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

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Abstract

We propose a new method for studying the medium and long run dynamic effects of horizontal mergers. Our method builds on the two-step estimator of Bajari, Benkard, and Levin (2007). Policy functions are estimated on historical pre-merger data, and then future industry outcomes are simulated both with and without the proposed merger. In our airline entry model, an airline's entry/exit decisions are made jointly across route segments, and depend on features of its own route network as well as the networks of the other airlines. We also allow for city-specific profitability shocks that affect all route segments out of a given city, as well as segment-specific shocks. Using data for 2003-2008, we apply our model to three recently proposed airline mergers. We find that a merger between two major hub carriers leads to increased entry by the other hub carriers, and can lead to substantial increased entry by low cost carriers, both effects offsetting some of the initial concentrating effects of the merger. Our model also suggests that a merger between two hub carriers can in certain cases lead to dismantling of a hub.

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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 addition, the static models do not account for post-merger changes in firms' behavior. By changing firms' incentives, a merger might lead to different levels of entry, exit, investment, and pricing than occured pre-merger, in both merging and nonmerging firms (Berry and Pakes (1993), Gowrisankaran (1999)). Lastly, several papers have shown that dynamics can weaken the link between market structure and performance (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.

We begin with the general framework of Ericson and Pakes (1995), 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 would require a detailed model of how mergers occur (see Gowrisankaran (1999)), resulting in a complex model that is likely to be extremely difficult to compute and to apply to data. Analyzing specific mergers would in general require further computation.

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

We then employ an important simplifying assumption: we assume that the equilibrium being played does not change after the merger, 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 proposed in 2008 and recently cleared and finalized. The United-Continental merger was proposed in May 2010 and is pending approval.

We find that in general when two hub carriers merge, the remaining unmerged carriers increase entry. Low cost carriers's response is more complicated, but in some cases they increase entry substantially as well. Both effects serve to counteract, and sometimes completely reverse, the initial concentrating effects of the merger. However, in some cases higher concentration persists long after the merger. We also find some evidence suggesting that if United and Continental merge they will substantially reduce service at Continental's Cleveland hub, in effect starting to dismantle the hub.

2 Related Literature

There are several other related papers in the literature that we have not mentioned yet. Probably the closest papers to ours are recent papers by Jeziorski (2009) and Stahl (2009). These papers 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 primary driving 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.

Another recent paper with a very similar goal to our own is Collard-Wexler (2009), which uses a Bresnahan and Reiss-style empirical model to evaluate the historesis effects of a merger from

duopoly to monopoly. He finds that merger to monopoly in ready-mix concrete would generate 15 years of monopoly.

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 (2009)) that estimates a structural dynamic oligopoly model of airline entry that is similar to our model. Relative to that paper, our approach is simpler and less ambitious. However, an advantage of our simpler approach is that we are able to allow for 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 Model/Methodology

We start with a general model of dynamic competition between oligopolistic competitors. The purpose of the general model is to show how our approach would work in general contexts. We develop a more detailed model for airlines below. Our general model closely follows BBL, and is a generalization of the Ericson and Pakes (1995) model. The defining feature of the model is that actions taken in a given period may affect both current profits and, by influencing a set of commonly observed state variables, future strategic interaction. In this way, the model can permit 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 $\nu_t = (\nu_{1t}, ..., \nu_{Nt})$.

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

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 $\sigma_i : S \times \mathcal{V}_i \to A_i$. A profile of Markov strategies is a vector, $\sigma = (\sigma_1, ..., \sigma_n)$, where $\sigma : S \times \mathcal{V}_1 \times ... \times \mathcal{V}_N \to A$.

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',

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

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

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

3.1 The Method and The Key Assumption

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

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

While it may in some cases require a large amount of data to estimate the choice distributions

flexibly, our approach has the advantage that in principle the reduced form choice distributions are always identified. Estimation becomes only an empirical problem. The problem with estimating the strategy functions (as in BBL) is that identification of σ can be difficult. It 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.

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

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

Recall that our model contains entry and exit, and that both the number of firms and their state variables are endogenously determined in equilibrium. Therefore, an equilibrium strategy profile σ is defined over any number of firms with any values of the state. Thus, it makes sense to think about the strategy profile remaining constant after a merger.

That said, the assumption would hold sometimes and not others. For example, it would hold any time that mergers represent equilibrium play in the game, so long as the primitives of the model and the policy environment remain constant. In that case, mergers would also need to be

represented in the strategy function σ, and the first stage estimation would need to include estimates of the probability of each merger taking place.

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

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

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

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

In practice, once the first step estimates have been obtained, we can use the BBL forward simulation procedure to simulate the distribution of future market outcomes both with and without the merger. The great benefit of assumption 1 is that we do not require the ability to compute a new

equilibrium to the game. As a result, for many markets, our proposed methods may be economical enough to be useful to policy makers such as the DOJ and the FTC.

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

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

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

Knowledge of the future distributions of actions and states given today's state typically would

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

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

4 Airline Mergers: Recent Experience

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

This logic was expressed quite cleanly in the approval of the merger between ValuJet and

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

In 1999, Northwest Airlines (NWA) and Continental Airlines formed an alliance that, although falling short of a full merger, was designed to provide many of the practical benefits thereof. The alliance involved code-sharing and joint marketing of flights so that Continental and Northwest agents could provide passengers tickets on either Continental or NWA flights. This significantly expanded the hub and spoke networks the airlines could provide, which is thought to be a major benefit to the lucrative business-class market. The alliance provided NWA with control of 51% of the Continental voting shares, which allowed NWA to veto any mergers or other significant business activity on the part of Continental. The Department of Justice (DoJ) filed suit over this arrangement with the final result that NWA sold back the controlling share of Continental prior to a final legal judgment being rendered.

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

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

In September 2005, US Airways emerged from bankruptcy to a form a merger with America West. Given that US Airways primarily serviced the eastern United States and America West the western states, the airlines had hoped to leverage complementarities in their regional networks to form a low cost carrier that could effectively compete with Southwest airlines. The primary objectors to the merger were the US Airways labor unions, which worried about the effects of combining two heterogeneous labor forces on the union's ability to effectively bargain with the firm. This merger is historically significant in that America West was not in financial distress at the time, although the pre-merger airlines did not provide significantly overlapping service and therefore the merger represented a lesser risk to competition.

In 2006 US Airways made an unsolicited takeover offer to Delta while Delta was in chapter 11 bankruptcy hearings. The offer was rejected by the unsecured creditors responsible for guiding the Delta reorganization through the bankruptcy hearings. Delta CEO Gerald Grinstein was quoted

in the July 29, 2006 Wall Street Journal as expressing doubt that any US Airways - Delta merger would be acceptable to regulators since the two airlines have competing hubs in the southeastern United States. In addition, the merger was opposed by US Airways labor unions still in disarray from the US Airways - America West merger. US Airways abandoned their hostile takeover efforts in early 2007.

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.

In May 2010, United Airlines and Continental proposed a merger that would create the world's largest airline in terms in 2009 revenues. Although the United-Continental merger has not obtained final regulatory approval, 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.

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 cleared in late 2008, and United-Continental, proposed in May 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 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 *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, including both incumbent airlines and potential entrants. 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 $m \in \{1, ..., J\}$.

5.1 Period Profits

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

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

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

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

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

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

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

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

5.2 Sunk Costs and Route Network Dynamics

We will assume that decisions are made in discrete time at yearly intervals. Each year, t, an airline can make entry and exit decisions that will be reflected in the network in the next year, N_{t+1}.

Changing the firm's network, however, involves some costs. Let D be a $J \times K$ matrix where each column d_k contains a vector of zeros and ones such that $d_{jk} = 1$ if segment 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)

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

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

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

Each period, each airline chooses it's next period's network so as to maximize the expected discounted value of profits, where the discount factor β is assumed constant across firms and time. Let Z_t be a matrix consisting of the variables z_m for all m in period t and assume that Z_t is Markov.[1]

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

Written recursively, the firm's problem is:

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

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

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

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

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

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

airline:

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

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

6 Data

The principle data source was the Bureau of Transportation Statistics (BTS) T-100 Domestic Segment Data set for the years 2003-2007. Much more historical data is readily available. However, due to the large impact of the events of 9/11/2001 on the airline industry, we view 2001 and 2002 as not representative of the current industry, so we dropped those from our sample. We did not use data from years prior either because our model requires us to use a period where airlines' entry/exit strategy functions are relatively 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 contains the list of airports included in each demographic area and our precise definition of entry, exit, and market presence.

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

Note that there are many flights in our data flown by regional carries (e.g. Mesa Air) that are 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. 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 (need an appendix listing affiliations), and treat it identically to a flight that Delta flies itself. Flights flown by regional carriers represent about 25-30% of the flights in the major carrier's networks in our data.

Table 1 lists some summary statistics for segment and market presence 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

endogenity problems in the estimation due to the iid error assumption. A third demand variable, "percent tourist", measures the percentage of passengers travelling in each market who report that their travel was for the purpose of tourism.

We have also computed route distance dummies and a large number of competition variables, including type of competitor, nonstop versus one-stop competition, number of code-sharing agreements for each airline on each city pair, whether the route involves a competitor hub, and several concentration measures. We measure concentration at both the route level and the city level (inspired by Borenstein (1989)). The route level HHI sums up the market shares of all other airlines on that specific route. The city level HHI measure sums up the market shares of all other airlines out of each endpoint city. We also separately measure the own airlines market share out of each endpoint city. The idea here is that an airline with a large market share out of a given city may have market power through frequent flyer programs, and this may effect both own and competitor entry behavior in that city.

Finally, we measure many properties of the own airline's network "local" to each city-pair, including both segment and market presence, airport presence, hub presence, and the number of nonstop flights out of each endpoint city. We also have a measure of "hub convenience", which is the nonstop flight distance divided by the shortest one-stop distance through one of the airline's own hubs. This measure ranges from zero to one, where zero reflects a very inconvenient hub and one reflects the hub lieing perfectly on a line between the two cities (or one of the cities actually being a hub). We also measure the distance to the nearest own hub from each endpoint city.

Finally, inspired by some anecdotes about how American Airlines makes its entry decisions, we made a variable called "Log Passenger Density New Markets". This variable considers the entire route network of each airline, and computes the 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 across the entire network from adding or subtracting each route segment individually.

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 (5.3) 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 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.

Our main probit results are shown in table 8, and pool together the airlines into two groups: hub carriers and low cost carriers. These groupings seemed like a good compromise between grouping all carriers and treating each one separately. We found that treating each airline separately increased the fit of the model (see below) but at the expense of noisier coefficient estimates, and more cases of unintuitive coefficient values. Meanwhile, grouping all carriers together did not reduce estimation error, and decreased fit.

In the probit results, city and year dummies are included but omitted. We also dummy out US Air in 2007 because that is the year that US Air absorbed America West. Carrier fixed effects are not included, but can be added to the regressions with only barely perceptable changes in the coefficients. We omit them because they were small and because it is not clear that they can be well estimated from only six years of data (even with many routes). Furthermore, if there are carrier fixed effects then we have to decide how to handle them when considering a merged firm.

For the hub carriers, the coefficients come out reasonably in both magnitude and sign. The demand variables are all positive, the most important one being the passenger density variable. Competition variables are negative, with nonstop competition being three times as important as one-stop competition. We find that code share agreements strongly increase the probability of entry on a route all else equal. As expected, a high own market share also strongly increases the

likelihood of entry into a city. Interestingly, high concentration among competitors also increases the likelihood of entry, though this effect is much smaller.

Hub and market presence increase the probability of segment entry, as does the distance from the nearest hub, and the number of nonstop destinations available at each endpoint city. Passenger density on new markets has a relatively strong effect as well.

The only variable that seems to have the “wrong sign” in the hub carriers regression is the “Present at Both Airports (not Market)” variable. We believe that this is due to an endogeneity problem. For the hub carriers, there are very few city pairs where they are present at both ends but not present in that market (with at least a one-stop). Such markets would typically be small cities that are also located inconveniently far apart, such as Norfolk and Reno. Relative to other city pairs, the density data likely overstates the profitability of flying between these cities, and the coefficient on “Present at Both Airports (not Market)” reflects this. We should also note again that the most likely impact of endogeneity on the regression results would be the competition variables not being negative enough.

Recall that for the probit the marginal effect of a variable depends on the predicted probability of market presence at the point under consideration, with the maximal marginal effect occuring at points where probability of market presence is 0.5 (at which point you multiply the coefficient by about 0.4 to obtain the marginal effect). Based on this we can see that many of the coefficients are quite large, and are having a large effect on predicting market presence.

There are some differences in the low cost carriers regression, most notably in the concentration measures. Low cost carriers are less likely to enter cities where they already have a large market share (excepting hubs) and are less likely to enter cities with highly concentrated competitors. They are also more responsive to competition in general. Many of the network variables are also

insignificant in the low cost carriers regression.

Tables 9-11 show the model fit for the pooled probits. We will concentrate on the middle table, corresponding to the pooling of hub and low cost carriers. We first show the fit for “stayers” (first panel), where the fit is near perfect as is to be expected. To test the model more rigorously, we also

data left to explain. However, we are still working on this aspect of the estimation problem and will likely report results from this model in a future draft of the paper. We also plan to add some nonparametric results to a future draft of the paper.

8 Merger Simulations

Tables 12-27 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.

Consider first table 12, which shows the median size of the nonstop network of each airline. Note that even the base case scenario shows some changes in airline networks over time. First, Southwest and Jet Blue continue their rapid expansion. We are not sure how much faith we put in this forecast. However, given their behavior in the past five years it is hard for an empirical model to predict anything different. In the base case, United, Continental, Northwest, Alaska and US Air are also predicted to show slow growth, while Delta is predicted to shrink somewhat and American is predicted to stay about the same size. In evaluating the effects of the proposed mergers, we will concentrate on differences between the base case trends and those forecast under the mergers.

Our first finding, and one of our main results, is that when there is a merger between two major hub carriers, the other major hub carriers respond by entering more routes. This trend holds quite broadly in the simulations. In each of the three mergers considered, American has about a 10% larger network after ten years than it would have had with no merger. United is 10% larger in year ten if Delta and Northwest merge. Delta is at least 10% larger in year ten under either of the United mergers.

The effect on the low cost carriers is not as uniform. The United-US Air merger has a big positive effect on low cost carrier entry, but the United-Continental merger leads to substantially less low cost carrier entry than the base case. These differences are caused by differences in the networks between US Air and Continental. The Delta-Northwest merger is somewhere in between. Table 13 shows that the same trends hold true if you look at city-pair markets (including one-stop flights).

Of course there is a whole distribution of possible outcomes in the simulations, and tables 14 and 15 provide some statistics about the distribution. In table 15 we can compare aggregate network concentration in year 10 across the different merger scenarios. All four cases have the same number of unserved markets. The Delta-Northwest and especially the United-US Air merger lead to a slight increase in the number of monopoly and duopoly markets after ten years, but the United-Continental merger actually leads to fewer of these. This is presumably due to the increased entry by other major carriers. These results suggest that a United-Continental merger may not have any negative effect on system-wide competition.

Tables 16-27 show the simulation results for the worst case cities for each merger. As we are now focusing in on small parts of the network, the results show that many different things can happen depending on local features of the airline networks. Consider first the case of Memphis, which is the worst case city in the Delta-Northwest merger. In the base case our simulations show Southwest entering Memphis in about year seven (2015), and Jet Blue entering not at all. If Delta and Northwest merge, however, Southwest enters Memphis right away, Jet Blue enters in year two, and both expand operations to 14 and 8 nonstop destinations by year ten, respectively. In response, the merged firm is forced to substantially cut back service, and in year ten Memphis is actually much less concentrated than it would have been had there been no merger.

A similar situation occurs, though not as dramatically, to Philadelphia under a United-US Air merger. If United and US Air merge, Southwest and Jet Blue enter aggressively while the merged firm cuts back service. In this case the end result is that after ten years overall market concentration looks about the same whether there is a merger or not, though if there is a merger there is a greater low cost carrier presence than if there is not.

On the other hand, none of this happens in Cincinatti, the second worst case city for the Delta-Northwest merger, or DC, the worst case city for the United-US Air merger. In fact, in those cases the merger if anything causes the merged firm to expand service slightly, while there is some crowding out of low cost carriers, and some increased entry of major carriers. All of these effects are small, however, and in these two cities the merger leads to a sustained higher level of concentration. A similar story holds for New York in the United-Continental merger.

Cleveland is an interesting case for the United-Continental merger. The main effect of the merger is that the merged firm reduces service substantially relative to the base case. Clearly, Cleveland is not as attractive as a hub for the merged carrier as it is for Continental alone, and this leads to a substantial reduction in service. There is also somewhat more entry by other firms under the merger, but the effect is not as large. The net effect is that in year ten Cleveland is substantially less concentrated under the merger than it would have been without. However, it also has about 12% fewer nonstop service destinations. From a social point of view, then, there is a tradeoff because we might expect lower fares in Cleveland from lower market power, but there is also less overall service and there is also a potential third effect because we might further expect that the merged firm is saving on cost by dismantling a hub. To evaluate the tradeoffs between these three effects we would require cost and demand models.

9 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.

Finally, we have some interesting findings regarding airline mergers in particular. In general we find that the major hub carriers increase entry in response to a merger by other hub carriers. Low cost carriers' response is somewhat more complex. However, in several cases we find that a merger by major carriers can prompt major and low cost carrier entry that in fact more than reverses the initial concentrating effect of the merger in some of the worst case cities.

This is not always the case however. In some cities the increased concentration persists. We also find in one case that a merger between major carriers can lead to the partial dismantling of a former hub.

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

B Gibbs Samp[illegible]ndom City [illegible]ect Model

Econometric model We [illegible] a behavi[illegible] strategy of a given airline. The data we observe are as follows: $(y_t, x_t,$ [illegible] $_t$ is [illegible]*dicator of firm being active* on the market ij (i and j denote the correspond[illegible] $i < j$) at time $t + 1$, $x_{ij,t}$ is the vector of the "explanatory variables".

Suppose that the airline is active [illegible] the behavioral strategy prescribes the firm to stay on the market for the next period ([illegible]

x_{i}' [illegible] $\xi_{i,}$ [illegible] $-\gamma,$

where $\xi_{i,t}$ are city specific shock[illegible]wn from [illegible]ndently across time and cities, $\varepsilon_{ij,t}$ are i.i.d. market specific shock[illegible]wn from $N(0,$ [illegible]tly of the city specific shocks $\xi_{i,t}$, and $(-\gamma)$ is some threshol[illegible]he inequality does [illegible]he airline will exit the market. The probability of any ti[illegible]ro.

The same strategy [illegible]umed to be true if the airline [illegible]tential entrant. The only difference is the ent[illegible]shold, which in this case is norm[illegible]

Thus, we obs[illegible]e following data generating process:

$y_{ij,t} = 1\{x'_{ij,t}\beta + \gamma y_{ij,t-1} + \xi_{i,t} + \xi_{j,t} + \varepsilon$ [illegible] $0\}$

[illegible]notations, denote $\theta = (\beta', \gamma)'$ and $\tilde{x}_{i}$[illegible]refore, the [illegible]llows.

In[illegible] Tf 12.4k Tf (|4 9.684 Td [()][illegible]098t)493

$\mathbf{z}_t | \tilde{\mathbf{x}}$ [illegible] $\tilde{\mathbf{x}}$

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

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

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

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

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

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

The algorithm goes as follows.

1. Start with initial values, $\mathbf{Z}_0$, θ_0, σ_0^2. Set $k = 1$.

2. Draw $\mathbf{Z}_k | \theta_{k-1}, \sigma^2_{k-1}, \mathbf{y}, \tilde{\mathbf{X}}$ from

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

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

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

where

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

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

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

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

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

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

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

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

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

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

(ii) Calculate:

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

(iii) Set

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

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

Note that for our data, Σ_{22}^{-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 segments so that the current segment under consideration is always “1-2” (that is reorder the cities and segments such that segment i becomes segment 1 and segment j becomes segment 2) for each of the 1770

segments in step 2, then Σ_{22} is always exactly the same matrix (since there is a segment 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, 2003-2008

	Routes						Markets		
Carrier	**Avg**	**Min**	**Max**	**Avg Entry**	**Avg Exit**	**Turnover**	**Avg**	**Min**	**Max**
American	224	219	232	7	8	0.067	1260	1237	1296
United	182	166	193	6	2	0.044	1331	1237	1372
Delta	230	220	241	14	14	0.122	1453	1400	1504
Continental	121	103	147	10	2	0.099	920	772	1126
Northwest	155	136	169	6	2	0.052	1173	1145	1215
USAirways	158	146	190	14	6	0.127	730	665	982
Southwest	298	269	323	15	4	0.064	937	824	1042
JetBlue	32	16	51	8	1	0.281	128	61	226
Alaska	41	37	43	2	1	0.073	115	94	123
DL + NW	373	349	386	18	14	0.086	1566	1550	1579
UA + US	309	292	341	16	7	0.074	1455	1379	1494
UA + CO	286	254	321	15	3	0.063	1485	1396	1523

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

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

Regressor	Avg	SD	Min	25%	50%	75%	Max
City Pair Characteristics:							
Pop1*Pop2 (*1e-12)	8.46	17.6	0.030	1.49	3.40	8.30	350
Pop1*Pop2 (*1e-12) * 2002 Dens=0	0.82	3.24	0	0	0	0.341	82.0
Log 2002 Passenger Density	7.62	5.60	0	0	10.7	12.6	16.0
Percent Tourist	0.37	0.35	0	0	0.33	0.67	1
Distance Variables:							
Route Distance $>$ than 250	0.95	0.21	0	1	1	1	1
Route Distance $>$ than 500	0.84	0.37	0	1	1	1	1
Route Distance $>$ than 1000	0.58	0.49	0	0	1	1	1
Route Distance $>$ than 1500	0.37	0.48	0	0	0	1	1
Route Distance $>$ than 2000	0.22	0.42	0	0	0	0	1
Route Distance $>$ than 2500	0.11	0.32	0	0	0	0	1
Route Distance $>$ than 3000	0.07	0.26	0	0	0	0	1
Competition Variables:							
Num Big 3 Comps.	2.06	0.92	0	1	2	3	3
Num Other Major Comps.	1.70	1.04	0	1	2	2	5
Southwest Competitor	0.48	0.50	0	0	0	1	1
Num Oth. Low Cost Comps.	0.422	0.58	0	0	0	1	2
Num Oth. Comps.	0.3	0.46	0	0	0	1	1
Number Nonstop Comps	0.78	0.99	0	0	0	1	6
Number One-Stop Comps	3.52	1.97	0	2	4	5	9
Number CS Agreements	0.051	0.23	0	0	0	0	3
Competitor Hub on Route	0.68	0.467	0	0	1	1	1
HHI Among Others (Market)	4869	4445	0	0	5085	9993	10000
HHI Among Others Large (City)	3377	1762	49	2018	3030	4200	8933
HHI Among Others Small (City)	1695	889	6	1200	1561	2023	7861
Own Share Large (City)	0.15	0.17	0	0.0367	0.089	0.19	0.94
Own Share Small (City)	0.05	0.06	0	0.0001	0.027	0.06	0.83
Own Local Network Variables:							
Present in Segment	0.09	0.29	0	0	0	0	1
Present in Market (not Segment)	0.41	0.49	0	0	0	1	1
Present at One Airport (not Both)	0.23	0.42	0	0	0	0	1
Present at Both Airports (not Market)	0.27	0.44	0	0	0	1	1
One Hub	0.135	0.34	0	0	0	0	1
Both Hubs	0.004	0.07	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	0.01	0.57	0.89	0.99	1
Dist Nearest Hub Small	440	489	0	119	286	553	4679
Dist Nearest Hub Large	1180	932	0	495	857	1797	4756
Log Pass. Dens. New Markets	2.63	4.46	0	0	0	5.2	15.8
# Nonstops Small (City)	2.28	3.10	0	0	2	3	53
# Nonstops Large (City)	8.38	11.8	0	2	4	8	56

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								
		Num Top 10 Carriers	HHI Passengers			HHI Departures		
CSA1	CSA2	pre	pre	post	chng	pre	post	chng
CVG	MSP	2	5066	9996	4930	5003	10000	4997
CVG	DTW	2	4918	9830	4912	4983	9860	4877
ATL	FLL, MIA	2	5230	9993	4763	5009	10000	4991
MSP	SLC	2	3526	6558	3032	3624	6655	3031
BUR, LAX, ONT, SNA	HNL	5	3520	6292	2772	3612	6472	2860
UA-US								
		Num Top 10 Carriers	HHI Passengers			HHI Departures		
CSA1	CSA2	pre	pre	post	chng	pre	post	chng
OAK, SFO, SJC	PHL	2	5348	9999	4651	5255	9982	4727
CLT	DEN	2	5893	10000	4107	5511	10000	4489
BUR, LAX, ONT, SNA	PHL	2	6155	9989	3834	5556	9963	4407
CLT	MDW, ORD	3	4250	7690	3440	3530	6107	2577
BWI, DCA, IAD	MSY	3	3617	6876	3259	3915	7568	3653
UA-CO								
		Num Top 10 Carriers	HHI Passengers			HHI Departures		
CSA1	CSA2	pre	pre	post	chng	pre	post	chng
CLE	DEN	2	5414	9988	4574	5522	10000	4478
DEN	HOU,IAH	3	3500	5889	2389	2949	5219	2270
DEN	EWR, JFK, LGA	4	3443	5223	1780	3241	4993	1752
BWI, DCA, IAD	CLE	3	3784	5058	1274	4216	6514	2298
HOU,IAH	MDW,ORD	4	3053	4296	1243	2977	4524	1547

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

DL-NW													
	Num Carriers Top 10	HHI Routes			HHI Markets			HHI Passengers			HHI Departures		
CSA	pre	pre	post	chng	pre	post	chng	pre	post	chng	pre	post	chng
MEM	6	5709	6232	523	1737	2145	408	5549	6606	1057	4697	5818	1121
CVG	6	6155	6555	400	1757	2129	372	7683	8143	460	6165	6858	693
MSP	6	5861	6378	517	1735	2108	373	5481	5928	447	4919	5517	598
BDL	7	1775	2238	463	1441	1688	247	1782	2222	440	1591	1942	351
DTW	7	4475	5039	564	1455	1707	252	4796	5187	391	4437	5030	593
IND	7	2128	2547	419	1444	1698	254	1490	1859	369	1444	1825	381
SDF	7	1824	2071	247	1497	1775	278	2049	2330	281	1517	1831	314
JAX	8	1675	1925	250	1357	1581	224	1518	1772	254	1300	1511	211
RSW	8	1468	1962	494	1371	1591	220	1245	1489	244	1249	1438	189
ORF	7	1632	1910	278	1457	1702	245	1865	2100	235	1951	2168	217

UA-US													
	Num Top 10 Carriers	HHI Routes			HHI Markets			HHI Passengers			HHI Departures		
CSA	pre	pre	post	chng	pre	post	chng	pre	post	chng	pre	post	chng
BWI, DCA, IAD	9	2120	2755	635	1242	1417	175	1597	2326	729	1533	2423	890
PHL	7	3375	3812	437	1468	1728	260	3573	4165	592	3919	4495	576
PIT	8	2148	2625	477	1303	1506	203	1852	2422	570	1813	2340	527
ALB	7	1800	2188	388	1445	1689	244	2305	2775	470	1817	2508	691
ORF	7	1632	1871	239	1457	1714	257	1865	2331	466	1951	2701	750
CLT	7	4771	5243	472	1568	1881	313	7041	7484	443	5907	6432	525
BDL	7	1775	1951	176	1441	1690	249	1782	2149	367	1591	2037	446
BOS, MHT, PVD	9	1523	1706	183	1218	1390	172	1313	1659	346	1385	1739	354
PHX	9	3285	3603	318	1353	1563	210	2886	3216	330	3129	3459	330
CMH	7	1712	1926	214	1446	1687	241	1596	1884	288	1423	1687	264

UA-CO													
	Num Top 10 Carriers	HHI Routes			HHI Markets			HHI Passengers			HHI Departures		
CSA	pre	pre	post	chng	pre	post	chng	pre	post	chng	pre	post	chng
CLE	7	4457	4889	432	1448	1706	258	3889	4559	670	3747	4365	618
EWR, JFK, LGA	8	2009	2146	137	1395	1624	229	1683	1975	292	1642	1914	272
OMA	7	1543	1790	247	1576	1790	214	1482	1741	259	1262	1538	276
DEN	9	3606	3861	255	1354	1553	199	3031	3281	250	2965	3159	194
MSY	8	1744	1929	185	1443	1687	244	1578	1828	250	1434	1635	201
HOU, IAH	8	3891	4225	334	1413	1640	227	4782	5024	242	4555	4821	266
OKC	7	1872	2256	384	1535	1818	283	1929	2130	201	1417	1706	289
OAK, SFO, SJC	9	1945	2128	183	1258	1436	178	1971	2158	187	2100	2235	135
SAT	7	2216	2529	313	1548	1833	285	2112	2296	184	1823	2037	214
ALB	7	1800	2000	200	1445	1691	246	2305	2472	167	1817	2089	272

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

	Hub Carriers		Low Cost Carriers		All Carriers Pooled	
Variable	Beta	SE	Beta	SE	Beta	SE
Pop1*Pop2(*1e-12)*Dens=0	6.60	15.8	20.6	11.6	16.7	6.00
Log (2002 Pass Dens)	0.089	0.012	0.066	0.021	0.093	0.0078
% Tourist	0.062	0.089	0.25	0.14	0.11	0.062
Distance $>$ 250	0.16	0.10	0.62	0.26	0.25	0.077
Distance $>$ 500	-0.025	0.093	-0.20	0.16	-0.16	0.068
Distance $>$ 1000	-0.14	0.084	-0.068	0.15	-0.17	0.060
Distance $>$ 1500	-0.19	0.10	-0.24	0.18	-0.22	0.073
Distance $>$ 2000	-0.036	0.13	0.027	0.22	-0.054	0.090
Distance $>$ 2500	0.11	0.18	-0.074	0.24	0.033	0.11
Distance $>$ 3000	-0.91	0.26			-0.84	0.20
Number NonStop Comps.	-0.12	0.034	-0.17	0.082	-0.15	0.028
Number One-Stop Comps.	-0.04	0.025	-0.058	0.050	-0.020	0.018
Number CS Agreements	0.45	0.075	-0.17	0.44	0.36	0.061
Competitor Hub on Route	0.14	0.095	-0.077	0.19	0.079	0.067
HHI Among Others (Market)	-0.0000029	0.0000073	0.0000016	0.000014	-0.0000044	0.0000055
HHI Among Oths Large (City)	0.00010	0.000047	-0.00038	0.000076	0.000079	0.000034
HHI Among Oths Small (City)	0.00015	0.000092	-0.00067	0.00011	0.00013	0.000060
Own Share Large (City)	2.43	0.53	-2.62	0.67	2.05	0.35
Own Share Small (City)	2.69	0.52	-1.54	1.11	1.80	0.38
Present in Segment	3.35	0.079	4.28	0.18	3.47	0.06
Present in Market (not Seg)	0.12	0.13	0.46	0.15	0.22	0.068
Present Both Apts (not Mark)	-0.17	0.13	0.32	0.17	0.035	0.069
Number of Hubs	0.68	0.10	0.22	0.13	0.38	0.057
Hub Conv (NS dist/OS dist)	-0.14	0.20	-1.19	0.45	-0.086	0.15
Dist Nearest Hub Small	0.00037	0.00013	-0.0010	0.00026	0.000025	0.000094
Dist Nearest Hub Large	0.00013	0.000075	-0.000045	0.00011	0.00016	0.000046
Log Pass. Den. New Markets	0.032	0.0062	-0.0060	0.012	0.026	0.0043
# Nonstops Small (City)	0.016	0.013	-0.023	0.018	0.0098	0.0079
# Nonstops Large (City)	0.027	0.0042	0.051	0.0079	0.023	0.0025
USAIR 2007 Dummy	0.82	0.15			0.87	0.12

Note: all probits have year and city dummies (and no constant term).

Table 9: Measures of Fit by Airline: All Airlines Pooled

	Actual Last Period Status				Full Sample Simulated	
	Stay		Switch		Switchers, Whole Period	
Airline	In	Out	In	Out	In	Out
American (25,27)	0.974	0.994	0.070	0.055	0.353	0.340
United (25,5)	0.983	0.995	0.070	0.088	0.291	0.449
Delta (34,51)	0.974	0.995	0.086	0.110	0.310	0.762
Continental (41,5)	0.980	0.997	0.124	0.141	0.544	0.885
Northwest (19,8)	0.979	0.997	0.024	0.124	0.128	0.742
USAirways (66,29)	0.980	0.992	0.125	0.095	0.273	0.444
Southwest (76,11)	0.965	0.988	0.067	0.049	0.279	0.274
JetBlue (38,0)	0.923	0.998	0.028	0.182	0.143	NaN
Alaska (7,1)	0.947	0.997	0.044	0.199	0.207	0.853
Note: table lists actual entries/exits in parentheses.						

Table 10: Measures of Fit by Airline: Hub and Low Cost Pooled

	Actual Last Period Status				Full Sample Simulated	
	Stay		Switch		Switchers, Whole Period	
Airline	In	Out	In	Out	In	Out
American (25,27)	0.961	0.994	0.083	0.092	0.396	0.498
United (25,5)	0.975	0.995	0.074	0.120	0.267	0.505
Delta (34,51)	0.965	0.995	0.105	0.157	0.340	0.836
Continental (41,5)	0.973	0.997	0.172	0.193	0.662	0.911
Northwest (19,8)	0.978	0.997	0.035	0.146	0.164	0.739
USAirways (66,29)	0.967	0.993	0.182	0.162	0.372	0.609
Southwest (76,11)	0.987	0.989	0.097	0.063	0.433	0.438
JetBlue (38,0)	0.989	0.996	0.062	0.048	0.299	—
Alaska (7,1)	0.984	0.998	0.060	0.046	0.216	0.590
Note: table lists actual entries/exits in parentheses.						

Table 11: Measures of Fit by Airline: Separate Probits

	Actual Last Period Status				Full Sample Simulated	
	Stay		Switch		Switchers, Whole Period	
Airline	In	Out	In	Out	In	Out
American (25,27)	0.980	0.997	0.134	0.237	0.526	0.742
United (25,5)	0.994	0.998	0.371	0.233	0.644	0.649
Delta (34,51)	0.960	0.995	0.192	0.326	0.605	0.904
Continental (41,5)	0.984	0.998	0.681	0.241	0.838	0.891
Northwest (19,8)	0.991	0.998	0.398	0.416	0.584	0.902
USAirways (66,29)	0.965	0.995	0.395	0.241	0.648	0.752
Southwest (76,11)	0.993	0.992	0.183	0.120	0.460	0.492
JetBlue (38,0)	0.978	0.997	0.382	0.185	0.767	—
Alaska (7,1)	0.998	1.000	0.305	0.159	0.698	0.993

Note: table lists actual entries/exits in parentheses.

Table 12: Airline Network Simulations: Next 10 years, 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	227	228	228	229	229	229	229	229	229	229
United	191	194	196	198	200	201	202	203	203	204	204
Southwest	336	343	351	360	369	379	388	398	407	417	427
Delta	224	223	222	222	221	220	218	217	216	215	214
Continental	147	150	152	154	156	157	158	159	160	161	162
Northwest	157	158	160	161	161	162	162	163	163	163	163
USAirways	193	199	205	210	214	219	222	226	229	232	234
JetBlue	55	61	69	77	85	93	102	111	121	131	142
Alaska	45	46	48	49	51	52	54	55	57	59	60
	DL-NW merger										
American	226	230	234	237	240	242	244	245	246	248	249
United	191	196	200	204	207	210	212	214	216	217	219
Southwest	336	345	356	367	378	389	401	412	423	435	447
DL + NW	370	367	362	357	353	347	342	336	331	325	319
Continental	147	151	154	157	159	161	163	164	166	167	168
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	193	202	211	218	224	230	235	240	244	247	250
JetBlue	55	62	72	81	91	103	114	125	138	152	166
Alaska	45	46	48	49	51	53	55	57	58	60	62
	UA-US merger										
American	226	232	237	241	245	248	251	253	255	257	259
UA + US	346	350	353	356	360	362	364	366	367	368	369
Southwest	336	352	367	382	398	415	432	448	463	476	488
Delta	224	228	230	233	235	236	238	239	239	240	240
Continental	147	152	155	159	162	165	167	169	170	172	173
Northwest	157	161	164	168	170	173	175	177	178	180	181
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	55	66	78	90	103	117	131	147	163	178	194
Alaska	45	47	49	52	54	57	59	61	63	65	68
	UA-CO merger										
American	226	231	235	239	242	245	247	249	250	252	253
UA + CO	322	324	326	327	328	328	328	328	327	326	325
Southwest	336	342	349	357	365	374	382	392	401	410	419
Delta	224	226	228	229	230	231	231	231	231	231	231
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	157	160	162	165	166	168	170	171	172	174	174
USAirways	193	203	212	219	225	231	237	241	245	249	252
JetBlue	55	60	65	71	76	82	89	95	102	109	116
Alaska	45	46	46	47	48	49	50	51	52	53	54

Table 13: Airline Network Simulations: Next 10 years, Markets

Median number of markets 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	1273	1283	1292	1297	1308	1316	1319	1324	1327	1331	1336
United	1366	1365	1363	1359	1355	1351	1349	1344	1340	1338	1336
Southwest	1057	1112	1166	1216	1258	1298	1335	1367	1396	1425	1452
Delta	1489	1482	1473	1465	1459	1453	1451	1445	1439	1436	1434
Continental	1133	1144	1153	1165	1174	1182	1191	1196	1200	1206	1209
Northwest	1145	1152	1167	1172	1177	1180	1182	1183	1183	1183	1182
USAirways	1140	1194	1232	1259	1275	1287	1295	1302	1306	1312	1315
JetBlue	210	232	257	285	314	348	385	425	473	526	589
Alaska	144	153	162	171	179	187	196	203	211	218	226
	DL-NW merger										
American	1273	1290	1309	1323	1336	1347	1356	1364	1369	1376	1381
United	1366	1370	1372	1373	1372	1373	1373	1372	1372	1371	1371
Southwest	1057	1134	1200	1252	1294	1331	1361	1386	1408	1431	1453
DL + NW	1580	1568	1557	1548	1541	1535	1530	1526	1522	1520	1516
Continental	1133	1150	1167	1182	1194	1203	1212	1221	1227	1234	1239
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	1140	1206	1251	1277	1296	1309	1319	1326	1332	1339	1342
JetBlue	210	237	269	299	333	368	407	455	508	571	638
Alaska	144	156	168	180	190	199	208	216	225	233	242
	UA-US merger										
American	1273	1293	1314	1329	1344	1356	1365	1374	1381	1388	1393
UA + US	1508	1509	1506	1502	1499	1495	1491	1488	1486	1483	1481
Southwest	1057	1141	1198	1252	1302	1352	1404	1458	1501	1539	1568
Delta	1489	1488	1485	1481	1481	1482	1481	1481	1480	1478	1480
Continental	1133	1150	1171	1187	1200	1209	1222	1233	1240	1245	1249
Northwest	1145	1167	1187	1200	1212	1220	1227	1233	1237	1241	1243
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	210	243	279	322	380	444	520	607	699	792	878
Alaska	144	160	175	186	196	205	214	224	233	241	250
	UA-CO merger										
American	1273	1291	1309	1324	1341	1352	1361	1371	1378	1385	1390
UA + CO	1527	1518	1509	1502	1494	1487	1482	1473	1469	1463	1459
Southwest	1057	1103	1148	1193	1231	1267	1303	1333	1364	1395	1421
Delta	1489	1486	1481	1475	1473	1473	1472	1472	1468	1467	1469
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	1145	1160	1179	1190	1199	1206	1212	1216	1220	1223	1224
USAirways	1140	1207	1252	1278	1298	1310	1320	1327	1333	1339	1344
JetBlue	210	225	246	265	287	310	334	360	391	424	463
Alaska	144	151	159	167	172	179	185	191	197	201	209

Table 14: Airline Network Simulations: 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

Table 15: Aggregate Concentration Measures: Distribution in Year 10

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	21	3	13	35	19	21	23
markets with 1 carrier	77	66	6	51	89	63	66	70
markets with 2 carriers	120	98	10	73	142	91	97	104
markets with 3 carriers	178	135	14	97	187	125	134	144
markets with 4 carriers	221	168	17	115	224	157	167	179
markets with 5 carriers	294	212	20	156	276	199	212	226
markets with 6 carriers	398	288	28	189	373	268	288	306
markets with 7 carriers	333	366	41	256	547	339	368	393
markets with 8 carriers	101	356	48	219	521	323	354	387
markets with 9 carriers	25	59	12	29	103	51	59	68
	DL-NW merger							
markets with 0 carriers	23	24	3	15	33	21	23	26
markets with 1 carrier	80	68	6	50	89	64	68	71
markets with 2 carriers	146	103	9	76	135	96	103	109
markets with 3 carriers	219	141	14	104	193	132	141	150
markets with 4 carriers	336	210	20	152	284	197	210	224
markets with 5 carriers	429	288	29	195	379	268	287	306
markets with 6 carriers	399	430	45	276	580	398	431	461
markets with 7 carriers	113	435	52	285	611	400	434	470
markets with 8 carriers	25	72	13	33	121	63	72	80
markets with 9 carriers	0	0	0	0	0	0	0	0
	UA-US merger							
markets with 0 carriers	23	21	3	14	32	19	21	23
markets with 1 carrier	80	63	5	44	101	60	63	66
markets with 2 carriers	149	88	10	62	128	80	87	94
markets with 3 carriers	245	146	14	104	194	136	145	154
markets with 4 carriers	268	179	18	133	238	165	178	191
markets with 5 carriers	420	257	24	189	333	240	255	272
markets with 6 carriers	446	357	46	228	533	325	355	388
markets with 7 carriers	114	567	53	382	712	533	568	604
markets with 8 carriers	25	94	18	45	159	81	92	105
markets with 9 carriers	0	0	0	0	0	0	0	0
	UA-CO merger							
markets with 0 carriers	23	22	3	14	36	20	22	24
markets with 1 carrier	75	69	5	53	86	66	69	73
markets with 2 carriers	125	105	10	80	147	98	105	111
markets with 3 carriers	203	138	16	90	189	126	136	148
markets with 4 carriers	332	212	21	136	286	197	212	226
markets with 5 carriers	503	360	31	256	473	338	361	380
markets with 6 carriers	380	476	45	345	640	445	478	506
markets with 7 carriers	104	334	45	212	473	303	331	363
markets with 8 carriers	25	54	11	23	98	47	54	62
markets with 9 carriers	0	0	0	0	0	0	0	0

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	4	4	4	4	4	4	4	3	3
United	2	2	2	2	2	2	2	2	2	2	2
Southwest	0	0	0	0	0	0	0	1	1	1	2
Delta	2	2	2	3	3	3	3	3	3	4	4
Continental	2	2	2	3	3	3	3	3	3	3	3
Northwest	38	38	37	37	37	37	37	37	36	36	36
USAirways	2	2	2	2	2	2	3	3	3	3	3
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	5835	5425	5425	5425	5237	5044	4970	4970	4795
						DL-NW merger					
American	5	5	4	4	4	4	4	4	4	3	3
United	2	2	2	2	2	2	2	2	2	2	2
Southwest	0	1	4	6	8	9	11	12	13	13	14
DL + NW	39	38	36	34	33	31	30	29	27	26	25
Continental	2	2	2	2	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	3	3	3	3	3
JetBlue	0	0	1	2	3	4	5	6	7	8	8
Alaska	0	0	0	0	0	0	1	1	1	1	1
HHI	6232	5928	5156	4527	3950	3607	3117	2944	2739	2703	2634
						UA-US merger					
American	5	5	5	4	4	4	4	4	4	4	4
UA + US	4	4	4	4	4	4	4	4	4	4	4
Southwest	0	0	0	0	0	1	1	2	2	3	3
Delta	2	2	3	3	3	3	4	4	4	4	4
Continental	2	2	3	3	3	3	3	3	3	3	3
Northwest	38	38	38	38	38	38	38	39	39	39	39
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	0	0	0	0	0	0	0	1	1	1
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	5740	5740	5351	5525	5525	5322	5151	5045	4872	4721	4721
						UA-CO merger					
American	5	5	5	4	4	4	4	4	4	4	4
UA + CO	4	4	4	5	5	5	5	5	5	5	5
Southwest	0	0	0	0	0	0	0	1	1	1	2
Delta	2	2	3	3	3	3	3	4	4	4	4
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	38	38	38	38	38	38	38	38	38	38	38
USAirways	2	2	2	2	3	3	3	3	3	3	3
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	5740	5740	5540	5540	5351	5351	5351	4995	4995	4995	4828

Table 17: City Simulations: Memphis, Markets

Median number of markets 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	43	43	42	41	40	40	40	40	39	39	39
United	34	34	34	34	33	33	33	33	33	33	33
Southwest	0	0	0	0	0	0	0	9	14	26	29
Delta	40	40	40	40	40	40	40	41	41	41	41
Continental	26	27	28	30	31	31	31	32	32	32	32
Northwest	51	51	51	51	51	51	51	50	50	50	50
USAirways	35	35	35	35	35	35	35	35	35	35	35
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	1737	1732	1726	1717	1716	1716	1716	1597	1551	1483	1473
	DL-NW merger										
American	43	43	42	41	41	41	40.5	40	40	40	40
United	34	34	34	33.5	33	33	33	32	32	32	32
Southwest	0	14	30	35	38	41	42	43	44	45	45
DL + NW	57	56	55	54	53	52	51	51	50	50	49
Continental	26	27	27	29	31	31	32	32	32	32	32
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	35	35	35	35	35	35	35	35	35	35	35
JetBlue	0	0	3.5	6	9	11	13	16	18	20	22
Alaska	0	0	0	0	0	0	1	3	7	9	9
HHI	2145	1898	1718	1659	1613	1589	1553	1510	1455	1428	1415
	UA-US merger										
American	43	43	42	42	41	41	41	41	41	41	41
UA + US	43	43	42	40	36	36	36	35	35	35	35
Southwest	0	0	0	0	0	8.5	20	24	27	30	35
Delta	40	40	40	40	41	41	41	42	43	43	43
Continental	26	27	29	31	31	32	32	32	32	32	33
Northwest	51	51	52	52	52	52	52	52	52	52	52
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	0	0	0	0	0	0	0	5	20	23
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	2081	2073	2064	2053	2060	1909	1783	1757	1673	1528	1501
	UA-CO merger										
American	43	43	42	41	41	41	41	41	41	41	40
UA + CO	37	37	37	37	37	37	37	37	36	36	36
Southwest	0	0	0	0	0	0	0	13	17	20	26
Delta	40	40	40	40	40	41	41	42	42	43	43
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	51	51	51	51	52	52	52	52	52	52	52
USAirways	35	35	35	35	35	35	35	35	35	35	35
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	2037	2037	2037	2037	2041	2041	2041	1841	1802	1777	1737

Table 18: 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	4	4	4	4	4	4	4	4
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	48.5	48.5	48	48	48
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	3	3	3	3	3	3	3	3	3
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	5977	5977	5977	5977	5950	5950	5923	5923	5923
						DL-NW merger					
American	4	4	4	4	4	4	4	4	4	4	4
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	49	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	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	6555	6555	6358	6358	6358	6358	6358	6226	6226	6226	6226
						UA-US merger					
American	4	4	4	4	4	4	4	4	4	4	4
UA + US	5	5	5	5	4	4	4	4	4	4	4
Southwest	0	0	0	0	0	0	0	1	1	1	2
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	3
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	0	0	0	0	0	0	0	0	0	1
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	6185	6185	6185	6185	6363	6363	6363	6165	6165	6165	5638
						UA-CO merger					
American	4	4	4	4	4	4	4	4	4	4	4
UA + CO	6	6	6	6	5	5	5	5	5	5	5
Southwest	0	0	0	0	0	0	0	0	0	0	0
Delta	49	49	49	49	49	49	49	49	49	49	49
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	2	2	2	2	2	2	2	2	2	2	2

Table 19: City Simulations: Cincinatti, Markets

Median number of markets 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	37	37	38	38	38	38	38	38	38	38	38
United	43	43	43	42	42	42	42	42	42	41	41
Southwest	0	0	0	0	0	0	0	0	0	0	0
Delta	59	59	59	58	58	58	58	58	58	57	57
Continental	39	39	40	40	40	40	40	41	41	41	41
Northwest	41	41	41	42	42	42	42	42	42	42	42
USAirways	27	27	32	38	39	39	39	39	39	39	39
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	1757	1757	1731	1710	1708	1708	1708	1707	1707	1704	1704
						DL-NW merger					
American	37	37	38	38	38	39	39	39	39	39	39
United	43	43	43	43	43	43	42	42	42	42	42
Southwest	0	0	0	0	0	0	0	0	0	0	0
DL + NW	59	59	59	59	59	59	59	59	59	59	59
Continental	39	40	40	40	41	41	41	41	41	41	42
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	27	28	38	39	39	39	39	39	39	39	39
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	2129	2120	2066	2063	2061	2058	2060	2060	2060	2060	2058
						UA-US merger					
American	37	37	38	38	38	39	39	39	39	39	39
UA + US	47	47	46	46	44	44	44	44	44	44	44
Southwest	0	0	0	0	0	0	0	22.5	33	37	40
Delta	59	59	59	59	58	58	58	58	58	58	58
Continental	39	39	40	40	41	41	41	41	41	42	42
Northwest	41	41	42	42	43	43	43	43	43	44	44
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	0	0	0	0	0	0	0	0	0	25
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	2063	2063	2055	2055	2048	2045	2045	1772	1719	1706	1495
						UA-CO merger					
American	37	37	38	38	38	39	39	39	39	39	39
UA + CO	48	48	47	47	47	47	46	46	46	45	45
Southwest	0	0	0	0	0	0	0	0	0	0	0
Delta	59	59	59	58	58	58	58	58	58	58	58
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	41	41	42	42	42	43	43	43	43	43	43
USAirways	27	28	38	39	39	39	39	39	39	39	39
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	2128	2120	2061	2053	[illegible]	2049	2049	2049	2049	2049	2049

Table 20: 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	9	9	9	9	8	8	8	8	8
United	42	43	44	44	45	45	46	46	46	47	47
Southwest	34	35	36	37	38	39	40	41	42	43	44
Delta	6	6	6	6	6	6	6	6	6	6	6
Continental	3	3	3	3	3	3	3	3	3	3	3
Northwest	4	4	4	4	4	4	4	4	4	4	4
USAirways	27	28	29	30	31	32	33	33	34	35	35
JetBlue	7	7	7	7	7	8	8	8	8	8	9
Alaska	2	2	2	2	2	2	2	2	2	2	2
HHI	2120	2138	2178	2182	2200	2182	2221	2228	2234	2250	2235
	DL-NW merger										
American	10	10	10	10	9	9	9	9	9	8	8
United	42	43	44	45	46	46	47	47	47	48	48
Southwest	34	35	36	37	38	39	40	41	42	43	44
DL + NW	10	10	10	11	11	11	11	11	11	11	11
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	27	28.5	30	31	32	33	34	35	36	37	37
JetBlue	7	7	7	7	7	7	8	8	8	8	8
Alaska	2	2	2	2	2	2	2	2	1	1	1
HHI	2146	2163	2179	2176	2213	2218	2211	2216	2250	2287	2292
	UA-US merger										
American	10	10	10	10	10	10	10	10	10	10	10
UA + US	45	46	47	48	48	49	49	50	50	50	50
Southwest	34	35	36	37	38	39	39	40	41	42	42
Delta	6	6	7	7	7	7	8	8	8	8	8
Continental	3	3	3	3	3	3	3	4	4	4	4
Northwest	4	4	4	4	4	4	4	5	5	5	5
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	7	7	8	8	8	8	8	8	8	8	9
Alaska	2	2	2	2	2	2	2	2	2	2	2
HHI	2755	2784	2737	2765	2771	2798	2762	2711	2719	2726	2695
	UA-CO merger										
American	10	10	10	10	9	9	9	9	9	9	8
UA + CO	42	43	45	46	47	47	47	48	48	48	49
Southwest	34	35	35	36	37	38	39	40	41	41	42
Delta	6	6	6	6	6	7	7	7	7	7	7
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	4	4	4	4	4	4	4	4	4	4	4
USAirways	27	29	30	31	32	34	35	35	36	37	38
JetBlue	7	7	7	7	7	7	7	7	7	8	8
Alaska	2	2	2	2	2	2	2	2	1	1	1
HHI	2212	2228	2254	2270	[illegible]	2286	2291	2306	2340	2316	2354

Table 21: City Simulations: DC, Markets

Median number of markets 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	43	43	43	43	44	44	44	44	44	44	44
United	56	56	57	57	57	57	58	58	57	57	58
Southwest	47	48	49	50	51	52	53	53	54	55	55
Delta	52	52	52	52	52	51	51	51	51	51	51
Continental	47	47	48	48	48	48	48.5	49	49	49	49
Northwest	36	36	37	37	37	37	37	37	38	38	38
USAirways	55	55	55	55	55	55	55	55	55	55	55
JetBlue	23	24	25	26	27	29	31	33	34	37	39
Alaska	12	12	12	12	12	12	12	12	12	12	12
HHI	1242										

Table 22: 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	4	4	4	4	4	4	4	4	4
United	5	5	5	5	5	5	5	5	5	5	5
Southwest	15	16	16	17	18	19	19	20	21	21	22
Delta	5	5	5	5	5	5	4	4	4	4	4
Continental	2	2	2	3	3	3	3	3	3	3	3
Northwest	4	4	4	4	4	4	3	3	3	3	3
USAirways	41	41	41	41	41	40	40	40	40	40	40
JetBlue	0	1	3	4	5	6	7	8	9	10	11
Alaska	0	0	0	0	1	1	1	1	1	2	2
HHI	3375	3257	3175	3015	2869	2760	2820	2763	2714	2623	2585
	DL-NW merger										
American	5	5	5	4	4	4	4	4	4	4	4
United	5	5	5	5	5	5	5	5	5	5	5
Southwest	15	16	17	17	18	19	19	20	20	21	21
DL + NW	9	9	9	8	8	8	8	7	7	7	6
Continental	2	2	3	3	3	3	3	3	3	3	3
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	41	41	41	41	41	41	41	41	41	41	41
JetBlue	0	1	2	4	5	6	7	8	9	10	11
Alaska	0	0	0	0	0	1	1	1	1	1	1
HHI	3442	3322	3144	3123	3039	2897	2849	2834	2793	2743	2753
	UA-US merger										
American	5	5	5	4	4	4	4	4	4	4	4
UA + US	41	40	39	37	36	35	33	32	31	30	29
Southwest	15	19	23	26	30	34	38	42	46	50	53
Delta	5	5	5	5	5	5	5	5	5	5	4
Continental	2	2	2	3	3	3	3	3	3	3	3
Northwest	4	4	4	4	4	4	4	4	4	3	3
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	3	7	10	13	16	19	23	27	31	36
Alaska	0	1	1	2	3	4	4	5	5	6	6
HHI	3812	3270	2934	2675	2541	2466	2460	2448	2494	2557	2642
	UA-CO merger										
American	5	5	5	4	4	4	4	4	4	4	4
UA + CO	7	7	8	8	8	8	8	8	8	8	8
Southwest	15	16	16	17	17	18	19	19	20	20	21
Delta	5	5	5	5	5	5	5	5	5	4	4
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	4	4	4	4	4	4	4	4	4	3	3
USAirways	41	41	41	41	41	41	41	41	41	41	41
JetBlue	0	1	2	3	4	5	6	7	8	8	9
Alaska	0	0	0	0	0	1	1	1	1	1	1
HHI	3409	3290	3157	3123	3[illegible]8	2910	2841	2794	2738	2842	2788

Table 23: City Simulations: Philadelphia, Markets

Median number of markets 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	36	36	37	37	38	38	39	42	49	50	50
United	52	52	53	53	53	53	53	54	53	53	53
Southwest	40	41	43	45	48	49	51	51	52	53	54
Delta	57	57	57	56	56	56	56	56	56	56	56
Continental	41	42	44	52	53	53	53	53	54	54	54
Northwest	42	42	43	43	43	43	43	43	43	43	43
USAirways	55	55	55	55	55	55	55	55.5	56	56	56
JetBlue	0	5	15	20	30	33	34	36	38	40	42
Alaska	0	0	0	0	1	7	12	12	13	13	13
HHI	1468	1424	1355	1329	1286	1243	1215	1210	1200	1198	1196
	DL-NW merger										
American	36	36	37	38	39	40	50	51	52	52	52
United	52	53	53	53	54	54	54	54	54	54	54
Southwest	40	42	44	45	47	49	50	51	52	53	53
DL + NW	57	57	57	57	57	57	57	57	57	56	56
Continental	41	42	45	53	53	54	54	54	54	54	54
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	55	55	55	55	56	56	56	56	56	57	57
JetBlue	0	3	14	19	25	32	35	37	39	41	43
Alaska	0	0	0	0	0	3.5	11	12	12	13	13
HHI	1717	1678	1570	1535	1503	1445	1378	1368	1364	1356	1353
	UA-US merger										
American	36	36	37	38	39	40	48.5	51	52	52	53
UA + US	59	59	59	59	59	59	59	59	59	59	59
Southwest	40	44	49	50	52	54	55	56	57	58	59
Delta	57	57	57	57	57	56	56	56	56	56	56
Continental	41	43	45	52	53	53	54	54	54	54	54
Northwest	42	42	43	43	44	44	44	44	44	44	44
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	15	25	31	34	37	39	42	45	47	50
Alaska	0	1	10	12	14	15	16	17	18	19	20
HHI	1728	1565	1429	1396	1376	1363	1349	1341	1334	1329	1324
	UA-CO merger										
American	36	36	37	38	39.5	50	51	52	53	53	53
UA + CO	55	55	58	59	59	59	59	59	59	59	59
Southwest	40	41	42	44	46	48	49	50	51	51	52
Delta	57	57	57	57	56	56	56	56	56	56	56
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	42	42	43	43	43	43	44	44	44	44	44
USAirways	55	55	55	55	56	56	56	56	56	57	57
JetBlue	0	2	13	17	21	29	31	33	34	35	37
Alaska	0	0	0	0	0	3	11	12	12	13	13
HHI	1719	1693	1590	1559	1530	1458	1395	1383	1381	1374	1370

Table 24: 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	4	4	5	5	5	5	6	6	6	6
United	3	3	4	4	4	4	5	5	5	5	5
Southwest	6	6	6	5	5	5	5	5	5	5	5
Delta	4	4	5	5	5	5	6	6	6	6	6
Continental	41	43	44	45	46	47	48	49	49	50	50
Northwest	3	3	3	3.5	4	4	4	4	4	4	4
USAirways	3	4	4	5	5	6	6	6	6	7	7
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	4346	4192	4097	4105	4072	3953	3925	3925	3900	3900
	DL-NW merger										
American	3	4	4	5	5	6	6	6	7	7	7
United	3	3	4	4	5	5	5	5	6	6	6
Southwest	6	6	5	5	5	5	5	5	5	4	5
DL + NW	7	8	8	9	9	10	10	10	11	11	11
Continental	41	43	45	46	47	48	49	50	50	51	51
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	3	4	5	5	6	6	7	7	7	7	8
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	4518	4304	4307	4178	4050	3947	3920	3970	3759	3883	3740
	UA-US merger										
American	3	4	5	5	6	6	6	7	7	7	7
UA + US	6	7	7	8	9	9	10	10	10	11	11
Southwest	6	6	5	5	5	5	5	5	6	6	6
Delta	4	4	5	6	6	6	7	7	7	7	8
Continental	41	43	45	46	47	48	49	50	51	51	52
Northwest	3	3	4	4	4	4	4	5	5	5	5
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	0	0	0	0	0	0	0	1	1	2
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	4502	4400	4295	4167	4053	4106	4004	3895	3780	3722	3626
	UA-CO merger										
American	3	4	4	5	5	5	6	6	6	6	6
UA + CO	41	41	40	40	39	39	38	38	38	37	37
Southwest	6	6	7	7	8	8	8	9	9	9	10
Delta	4	4	5	5	5	6	6	6	6	6	6
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	3	3	3	4	4	4	4	4	4	4	4
USAirways	3	4	4	5	6	6	6	6	7	7	7
JetBlue	0	0	0	0	1	1	2	2	2	3	3
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	4889	4615	4321	3994	3651	3569	3339	3279	3214	3079	3031

Table 25: City Simulations: Cleveland, Markets

Median number of markets 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	40	41	42	42	43	43	44	44	44	44	45
United	50	50	50	50	50	50	50	50	50	50	50
Southwest	41	41	42	43	44	44	45	46	46	47	48
Delta	53	53	53	53	53	53	53	53	53	53	53
Continental	52	53	53	54	54	54	55	55	55	56	56
Northwest	51	51	52	52	52	52	52	52	52	52	52
USAirways	41	41	41	41	42	42	42	42	42	43	43
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	1448	1447	1446	1446	1442	1442	1442	1441	1441	1440	1439
						DL-NW merger					
American	40	41	42	43	44	44	45	45	46	46	46
United	50	50	50	50	50	50	50	50	50	50	50
Southwest	41	42	43	43	44	45	45	46	46	47	48
DL + NW	55	55	55	55	55	55	55	55	55	55	55
Continental	52	53	53	54	55	55	56	56	56	56	57
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	41	41	41	42	42	43	43	43	43	44	44
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	1695	1693	1690	1688	1687	1684	1684	1684	1683	1680	1681
						UA-US merger					
American	40	41	42	43	44	44	45	45	46	46	47
UA + US	51	51	51	51	51	51	51	51	51	51	51
Southwest	41	42	43	43	44	45	46	48	49	50	51
Delta	53	53	53	53	53	53	53	53	53	53	53
Continental	52	53	54	54	55	55	56	56	56	57	57
Northwest	51	51	52	52	53	53	53	53	53	53	53
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	0	0	0	0	0	0	0	0	20	27	33
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	1687	1685	1683	1681	1680	1678	1677	1675	1512	1480	1459
						UA-CO merger					
American	40	41	42	43	43	44	45	45	45	46	46
UA + CO	59	59	58	58	58	58	58	57	57	57	57
Southwest	41	42	42	43	44	45	46	47	48	49	50
Delta	53	53	53	53	53	53	53	53	53	53	53
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	51	51	52	52	52	52	53	53	53	53	53
USAirways	41	41	41	42	42	42	43	43	43	43	44
JetBlue	0	0	0	0	3	6	10	17	20	23	26
Alaska	0	0	0	0	0	0	0	0	0	0	0
HHI	1706	1702	1698	1693	1659	1626	1589	1536	1518	1501	1487

Table 26: 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	30	31	33	34	35	37	37	38	39	40
United	6	6	7	7	7	7	7	7	8	8	8
Southwest	0	1	2	3	5	6	7	8	9	9	10
Delta	39	40	41	42	43	44	44	44	45	45	45
Continental	49	49	49	50	50	50	50	50	50	50	50
Northwest	4	4	4	4	4	4	4	4	4	4	4
USAirways	14	13	13	12	12	11	11	10	10	10	10
JetBlue	28	29	29	30	31	32	32	33	34	35	36
Alaska	1	1	1	1	1	1	1	1	1	1	1
HHI	2009	1993	1954	1954	1916	1914	1897	1893	1865	1865	1851
	DL-NW merger										
American	28	30	32	34	36	37	39	40	41	42	43
United	6	6	7	7	7	8	8	8	8	8	9
Southwest	0	1	2	3	5	6	7	8	9	9	10
DL + NW	41	42	43	45	45	46	47	47	47	48	48
Continental	49	49	50	50	50	50	51	51	51	51	51
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	14	14	13	13	12	12	12	11	11	11	11
JetBlue	28	29	30	31	32	33	33	34	35	36	36
Alaska	1	1	1	1	1	1	1	1	1	1	1
HHI	2109	2075	2050	2029	1999	1965	1958	1954	1937	1940	1912
	UA-US merger										
American	28	30	33	35	36	38	39	40	41	42	43
UA + US	18	18	18	18	18	18	18	18	17	17	17
Southwest	0	1	2	4	6	7	8	9	9	10	10
Delta	39	41	42	43	44	45	46	46	47	47	48
Continental	49	49	50	50	50	51	51	51	51	51	51
Northwest	4	4	4	4	5	5	5	5	5	5	5
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	28	28	29	29	30	30	30	31	31	32	32
Alaska	1	1	1	1	1	1	1	1	1	1	1
HHI	2091	2065	2041	2000	1944	1938	1926	1908	1923	1907	1912
	UA-CO merger										
American	28	31	33	36	38	40	41	43	44	45	45
UA + CO	49	49	49	49	49	49	49	49	49	49	49
Southwest	0	1	2	3	5	6	7	8	8	9	9
Delta	39	41	42	44	45	46	47	48	48	49	49
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	4	4	4	4	5	5	5	5	5	5	5
USAirways	14	14	14	13	13	13	12	12	12	12	11
JetBlue	28	28	29	29	30	30	31	31	32	32	33
Alaska	1	1	1	1	1	1	1	1	1	1	1
HHI	2146	2115	2085	2081	2020	2008	2006	1997	1995	1986	1996

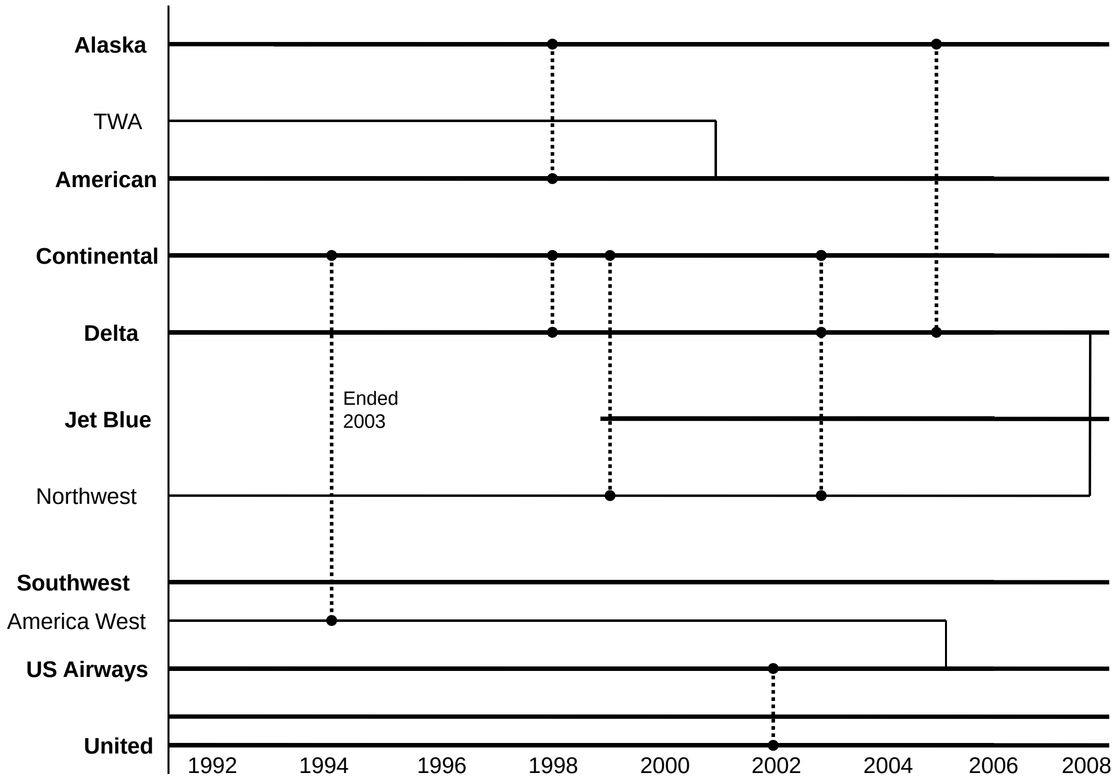
Table 27: City Simulations: NYC, Markets

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	51	52	52	52	53	53	54	54	54	55	55
United	53	53	53	53	54	54	54	54	53	53	53
Southwest	0	11	25	34	40	44	46	48	50	51	52
Delta	59	59	59	58	58	58	58	58	58	58	58
Continental	55	55	56	56	56	56	57	57	57	57	57
Northwest	45	45	46	46	46	46	46	46	47	47	47
USAirways	53	53	53	54	54	54	54	54	54	54	54
JetBlue	28	29	31	32	34	35	37	38	40	42	44
Alaska	12	12	12	12	12	12	13	13	13	13	13
HHI	1395	1319	1254	1229	1217	1211	1204	1201	1198	1196	1194
						DL-NW merger					
American	51	52	52	53	54	54	55	55	56	56	56
United	53	53	54	54	54	54	54	54	54	54	54
Southwest	0	8	23	33	39	43	46	48	49	50	51
DL + NW	59	59	59	59	59	59	59	59	59	59	59
Continental	55	56	56	56	57	57	57	57	57	57	57
-merged-	0	0	0	0	0	0	0	0	0	0	0
USAirways	53	53	54	54	54	55	55	55	55	55	55
JetBlue	28	30	32	34	35	37	38	40	41	43	45
Alaska	12	12	12	12	12	12	12	13	13	13	13
HHI	1618	1538	1441	1400	1386	1377	1372	1362	1360	1357	1355
						UA-US merger					
American	51	52	53	53	54	55	55	55	56	56	56
UA + US	58	58	58	58	58	58	58	58	57	57	57
Southwest	0	13	30	40	46	49	52	53	55	56	56
Delta	59	59	59	59	59	59	58	58	58	58	58
Continental	55	56	56	56	57	57	57	57	57	57	57
Northwest	45	45	46	46	47	47	47	47	47	47	47
-merged-	0	0	0	0	0	0	0	0	0	0	0
JetBlue	28	29	31	33	35	37	40	42	44	47	49
Alaska	12	12	12	12	12	12	12	13	13	13	13
HHI	1626	1511	1421	1392	1381	1376	1369	1360	1358	1355	1354
						UA-CO merger					
American	51	52	53	54	54	55	55	56	56	56	57
UA + CO	58	58	59	59	59	59	59	59	59	59	59
Southwest	0	12	26	34	39	43	46	47	48	50	50
Delta	59	59	59	59	59	59	59	59	58	58	58
-merged-	0	0	0	0	0	0	0	0	0	0	0
Northwest	45	45	46	46	46	47	47	47	47	47	47
USAirways	53	53	54	54	54	55	55	55	55	55	55
JetBlue	28	29	30	31	32	33	35	35	37	38	39
Alaska	12	12	12	12	12	12	12	12	13	13	13
HHI	1624	1515	1438	1410	1396	1389	1381	1381	1370	1367	1366

Figure 1: Recent Merger and Code-Share Activity



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