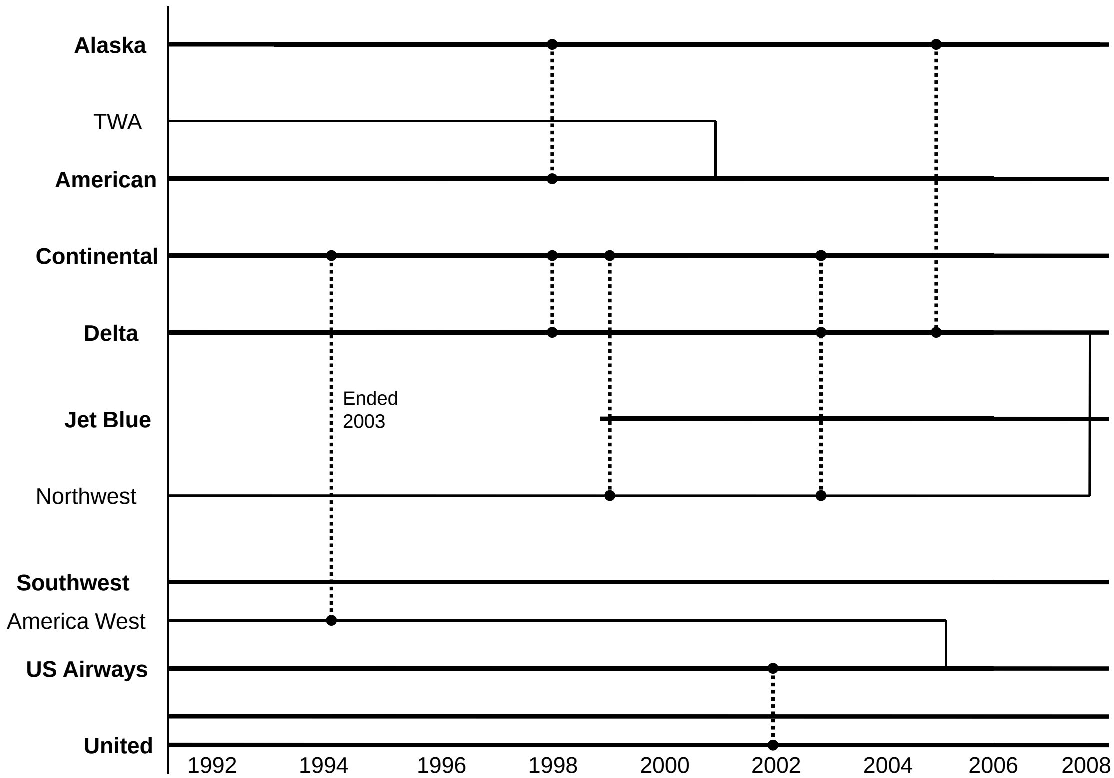
Number of simulations: M = 10,000 **Average year dummy (2003-2007)**

CSA = 44 (PHL)

Median number of **markets** served and HHI by year

	Year	**0**	1	2	3	4	5	6	7	8	9	10
NOT approved	American (AA)	**33**	33	33	32	32	31	31	31	30	30	30
	United (UA)	**27**	27	27	27	27	27	27	27	27	27	27
	Southwest (WN)	**41**	41	41	41	41	41	42	42	42	42	42
	Delta (DL)	**41**	40	38	38	37	37	37	36	36	36	36
	Continental (CO)	**22**	22	21	21	21	21	20	20	21	22	35
	Northwest (NW)	**40**	40	39	39	38	38	37	36	36	35	35
	US Airways (US)	**43**	42	41	41	40	40	40	40	40	40	40
	JetBlue (B6)	**0**	0	0	0	55	56	57	57	57	57	57
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**1494**	1494	1494	1482	1346	1351	1355	1357	1360	1363	1365
DL-NW merger	American (AA)	**33**	33	33	32	32	32	32	32	32	31	31
	United (UA)	**27**	27	27	27	27	27	27	27	27	27	27
	Southwest (WN)	**41**	41	41	41	41	41	42	42	42	42	42
	DL+NW	**48**	48	48	47	47	47	46	46	46	46	45
	Continental (CO)	**22**	22	21	21	21	21	21	21	21	35	38
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	US Airways (US)	**43**	42	42	41	41	41	41	41	41	41	42
	JetBlue (B6)	**0**	0	0	0	54	56	57	57	57	57	57
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**1777**	1777	1779	1771	1556	1555	1557	1557	1555	1552	1546
UA-US merger	American (AA)	**33**	33	33	32	32	32	32	32	31	31	31
	UA+US	**48**	47	46	46	46	46	46	46	47	47	48
	Southwest (WN)	**41**	41	41	41	41	41	41	41	41	42	42
	Delta (DL)	**41**	40	38	38	37	37	37	37	36	36	36
	Continental (CO)	**22**	22	21	21	21	21	21	21	21	34	37
	Northwest (NW)	**40**	40	39	39	38	38	37	37	36	36	35
	--merged--	**0**	0	0	0	0	0	0	0	0	0	0
	JetBlue (B6)	**0**	0	0	0	55	56	57	57	57	57	57
	Alaska (AS)	**0**	0	0	0	0	0	0	0	0	0	0
	HHI	**1746**	1745	1746	1739	1529	1532	1536	1538	1540	1541	1541

Figure 1: Recent Merger and Code-Share Activity



Note: solid lines represent mergers and dotted line represent code-sharing agreements.