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

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This version: April 2014
PRELIMINARY AND INCOMPLETE

Abstract

We propose a simple 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. We apply our method to two recent airline mergers as well as one that was proposed but blocked. We find that the potential for offsetting entry depends critically on the local networks of the competitor airlines in the areas around a given route. In some cases (United-USAir), there would have been substantial potential for offsetting entry, while in others (Delta-Northwest) there is not. Thus, the dynamic analysis is highly complementary and leads to different conclusions than the more traditional static analyses.

*This draft is preliminary and incomplete but we expect a final draft during summer 2016. The first draft of this paper was in March 2009. We thank Steve Berry, Severin Borenstein, Phil Haile, Darin Lee, and Jon Levin for their useful input. Correspondence: lanierb@stanford.edu; acreed@haas.berkeley.edu; jlazarev@nyu.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), US Department of Justice (1997)). More sophisticated methods (Berry and Pakes (1993), Berry, Levinsohn, and Pakes (1995), Nevo (2000)) are available 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 general, 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 (Berry and Pakes (1993), 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 three recently proposed mergers in the airline industry.

Much work on dynamic oligopoly uses the general framework of Ericson and Pakes (1995) (hereafter EP), which models a dynamic industry in Markov perfect equilibrium (MPE). It is not possible to characterize equilibria to the model analytically, so they must be computed numerically on a computer. In general, inserting mergers into this framework requires a detailed model of how mergers occur (Gowrisankaran (1999)), resulting in a complex model that is difficult to compute and to apply to data.

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, in the sense that firms' strategy functions do not change. 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, an option that, while attractive, would be computationally infeasible in many cases.

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 methods to three recently proposed mergers in the U.S. airline industry: United-USAir, Delta-Northwest, and United-Continental. The United-USAir merger was proposed in

2000 and rejected by anti-trust authorities (see below for more details). The Delta-Northwest merger was finalized in late 2008. The United-Continental merger was finalized in late 2010.

[ADD FINDINGS]

2 Related Literature

There are several other related papers in the literature that we have not mentioned yet. Probably the closest paper to ours is a recent paper by Collard-Wexler (2014) that uses a Bresnahan and Reiss-style empirical dynamic model to evaluate the historesis effects of a merger from duopoly to monopoly in the ready-mix concrete industry. The paper finds that merger to monopoly would generate about 15 years of monopoly. The approach in the paper is similar to ours, but is even simpler than ours as it assumes homogeneous firms.

Two other recent papers (Jeziorski (2014a), Jeziorski (2014b), and Stahl (2009)) use dynamic models similar in spirit to ours to consider recent merger waves in radio and broadcast television respectively. However, the goals of these papers are quite different from ours. They use data on past mergers primarily to evaluate the forces that drove the merger waves, but also to evaluate (ex post) the welfare effects of the merger waves. Our paper instead evaluates the potential future dynamic effects of proposed mergers.

There are also several papers looking at past airline mergers. Most notably, Borenstein (1990) evaluates (ex post) the anticompetitive effects of two airline mergers that occurred in the mid-1980s, each of which led to substantially increased concentration at a major hub. He finds that there is evidence of both price increases and capacity reductions at these hubs after the mergers. Kim and Singal (1993) does a broader ex post evaluation of fourteen airline mergers in the 1980s.

Overall they find that after a merger both the merged and unmerged firms substantially increased fares. Peters (2006) also does an ex-post evaluation of static merger simulations (as in Nevo (2000)) using five airline mergers from the mid-1980s. He finds that the standard model appears to omit some important supply-side factors (e.g., cost or conduct).

There are also some important results in the literature regarding airline network structure and airline competition that are relevant to our work. Borenstein (1991) finds evidence that a carrier that has a dominant market share of flights out of a given city has increased market power on routes out of that city, even on individual routes where there may be substantial competition. Borenstein (1989) similarly shows that both an airline's market share on an individual route and its share at the endpoint cities influence its ability to mark up price above cost.

Berry (1992) estimates a static model of airline entry with heterogeneous firms and finds, similarly to Borenstein (1989), that an airline's market share of routes out of a given city is an important determinant of entry into other routes from that city. Ciliberto and Tamer (2007) estimates a static entry model that allows for multiple equilibria and for asymmetric strategies. Boguslaski, Ito, and Lee (2004) estimates a static entry model for Southwest that fits the data extremely well and helped inspire some features of our model, such as the way we define entry and exit. Other relevant static airline entry papers include Sinclair (1995) and Reiss and Spiller (1989).

There is also a recent paper(Aguirregabiria and Ho (2012)) that estimates a structural dynamic oligopoly model of airline entry that is similar to our model. Relative to that paper, which computes equilibrium entry strategies for airlines, our approach is simpler and less ambitious. However, an advantage of our simpler approach is that we are able to include a richer set of state variables in our model, potentially allowing for more robust network-wide route optimization on the part of firms, rather than focusing on one route at a time in isolation from the broader network.

3 Notation and General Approach

We start with a brief characterization of our general approach. The purpose of the general model is to show how our approach would work in contexts other than airlines. We develop a more detailed model for airlines below.

Our general model closely follows BBL, and is a generalization of the EP 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 many aspects of dynamic competition such as entry and exit decisions, mergers, learning, product entry and exit, investment, dynamic pricing, 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 $\mathbf{a}_t = (a_{1t}, \ldots, a_{Nt}) \in A$ 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 $\nu_t = (\nu_{1t}, ..., \nu_{Nt})$.

The assumption of iid private shocks is troublesome. In many empirical applications there would often be serial correlation in these shocks. In the empirical work we will both test for serial correlation and also use several simple approaches to account for it. There is also ongoing research in this area aimed at relaxing this assumption further. [1]

BBL and EP outline primitives of the dynamic oligopoly model consisting of a profit function, investment, entry, and exit processes. We omit these details here for brevity. We do note, however, that they are important fundamentals of the model. A nice feature of our approach is that it is possible to proceed while leaving their details unspecified. This also makes the approach more general.

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 $\sigma_i : S \times \mathcal{V}_i \to A_i$. A profile of Markov strategies is a vector, $\sigma = (\sigma_1, ..., \sigma_n)$, where $\sigma : S \times \mathcal{V}_1 \times ... \times \mathcal{V}_N \to A$. Here, we simply assume that an MPE exists, noting that there could be many such equilibria.[2]

[1] See for example Arcidiacono and Miller (2010), Kasahara and Shimotsu (2009), **?**).

[2] Doraszelski and Satterthwaite (2007) provide conditions for equilibrium existence in a closely related model.

3.1 An Outline of the Method

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 are estimated.

Our approach in this paper is a simplification of the BBL first stage. The simplification is possible because we omit the second step of BBL entirely. 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. Since we will not require estimates of the profit function parameters, 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 $\mathbf{s}_t$. Estimating the choice distributions is simpler than estimating the strategy functions because in general the strategy functions may not be identified. Identification of the strategy functions would typically require, for example, 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. They are always identified.

We now 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. First, note that the first stage estimates completely determine the future distribution of actions and states conditional on the current state,

$$(3.1) \quad P((\mathbf{a}_{t+1}, \mathbf{s}_{t+1}), ..., (\mathbf{a}_{t+r}, \mathbf{s}_{t+r})|\mathbf{a}_t, \mathbf{s}_t) =$$

$$= Pr(\mathbf{a}_{t+r}|\mathbf{s}_{t+r})Pr(\mathbf{s}_{t+r}|\mathbf{a}_{t+r-1}, \mathbf{s}_{t+r-1}) \ldots Pr(\mathbf{a}_{t+1}|\mathbf{s}_{t+1})Pr(\mathbf{s}_{t+1}|\mathbf{a}_t, \mathbf{s}_t)$$

In practice, as in BBL we can obtain the future distribution of actions and states through simulation.

Second, note that the effect of a merger on the system is simply to change the initial state of the industry, $\mathbf{s}_t$. For example, if we are considering a merger between two airlines, then a merger would simply replace the two merging airlines with a single larger airline whose network was the union of the two merging carriers.

Using these two results it is straightforward to determine the future distribution of industry outcomes both with and without the merger. 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. These can then be directly compared.

The great benefit of such an approach is that we do not require the ability to compute a new equilibrium to the game. As a result, for many markets, the method may even be economical enough to be useful to policy makers such as the DOJ and the FTC.

In general, policy makers are interested in the effects of a merger on competition, prices, quantities, and ultimately consumer and producer surplus. The procedure described above constructs the probability distribution of actions and states (3.1) at every point in time for both the merger and no merger cases. Note that the model does not necessarily imply that the equilibrium Markov process of industry states be ergodic, but 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.

Knowing the future distribution of industry structures both with and without the merger may already be enough to evaluate the medium and long run competitive effects of a merger. However, if we wanted a more precise estimate of the welfare implications of the merger we could also estimate demand and supply models (e.g., Berry, Levinsohn, and Pakes (1995)), so that we could compute the prices that would prevail, and consumer and producer surplus. On the other hand, for most welfare 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/alleviate this phenomenon.

3.2 Assumptions

As mentioned above, since $\mathbf{a}$ and $\mathbf{s}$ are assumed to be observed, the choice probabilities and the complete future distribution of actions and states are always identified. However, in practice there could be an issue in the empirical implementation of the approach if there were not enough past data to identify all of the areas of the choice distributions ($Pr(\mathbf{a}|\mathbf{s})$) of interest. For example, it would be difficult to estimate the dynamic effects of a merger to monopoly, for an industry that had always had more than two firms in the past data. There simply would be no past data that would tell us the likelihood of entry when there is a monopolist. We will see below that in our airlines example the data are sufficiently rich that this will not be a problem. Nevertheless, it is something to watch out for in other applications.

Second, note that we are implicitly maintaining an assumption that the policy environment is constant in the past data and in the future period of interest. This implies that the equilibrium strategies, σ are constant. If something about the policy environment were to change, either at the point of the merger or any other time, then equilibrium behavior might change, and the past estimates or the future simulations would be invalid. We might particularly worry about evaluating a "game-changing" merger, i.e., one that would never have been approved under the past policy regime. If such a merger were to go through, we might expect that firms would update their beliefs about the future policy regime, and new equilibrium strategies would result. Our method will instead evaluate what would have happened in the industry had the merger taken place and then the old equilibrium strategies remained in place.

The only way that we know of to fully evaluate a game changing 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. Certainly such an approach would be intractible in the airlines model we outline below.

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. In the wake of the Airline Deregulation Act of 1978 and the closure of the Civil Aeronautics Board in 1985, policy makers feared that the commercial airline industry could become overly concentrated. 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.

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. On July 2, 2001, United announced opposition to the merger 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 hoped to leverage complementarities in their regional networks to form a low cost carrier that could effectively compete with Southwest Airlines. 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 April 2008, Delta announced that it would merge with Northwest Airlines. 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.

Again, neither airline was in financial distress at the time of the merger, and in this merger there was some overlap between the two carriers so there was a possibility for the merger to reduce competition (see below for more discussion).

In May 2010, United Airlines and Continental airlines announced a merger that would create the world's largest airline in terms in 2009 revenues. The stated reasons for the merger include cost savings and domestic and international network complementarities with a special focus on access to international markets from the combined airline's network of gateway hubs. The merger was approved by the DoJ in late 2010.

Shareholders of AirTran approved a merger with Southwest Airlines in March 2011. The motivation for the merger is principally to reap the benefit of the complementary route networks served by AirTran and Southwest Airlines. The merger has yet to receive approval from anti-trust authorities.

Below, we analyze the potential medium and long term effects of three recently proposed mergers: United-USAir, which was blocked in mid 2000, Delta-Northwest, which was approved in late 2008, and United-Continental, approved in late 2010.

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 a subset of each others flights, which can effectively extend the flight offerings of each member airline. 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 networks.

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. Northwestern

Airlines and Continental formed a code-sharing alliance in 1999. 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. The Transportation deparment mandated independent schedule and price planning and forbid code-sharing on routes in which both airlines offered non-stop service.

[ADD AMERICAN USAIR discussion]

5 A Model of the U.S. Airline Industry

We now outline a dynamic model of the US airline industry. The US airline network is complex and high dimensional. In the interest of keeping the model as simple as possible we will model only airline route presence. It would be possible, computationally tractible even, to also model the extent of entry (e.g., number of seats, or flights per day) on each route, but we believe that the marginal benefit of doing so may not be worth the additional complexity. Our hope is that the current approach is both easy to understand and also provides the main insights to be gleaned from the dynamic analysis.

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

There are a fixed number, A, of airlines. As entry of new airline carriers is very rare, it would not be possible to estimate the likelihood of it occuring using past data, so we will rule it out in the analysis. Each airline i has a network of segments defined by a J dimensional vector, n_i. The jth element of n_i equals one if airline i currently flies segment 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 $m \in \{1, ..., J\}$.

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 as described by the airline route network (N_t), and some unobserved profit shifters that we leave unspecified.

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 the next year, N_{t+1}. Changing the firm's network may also involve costs. We imagine there could be three potential sources of costs, in order from largest to smallest: (a) costs of opening or closing a new airline, (b) costs of opening or closing operations at a given airport, (c) costs of opening or closing operations on a given route segment (in which both endpoints already have service). Again, in our approach there is no need to specify these in detail.

Each period, each airline chooses it's next period's network so as to maximize the expected discounted value of profits. Let Z_t be a matrix consisting of the profit shifters z_m for all markets m in period t, and assume that Z_t is Markov. Note that the notation allows Z_t to contain aggregate variables that are relevant to all markets. A Markov perfect equilibrium in this model is characterized by a set of strategy functions of the form:

$$n_i^{t+1}(N_t, Z_t, \nu_{it}),$$

where ν_{it} represents all of the unobserved profit and cost shifters for airline i in all markets.

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.

The model above will result a set of behavioral probability distributions for each airline:

$$Pr(n_i^{t+1}|N_t, Z_t) \tag{5.1}$$

If we knew the underlying primitives of the model, these probabilities could be obtained by computing an equilibrium. However, in our context computing an equilibrium is most definitely out of the question, and furthermore there are almost surely going to be many equilbria (with associated strategy functions and behavioral probabilities). Alternatively, we will follow the general method described above and begin by attempting to recover these probabilities empirically.

5.1 Abstractions

In trying to keep the model simple, we have necessarily omitted some important features of the airline industry. Most notably, in modelling the airline network and entry and exit, we have modeled presence only and have not accounted for the extent of entry (the number and size of flights). There is plenty of available data so it would surely be possible to model the extent of entry. However, it would make the model and estimation much more complex, surely beyond what would be possible in a typical merger analysis by the FTC or DOJ. Additionally, it was not obvious to us that the benefit of such an analysis, which would primarily be a slightly more precise measure of post-merger concentration, was worth the large cost.

Additionally, in the model we have omitted the possibility of future mergers. In a market where mergers had an important influence on the industry structure over time, we would definitely want to include a model of mergers. However, because mergers between financially healthy carriers have been so rare in the airline industry, there is essentially no past data to work with. It seems unlikely that there will be many more mergers between major carriers after the mergers recently proposed are finalized, and our analysis will ignore this possibility.

Finally, in our analysis we will not explicitly allow for hub formation and destruction. Our set of city characteristics variables (Z_t) will include whether or not a city is a hub for a given airline, but this will be treated as exogenous and fixed. Airlines can grow and shrink their networks in each city (hubs and non-hubs), but they cannot form new hubs or dissolve old ones. It would be relatively straightforward to relax this assumption, but we think it is a reasonable approximation of the industry in the medium term so we will maintain it.

6 Data

The principle data source is the Bureau of Transportation Statistics (BTS) T-100 Domestic Segment Data set for the years 2003-2008. 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 relatively stationary, 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). Note that this means we are treating multiple airports at the same city as one. We feel that this is more appropriate for our purposes than treating them as separate destinations. Appendix A 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. Using the data on itineraries actually travelled as a guide (DB1B), we define an airline 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 so we exclude this possibility entirely. 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).

There are many flights that show up in our data as flown by regional carries (e.g. Mesa Air) that are in fact flown under contract with a major carrier. On these flights, the major carrier sells the tickets and, typically, the plane would have the major carrier's name on the outside and would generally appear to passengers to be owned by the major carrier (though in many cases it is not). Major carriers can contract with different regional airlines in different parts of the country and contracts change over time in terms of what routes are covered. Regional carriers may also fly some routes under their own name, selling tickets themselves. Flights flown by regional carriers represent about 25-30% of the flights in the major carrier's networks in our data, so ignoring them could potentially be very problematic. In our analysis we attribute flights flown by regional carriers under contract to a major carrier to the major carrier that they are contracted to. That is, if Mesa flies a plane under contract for Delta, we will call that a Delta flight for the purposes of the analysis, and treat it identically to a flight that Delta flies itself. (APPENDIX LISTING AFFILIATIONS?)

ENTRY/EXIT DEFS SOMEWHERE HERE OR JUST APPENDIX?

Table 1 lists some summary statistics for segment and market presence by airline for this data. Southwest has the most nonstop 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 nonstop routes. A striking feature of the data is the rapid expansion of Southwest and Jet Blue. The other major airlines are growing much more slowly. (Growth in US Airways' network is largely due to the merger with America West.) On average airlines enter and exit between five and ten percent of their routes per year.

Table 2 lists some summary statistics for the airline's networks, concentrating on the variables that we will use in the estimations. One observation in the data is an airline-city pair and there are ten airlines (not counting America West before it was merged into US Air) and 1770 city pairs.

City Pair Characteristics

In the literature, the most commonly used measure the underlying demand for air travel between two cities is the interaction of the populations of the cities. This population variable is intended to measure the total possible number of visits between residents of the two cities, but has the disadvantage that it ignores many other important features of demand such as city proximity, availability of alternative methods of transport, industrial activity, etc. We instead use a much better measure of underlying demand that we call "Log(2002 Passenger Density)" that measures the log actual passenger density (enplanements) for each market in the year 2002. The density variable more directly captures many of the unobservable aspects of market demand that are peculiar to a given city pair. Our hope is that using this variable will largely mitigate endogenity problems in the estimation due to the iid error assumption. Additionally, Boguslaski, Ito, and Lee (2004) have shown fairly that passenger density does a very good job in predicting Southwest's entry behavior. Note that in cases such as unserved markets where the density variable equals zero (over 25% of cases – see table 2), we set Log(Density) equal to zero.

A potential problem with using the density variable is that, if there were further unobserved demand shifters that were serially correlated, then, because density depends on the airline network, it would be endogenous. To mitigate this issue, rather than measuring density lagged one period, which would be valid under the iid assumption but invalid otherwise, we measure density in the period just prior to our estimation sample. As a robustness check we have also tried using density lagged one period and the results were virtually identical.

We also construct an additional density measure that we call "Log(Passenger Density in New Markets)" that reflects a particular route segment's importance in each airline's overall network from the point of view of total underlying network demand. Specifically, this variable considers the entire current route network of each airline and computes the log difference in total passenger density on the network (in 2002) with and without the route segment under consideration. It is meant to capture total potential revenue gain/loss across the entire network from adding/subtracting each route segment individually. This variable was inspired by an anecdote from Steve Berry... FIX THIS ... Note that this variable is zero more than 50% of the time reflecting both the presence of unserved markets as above, and also the fact that some routes in an airline's network are typically extraneous in the sense that they do not add any new markets to the network but merely duplicate existing service in a more convenient way.

Since passenger density is zero in unserved markets, we also use the standard population interaction variable to proxy underlying demand in those markets. Finally, a fourth demand variable, "percent tourist", measures the percentage of passengers travelling in each market who reported that their travel was for the purpose of tourism in the Household Transportation Survey. We found that other city characteristics such as household income had no explanatory power in our data so we excluded them from the analysis.

Competition Variables

We have also computed a large number of variables that measure competition on each route segment. First we divide competitors into non-stop and one-stop to help pick up consumers' preference for non-stop travel, as well as any cost considerations. The average city-pair has slightly less than one non-stop competitor and 3.5 one-stop competitors. Of course both of these variables have very skewed distributions with many zeros and few city-pairs that have a lot of competition. We also measure the number of code-share agreements that each airline has on each route segment.[3] Code shares are quite rare on average.

We have also computed a large number of concentration measures for each market. The variable "HHI Among Others (Market)" directly measures the concentration among rival carriers on the city pair in question, including both non-stop and one-stop competitors. The HHI among competitors averages about 0.5 in our sample (where HHI ranges from 0 to 1).

There is also substantial evidence (Borenstein (1989), Borenstein (1990), Borenstein (1991), Berry (1992)) that the size of a carrier's operations at the endpoint cities influences a carrier's market power on travel between those cities independently of concentration on the market itself. Thus, we also include variables measuring a carrier's market share at each endpoint city ("Own Share (City) Large/Small"). Note that these variables might also influence entry for cost reasons. For similar reasons we also include measures of concentration at each endpoint city ("HHI Among Others (City) Large/Small").

Note that if we measured the market share and HHI variables in the natural way, using enplaned passengers, then it would not be possible to simulate future values of the competition variables

[3]Note that this variable is compiled from data that is separately measured for each airline pair-route segment using the ticket data.

under a merger without also estimating a demand system that predicted enplaned passengers at future dates. Thus, we instead measure all of the HHI variables above using the number of routes served out of each city. It turns out that this yields essentially identical estimates empirically, so it seems to have little consequences.[4]

Our final measure of competition is whether or not a competitor has a hub on the route. (Own hubs are treated separately below.)

Network Characteristics

For each city-pair route segment we also have a large number of measures of local network characteristics. We measure segment (non-stop) presence and market (feasible one-stop) presence separately, as well as endpoint presence ("Present at Both Airports (not Market)"). All of these should have large effects on market presence through the cost side.

We also measure how many endpoint cities are own hubs for each airline. We also measure how convenient the most convenient hub is to the route segment by taking the non-stop distance and dividing by the one-stop distance for the closest hub. If a hub is very convenient, nearly on a straight line between the two cities, one might expect that the airline could very easily serve the route via one-stop travel. We also measure the distance to the nearest hub for each end, ranked (Large/Small), which is meant to be a measure of how central to the network the two endpoints are.

Finally, we measure the size of each airlines' network at the endpoint cities using the number of non-stop destinations served at each endpoint city, ranked (Large/Small). This variable could influence market presence through both the demand and the supply sides. Note that it is different

[4]It is not possible to do this for the "HHI Among Others (Market)" variable, so as mentioned below that variable is simply left fixed over the merger simulations.

than the share variables above because it measures network size rather than network share.

Distance Variables

Lastly, we include seven dummy variables for length of route. Again these variables could influence market presence through both the demand and the cost sides.

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

Tables 3-5 describe the amount of route overlap that currently exists in the U.S. airline network. The general story is that, with the exception of Southwest, there is not much direct overlap (typically around 10-20 percent) between any pair of major airlines in terms of nonstop flights. Meanwhile, there is much higher overlap (typically around 60-80 percent) if you include one-stop itineraries. The broad picture is one where passengers can choose between several major airlines for flights between most city pairs, but they would typically be routed on a one-stop flight through a different hub depending on which airline they chose. There is far less nonstop competition, except from Southwest, which has many nonstop flights and has substantial nonstop overlap with many of the major carriers.

Table 4 shows that Southwest, Delta and Northwest are the most isolated from competition in the sense that they have by far the most monopoly and duopoly nonstop routes. Note that the Delta-Northwest merger creates an airline that has substantial market power in nonstop routes. The story is less stark when we include one-stop routes. However, Delta and Northwest still have 31 monopoly one-stop markets and an additional 97 duopoly one-stop markets.

Table 5 allows us to look more closely at route overlap between any pair of carriers. Delta and

Northwest, for example, had only two nonstop routes on which they were the only two carriers prior to the merger (and three more in which there was a third carrier). United and US Air have one nonstop route on which they are the only two carriers, and United and Continental have none at all. There are also 34 one-stop markets in which Delta and Northwest were the only carriers with a third carrier. All of these markets would be expected to see price increases after the merger.

Table 6 shows the most affected individual city pairs for the three mergers in terms of increase in the HHI. For Delta-Northwest, there are two routes out of Cincinnati and one out of each of Atlanta and Minneapolis. For United-US Air the worst affected markets are out of Charlotte, Philidelphia, and Washington. For United-Continental, the worst affected routes are out of Denver and Cleveland.

There is some evidence (Borenstein (1989), Berry (1992)) that, due to frequent flyer programs, 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 Memphis and Cincinatti. 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. For United-Continental the worst affected markets are Cleveland and New York, though Houston should also be considered because it is already very highly concentrated.

7 Estimation and Results

The HHI 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 (5.1) 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 at least two types of carriers: hub carriers and low cost carriers, we do not necessarily want to assume symmetry across all carriers — at very least we should explore this empirically. Furthermore, given that we have only ten carriers and six years of data, that still only leaves 60 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 within an airline's network (across city pairs) 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 segments 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 segments that are geographically distant and also not connected in the network.

The simplest model we can think of would allow the entry decisions across segments 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 segment level shocks and that these shocks are independent across segments. We model segment presence, entry, and exit, using a probit model.

Note that in a model of this type, with entry on one side and competition on the other, we might expect there to be an upward bias in the coefficients on the competition variables if there are important omitted serially correlated 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, biasing the coefficients upward. One way to solve this problem is to have very good measures of underlying demand. We believe that in our case the passenger density variable largely solves this problem by giving us a very good measure of the underlying demand on each market. We will also include city fixed effects. Of course these two things would not entirely solve the problem if underlying demand conditions on a market change over time in a persistent way, but we have found that they seem to alleviate the problem considerably.

Best model has route fixed effects. See table 9 for estimates.

[ESTIMATES]

8 Robustness

9 Merger Simulations

Tables 12-**??** show simulation results for the hub/low cost pooled model above over the next 10 years. We run four simulations: no mergers, Delta-Northwest, United-USAir, and United-Continental.

[Partial Results in tables 8-20]

10 Conclusions

We draw two sets of conclusions from this research. The first is that our method seems like a simple yet effective way to provide some empirical insight and rigor to questions of how a particular merger will affect the evolution of an industry over time. While we have applied the method to airlines, it could equally well be applied to many industries, so long as there is rich enough past data available.

Of course the method is not without flaws, the primary one being that we can only consider mergers holding merger policy constant (assumption 1). On the other hand, while an ideal method of evaluating merger policy might involve computing new equilibria to the model under alternative policies, in many cases this would be infeasible. Clearly it would be far beyond what is currently possible to compute an equilibrium for the complex U.S. airline network.

[MORE]

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 segment 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 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.2 CSA Airport Correspondences

CSA code	CSA Airports	Pop 2000	Median Inc.	# pass (mark, 2000)	# deps 2000
12	BUR, LAX, ONT, SNA	16373645	52069	63366291	651974
32	MDW, ORD	9312255	54421	62343200	699212
22	EWR, JFK, LGA	21361797	56978	58882013	689529
4	ATL	4548344	52957	55337406	499976
37	OAK, SFO, SJC	7092596	66657	51131131	503844
18	DAL, DFW	5346119	49146	49770836	580463
13	BWI, DCA, IAD	7538385	67752	42311686	514799
45	PHX	3251876	48124	33102813	367510
26	HOU, IAH	4815122	46480	31547559	388080
19	DEN	2449054	55149	31311309	300264
29	LAS	1408250	49171	31081307	299968
10	BOS, MHT, PVD	1582997	51310	29349066	360982
23	FLL, MIA	5007564	43091	29309146	275868
57	STL	2698687	48361	25674940	303880
31	MCO	1697906	43952	25459140	236478
20	DTW	5357538	50471	25396816	280110
35	MSP	3271888	58459	25124724	267797
53	SEA	3604165	53900	22497342	238320
44	PHL	5833585	53266	18812458	241778
55	SLC	1454259	50357	16205369	148173
15	CLT	1897034	44402	16052317	198542
17	CVG	2050175	48022	15283486	197718
50	SAN	2813833	56335	15118565	163921
58	TPA	2395997	41852	14373207	144221
46	PIT	2525730	41648	13979823	182791
43	PDX	1927881	49227	12134527	150319
30	MCI	1901070	50179	11320857	151568
14	CLE	2945831	44049	10842047	192681
25	HNL	876156	60485	10320878	71179
36	MSY	1360436	39479	9497691	108138
47	RDU	1314589	49449	9221253	137888
33	MEM	1205204	41065	8651773	118131
8	BNA	1381287	45194	8552027	120258
56	SMF	1930149	54071	7728952	80867
54	SJU	2509007	19403	7067099	51241
6	BDL	1257709	59912	6963738	84986
5	AUS	1249763	50484	6950039	82864
27	IND	1843588	48399	6885666	93134
51	SAT	1711703	43263	6624018	77632
16	CMH	1835189	47075	6163317	89701
1	ABQ	729649	43070	5871686	71116
34	MKE	1689572	47799	5445851	90630
42	PBI	5007564	43091	5376385	51452
48	RNO	342885	48974	5294211	61475
28	JAX	1122750	47323	4955361	60860
38	OGG	128094	57573	4840509	49519
49	RSW	2395997	41852	4629297	42883
11	BUF	1170111	41947	3770970	54207
52	SDF	1292482	42943	3702821	57119
40	OMA	803201	48826	3585827	49920
60	TUS	843746	41521	3500323	39440
39	OKC	1160942	39743	3367555	53260
59	TUL	908528	40512	3253687	53582
21	ELP	679622	30968	3142143	47032
24	GEG	417939	41667	2933340	42947
7	BHM	1129721	43290	2884829	43839
9	BOI	464840	46960	2667242	41537
41	ORF	234403	31815	2577507	39326
2	ALB	825875	50828	2438339	37108
3	ANC	319605	60180	2293263	21837

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B Tables and Figures

Table 1: Airline Route and Market Statistics, 2003-2008

	Routes					Markets		
Carrier	**Avg**	**Min**	**Max**	**Entry/yr**	**Exit/yr**	**Avg**	**Min**	**Max**
American	224	219	232	7	8	1260	1237	1296
United	182	166	193	6	2	1331	1237	1372
Delta	230	220	241	14	14	1453	1400	1504
Continental	121	103	147	10	2	920	772	1126
Northwest	155	136	169	6	2	1173	1145	1215
USAirways	158	146	190	14	6	730	665	982
Southwest	298	269	323	15	4	937	824	1042
JetBlue	32	16	51	8	1	128	61	226
Alaska	41	37	43	2	1	115	94	123
DL + NW	373	349	386	18	14	1566	1550	1579
UA + US	309	292	341	16	7	1455	1379	1494
UA + CO	286	254	321	15	3	1485	1396	1523

Table 2: Airline Route and Market Statistics, 2003-2008

Regressor	**Avg**	**SD**	**Min**	**25%**	**50%**	**75%**	**Max**
City Pair Characteristics:							
Log(2002 Pass Dens)	7.6	5.6	0	0	11	13	16
Pop1*Pop2(*1e-12)*Dens=0	0.82	3.2	0	0	0	0.34	82
Log(Pass. Den. New Markets)	2.7	4.6	0	0	0	5.5	16
% Tourist	0.37	0.35	0	0	0.33	0.67	1
Competition Variables:							
Number Non-Stop Comps.	0.76	0.99	0	0	0	1	6
Number One-Stop Comps.	3.5	2	0	2	4	5	9
Number CS Agreements	0.051	0.23	0	0	0	0	3
Competitor Hub on Route	0.68	0.47	0	0	1	1	1
HHI Among Others (Market)	0.49	0.44	0	0	0.51	1	1
HHI Among Others Large (City)	0.32	0.15	0.012	0.2	0.28	0.42	0.72
HHI Among Others Small (City)	0.17	0.079	0.0054	0.13	0.16	0.2	0.68
Own Share Large (City)	0.16	0.16	0	0.051	0.11	0.21	0.85
Own Share Small (City)	0.056	0.068	0	0	0.042	0.074	0.77
Network Characteristics:							
Present in Segment	0.09	0.29	0	0	0	0	1
Present in Market (not Seg)	0.41	0.49	0	0	0	1	1
Present Both Apts (not Mark)	0.18	0.38	0	0	0	0	1
Number of Hubs	0.15	0.37	0	0	0	0	2
Hub Conv (NS dist/OS dist)	0.76	0.28	0.011	0.57	0.89	0.99	1
Dist Nearest Hub Sm (100s)	4.4	4.9	0	1.2	2.9	5.5	47
Dist Nearest Hub Lg (100s)	12	9.3	0	5	8.6	18	48
# Nonstops Small (City)	2.3	3.1	0	0	2	3	53
# Nonstops Large (City)	8.4	12	0	2	4	8	56
Distance Variables:							
Distance > 250	0.95	0.21	0	1	1	1	1
Distance > 500	0.84	0.37	0	1	1	1	1
Distance > 1000	0.58	0.49	0	0	1	1	1
Distance > 1500	0.37	0.48	0	0	0	1	1
Distance > 2000	0.22	0.42	0	0	0	0	1
Distance > 2500	0.11	0.32	0	0	0	0	1
Distance > 3000	0.075	0.26	0	0	0	0	1

Table 3: Airline Route Network Overlap A

In each cell is the percentage of segments/markets flown by the row airline, that are also flown by the column airline. The diagonal is the total number of segments flown by the row airline.

	2008: segments	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Other	370	53	15	14	17	9	8	11	11	5	2	19	23	21
2	Other Low Cost	27	715	18	17	20	14	8	11	14	5	2	24	27	23
3	American (AA)	25	59	223	37	34	22	15	8	13	11	3	28	45	48
4	United (UA)	28	62	44	190	51	15	8	7	21	7	8	21	100	100
5	Southwest (WN)	20	45	24	30	323	11	10	4	25	2	6	14	46	37
6	Delta (DL)	15	45	22	13	15	220	20	5	12	15	2	100	22	29
7	Continental (CO)	21	41	23	11	23	29	146	7	12	19	1	34	22	100
8	Northwest (NW)	25	50	11	9	8	7	6	157	10	0	1	100	17	15
9	USAirways (US)	21	52	16	21	42	14	9	8	190	8	2	21	100	29
10	JetBlue (B6)	34	74	48	28	16	66	56	0	32	50	4	66	48	72
11	Alaska (AS)	16	28	16	37	44	9	5	5	9	5	43	12	47	42
12	DL + NW	19	47	17	11	12	60	14	43	11	9	1	366	19	22
13	UA + US	25	57	29	56	43	14	9	8	56	7	6	21	341	60
14	UA + CO	25	52	33	59	38	20	46	7	17	11	6	26	64	320

	2008: markets	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Other	370	53	89	92	63	91	74	78	62	17	8	95	94	97
2	Oth Low Cost	27	715	83	90	65	93	72	75	79	21	8	96	96	93
3	American (AA)	26	46	1272	84	62	91	80	74	58	17	4	94	88	93
4	United (UA)	25	47	79	1366	62	91	71	74	63	16	8	95	100	100
5	Southwest (WN)	22	45	76	81	1042	86	69	67	64	15	8	89	87	91
6	Delta (DL)	23	45	78	84	60	1489	70	71	62	15	7	100	90	91
7	Cont. (CO)	24	46	91	86	64	93	1125	77	65	20	4	95	90	100
8	Northwest (NW)	25	47	82	88	61	92	76	1145	60	16	6	100	91	95
9	US Air (US)	23	58	76	88	67	95	75	70	982	20	8	96	100	92
10	JetBlue (B6)	27	65	97	95	67	100	99	82	87	226	14	100	98	99
11	Alaska (AS)	24	48	43	88	70	85	40	53	60	26	123	85	89	91
12	DL + NW	22	43	76	82	59	94	68	72	59	14	7	1580	88	90
13	UA + US	23	46	75	92	61	91	68	71	66	15	7	94	1483	95
14	UA + CO	24	44	78	90	62	89	74	71	59	15	7	93	92	1526

Table 4: Airline Route Network Overlap B

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

			with number of competitors equal to										
	2008: segments	Total	0	1	2	3	4	5	6	7	8	9	10
1	Other	370	108	111	76	43	21	8	3	0	0	0	0
2	Other Low Cost	715	200	245	144	79	33	10	4	0	0	0	0
3	American (AA)	223	21	49	66	41	31	11	4	0	0	0	0
4	United (UA)	190	4	31	71	49	22	9	4	0	0	0	0
5	Southwest (WN)	323	51	94	92	64	14	7	1	0	0	0	0
6	Delta (DL)	220	64	66	35	17	21	13	4	0	0	0	0
7	Continental (CO)	146	30	45	28	13	18	9	3	0	0	0	0
8	Northwest (NW)	157	42	60	33	15	5	1	1	0	0	0	0
9	USAirways (US)	190	30	46	54	38	13	8	1	0	0	0	0
10	JetBlue (B6)	50	0	4	8	10	14	11	3	0	0	0	0
11	Alaska (AS)	43	6	17	11	3	3	3	0	0	0	0	0
12	DL + NW	366	108	125	63	33	21	13	3	0	0	0	0
13	UA + US	341	35	85	121	61	28	8	3	0	0	0	0
14	UA + CO	320	34	78	99	57	38	13	1	0	0	0	0

			with number of competitors equal to										
	2008: markets	Total	0	1	2	3	4	5	6	7	8	9	10
1	Other	370	0	2	13	35	23	52	50	86	62	34	13
2	Other Low Cost	715	0	10	24	40	64	93	143	173	112	43	13
3	American (AA)	1272	13	29	58	105	174	237	261	219	120	43	13
4	United (UA)	1366	6	21	87	113	209	271	265	218	120	43	13
5	Southwest (WN)	1042	11	49	64	83	136	169	197	168	114	38	13
6	Delta (DL)	1489	13	50	99	143	238	274	276	220	120	43	13
7	Continental (CO)	1125	7	14	33	67	152	217	242	217	120	43	13
8	Northwest (NW)	1145	15	19	59	80	153	204	234	205	120	43	13
9	USAirways (US)	982	5	21	42	55	107	152	221	203	120	43	13
10	JetBlue (B6)	226	0	0	1	3	7	21	29	50	59	43	13
11	Alaska (AS)	123	2	11	12	12	17	14	14	1	13	14	13
12	DL + NW	1580	31	97	150	249	303	312	247	135	43	13	0
13	UA + US	1483	13	57	121	204	286	342	265	139	43	13	0
14	UA + CO	1526	13	38	144	250	329	311	260	125	43	13	0

Note: the 13 markets that are served by ALL 11 carriers are as follows:
Boston - Los Angeles, Boston - Las Vegas, Boston - San Francisco, Boston - Phoenix, Boston - San Diego, Los Angeles - Washington, Los Angeles - Miami, Los Angeles - Orlando, Washington - Las Vegas, Washington - San Francisco, Washington - San Diego, Miami - San Francisco, Orlando - San Francisco

Table 5: Airline Route Network Overlap C

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

	2008: segments	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Other	—	72	6	2	2	3	10	11	2	1	2	14	4	13
2	Other Low Cost	55	—	20	19	26	35	12	39	19	0	3	77	41	31
3	American (AA)	14	41	—	3	14	4	0	2	0	0	0	6	3	3
4	United (UA)	16	33	26	—	2	2	0	0	1	0	2	2	0	0
5	Southwest (WN)	26	47	20	38	—	12	13	2	15	0	8	14	24	16
6	Delta (DL)	6	25	9	4	9	—	5	2	3	0	0	0	5	7
7	Continental (CO)	8	15	5	2	10	6	—	2	2	0	1	7	2	0
8	Northwest (NW)	15	25	5	5	2	3	4	—	2	0	0	0	2	2
9	USAirways (US)	9	36	9	10	26	5	4	7	—	2	0	5	0	3
10	JetBlue (B6)	2	7	2	0	0	3	2	0	0	—	1	0	2	0
11	Alaska (AS)	1	4	1	8	6	0	0	0	2	0	—	0	2	3
12	DL + NW	22	45	14	9	11	0	10	0	12	3	0	—	0	0
13	UA + US	28	71	40	0	62	11	6	14	0	0	10	0	—	0
14	UA + CO	22	51	32	0	50	10	0	9	14	2	8	0	0	—

	2008: markets	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Other	—	0	1	0	0	1	0	0	0	0	0	1	0	0
2	Other Low Cost	0	—	2	4	0	4	0	0	0	0	0	5	5	4
3	American (AA)	6	5	—	1	12	9	0	4	0	0	0	15	3	1
4	United (UA)	8	8	18	—	3	3	0	7	2	0	1	29	0	0
5	Southwest (WN)	2	3	20	33	—	14	6	0	9	0	5	18	22	9
6	Delta (DL)	8	15	31	41	19	—	2	3	10	0	4	0	16	5
7	Continental (CO)	0	0	21	1	9	19	—	5	0	0	1	14	1	0
8	Northwest (NW)	1	5	12	37	15	34	11	—	0	0	0	0	9	12
9	USAirways (US)	0	11	2	17	18	28	5	3	—	0	0	11	0	3
10	JetBlue (B6)	0	1	1	0	0	0	0	0	0	—	0	0	0	0
11	Alaska (AS)	1	0	0	11	9	3	0	0	0	0	—	4	1	4
12	DL + NW	13	31	61	77	40	0	26	0	40	0	12	—	0	0
13	UA + US	9	20	23	0	48	80	10	41	0	0	11	0	—	0
14	UA + CO	8	10	56	0	44	82	0	50	26	0	12	0	0	—

Table 6: Top 5 Routes by HHI Increase, Passengers Enplaned, 2008

DL-NW					
		# Top 10 Carriers	HHI Passengers		
CSA1	CSA2	Pre-Merger	Pre	Post	Chng
CVG	MSP	2	5066	9996	4930
CVG	DTW	2	4918	9830	4912
ATL	FLL, MIA	2	5230	9993	4763
MSP	SLC	2	3526	6558	3032
BUR, LAX, ONT, SNA	HNL	5	3520	6292	2772
UA-US					
		# Top 10 Carriers	HHI Passengers		
CSA1	CSA2	Pre-Merger	Pre	Post	Chng
OAK, SFO, SJC	PHL	2	5348	9999	4651
CLT	DEN	2	5893	10000	4107
BUR, LAX, ONT, SNA	PHL	2	6155	9989	3834
CLT	MDW, ORD	3	4250	7690	3440
BWI, DCA, IAD	MSY	3	3617	6876	3259
UA-CO					
		# Top 10 Carriers	HHI Passengers		
CSA1	CSA2	Pre-Merger	Pre	Post	Chng
CLE	DEN	2	5414	9988	4574
DEN	HOU,IAH	3	3500	5889	2389
DEN	EWR, JFK, LGA	4	3443	5223	1780
BWI, DCA, IAD	CLE	3	3784	5058	1274
HOU,IAH	MDW,ORD	4	3053	4296	1243

Table 7: Top 10 Cities by HHI Increase, Passengers Enplaned, 2008

DL-NW				
	# Top 10 Carriers	HHI Passengers		
CSA	Pre-Merger	Pre	Post	Chng
MEM	6	5549	6606	1057
CVG	6	7683	8143	460
MSP	6	5481	5928	447
BDL	7	1782	2222	440
DTW	7	4796	5187	391
IND	7	1490	1859	369
SDF	7	2049	2330	281
JAX	8	1518	1772	254
RSW	8	1245	1489	244
ORF	7	1865	2100	235
UA-US				
	# Top 10 Carriers	HHI Passengers		
CSA	Pre-Merger	Pre	Post	Chng
BWI, DCA, IAD	9	1597	2326	729
PHL	7	3573	4165	592
PIT	8	1852	2422	570
ALB	7	2305	2775	470
ORF	7	1865	2331	466
CLT	7	7041	7484	443
BDL	7	1782	2149	367
BOS, MHT, PVD	9	1313	1659	346
PHX	9	2886	3216	330
CMH	7	1596	1884	288
UA-CO				
	# Top 10 Carriers	HHI Passengers		
CSA	Pre-Merger	Pre	Post	Chng
CLE	7	3889	4559	670
EWR, JFK, LGA	8	1683	1975	292
OMA	7	1482	1741	259
DEN	9	3031	3281	250
MSY	8	1578	1828	250
HOU, IAH	8	4782	5024	242
OKC	7	1929	2130	201
OAK, SFO, SJC	9	1971	2158	187
SAT	7	2112	2296	184
ALB	7	2305	2472	167

Table 8: Probit for Entry/Exit/Stay, Pooled Estimates

	Hub Carriers		Low Cost Carriers		All Carriers Pooled	
	Beta	SE	Beta	SE	Beta	SE
Demand Vars:						
Log(2002 Pass Dens)	0.089	0.012	0.067	0.022	0.092	0.0078
Pop1*Pop2(*1e-12)*Dens=0	0.0057	0.015	0.021	0.012	0.017	0.0060
Log Pass. Den. New Markets	0.028	0.0062	-0.011	0.012	0.022	0.0044
% Tourist	0.075	0.089	0.26	0.14	0.12	0.063
Competition Vars:						
Number NonStop Comps.	-0.093	0.035	-0.18	0.083	-0.13	0.028
Number One-Stop Comps.	-0.046	0.025	-0.064	0.050	-0.019	0.019
Number CS Agreements	0.45	0.072	-0.19	0.43	0.36	0.059
Competitor Hub on Route	0.14	0.096	-0.15	0.19	0.072	0.068
HHI Among Others (Market)	-0.030	0.072	-0.00039	0.15	-0.036	0.055
HHI Among Others Large (City)	1.43	0.53	-4.01	0.95	1.30	0.38
HHI Among Others Small (City)	1.21	1.24	-8.02	1.24	1.30	0.72
Own Share Large (City)	3.39	0.67	-2.37	0.87	2.99	0.44
Own Share Small (City)	2.72	0.63	-2.22	1.38	2.29	0.43
Network Vars:						
Present in Route	3.06	0.14	4.59	0.17	3.42	0.074
Present in Market (not Rt)	0.050	0.14	0.47	0.16	0.16	0.070
Present Both Apts (not Mark)	-0.24	0.14	0.33	0.17	-0.0090	0.072
Number of Hubs	0.73	0.10	0.24	0.14	0.48	0.058
Hub Conv (NS dist/OS dist)	-0.11	0.21	-1.18	0.45	-0.086	0.15
Dist Nearest Hub Sm (100s)	0.040	0.013	-0.10	0.026	0.0037	0.0098
Dist Nearest Hub Lg (100s)	0.0050	0.0073	-0.0045	0.011	0.013	0.0046
# Nonstops Small (City)	-0.0001	0.016	-0.025	0.022	-0.0049	0.0090
# Nonstops Large (City)	0.018	0.0050	0.048	0.010	0.014	0.0032
Distance > 250	0.16	0.11	0.62	0.26	0.25	0.080
Distance > 500	-0.030	0.093	-0.20	0.16	-0.17	0.069
Distance > 1000	-0.13	0.082	-0.074	0.15	-0.16	0.060
Distance > 1500	-0.19	0.10	-0.24	0.19	-0.22	0.074
Distance > 2000	-0.025	0.12	0.017	0.22	-0.056	0.090
Distance > 2500	0.14	0.17	-0.095	0.23	0.065	0.11
Distance > 3000	-0.84	0.26			-0.82	0.21
USAIR 2007 dummy	0.85	0.15			0.88	0.12
N	63720		31860		95580	
Likelihood	-1939		-750		-2897	
Note: includes year and city dummies.						

Table 9: Probit for Entry/Exit/Stay, Pooled, Route Fixed Effects

		All Carriers Pooled			
Variable	Units	Beta	SE	Marg Eff	Marg Eff 1SD
Demand Vars:					
Log Pass Dens New Mkts		2.09	5.02	0.83	0.004
Direct Competitors:					
1 Nonstop Comp	{0,1}	-1.76	0.07	-0.70	-0.32
2 Nonstop Comps	{0,1}	-2.67	0.11	-1.07	-0.36
3 Nonstop Comps	{0,1}	-3.40	0.14	-1.36	-0.28
4 Nonstop Comps	{0,1}	-4.26	0.20	-1.70	-0.19
>4 Nonstop Comps	{0,1}	-4.96	0.30	-1.98	-0.14
Other Comp Vars:					
Number CS Agreements	0-3	0.12	0.06	0.05	0.011
Competitor Hub on Route	{0,1}	-0.39	0.08	-0.16	-0.073
HHI Among Others Lg (City)	[0,1]	0.44	0.16	0.18	0.027
HHI Among Others Sm (City)	[0,1]	-2.09	0.08	-0.84	-0.066
Own Share Large (City)	[0,1]	2.14	0.06	0.85	0.140
Own Share Small (City)	[0,1]	1.77	0.06	0.71	0.048
Network Vars:					
Present in Route	{0,1}	2.75	0.06	1.10	0.32
Present in Mkt (not Rt)	{0,1}	0.12	0.07	0.05	0.024
Number of Hubs	0-2	0.39	0.08	0.16	0.059
Hub Conv (NS dist/OS dist)	[0,1]	-0.28	0.02	-0.11	-0.031
Dist Nearest Hub Sm	1000mi	-0.25	0.02	-0.10	-0.048
Dist Nearest Hub Lg	1000mi	0.49	0.06	0.19	0.18
# Nonstops Small (City)	0-54	0.008	0.013	0.003	0.011
# Nonstops Lg (City)	0-57	0.027	0.004	0.011	0.13
N		95580			
Likelihood		-2370			
Note: includes year and route dummies.					

Table 10: Measures of Fit by Airline: All Airlines Pooled, Route FE's

	Actual Last Period Status				Full Sample Simulated	
	Stay		Switch		Switchers, Whole Period	
Airline	In	Out	In	Out	In	Out
American (25,27)	0.978	0.996	0.166	0.148	0.482	0.617
United (25,5)	0.986	0.997	0.204	0.248	0.679	0.595
Southwest (76,11)	0.979	0.989	0.183	0.150	0.629	0.643
Delta (34,51)	0.976	0.995	0.174	0.172	0.572	0.891
Continental (41,5)	0.985	0.996	0.226	0.110	0.796	0.769
Northwest (19,8)	0.992	0.997	0.095	0.139	0.664	0.809
USAirways (73,29)	0.983	0.996	0.122	0.211	0.902	0.750
JetBlue (38,0)	0.927	0.997	0.062	0.250	0.305	NaN
Alaska (7,1)	0.971	0.997	0.127	0.309	0.503	0.999

Table 11: Model Selection: Probit and ANN dimension

Model	CV Likelihood	BIC
Probit	-618	4941
ANN (dim=0)	-630	5000
ANN (dim=1)	-641	4981
ANN (dim=2)	-686	5077
ANN (dim=3)	-697	5264
ANN (dim=4)	-730	5484
ANN (dim=5)	-757	5597
ANN (dim=15)	–	7894
ANN (dim=20)	–	9104

Table 12: 10 year simulations, Median Routes

Median number of routes served, by year

Number of simulations: 1,000 Time dummies: year 2008

Year	**0**	1	2	3	4	5	6	7	8	9	10
	No merger										
American	226	224	222	222	220	220	218	217	217	216	214
United	191	192	194	193	194	194	194	194	193	193	192
Southwest	336	342	348	353	358	361	366	368	371	375	378
Delta	224	222	220	217	216	213	212	211	209	207	205
Continental	147	148	148	150	150	150	151	152	151	152	152
Northwest	157	159	160	162	162	162	162	162	162	162	162
USAirways	200	201	202	202	202	202	202	204	204	205	205
JetBlue	55	54	53	51	50	50	49	48	46	46	44
Alaska	45	47	49	51	52	54	54	55	56	58	60
	DL-NW merger										
American	226	224	223	221	219	219	218	217	215	213	212
United	191	192	194	194	193	194	193	193	192	191	191
Southwest	336	341	346	350	354	357	359	361	364	366	367
DL + NW	370	374	376	379	381	383	385	385	388	389	391
Continental	147	148	149	149	149	149	150	150	150	149	149
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	200	201	202	202	202	202	202	201	201	200	201
JetBlue	55	54	54	52	51	49	49	47	45	45	43
Alaska	45	47	49	50	51	53	54	55	57	56	57
	UA-US merger										
American	226	226	224	223	222	220	219	219	217	216	214
UA + US	353	357	361	366	369	371	375	377	380	382	384
Southwest	336	344	350	355	359	363	366	370	371	373	375
Delta	224	223	221	219	217	215	213	210	208	205	204
Continental	147	149	150	151	151	152	152	151	152	152	152
Northwest	157	160	162	163	163	163	163	163	163	162	163
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	55	55	55	54	53	52	51	50	48	47	46
Alaska	45	49	51	54	55	58	59	60	61	63	64
	UA-CO merger										
American	226	224	223	221	220	219	218	218	217	217	216
UA + CO	322	325	328	330	334	336	338	340	342	342	344
Southwest	336	342	348	353	357	360	364	366	368	370	372
Delta	224	222	219	216	214	212	210	206	205	204	201
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	157	159	161	162	162	162	162	162	161	161	161
USAirways	200	202	204	204	204	205	206	206	205	205	206
JetBlue	55	54	54	54	52	51	49	50	49	47	46
Alaska	45	48	50	51	53	53	56	57	58	60	61

Table 13: Routes: Distribution in Year 10

Number of simulations: 1,000 Horizon: effect in 10 years

	Number of Routes Served								Number of Markets Served							
Carrier	**base**	mean	std	min	max	q0.25	med	q0.75	**base**	mean	std	min	max	q0.25	med	q0.75
	No merger															
American	226	214	8	190	233	371	214	210	1273	1282	29	1215	1363	1323	1283	1159
United	191	193	7	178	214	371	192	210	1366	1378	35	1275	1441	1323	1384	1159
Southwest	336	378	11	349	411	371	378	210	1057	1362	52	1248	1490	1323	1361	1159
Delta	224	204	7	191	223	371	205	210	1489	1465	17	1409	1497	1323	1465	1159
Continental	147	152	5	138	165	371	152	210	1133	1152	26	1091	1204	1323	1155	1159
Northwest	157	162	5	151	172	371	162	210	1145	1156	11	1135	1191	1323	1155	1159
USAirways	200	205	7	180	221	371	205	210	1158	1135	32	1035	1195	1323	1137	1159
JetBlue	55	45	8	26	71	371	44	210	210	176	45	81	292	1323	177	1159
Alaska	45	60	8	43	89	371	60	210	144	201	31	135	329	1323	198	1159
	DL-NW merger															
American	226	212	7	190	230	361	212	205	1273	1283	33	1212	1369	1302	1279	1153
United	191	191	7	174	213	361	191	205	1366	1378	34	1276	1439	1302	1379	1153
Southwest	336	367	10	333	390	361	367	205	1057	1334	47	1211	1452	1302	1333	1153
DL + NW	370	392	10	371	411	361	391	205	1580	1585	9	1563	1609	1302	1584	1153
Continental	147	149	5	138	161	361	149	205	1133	1148	25	1089	1193	1302	1153	1153
-merged-	0	0	0	0	0	361	0	205	0	0	0	0	0	1302	0	1153
USAirways	200	200	7	183	214	361	201	205	1158	1134	29	1028	1208	1302	1137	1153
JetBlue	55	43	8	21	64	361	43	205	210	184	47	56	306	1302	187	1153
Alaska	45	58	7	45	79	361	57	205	144	195	24	147	259	1302	191	1153
	UA-US merger															
American	226	215	7	193	236	369	214	0	1273	1277	31	1202	1347	1329	1270	0
UA + US	353	383	9	362	411	369	384	0	1511	1533	15	1478	1566	1329	1535	0
Southwest	336	375	10	354	403	369	375	0	1057	1365	48	1267	1474	1329	1362	0
Delta	224	204	8	182	221	369	204	0	1489	1469	15	1432	1502	1329	1470	0
Continental	147	152	5	141	164	369	152	0	1133	1151	26	1090	1203	1329	1156	0
Northwest	157	163	5	154	177	369	163	0	1145	1162	15	1132	1219	1329	1162	0
-merged-	0	0	0	0	0	369	0	0	0	0	0	0	0	1329	0	0
JetBlue	55	47	8	30	70	369	46	0	210	179	49	88	311	1329	177	0
Alaska	45	64	8	47	89	369	64	0	144	220	32	148	301	1329	219	0
	UA-CO merger															
American	226	215	7	201	231	367	216	210	1273	1282	27	1229	1361	1317	1281	1157
UA + CO	322	344	8	317	359	367	344	210	1527	1560	15	1513	1592	1317	1564	1157
Southwest	336	373	11	349	404	367	372	210	1057	1344	43	1234	1461	1317	1340	1157
Delta	224	202	6	187	217	367	201	210	1489	1466	14	1429	1499	1317	1468	1157
-merged-	0	0	0	0	0	367	0	210	0	0	0	0	0	1317	0	1157
Northwest	157	161	5	148	175	367	161	210	1145	1158	15	1134	1209	1317	1154	1157
USAirways	200	206	7	181	222	367	206	210	1158	1133	32	1056	1189	1317	1142	1157
JetBlue	55	46	7	30	70	367	46	210	210	189	42	119	330	1317	188	1157
Alaska	45	61	7	45	79	367	61	210	144	202	25	137	274	1317	206	1157

Table 14: Aggregate Concentration: Distribution in Year 10 (Markets)

Number of simulations: 1,000 Horizon: effect in 10 years

Number of ...	**base**	mean	std	min	max	q0.25	med	q0.75
	No merger							
markets with 0 carriers	23	17	2	12	22	16	17	19
markets with 1 carrier	76	67	5	57	83	64	67	69
markets with 2 carriers	119	115	6	101	128	112	114	119
markets with 3 carriers	178	159	10	139	190	152	157	165
markets with >=4 carriers	1374	1412	13	1381	1439	1404	1415	1422
	DL-NW merger							
markets with 0 carriers	23	17	2	12	24	16	17	18
markets with 1 carrier	79	68	5	58	89	65	69	71
markets with 2 carriers	145	142	7	125	162	137	142	147
markets with 3 carriers	219	191	16	153	229	181	190	202
markets with >=4 carriers	1304	1352	20	1315	1402	1340	1352	1365
	UA-US merger							
markets with 0 carriers	23	17	2	13	22	16	16	18
markets with 1 carrier	79	67	4	59	76	64	67	70
markets with 2 carriers	148	128	8	106	148	122	128	134
markets with 3 carriers	247	217	14	184	247	207	218	227
markets with >=4 carriers	1273	1341	19	1299	1385	1327	1345	1353
	UA-CO merger							
markets with 0 carriers	23	17	2	12	23	16	16	17
markets with 1 carrier	74	66	5	56	84	63	66	69
markets with 2 carriers	124	120	6	103	136	115	119	124
markets with 3 carriers	203	184	11	164	215	176	182	190
markets with >=4 carriers	1346	1384	14	1348	1410	1376	1386	1394

Table 15: Concentration: Distribution in Year 10 (Routes)

Number of simulations: 1,000 Horizon: effect in 10 years

Number of ...	**base**	mean	std	min	max	q0.25	med	q0.75
	No merger							
markets with 0 carriers	843	838	4	829	847	836	838	841
markets with 1 carrier	504	512	6	499	532	509	513	516
markets with 2 carriers	265	242	7	222	262	237	243	247
markets with 3 carriers	107	119	7	104	138	115	119	123
markets with >=4 carriers	51	59	4	49	68	56	58	61
	DL-NW merger							
markets with 0 carriers	843	835	4	826	844	832	834	837
markets with 1 carrier	510	519	6	505	533	515	519	523
markets with 2 carriers	259	239	7	222	257	233	239	244
markets with 3 carriers	109	119	6	105	135	114	119	123
markets with >=4 carriers	49	59	4	49	70	56	59	61
	UA-US merger							
markets with 0 carriers	843	836	4	828	844	833	836	838
markets with 1 carrier	510	512	6	491	526	507	511	516
markets with 2 carriers	276	252	9	233	284	247	252	257
markets with 3 carriers	100	118	7	98	134	114	118	123
markets with >=4 carriers	41	52	4	43	61	50	53	55
	UA-CO merger							
markets with 0 carriers	843	838	4	830	847	835	838	840
markets with 1 carrier	505	513	7	493	528	509	513	519
markets with 2 carriers	268	242	8	213	262	236	242	248
markets with 3 carriers	107	122	7	108	144	117	121	125
markets with >=4 carriers	47	56	4	46	68	53	56	57

Table 16: City Simulations: Memphis, Routes

Median number of routes served, by year

Number of simulations: 1,000 Time dummies: year 2008

Year	**0**	1	2	3	4	5	6	7	8	9	10
	No merger										
American	5	5	5	4	4	4	4	4	4	4	4
United	2	2	2	2	2	2	2	2	2	2	2
Southwest	0	0	0	1	1	1	1	1	1	1	1
Delta	2	2	2	2	2	2	2	2	2	2	2
Continental	2	2	2	2	2	2	2	2	2	2	2
Northwest	38	38	38	38	38	38	39	39	39	39	39
USAirways	2	2	2	2	2	2	2	2	2	2	2
JetBlue	0	0	0	0	0	0	0	0	0	0	0
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	5709	5709	5709	5679	5679	5679	5713	5713	5747	5747	5747
	DL-NW merger										
American	5	5	4	4	4	4	4	4	4	4	4
United	2	2	2	2	2	2	2	2	2	2	2
Southwest	0	0	0	1	1	1	1	1	1	1	1
DL + NW	39	40	40	40	40	40	40	40	40	40	41
Continental	2	2	2	2	2	2	2	2	2	2	2
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	2	2	2	2	2	2	2	2	2	2	2
JetBlue	0	0	0	0	0	0	0	0	0	0	0
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	6232	6294	6512	6263	6263	6263	6263	6263	6263	6263	6324

Table 17: City Simulations: Cincinatti, Routes

Median number of routes served, by year

Number of simulations: 1,000 Time dummies: year 2008

Year	**0**	1	2	3	4	5	6	7	8	9	10
	No merger										
American	4	4	4	3	3	3	3	3	3	3	3
United	3	3	3	3	3	3	3	3	3	3	3
Southwest	0	0	0	0	0	0	0	0	0	0	0
Delta	49	49	49	49	49	49	49	49	49	49	49
Continental	3	3	3	3	3	3	3	3	3	3	3
Northwest	2	2	2	2	2	2	2	2	2	2	2
USAirways	2	2	2	2	2	2	2	2	2	2	2
JetBlue	0	0	0	0	0	0	0	0	0	0	0
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	6155	6155	6155	6337	6337	6337	6337	6337	6337	6337	6337
	DL-NW merger										
American	4	4	4	4	4	3	3	3	3	3	3
United	3	3	3	3	3	3	3	3	3	3	3
Southwest	0	0	0	0	0	0	0	0	0	0	0
DL + NW	49	49	49	49	49	49	50	50	50	50	50
Continental	3	3	3	3	3	3	3	3	3	3	3
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	2	2	2	2	2	2	2	2	2	2	2
JetBlue	0	0	0	0	0	0	0	0	0	0	0
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	6555	6555	6555	6555	6555	6756	6802	6802	6802	6802	6802

Table 18: City Simulations: DC, Routes

Median number of routes served, by year

Number of simulations: 1,000 Time dummies: year 2008

Year	**0**	1	2	3	4	5	6	7	8	9	10
	No merger										
American	10	10	10	9	9	9	8	8	8	8	8
United	42	42	42	42	43	43	43	43	43	43	43
Southwest	34	35	35	36	36	37	38	39	39	40	40
Delta	6	6	6	6	6	6	6	6	6	6	6
Continental	3	3	3	3	3	3	4	4	4	4	4
Northwest	4	4	4	4	4	4	4	5	5	5	5
USAirways	27	27	27	27	27	27	27	27	27	26	26
JetBlue	7	7	6	5	5	5	4	4	3	3	3
Alaska	2	2	3	3	3	4	4	4	4	4	4
HHI	2120	2126	2122	2176	2190	2196	2198	2175	2201	2221	2215
	UA-US merger										
American	10	11	11	11	11	10	10	10	10	9	9
UA + US	45	45	46	46	46	46	46	46	46	46	46
Southwest	34	36	37	38	39	40	41	41	42	42	42
Delta	6	7	7	8	8	8	8	8	8	8	8
Continental	3	4	4	4	5	4	4	5	4	4	5
Northwest	4	4	5	5	5	6	6	6	6	6	6
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	7	7	7	7	6	6	6	5	5	5	5
Alaska	2	3	4	5	6	7	7	8	8	8	9
HHI	2755	2631	2569	2510	2484	2491	2496	2470	2515	2543	2480

Table 19: City Simulations: Philadelphia, Routes

Median number of routes served, by year

Number of simulations: 1,000 Time dummies: year 2008

Year	0	1	2	3	4	5	6	7	8	9	10
	No merger										
American	5	5	5	5	5	5	5	5	5	5	5
United	5	5	5	5	5	5	5	5	5	5	5
Southwest	15	15	15	15	15	15	15	15	15	15	15
Delta	5	5	5	5	5	5	5	5	5	5	5
Continental	2	2	2	2	3	3	3	3	3	3	3
Northwest	4	4	4	4	4	4	4	4	4	4	4
USAirways	42	42	42	42	42	42	42	42	42	42	42
JetBlue	0	0	0	0	0	0	0	0	0	0	0
Alaska	0	0	0	1	1	1	1	1	2	2	2
HHI	3425	3425	3425	3341	3302	3266	3266	3266	3207	3190	3190
	UA-US merger										
American	5	5	5	6	5	5	5	6	6	5	5
UA + US	42	42	42	42	42	42	42	42	42	42	42
Southwest	15	16	16	16	16	16	16	16	16	16	17
Delta	5	5	5	5	5	5	5	5	5	5	4
Continental	2	2	3	3	3	3	3	3	3	3	3
Northwest	4	4	4	4	4	4	4	4	4	4	4
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	0	0	0	0	0	0	0	0	0	0
Alaska	0	1	1	2	2	2	2	2	3	3	3
HHI	3864	3717	3672	3468	3540	3540	3540	3468	3389	3495	3498

Table 20: City Simulations: Cleveland, Routes

Median number of routes served, by year

Number of simulations: 1,000 Time dummies: year 2008

Year	**0**	1	2	3	4	5	6	7	8	9	10
	No merger										
American	3	3	3	3	3	3	4	4	4	4	4
United	3	3	3	3	3	3	3	3	3	3	3
Southwest	6	6	6	6	6	6	6	6	6	6	6
Delta	4	4	4	4	4	4	4	4	4	4	4
Continental	41	41	41	41	41	41	41	41	41	41	41
Northwest	3	3	3	3	3	3	3	3	3	3	3
USAirways	3	3	3	3	3	3	3	4	4	4	4
JetBlue	0	0	0	0	0	0	0	0	0	0	0
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	4457	4457	4457	4457	4457	4457	4336	4277	4220	4220	4220
	UA-CO merger										
American	3	3	3	3	3	3	4	4	4	4	4
UA + CO	41	41	41	41	41	41	41	41	41	41	41
Southwest	6	6	6	6	6	6	6	6	6	6	6
Delta	4	4	4	4	4	4	4	4	4	4	4
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	3	3	3	3	3	3	3	3	3	3	3
USAirways	3	3	4	4	4	4	4	4	4	4	4
JetBlue	0	0	0	0	0	0	0	0	0	0	0
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	4889	4889	4749	4749	4749	4749	4615	4615	4615	4615	4615

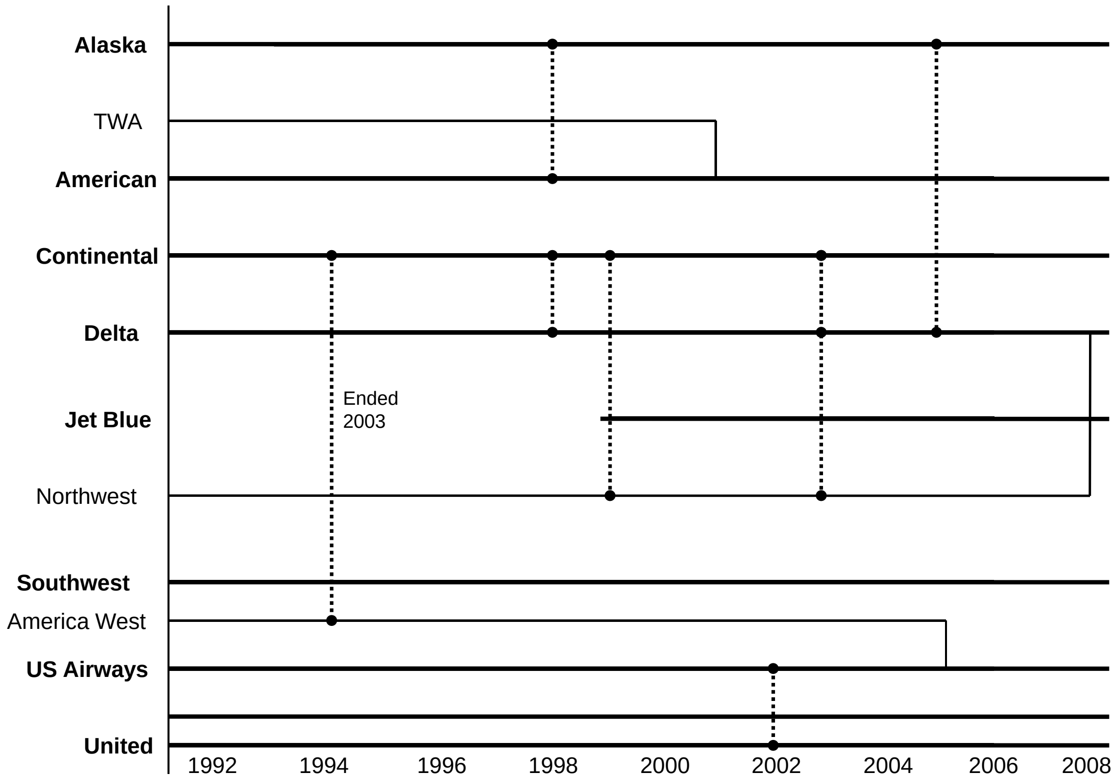
Table 21: City Simulations: NYC, Routes

Median number of routes served, by year

Number of simulations: 1,000 Time dummies: year 2008

Year	**0**	1	2	3	4	5	6	7	8	9	10
						No merger					
American	28	27	25	25	24	24	23	23	22	22	21
United	6	6	6	6	6	6	6	6	6	6	6
Southwest	0	1	2	3	4	5	6	7	8	9	9
Delta	39	38	37	37	37	37	37	37	37	36	36
Continental	49	48	48	47	47	47	47	48	47	48	48
Northwest	4	4	4	4	4	4	4	4	5	5	4
USAirways	14	13	12	11	10	9	9	9	8	8	8
JetBlue	28	27	26	25	25	25	25	25	24	23	23
Alaska	1	1	2	2	3	3	3	4	4	5	5
HHI	2009	1994	1973	1959	1936	1935	1918	1889	1868	1849	1872
						UA-CO merger					
American	28	27	26	26	25	25	24	24	24	23	22
UA + CO	49	48	48	48	48	48	48	48	48	48	48
Southwest	0	1	2	4	5	5	6	7	8	9	9
Delta	39	38	37	37	37	37	36	36	36	36	36
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	4	4	4	4	5	5	5	4	4	4	4
USAirways	14	12	12	11	10	9	9	8	8	8	8
JetBlue	28	27	27	27	26	25	25	25	24	25	24
Alaska	1	2	2	3	4	4	4	4	5	5	6
HHI	2146	2125	2101	2049	2019	2045	2023	2032	1996	1981	1970

Figure 1: Recent Merger and Code-Share Activity



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