

The Long Run Effects of U.S. Airline Mergers*

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Abstract

We introduce a new method for studying the medium and long run dynamic effects of 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 some 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 extremely well. See paper for preliminary conclusions.

Note: This is not a paper. It is the incomplete outline of a paper. Citations are very incomplete. Please do not quote findings.

*This draft is a very rough first effort – not even really a paper yet. We thank Darin Lee and Severin Borenstein 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 (cite merger guidelines). 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 of the products they sell. 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 occurred 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 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 also, in general, require more 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 policy functions. The estimated policy functions represent our best estimates of equilibrium play in the game.

We then employ an important simplifying assumption: we assume that the equilibrium being played does not change after the merger. For example, this might happen if mergers are a standard occurrence 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 happens). The assumption would not hold in the event that allowing the proposed merger

would represent a 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.

We apply these 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.

(Incomplete: results below.)

2 Literature Review

Berry (1992), Borenstein (1989), Borenstein (1990), Borenstein (1991), Borenstein (1992), Borenstein and Rose (2007), Brueckner and Spiller (1994), Kim and Singal (1993), Morrison and Winston (1995), Ciliberto and Williams (2007), 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),

3 Model/Methodology

We start with a general model of dynamic competition between oligopolistic competitors. Our general model is based on that of Bajari, Benkard and Levin (2007) (henceforth BBL). 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 $i = 1, \dots, N$, who make decisions at times $t = 1, 2, \dots, \infty$. 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 $\nu_t = (\nu_{1t}, \dots, \nu_{Nt})$.

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, $\sigma = (\sigma_1, \dots, \sigma_n)$, where $\sigma : S \times \mathcal{V}_1 \times \dots \times \mathcal{V}_N \rightarrow A$.

If behavior is given by a Markov strategy profile σ , firm i 's expected profit given a state \mathbf{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 \mathbf{s} , and Markov strategies σ'_i ,

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

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 π_1, \dots, π_N , the transition probabilities P , and the distributions of the private shocks G_1, \dots, 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 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, agents' policy functions (σ) are estimated from observations on actions and states. In a second step, the profit function parameters, θ , are estimated.

In this paper we consider how to measure the dynamic effects of a proposed merger in this

model, between two firms at a particular 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 both before and after the merger of interest.

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 policy function σ , and the policy function estimation would need to include estimates of a merger policy.

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 policy function 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 policy functions recovered from the data in the first step of estimation are relevant, whether or not the merger being evaluated takes place. In that case, we can use the BBL forward simulation procedure to simulate future market

outcomes both with and without the merger. In the model, whether or not the merger takes place represents only a change in the industry state, s , and not in the equilibrium being played, σ . The great benefit of this assumption 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 policy functions 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 profile under the new policy, a much more difficult approach than the one we consider 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 policy functions and for the one period transition probabilities, we are able to construct/simulate the implied probability distribution of actions and states at every point in time: $P((\mathbf{a}_{t+r}, \mathbf{s}_{t+r})|\mathbf{a}_t, \mathbf{s}_t)$, for all $r = 1, 2, \dots, \infty$. 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,

¹Cite computational references here.

even in that case there may still be important medium term effects of a merger.

Finally, 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, to calculate the prevailing prices and consumer and producer surplus. This would typically require an additional set of estimates, for example, from a model Berry, Levinsohn, and Pakes (1995)-style model.

4 Airline Mergers

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 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 approval, 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 $j \in \{1, \dots, J\}$ 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 j th 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 $m \in \{1, \dots, J\}$.

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 do not elaborate this further in this draft of the paper, 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 this need not be the case 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)

$$S_{it}(n_i^t, n_i^{t+1}) = \left\{ \sum_{j=1}^J n_{ij}^t > 0 \right\} \left\{ \sum_{j=1}^J n_{ij}^{t+1} = 0 \right\} \Phi_{it} - \left\{ \sum_{j=1}^J n_{ij}^t = 0 \right\} \left\{ \sum_{j=1}^J n_{ij}^{t+1} > 0 \right\} \Xi_{it} + \sum_k \left(\left\{ \sum_j d_{jk} n_{ij}^t > 0 \right\} \left\{ \sum_j d_{jk} n_{ij}^{t+1} = 0 \right\} \Phi_{ikt} - \left\{ \sum_j d_{jk} n_{ij}^t = 0 \right\} \left\{ \sum_j d_{jk} n_{ij}^{t+1} > 0 \right\} \Xi_{ikt} \right) + \sum_{j=1}^J (\{n_{ij}^{t+1} < n_{ij}^t\} * \phi_{ijt} - \{n_{ij}^{t+1} > n_{ij}^t\} * \kappa_{ijt})$$

where the notation $\{ \dots \}$ 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 , $\omega_{it} = (\Phi_{it}, \Xi_{it}, \Phi_{i1t}, \dots, \Phi_{iKt}, \Xi_{i1t}, \dots, \Xi_{iKt}, \phi_{i1t}, \dots, \phi_{iJt}, \kappa_{i1t}, \dots, \kappa_{iJt})$.

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

²Note 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:

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

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 policy 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 policy 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 policy 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:

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

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 equilibria (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 policy 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 policy 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).

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 the majors. 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. 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 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 show a short run snapshot of the increase in concentration that will result from the two proposed mergers. In this section, we use the model above 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 probabilities 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 we 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 policy 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.

(Results incomplete: see tables 11-22)

8 Estimation

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 event 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 enplaned 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 event 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. γ Carrier Dummy γ
 \times 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 Number	Airport Code
1	ABQ
2	ALB
3	ANC
4	ATL
5	AUS
6	BDL
7	BHM
8	BNA
9	BOI
10	BOS, MHT, PVD
11	BUF
12	CLE
13	CLT
14	CMH
15	CVG
16	DAL, DFW
17	BWI, DCA, IAD
18	DEN
19	DTW
20	ELP
21	FLL, MIA
22	GEG
23	HNL
24	HOU, IAH
25	IND
26	JAX
27	EWR, JFK, LGA
28	LAS
29	BUR, LAX, ONT, SNA
30	MCI
31	MCO
32	MDW, ORD
33	MEM
34	MKE
35	MSP
36	MSY
37	OGG
38	OKC
39	OMA
40	ORF
41	PBI
42	PDX
43	PHL
44	PHX
45	PIT
46	RDU
47	RNO
48	RSW
49	SAN
50	SAT
51	SDF
52	SEA
53	OAK, SFO, SJC
54	SJU
55	SLC
56	SMF
57	STL
58	TPA
59	TUL
60	TUS

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:

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

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

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

where

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

Combining the observations for all periods $t = 1, \dots, T$ 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 $N(0, \Omega = I_T \otimes \Sigma)$.

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.

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

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

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

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, $\mathbf{Z}_0, \theta_0, \sigma_0^2$. Set $k = 1$.
2. Draw $\mathbf{Z}_k | \theta_{k-1}, \sigma_{k-1}^2, \mathbf{y}, \tilde{\mathbf{X}}$ from

$$N\left(\tilde{\mathbf{X}}\theta_{k-1}, I_T \otimes \Sigma(\sigma_{k-1}^2)\right) \text{ truncated so that}$$

$$z_{ij,t} < 0 \text{ whenever } y_{ij,t} = 0 \text{ and } z_{ij,t} \geq 0 \text{ whenever } y_{ij,t} = 1.$$

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

$$z_{ij,t,k} \sim N(E(z_{ij,t,k} | z_{-ij,t,k-1}), \text{Var}(z_{ij,t,k} | z_{-ij,t,k-1})) \text{ truncated so that}$$

$$z_{ij,t,k} < 0 \text{ if } y_{ij,t} = 0 \text{ and } z_{ij,t,k} \geq 0 \text{ if } y_{ij,t} = 1,$$

where

$$E(z_{ij,t,k} | z_{-ij,t,k-1}) = \tilde{x}_{ij,t}\theta_{k-1} + \Sigma_{12}(\sigma_{k-1}^2) \Sigma_{22}^{-1}(\sigma_{k-1}^2) (z_{-ij,t,k-1} - x_{-ij,t}\theta_{k-1}),$$

$$\text{Var}(z_{ij,t,k} | z_{-ij,t,k-1}) = 2 + \sigma_{k-1}^2 - \Sigma_{12}(\sigma_{k-1}^2) \Sigma_{22}^{-1}(\sigma_{k-1}^2) \Sigma_{21}(\sigma_{k-1}^2).$$

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 $\theta_k | \mathbf{Z}_k, \sigma_{k-1}^2, \mathbf{y}, \tilde{\mathbf{X}}$ from $N(\tilde{\theta}, V)$, where

$$\begin{aligned} V &= \left(\tilde{\mathbf{X}}^{*'} \tilde{\mathbf{X}}^* + A \right)^{-1}, \\ \tilde{\theta} &= V \left(\tilde{\mathbf{X}}^{*'} \mathbf{Z}_k^* + A \bar{\theta} \right), \\ \Sigma_0^{-1}(\sigma_{k-1}^2) &= C' C, \\ \tilde{\mathbf{x}}_t^* &= C' \tilde{\mathbf{x}}_t, \\ \mathbf{z}_{t,k}^* &= C' \mathbf{z}_{t,k}, \\ \tilde{\mathbf{X}}^* &= \begin{bmatrix} \tilde{\mathbf{x}}_1^* \\ \vdots \\ \tilde{\mathbf{x}}_T^* \end{bmatrix} \end{aligned}$$

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

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

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

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

(ii) Calculate:

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

(iii) Set

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

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

Carrier	Routes						Markets		
	Avg	Min	Max	Avg Entry	Avg Exit	Turnover	Avg	Min	Max
American	163	152	185	3	10.6	4.2%	923	886	990
United	131	131	132	1.8	2	1.5%	882	867	889
Southwest	304	271	325	14.4	3.2	2.9%	958	834	1039
Delta	149	140	163	6.2	11.8	6.0%	1124	1101	1158
Continental	95	93	97	0.8	1.4	1.2%	739	697	798
Northwest	131	128	136	3.4	2.8	2.4%	1040	1001	1080
USAirways	102	92	112	4.2	8.2	6.1%	481	436	540
JetBlue	35	17	51	7.2	0.2	10.5%	140	67	224
America West	64	63	67	2.6	2.6	4.0%	447	406	492
Alaska	31	29	32	2.2	0.2	3.9%	99	90	102
Other	356	276	396	51	15.4	9.3%	1107	1005	1164
Other Low Cost	224	194	235	24	9.8	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

DL-NW									
CSA1	CSA2	Num Carriers	HHI Passengers			HHI Departures			
			pre	post	chg	pre	post	chg	
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									
CSA1	CSA2	Num Carriers	HHI Passengers			HHI Departures			
			pre	post	chg	pre	post	chg	
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														
CSA	Num Carriers		HHI Routes			HHI Markets			HHI Passengers			HHI Departures		
	pre	post	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														
CSA	Num Carriers		HHI Routes			HHI Markets			HHI Passengers			HHI Departures		
	pre	post	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

Variable	Hub Carriers		Southwest		Jet Blue		Alaska	
	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

Airline	Actual Last Period Status				Full Sample Simulated	
	Stay		Switch		Switchers, Whole Period	
	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

Airline	Actual Last Period Status				Full Sample Simulated	
	Stay		Switch		Switchers, Whole Period	
	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	4	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

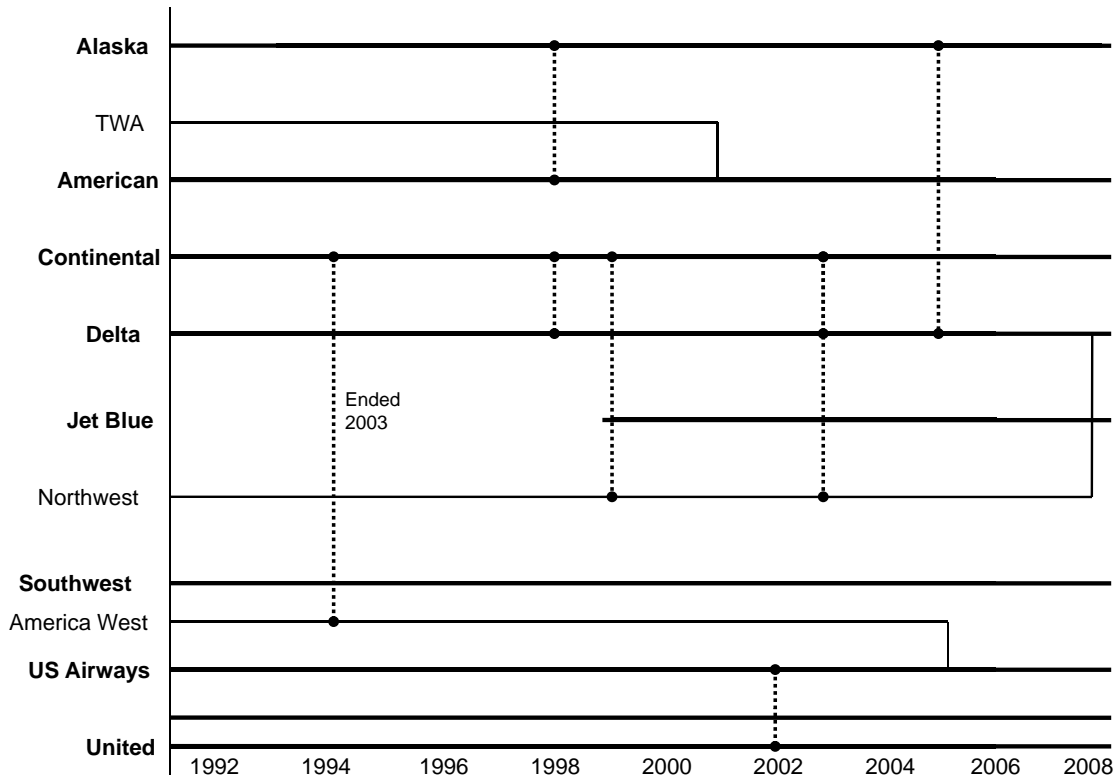
Number of simulations: M = 10,000 Average year dummy (2003-2007)

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.