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U.S. AIR PASSENGER SERVICE: A TAXONOMY OF ROUTE NETWORKS, HUB LOCATIONS, AND COMPETITION

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ABSTRACT

In this paper, we analyze the service provided by the 13 largest U.S. passenger airlines to the 100 most populous U.S. metropolitan areas in 1989. We classify the route systems by their nature and geographical extent using a variety of measures based on route-level data. We then identify individual airline hub locations and derive and calculate several measures of the extent of competition both on individual routes and at the airports in our sample. The results show the wide diversity of route networks that existed in the airline industry in 1989--a phenomenon that may help to explain the failure of several major carriers since then.

Introduction

Beginning with the Airline Deregulation Act of 1978, airlines have been constructing route networks of their own choosing rather than operating ones implicitly chosen for them by the Civil Aeronautics Board.[1] This regulatory reform has led to the development of hub-and-spoke networks. As its name implies, a hub-and-spoke network has most flights coming to a "hub" airport from "rim" airports, concentrating airline activity at a few locations. Travel between two rim airports involves flying first to the hub and then on to the final destination.

This change in the nature of route systems has important implications for the performance of the air transportation system, because airports receive widely varying levels of service and have very different levels of concentration, depending on whether the facility is a hub or not. Another important implication is that capacity constraints are much more likely to be binding as a direct result of the concentration of activity at hubs, possibly leading to congestion and delays for passengers.

The evolution of United Airlines' route network from 1965 to 1989 (see figure 1) illustrates the development of hub-and-spoke systems. In 1965, United had a route system characterized by many multistop flights. By 1989, however, it employed an extensive hub-and-spoke network comprising mostly nonstop and one-stop flights.

For the airlines, there are many advantages to switching to a hub-and-spoke network. Kanafani and Ghobrial (1985) pointed out that this system enables airlines to take advantage of economies of aircraft size, Toh and Higgins (1985) found an increase in airline profitability, and McShan and Windle (1989) reported significant cost savings.

But the airlines are not the only ones to benefit from the adoption of hub-and-spoke networks. Morrison and Winston (1986) found that passengers have benefited from airline deregulation mainly through increased flight frequency, which is a direct result of the increase in hub-and-spoke activity. Butler and Huston (1990) examined service to small nonhub airports

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[1] For a broader discussion of the evolution of the U.S. airline industry after deregulation, see Borenstein (1992).

(those most at risk to lose service) and discovered that most passengers using these airports have benefited from more-frequent flights to a hub airport, even though service to nonhub facilities has been curtailed. Due to this change, passengers originating from small nonhub airports can reach many more destinations on a one-stop-or-less flight than before. Even the oft-heard complaint about fewer nonstop flights is more perception than reality. Barnett et al. (1992) discovered that a 1989 traveler was far more likely to find a timely nonstop jet flight than was her 1977 counterpart, even after adjusting for the growth in passenger traffic since 1977.

While the net benefits to passengers from the adoption of hub-and-spoke networks have been substantial, not all passengers have fared equally. Travel times for those who lost nonstop service have increased, and passengers originating from hub airports or facilities with severe capacity constraints face higher fares than they otherwise would. In the case of hub airports, travelers are at least partially compensated by receiving service to relatively more nonstop destinations and by more frequent nonstop flights to those destinations (for further details, see Huston and Butler [1988]).

So far, we have discussed hub-and-spoke networks as something that either exists or does not. Actual flight schedules are less clear cut, however, since airlines vary in the extent to which they employ such networks. Even before the regulatory reforms of the late 1970s, many airlines engaged in some activity characteristic of the hub-and-spoke system. Given the importance of the hub-and-spoke phenomenon, pinpointing the nature and effect of the new route structures is necessary not only for understanding recent changes in the airline industry, but also for anticipating the changes that are likely to occur in the future.

There has been some work aimed at developing objective measures of the extent to which airlines have adopted hub-and-spoke networks. The Toh and Higgins (TH) index is calculated as the number of cities served by a previously identified hub divided by the number of spoke routes extending from it. If an airline has more than one hub, each is assigned a weight based on the proportion of cities in the airline's route system that it serves.

Alternatively, the McShan and Windle (MW) index is the proportion of an airline's total departures leaving from the 3 percent most utilized airports in its network. For example, if an airline serves 100 airports, the proportion of the carrier's total departures from the three airports with the most flights would be computed.

The TH and MW indexes are calculated using individual airline data for 1982 and 1970-84, respectively. While both indexes provide quantitative information on hub-and-spoke systems, each has limitations. For instance, the TH index must assign rim airports to a particular hub--an arbitrary decision for rim airports with flights to multiple hubs. Also, both indexes try to capture a complex, multidimensional activity with a single scalar measure.

Our objective in this paper is to overcome these limitations and provide a better understanding of the hub-and-spoke phenomenon by rigorously examining the route networks of the 13 largest U.S. carriers in 1989. First, we classify these airlines' route systems by their nature and geographical extent using a variety of measures based on route-level data. We then identify individual airline hub locations using an index derived from the same data. Finally, we derive and calculate several measures of the extent of competition both on individual routes and at the airports in our sample. The results show the wide diversity of route networks that existed in the airline industry in 1989--a phenomenon that may help to explain the failure of several of the carriers since then.

I. The Data

Our unique data set is the key to the various measures of hub-and-spoke activity developed here. We acquired the 1989 flight schedules for the 13 largest domestic carriers--Air Alaska, America West, American, Braniff, Continental, Delta, Eastern, Midway, Northwest, Southwest, TWA, United, and USAir--which together accounted for more than 90 percent of the U.S. market for scheduled service that year (based on revenue passenger miles).

Using these, we constructed a matrix describing which airports are linked by nonstop air service for each carrier. A one in the i, j-th element indicates that the carrier offers service from the i-th airport to the j-th airport, whereas a zero indicates no service. While the data do not measure the number of departures or passenger enplanements, they do provide detail on airline route networks not available in other data sets.[2]

Our sample is composed of the 112 airports located in the 100 most populated Metropolitan Statistical Areas (MSAs).[3] There are more airports than MSAs because some areas contain multiple airports. MSAs with more than one airport are listed in table 1.

II. Airline Classification

Our goal in this section is to classify the selected airlines by geographic extent, scale of operations, and type of route structure. We report the results of our classifications in table 2, columns 1 and 2. In general, our method is to construct measures of a particular quality of route networks, and then to rely on large gaps in these measures to assign airlines to the various categories.

The key variable in classifying an airline's geographic extent is the percentage of its flights that depart and arrive within the same or adjacent U.S. census divisions (column 3).[4] Air Alaska and Southwest have much higher regional concentrations than the other airlines and are designated "regional carriers." The others are designated "national carriers" not because they necessarily serve the entire country, but because they serve a much larger portion of the country than the regionals.[5] The contrast between regional and national carriers is well illustrated by

[2]For example, McShan and Windle (1989) used annual departure data disaggregated by airlines and airports, but gathered no information on the destination of those departures.

[3]The sample includes 12,432 possible routes, but we collected data for only half of these and assumed that service was symmetric. For example, we gathered data for the route from Portland to Atlanta and assumed that if an airline serviced this route, then it also serviced the Atlanta-Portland route. To check this assumption, we selected one airline (American) and collected data for routes in both directions. For this case, the symmetry assumption was valid in all but one instance.

[4]The nine census divisions are New England, Middle Atlantic, South Atlantic, East South Central, East North Central, West South Central, West North Central, Mountain, and Pacific.

[5]Our definition of national carriers should not be confused with the Department of Transportation's designation, which is based solely on an airline's total revenue.

figure 2, which presents route maps for Southwest and Northwest Airlines.

We further classify the national airlines on the basis of scale of operations, looking at the number of airports that each serves (column 4). There appear to be three distinct size classes: large carriers that serve 89 or more airports, medium carriers that serve about 70 airports, and small carriers that serve fewer than 55 airports.

An alternative measure of an airline's scale of operations would be the number of nonstop routes that it flies (column 5). Using this criterion, our size classifications for the national carriers would be unaltered. Large carriers serve 400 or more nonstop routes; medium carriers, around 300; and small carriers, around 100. Of the two regional carriers, Southwest, with 134 nonstop routes, is more than twice the size of Air Alaska. If the census divisions had been drawn a little differently, Midway might have been classified as a regional carrier and Southwest a national. We prefer our stated classifications, because the area served by Midway contains a much larger share of the U.S. population than that served by Southwest.

Some characteristics of the nature of service provided by the airlines in our sample (and the total U.S. airline network) are reported in columns 6 to 9. We calculate the percentage of the 12,432 possible routes for which an airline offered no service, nonstop service, one-stop service, or two-or-more-stop service.

Two important inferences can be culled from these measures. First, the size classifications developed above would be unaltered if we categorized airlines by the number of routes that received *some* level of service. Large carriers offered at least partial service to two-thirds of the total possible routes; medium carriers, only 40 to 50 percent; small carriers, 10 to 25 percent; and regional carriers, 10 percent or less.

Second, only one-fifth of all airport pairs received nonstop service from at least one carrier (of course, these tended to be the most frequently flown routes). The most common level of service for an airport pair was one-stop (about three-fourths of all flights). Only 5 percent of the possible routes--those least frequently flown--required more than a one-stop flight .

Next, we turn to our measures of the type of route structure, the most complex characteristic to pin down. Figure 2 not only illustrates the differences between regional and national carriers, but also demonstrates the contrast between two very different airline route networks: Southwest's, which is a relatively diffuse network, and Northwest's, whose three hubs (Detroit, Minneapolis, and Memphis) clearly stand out.

To better understand our terminology, consider figure 3, which depicts four hypothetical route systems (mono-hub, dual-hub, and two diffuse systems) each serving six airports. With a pure mono-hub network, all of an airline's flights originate or arrive at a central location. A multi-hub is similar, but has two or more airports at which activity is concentrated. Finally, there are many possible types of diffuse route networks, ranging from each airport offering nonstop service to all other airports, to a network in which there is a relatively smooth decline in the level of service offered to the most connected to the least connected airports.

The measures in columns 10 to 13 represent the percentage of an airline's routes that originate from its one, two, four, and six most connected airports. When using these measures, different criteria must be employed for airlines of different sizes. The reason for this is that with small carriers such as Air Alaska, six airports may represent more than a third of the total number of locations served, while for large airlines such as American, the corresponding percentage would be considerably less (under 3 percent). The MW index overcomes this problem by looking only at the share of departures from the 3 percent most utilized airports, thus automatically adjusting for the size of the network.[6]

In a pure mono-hub system (see figure 3), 50 percent of an airline's routes would originate in its most connected airport (the other half would terminate there). Because actual airline operations are less clear cut, an n-airport route concentration of 35 percent or greater (depending

[6]A minor difficulty is that this approach results in an integer problem, because n airports may fall short of 3 percent, while n+1 may exceed 3 percent. McShan and Windle (1989) employ linear interpolation to overcome this drawback.

on the size of the carrier) is sufficient for us to conclude that the airline in question has n hubs.[7]

From table 2, we can see that airlines rely on hub-and-spoke systems to varying extents. Midway is the closest to being a pure mono-hub, with 48.6 percent of its routes originating at Chicago Midway airport (only one of the airline's routes does not originate or end there). We also classify Eastern Airlines as a mono-hub system. Although its one-airport concentration is only 38.1 percent, it has no significant concentration of activity at any of the other airports it serves. For both Eastern and Midway, fewer than 6 percent of their routes originate from the second most connected airport.

The dual-hub carriers (TWA, Braniff, and America West) are identified by the large share of departures at their two most connected airports. At least 26 percent of their routes originate from the most connected airport, and more than 9 percent originate from the second most connected airport.

The multi-hub carriers (American, Delta, Northwest, United, and Continental) have one-airport concentrations of 13 percent or more, and their four-airport measures are at least 13 percentage points higher than their two-airport concentrations.

USAir is the only diffuse national carrier. At each route concentration level, its measures are significantly lower than those of the other large national carriers. Its six-airport concentration measure is only 33.6 percent, compared to an average of 45.7 percent for the other large nationals. Perhaps this is why several of USAir's 1989 hubs no longer receive hub service. Hardest hit was Dayton's airport, which has lost three-fourths of its nonstop destinations since 1989. Cleveland Hopkins International has also been severely affected, losing about half of its nonstop flights over the same period. Some restructuring of USAir's route network was to be expected, because in 1989, the merger with Piedmont had not been fully consummated, and the two airlines' route networks had not yet been fully rationalized. Still, the economics of hub-and-

[7]The hub index developed in the next section yields a similar classification of airline route networks and also identifies airline hub locations.

spoke systems also played a role.

Air Alaska and Southwest were likewise found to have relatively diffuse route networks, once their small size was taken into account. Both airlines do have some hub-and-spoke components, but their operations are not nearly as concentrated as those of the nondiffuse carriers.

For comparison, we report a modified MW index in column 14. Instead of the share of total departures at an airport, we look at the share of total *routes*. The reported value for a particular airline indicates the proportion of its routes originating from the 3 percent most connected airports in its network, with larger values corresponding to greater centralization. While the MW single-valued measure does accurately reflect the degree of hub-and-spoking behavior, it cannot be used to determine the number of hub airports an airline has.

III. Airline Hub Locations

We now turn our attention toward examining the route networks from the perspective of the airports rather than the airlines. In particular, we look at where airlines have located their hubs and analyze the characteristics of overall service provided there.

First, for each airline and airport, we construct an index of hub activity that measures the degree to which the airport is connected to the rest of the airline's network. In a hub-and-spoke system, we would expect to find that most airports are not well connected, with only a few hub airports diverging from this pattern.

Our hub index for an airport is the percentage of other airports in a given airline's route system that can be reached with nonstop service. For example, passengers originating from hub airport (C) in figure 3's mono-hub network can reach 100 percent of the other airports, while only 20 percent of the other airports can be reached from airports A, B, D, E, or F. The corresponding values for the route concentration measures are included for comparison.

In the dual-hub network, both hub airports (C and D) have an index of 100 percent. The other facilities in the network have hub indexes of only 40 percent.

The two hypothetical diffuse networks have a relatively smooth hub-index distribution across airports. In the first, every airport offers nonstop service to every other location and the hub index is 100 percent for every airport. In the second, some airports are more connected than others, but there is no discrete jump in the hub-index values, unlike the case with the two hypothetical hub networks. We characterize the airports with the most nonstop service as hubs, but the distinction between hub and nonhub service is more arbitrary in this hypothetical example.

For the 44 airport-airline combinations (out of a possible 837) that we classified as hubs, the value of the hub index is reported in table 3 (column 7), along with some other information about the airlines' level and quality of service (columns 3 to 6). Note that the demand for air transportation at some airports is sufficient to support more than one airline with hub activity.

To determine hub locations using this index, we examined the distributions of the hub index for each airline. They range from a high of 100 percent (Midway Airlines at Chicago Midway airport) to a low of 17 percent (United Airlines at Los Angeles International). Figure 4 displays these distributions.

Every carrier concentrates its service in a relatively small number of airports, making it easy to identify hub locations. Only a handful of airports had very high service levels, with most offering comparatively low levels. The exceptions were the hubs of the relatively diffuse carriers (Air Alaska, USAir, and Southwest). These airlines do concentrate their activity in a small number of airports, but there is a relatively smooth progression from the least served to the most served locations. Thus, determining the lower bound of what constitutes hub service for these carriers is more difficult. We set an arbitrary cutoff point for each carrier based on where there was a gap in the index between airports with higher versus lower levels of service. Airports offering levels of service above this threshold were designated as hubs.

The locations of the metropolitan areas with the 44 hub airport-airline combinations are shown in figure 5. Airports located in the east central portion of the country appear to have a distinct advantage in acquiring hub status, due to population densities.

Individual airport-airline hubs differ in terms of the breadth of the areas they serve. To identify the geographic scope of each of our 44 hub airport-airline combinations, we computed the percentage of an airline's nonstop connections from the hub airport to destinations in either the same U.S. census division or neighboring divisions. The results, presented in column 4 of table 3, range from a high of 100 to a low of 44, with a median of 75. For example, American Airlines' Chicago O'Hare hub serves points throughout the country, while activity at its Raleigh-Durham hub is concentrated in the east (see figure 6).

IV. Measures of Competition

If the airline industry were perfectly contestable, there would be no point in calculating any measures of the extent of competition, since such indexes would have no meaning.[8] Because no one has found that the airline industry meets these conditions, we construct various indexes of the extent of competition based on the number of carriers offering service on a route or, alternatively, from an airport.[9] A drawback common to all of these indexes is that infrequent service on a route is treated as equivalent to more frequent service.

We calculate several indexes of the degree of competition faced by each airline at its hubs (as identified in table 3). The first is the percentage of routes on which the airline faces competition, calculated separately for nonstop and one-stop connections (columns 8 and 9).[10] For example, in 1989 Delta faced competition from at least one other airline on 67 percent of its 79 routes that originate from its largest hub, Atlanta's Hartsfield airport. However, for the 100 one-stop or fewer routes served from Atlanta, Delta had at least one competitor on all of them.

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[8]A market is perfectly contestable if the threat of entry into the industry is sufficient to keep prices equal to marginal costs, even when there are as few as two existing firms (see Baumol, Panzar, and Willig [1982]).

[9]In fact, most studies have shown that the more competitors there are on a route, the lower fares tend to be (see Bailey, Graham, and Kaplan [1985], Bauer and Zlatoper [1989], Borenstein [1989], Call and Keeler [1985], Hurdle et al. [1989], and Morrison and Winston [1987]).

[10]The one-stop calculation involved an aggregation of the nonstop and one-stop data. For example, we considered a nonstop flight from New Orleans to Denver on United Airlines to be competition for American Airlines' one-stop flight from New Orleans to Denver via its Dallas hub. We applied this same principle to all the one-stop measures of competition discussed in this paper.

Eastern also had a hub at Hartsfield airport in 1989, but it faced competition on 94 percent of its nonstop routes (mostly from Delta). This situation undoubtedly exacerbated Eastern's other financial problems and helped lead to its eventual demise.

There is substantial variation in the percentage of nonstop routes having competition across airport-airline combinations (the range is 0 to 98 percent).[11] In contrast, the percentage of a hub's one-stop routes facing competition tends to be very large, with at least some competition on 88 percent of the routes for all but one hub (Love Field).

To gauge the quantity of competition at the hub airport-airline combinations, we also computed the average number of competitors on each route an airline serves. These measures for nonstop and one-stop routes are displayed in columns 10 and 11 of table 3. Note that with only three exceptions (USAir, United, and Delta's hub operations in Los Angeles), the average number of competitors on nonstop flights is less than two.

The story is radically different for one-stop routes. With only two exceptions, the average number of competitors is greater than two. The difference between nonstop and one-stop competition is to be expected, since the hub-and-spoke networks adopted by most airlines allow them all to compete with one another on most one-stop routes.

Next, instead of looking at the amount of competition airlines encounter at their busier airports, we construct measures of competition from the perspective of a passenger at a particular airport. For each of the 112 airports in our sample, table 4 reports several such measures. First, the level of overall service at an airport is indicated by the number of airports that can be reached by nonstop and one-stop flights (columns 2 and 3). Columns 4 and 5 report the percentage of these routes served by more than one carrier for nonstop and one-stop service. For example, of the 47 nonstop routes from Baltimore-Washington airport, 26 percent have competition, while 97

[11]The zeros occur at only three airports--Dallas' Love Field, Chicago's Midway, and Dayton. Carriers at the first two airports face stiff competition from other airports in the metropolitan area, so high concentrations at these airports pose little cause for concern. Dayton's situation in 1989 was unique in that it was blessed by receiving a major carrier's service, but cursed by attracting only one.

percent of the 64 one-stop connections are served by more than one carrier. On average, more than one carrier serves 28 percent of the nonstop routes and 84 percent of the one-stop routes.

The average number of competitors on nonstop and one-stop routes from each airport are reported in columns 6 and 7, respectively. The values for nonstop connections range from 1.0 to 2.2, with a mean of 1.4. For one-stop routes, the figures range from 1.0 to 5.9, with a mean of 3.8. Again, there is more competition on the one-stop level than on the nonstop level for all of the airports.

Two additional measures of the overall degree of competition at each airport are computed based on the Herfindahl index.[12] In columns 8 and 9, we report the nonstop and one-stop Herfindahl index, computed as

$$HO_i = 10,000 \cdot \sum_j \left(service_{ij} \Big/ \sum_j service_{ij} \right)^2,$$

where $service_{ij}$ is the number of nonstop routes from airport i for the j^{th} airline. This measure is sensitive only to the *level* of service, not to the actual destinations of the service. The measure for one-stop connections was calculated in a similar manner.

The main limitation of these estimates is that they are not sensitive to the destinations of the routes. For example, suppose an airport has 10 airlines, each serving 10 other airports with no overlap. In this case, there is no route-by-route competition, yet HO will be equal to 1,000, its theoretical minimum for 10 carriers. This is an appropriate measure of the degree of competition at the airport only if potential competition from carriers serving the facility (but not the same routes) is very strong. Otherwise, route-by-route measures of competition must be developed (as we do below). This is an issue we can explore only because of our unique data set. From the example above, it is clear that airport-level and route-level measures of competition can yield very

[12]The Herfindahl index is a measure of concentration, with larger values corresponding to greater concentration. For a description of this measure, see Koch (1980, pp. 179-180).

different results.

To develop an overall measure of competition at the airport level that is sensitive to the actual level of competition on a route-by-route basis, we computed another version of the Herfindahl index as

$$HHO_{ik} = 10,000 \cdot \sum_j \left(service_{ijk} \Big/ \sum_j service_{ijk} \right)^2,$$

where $service_{ijk}$ is one if the j^{th} airline services the route from i to k, and zero otherwise.[13] HHO_{ik} is the nonstop Herfindahl index for the route between airport i and airport k. To get an overall measure for each airport, we used the average of HHO_{ik} computed over all airports k. This index assumes that only airlines offering service on the same route are effective potential competitors.

The resulting indexes for nonstop and one-stop connections are reported in table 4, columns 10 and 11. While these measures are sensitive to the route-by-route patterns of competition, they are not affected by the actual level of service (as measured by the number of airports that can be reached with a nonstop connection), since only routes with at least some service are included in the calculation.

Although a Herfindahl index of 3,200 would be considered very high in most industries (i.e., the Department of Justice's antimerger guidelines would take effect), there is reason to treat this as a somewhat moderate level for the airlines. For example, Bauer and Zlatoper (1989) found that air fares cease to fall once three carriers serve a route--equivalent to a Herfindahl index of roughly 3,200 using our definitions.

V. Summary

In this paper, we analyzed the service provided by the 13 largest U.S. passenger airlines to the 100 most populous U.S. metropolitan areas in 1989. Using route-specific data from that year,

[13] At least some service had to be offered on a route for it to be included in this calculation.

we examined aspects of airline service not covered in previous studies, which have tended to rely on aggregate departure information.

Using this route-specific data, we developed measures to categorize the airlines in terms of geographic scope and route structure. We also determined the location of airline hubs and computed various measures of the intensity of competition at individual airports.

We found many differences among the 13 airlines in terms of geographic scope and route structure. Only two were primarily regional in their coverage, while the others were more national in scope. Among the latter carriers, we found significant variation in the number of routes that they serve. Although all 13 airlines have hub-and-spoke systems, differences were shown to exist in the degree of centralization. Two (Eastern and Midway) operated mono-hub networks; three (TWA, Braniff, and America West) flew dual-hub networks; five (American, Delta, Northwest, United, and Continental) managed complex multi-hub networks; and three (USAir, Air Alaska, and Southwest) served diffuse networks.

To determine the location of the hub airports for each airline, we computed the percentage of the other airports in the airline's route system that can be reached with nonstop flights for each airport-airline combination. We then examined the distribution of this index for each airline and identified as hubs those airports having large values.

Forty-four airport-airline combinations in the sample were classified as hubs. These combinations include only 35 different airports, since some of these facilities had more than one airline with hub activity. While hub airports are found throughout the United States, they tend to be concentrated within roughly 500 miles of Cincinnati. Some of the hubs are predominantly regional in their orientation, while others are more national in scope.

Finally, we computed several different measures of competition at the airports in the sample. These measures indicate that there was substantially more competition on one-stop routes than on nonstop routes, and that the level of competition at these facilities varied tremendously.

Using our airport-airline competition measures, we found that the carriers in our 1989 sample that have since failed (Braniff, Eastern, and Midway), as well as those that are currently experiencing the most financial difficulty (America West, Continental, and TWA), tended to face more competition at the airports they served than did the other carriers (although the sample is too small for rigorous testing). It is possible that the type of route network operated by the failed carriers may not have been viable, since it is the large national and the regional airlines that have remained financially stronger. Survival in this competitive industry during the 1990s requires a large multihub route network or a solid regional niche.

The number of airlines that have failed in the last few years has some industry observers concerned. Other things held constant, fewer carriers tend to mean less competition; however, other things have not remained constant in the airline industry. The carriers that have survived tend to serve most of the airports in the system (e.g., compare the extent of United's route network in 1965 with its 1989 schedule). Thus, effective competition has probably *increased*, since five large national carriers would offer more competition, route by route, than 12 smaller carriers serving more-restricted route networks.

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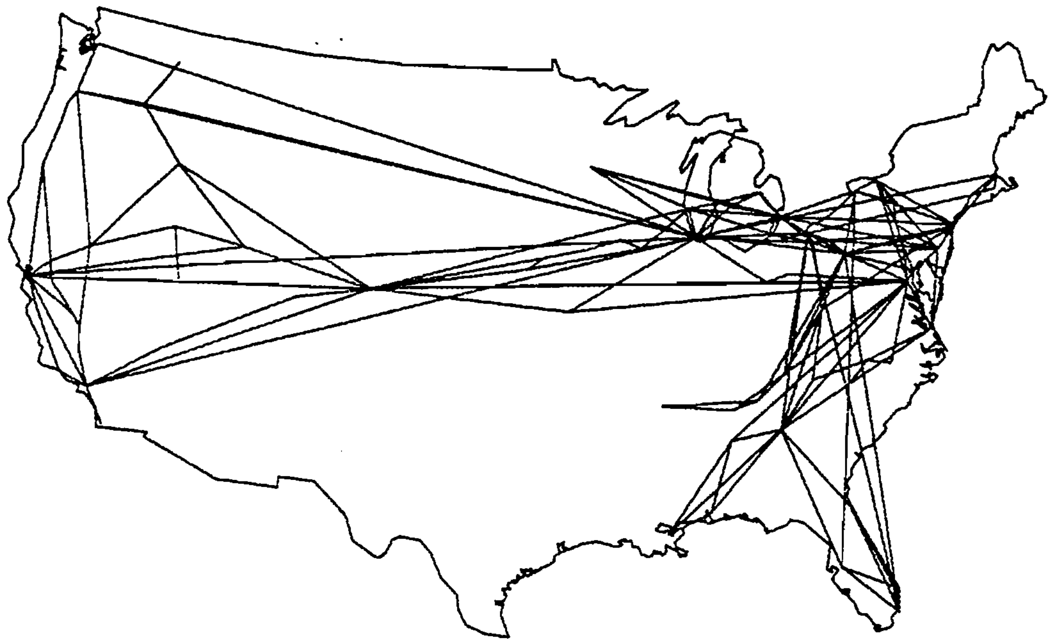
Figure 1. United Airlines Route Structure, 1965 and 1989

1965



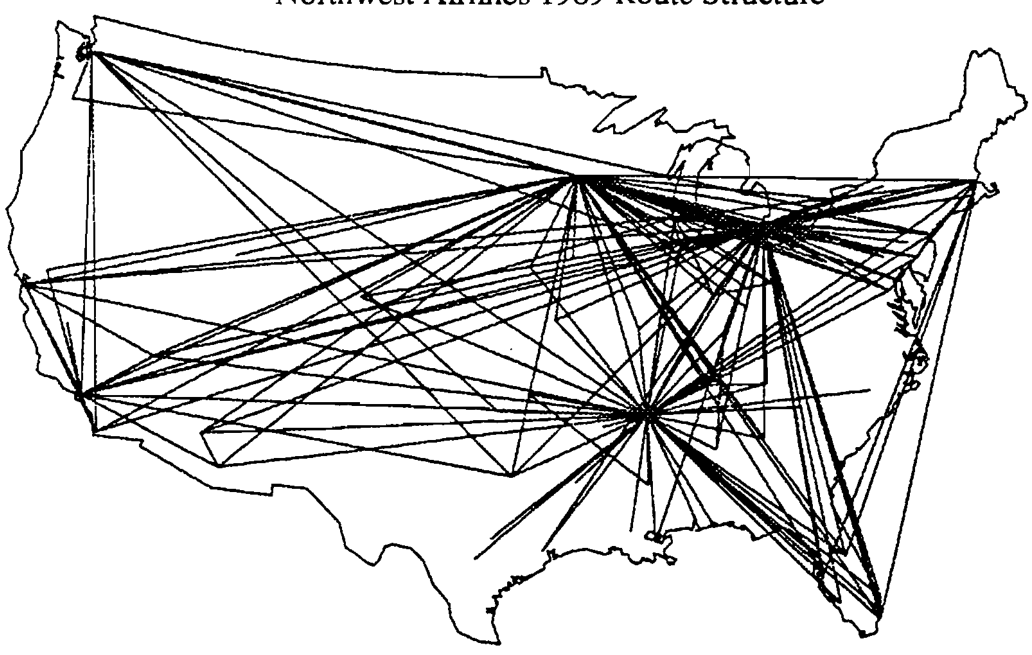
1989

Source: United Airlines schedule guides, 1965 and summer 1989.

Figure 2. Examples of Airline Route Structures

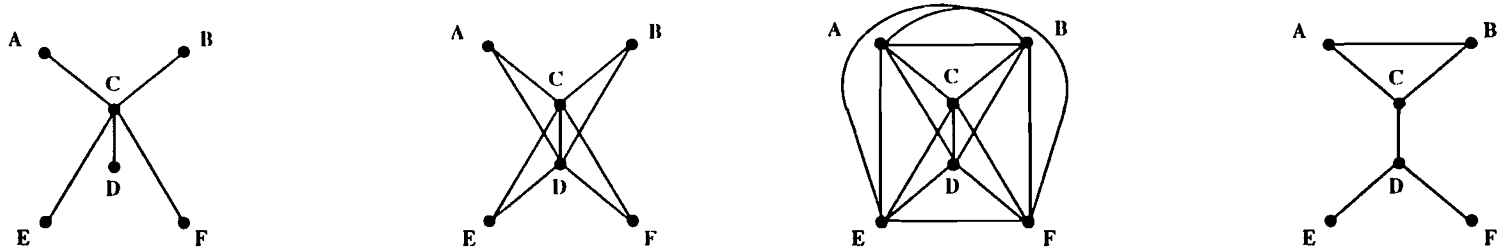
Southwest Airlines 1989 Route Structure

Northwest Airlines 1989 Route Structure



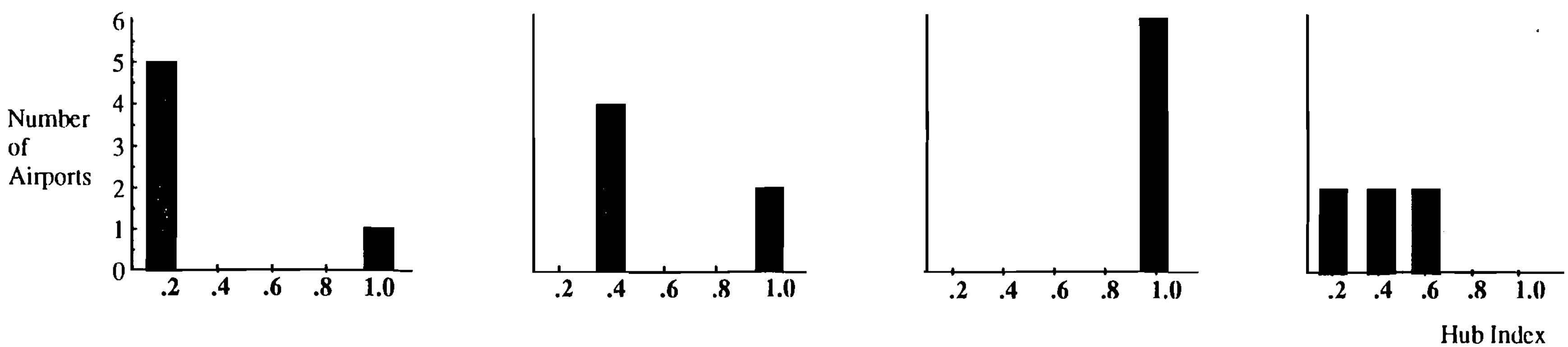
Source: Southwest and Northwest Airlines schedule guides, summer 1989.

Figure 3. Hypothetical Airline Route Structures



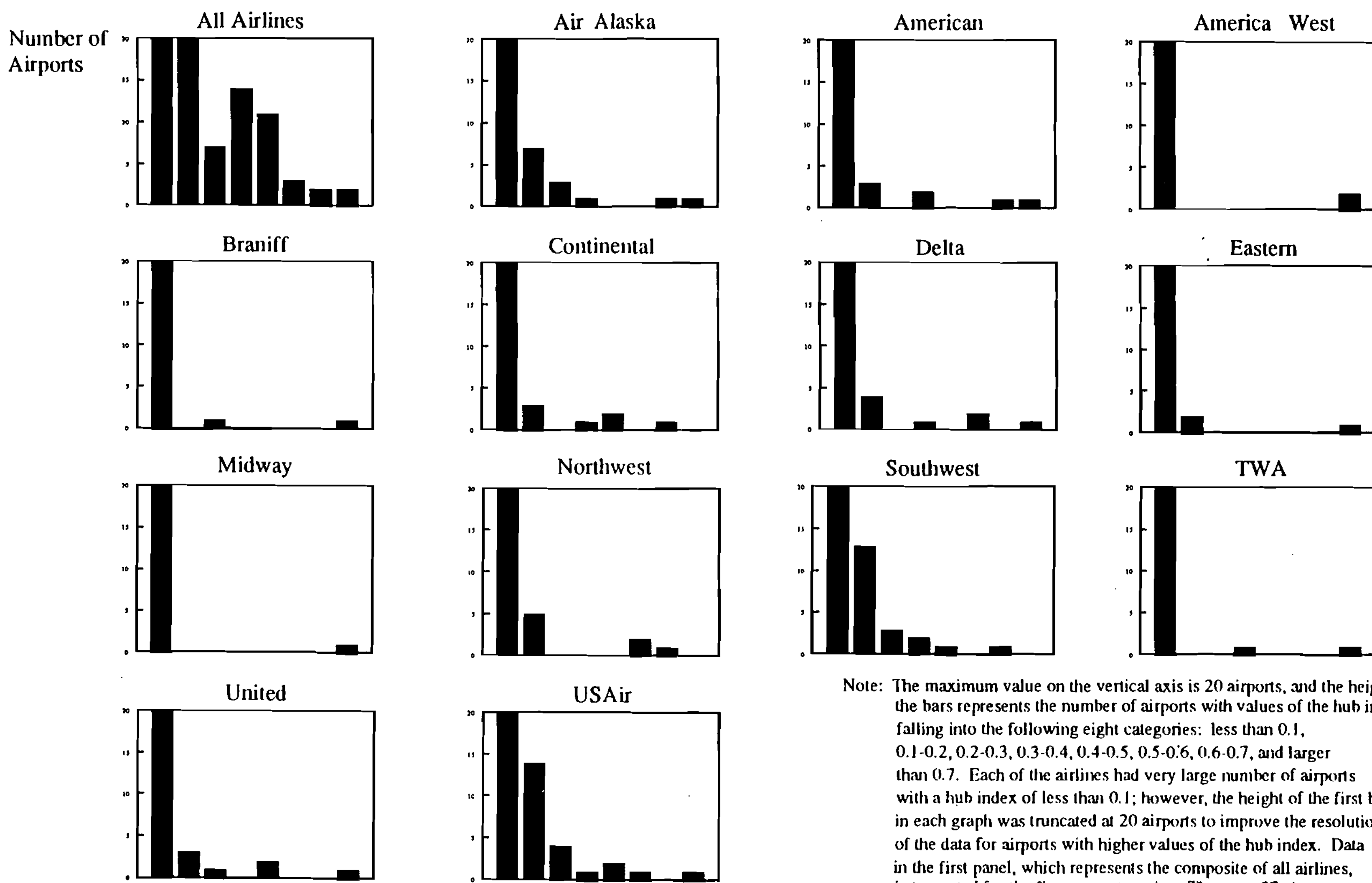
Mono-hub | Dual-hub | Diffuse system-1 | Diffuse system-2

	Mono-hub			Dual-hub			Diffuse system-1			Diffuse system-2		
Airport	Service	Hub Index	Route Concentration	Service	Hub Index	Route Concentration	Service	Hub Index	Route Concentration	Service	Hub Index	Route Concentration
C	5	1.00	0.50	5	1.00	0.28	5	1.00	0.17	3	0.60	0.25
D	1	0.20	0.60	5	1.00	0.56	5	1.00	0.33	3	0.60	0.50
A	1	0.20	0.70	2	0.40	0.67	5	1.00	0.50	2	0.40	0.67
B	1	0.20	0.80	2	0.40	0.78	5	1.00	0.67	2	0.40	0.83
E	1	0.20	0.90	2	0.40	0.89	5	1.00	0.83	1	0.20	0.92
F	1	0.20	1.00	2	0.40	1.00	5	1.00	1.00	1	0.20	1.00
	10			18			30			12		



Source: Authors' calculations.

Figure 4. Distribution of Nonstop Service by Airline and Airport

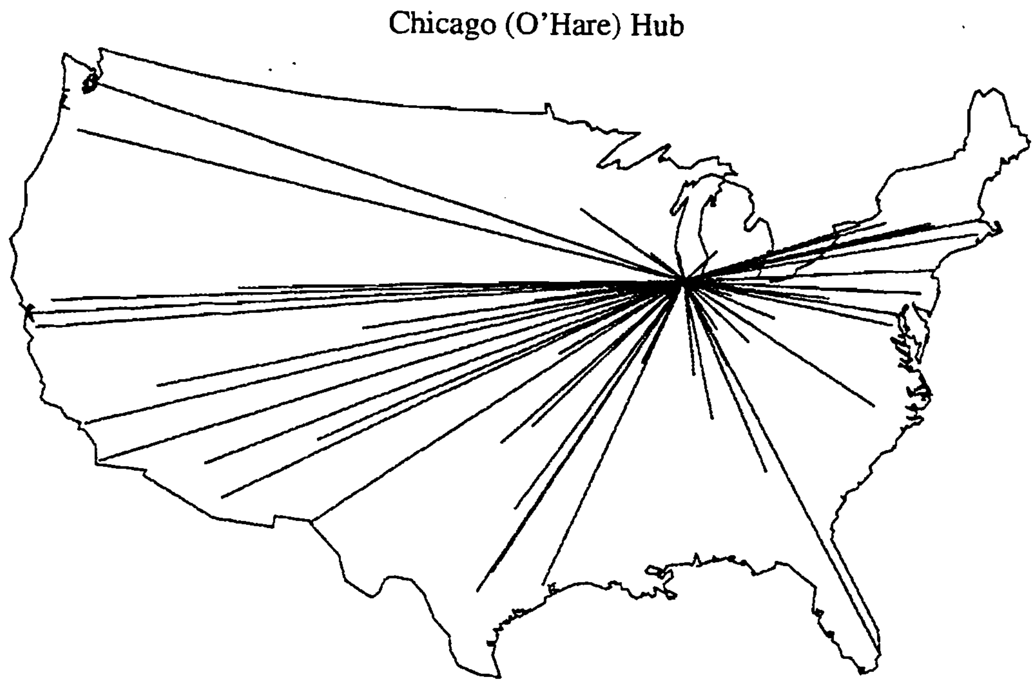


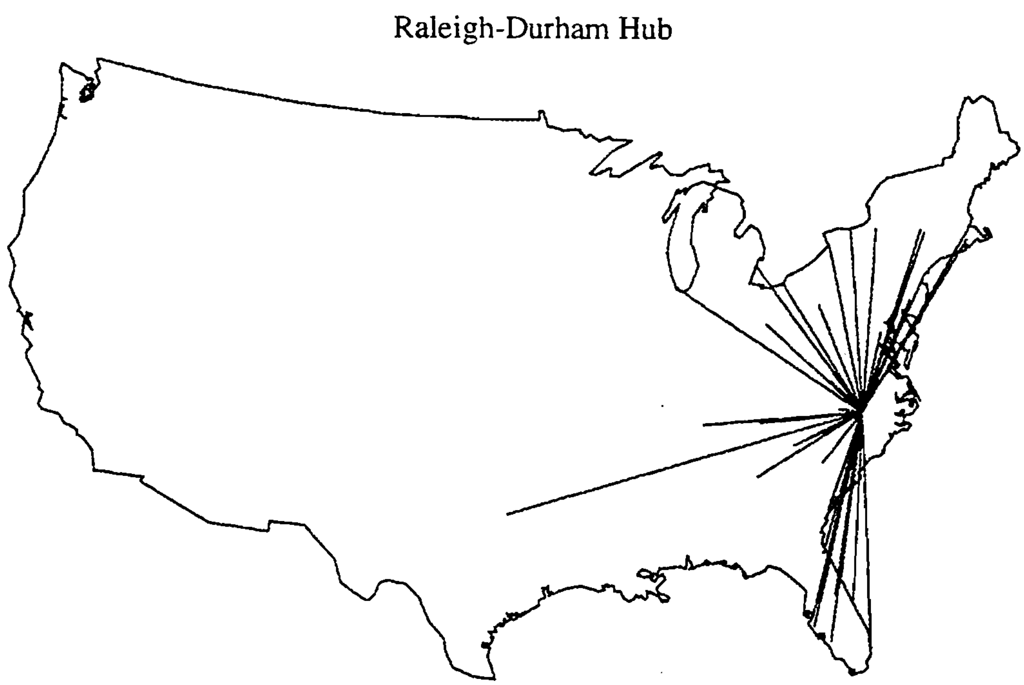
Source: Various airline schedule guides, 1989, and authors' calculations.

Note: The maximum value on the vertical axis is 20 airports, and the height of the bars represents the number of airports with values of the hub index falling into the following eight categories: less than 0.1, 0.1-0.2, 0.2-0.3, 0.3-0.4, 0.4-0.5, 0.5-0.6, 0.6-0.7, and larger than 0.7. Each of the airlines had very large number of airports with a hub index of less than 0.1; however, the height of the first bar in each graph was truncated at 20 airports to improve the resolution of the data for airports with higher values of the hub index. Data in the first panel, which represents the composite of all airlines, is truncated for the first two categories. There are 37 airports with a hub index less than 0.1 and 35 airports with a hub index between 0.1 and 0.2.

Figure 5. Hub Cities, 1989

Figure 6. Service at Selected American Airlines Hubs, 1989





Source: American Airlines schedule guide, summer 1989.

Table 1. Metropolitan Areas with Multiple Airports

Metropolitan Area	Airport
Chicago-Gary-Lake County, IL-IN-WI CMSA	Chicago Midway Chicago O'Hare
Cleveland-Akron-Lorain, OH CMSA	Akron Canton Regional Cleveland Hopkins International
Dallas-Fort Worth, TX CMSA	Dallas Love Field Dallas Ft. Worth International
Houston-Galveston-Brazoria, TX CMSA	William P. Hobby Houston Intercontinental
Los Angeles-Anaheim-Riverside, CA CMSA	Burbank-Glendale-Pasadena Los Angeles International Long Beach Ontario International John Wayne Airport
Miami-Fort Lauderdale, FL CMSA	Fort Lauderdale Miami International
New York-N. New Jersey-Long Island, NY-NJ-CT CMSA	Long Island MacArthur Newark International John F. Kennedy International La Guardia
San Francisco-Oakland-San Jose, CA CMSA	Metropolitan Oakland San Francisco International San Jose International
Tampa-St. Petersburg-Clearwater, FL MSA	St. Petersburg-Clearwater Tampa International
Washington, DC-MD-VA MSA	Washington National Airport Washington Dulles Airport

Source: Authors' assignments.

Table 2. Selected Statistics for Principal U.S. Passenger Airlines

					Percentage of Airport Pairs with				Percentage of Airline's Routes that Originate from				
Airline [1]	Type [2]	Percentage Regional [3]	Airports Served [4]	Nonstop Routes [5]	No Service [6]	Nonstop Service [7]	One-stop Service [8]	Two-or-more-stop Service [9]	1 Airport [10]	2 Airports [11]	4 Airports [12]	6 Airports [13]	MW Index [14]
Large National													
American	Multi-hub	68.9	102	532	17.1	4.3	62.3	16.3	13.7	25.6	39.8	45.5	0.3331
Delta	Multi-hub	74.3	101	592	18.8	4.8	59.7	16.8	13.3	22.1	36.7	43.2	0.3092
Northwest	Multi-hub	66.2	89	408	37.0	3.3	42.5	17.2	14.0	26.2	41.4	48.0	0.3394
USAir	Diffuse	78.7	89	752	37.0	6.0	39.9	17.1	8.5	15.3	25.9	33.6	0.1912
United	Multi-hub	71.8	100	496	20.4	4.0	60.5	15.0	16.9	26.0	39.9	46.0	0.3488
Medium National													
Continental	Multi-hub	65.9	71	328	60.0	2.6	25.6	11.8	14.0	25.0	43.0	50.0	0.2635
TWA	Dual-hub	66.7	76	276	54.5	2.2	40.9	2.7	26.1	35.5	40.6	44.6	0.3632
Small National													
Braniff	Dual-hub	71.7	43	106	85.5	0.9	11.7	1.9	35.8	47.2	50.9	54.7	0.3913
Eastern	Mono-hub	83.6	53	134	77.8	1.1	20.3	0.8	38.1	43.3	52.2	58.2	0.4114
Midway	Mono-hub	80.0	35	70	90.4	0.6	9.0	0.0	48.6	51.4	55.7	58.6	0.4871
America West	Dual-hub	80.7	36	124	89.9	1.0	8.5	0.6	26.6	47.6	52.4	57.3	0.2829
Regional													
Air Alaska	Diffuse	100.0	15	60	98.3	0.5	1.0	0.2	21.7	38.3	53.3	66.7	0.0975
Southwest	Diffuse	92.5	27	134	94.4	1.1	2.8	1.7	12.7	22.4	37.3	47.8	0.1028
Total	Diffuse	71.0	112	2750	0.0	22.1	72.4	5.5	3.3	6.3	11.7	16.2	0.1003

Sources: Various airline service guides, summer 1989, and authors' calculations.

Table 3. Selected Statistics for Hub Airport-Airline Combinations, 1989

Airport [1]	Airline [2]	Airports Served by Airline [3]	Percent Regional [4]	Hub Service: Nonstop [5]	Hub Service: One-stop [6]	Hub Index [7]	Percentage of Routes with Competition: Nonstop [8]	Percentage of Routes with Competition: One-stop [9]	Average Number of Competitors: Nonstop [10]	Average Number of Competitors: One-stop [11]
Portland-Vancouver, OR-WA	Air Alaska	15	100	10	4	71.43	60.0	100.0	1.30	6.00
Seattle-Tacoma, WA	Air Alaska	15	100	13	1	92.86	76.9	100.0	1.85	9.00
Chicago-Gary-Lake County, IL-IN-WI (O'Hare)	American	102	60	63	38	62.38	92.1	100.0	1.25	4.74
Dallas-Ft. Worth, TX (International)	American	102	44	73	28	72.28	76.7	100.0	0.92	4.04
Nashville, TN	American	102	84	37	64	36.63	27.0	98.4	0.41	4.13
Raleigh-Durham, NC	American	102	92	39	61	38.61	25.6	96.7	0.33	3.02
Las Vegas, NV	America West	36	81	26	8	74.29	57.7	100.0	1.04	7.13
Phoenix, AZ	America West	36	82	33	2	94.29	63.6	100.0	1.09	6.50
Kansas City, MO-KS	Braniff	43	63	38	4	90.48	44.7	100.0	0.61	9.00
Orlando, FL	Braniff	43	83	12	30	28.57	83.3	100.0	1.67	7.17
Cleveland-Akron-Lorain, OH (Akron-Canton)	Continental	71	72	25	44	35.71	72.0	100.0	0.84	5.50
Houston-Galveston-Brazoria, TX (International)	Continental	71	48	46	23	65.71	26.1	100.0	0.33	4.04
New York-New Jersey-Long Island, NY-NJ-CT (Newark)	Continental	71	74	34	36	48.57	64.7	100.0	0.74	5.64
Denver-Boulder, CO	Continental	71	72	36	33	51.43	88.9	100.0	1.11	6.18
Atlanta, GA	Delta	101	66	79	21	79.00	67.1	100.0	0.87	3.62
Dallas-Ft. Worth, TX (International)	Delta	101	50	52	48	52.00	98.1	97.9	1.19	4.21
Cincinnati-Hamilton, OH-KY-IN	Delta	101	78	51	49	51.00	17.6	87.8	0.22	2.80
Los Angeles-Anaheim-Riverside, CA (LA International)	Delta	101	75	20	78	20.00	80.0	100.0	2.40	6.18
Salt Lake City-Ogden, UT	Delta	101	80	35	64	35.00	22.9	89.1	0.31	2.63
Atlanta, GA	Eastern	53	80	51	1	98.08	94.1	100.0	1.25	5.00
Chicago-Gary-Lake County, IL-IN-WI (Midway)	Midway	35	79	34	0	100.00	17.6	89.1	0.26	0.00
Detroit-Ann Arbor, MI	Northwest	89	75	57	31	64.77	38.6	100.0	0.46	4.23
Memphis, TN-AR-MS	Northwest	89	68	50	38	56.82	14.0	97.4	0.20	3.63
Minneapolis-St. Paul, MN-WI	Northwest	89	47	47	41	53.41	29.8	100.0	0.36	4.41
Dallas-Ft. Worth, TX (Love Field)	Southwest	27	100	10	10	38.46	0.0	0.0	0.00	0.00
El Paso, TX	Southwest	27	70	10	13	38.46	20.0	100.0	0.30	2.62
Phoenix, AZ	Southwest	27	88	17	8	65.38	76.5	87.5	1.29	5.25
Houston-Galveston-Brazoria, TX (Hobby)	Southwest	27	100	13	12	50.00	23.1	100.0	0.23	6.58
New York-New Jersey-Long Island, NY-NJ-CT (JFK)	TWA	76	69	26	48	34.67	50.0	100.0	0.65	3.71
St. Louis, MO-IL	TWA	76	50	72	3	96.00	27.8	100.0	0.31	4.67
Chicago-Gary-Lake County, IL-IN-WI (O'Hare)	United	100	63	84	14	84.85	75.0	100.0	1.01	4.36
Los Angeles-Anaheim-Riverside, CA (LA International)	United	100	59	17	77	17.17	94.1	98.7	2.76	6.40
San Francisco-Oakland-San Jose, CA (San Francisco)	United	100	60	25	69	25.25	80.0	98.6	1.56	5.74
Denver-Boulder, CO	United	100	67	45	51	45.45	75.6	100.0	0.96	5.22
Washington, DC-MD-VA (Dulles)	United	100	75	44	54	44.44	20.5	98.1	0.25	4.33
Baltimore, MD	USAir	89	76	37	49	42.05	27.0	100.0	0.30	5.14
Charlotte-Gastonia-Rock Hill, NC-SC	USAir	89	75	51	36	57.95	13.7	94.4	0.18	2.78

Table 3. (continued)

Airport [1]	Airline [2]	Airports Served by Airline [3]	Percent Regional [4]	Hub Service Nonstop [5]	Hub Service One-stop [6]	Hub Index [7]	Percentage of Routes with Competition Nonstop [8]	Percentage of Routes with Competition One-stop [9]	Average Number of Competitors Nonstop [10]	Average Number of Competitors One-stop [11]
Cleveland-Akron-Lorain, OH (Akron-Canton)	USAir	89	71	21	66	23.86	71.4	100.0	0.76	5.41
Pittsburgh-Beaver Valley, PA	USAir	89	64	64	24	72.73	18.8	95.8	0.22	3.46
Indianapolis, IN	USAir	89	81	21	61	23.86	33.3	100.0	0.38	5.72
Dayton-Springfield, OH	USAir	89	78	23	63	26.14	0.0	98.4	0.00	3.33
Los Angeles-Anaheim-Riverside, CA (LA International)	USAir	89	50	18	69	20.45	66.7	100.0	2.00	6.28
Philadelphia-Wilmington-Trenton, PA-NJ-DE-MD	USAir	89	86	35	46	39.77	31.4	100.0	0.40	5.89
Washington, DC-MD-VA (National)	USAir	89	81	43	43	48.86	37.2	97.7	0.51	5.33

Sources: Various airline schedule guides, summer 1989, and authors' calculations.

Table 4. Concentration Statistics for Airports in Large Metropolitan Areas, 1989

Airport	Nonstop (all airlines)	One-stop (all airlines)	Percentage of Routes with Competition		Average Number of Airlines per Route		Herfindahl Index (overall service)		Herfindahl Index (airport pairs)	
			Nonstop	One-stop	Nonstop	One-stop	Nonstop	One-stop	Nonstop	One-stop
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Adams Field (Little Rock, AK)	11	95	27.3	80.6	1.4	3.2	1733.3	1956.5	8484.8	4204.4
Akron-Canton Regional	7	99	14.3	83.5	1.1	3.5	1875.0	1747.9	9285.7	3929.5
Albany County Airport	16	92	37.5	83.5	1.6	4.1	1872.0	1398.2	7937.5	3500.2
Albuquerque	16	90	50.0	93.3	1.6	4.6	1479.3	1266.0	7291.7	2876.7
Allen C. Thompson Field (Jackson, MS)	8	95	12.5	73.9	1.1	2.2	4074.1	3518.8	9375.0	5433.3
Allentown-Bethlehem	8	99	12.5	73.6	1.1	2.6	3333.3	2636.7	9375.0	4924.2
Anchorage International	4	88	25.0	40.5	1.8	1.6	3061.2	4056.1	8125.0	7509.5
Atlanta Hartsfield	84	27	63.1	96.2	1.8	4.2	3810.1	1103.7	6537.7	1912.2
Baltimore-Washington, DC	47	64	25.5	96.8	1.3	5.1	3904.9	1191.2	8652.5	2152.4
Baton Rouge Metropolitan	7	95	14.3	76.7	1.1	2.7	3125.0	2689.7	9285.7	4828.2
Birmingham Municipal	17	89	23.5	91.0	1.3	3.8	1818.2	1710.5	8725.5	3212.5
Blue Grass (Lexington, KY)	13	95	0.0	85.1	1.0	3.2	3491.1	2122.3	10000.0	3939.3
Burbank-Glendale-Pasadena	13	76	15.4	73.3	1.2	2.2	1875.0	2457.9	9102.6	5337.4
Bush Field (Augusta, GA)	1	83	100.0	58.0	2.0	1.6	5000.0	5232.0	5000.0	7073.2
Charleston International (SC)	14	93	21.4	77.8	1.2	3.0	3771.6	2165.6	8928.6	4331.7
Charlotte/Douglas International	51	60	13.7	88.1	1.2	3.3	7277.8	1711.7	9248.4	3054.5
Chicago Midway	38	72	18.4	77.8	1.3	2.5	5164.9	1701.5	8969.3	3915.1
Chicago O'Hare	90	21	71.1	100.0	2.0	4.3	3603.4	1098.4	6055.6	1822.0
City of Colorado Springs	9	93	22.2	80.4	1.2	3.4	1900.8	1832.8	8888.9	4102.3
Cleveland Hopkins International	43	68	51.2	97.0	1.6	5.0	2491.3	1095.5	7345.0	2020.3
Columbia Metropolitan (SC)	9	98	22.2	76.6	1.2	3.0	2892.6	2174.7	8888.9	4551.8
Corpus Christi International	4	74	0.0	60.6	1.0	1.7	3750.0	4369.8	10000.0	6644.4
Dallas-Ft. Worth International	76	35	73.7	94.1	1.9	4.4	3957.7	1224.5	6085.5	2011.3
Dallas Love Field	10	49	0.0	0.0	1.0	1.0	10000.0	10000.0	10000.0	10000.0
Dane County Regional (Madison, WI)	6	90	16.7	81.1	1.2	3.3	2653.1	2134.2	9166.7	4078.1
Daytona Beach Regional	7	81	28.6	73.7	1.4	3.0	1800.0	2102.6	8333.3	4687.7
Des Moines International	8	94	25.0	83.0	1.3	3.7	1800.0	1656.4	8750.0	3776.4
Detroit Metropolitan	60	51	36.7	98.0	1.4	4.8	4553.8	1058.1	8055.6	1915.9
El Paso International	14	90	21.4	65.0	1.3	2.3	3580.2	2441.9	8809.5	5372.3
Eppley Airfield (Omaha, NE)	13	98	7.7	91.8	1.1	4.8	1326.5	1263.6	9615.4	2876.4
Evansville Regional	8	100	0.0	81.7	1.0	2.9	2187.5	2267.7	10000.0	4399.3

Table 4. (continued)

Airport [1]	Nonstop (all airlines) [2]	One-stop (all airlines) [3]	Percentage of Routes with Competition: Nonstop [4]	Percentage of Routes with Competition: One-stop [5]	Average Number of Airlines per Route: Nonstop [6]	Average Number of Airlines per Route: One-stop [7]	Herfindahl Index (overall service): Nonstop [8]	Herfindahl Index (overall service): One-stop [9]	Herfindahl Index (airport pairs): Nonstop [10]	Herfindahl Index (airport pairs): One-stop [11]
Fayetteville Municipal	8	95	0.0	75.5	1.0	2.8	2500.0	2103.1	10000.0	4831.7
Fort Lauderdale	25	85	48.0	96.4	1.7	5.4	1689.3	1152.0	7300.0	2189.1
Fort Wayne Municipal (Fort Wayne, IN)	10	96	20.0	78.1	1.2	3.3	1944.4	1882.0	9000.0	4259.4
Fresno Air Terminal	12	57	33.3	67.3	1.6	2.5	2465.4	1960.0	8083.3	5299.5
General Edward Lawrence (Boston, MA)	43	68	32.6	98.5	1.5	5.9	1417.8	1024.7	8108.5	1782.6
General Mitchell Field (Milwaukee, WI)	22	87	27.3	93.1	1.3	4.8	2627.6	1202.8	8636.4	2603.5
Greater Buffalo International	19	90	21.1	86.5	1.3	4.1	2986.1	1514.8	8859.6	3300.5
Greater Cincinnati International	53	58	17.0	86.0	1.2	3.6	6445.3	1711.7	9088.1	3010.6
Greater Pittsburgh International	64	47	18.8	89.1	1.2	3.9	6778.4	1216.6	9010.4	2445.7
Greensboro High Point (NC)	15	94	20.0	85.1	1.2	3.2	4814.8	2058.2	9000.0	3856.3
Greenville Spartanburg (Greer, SC)	4	85	50.0	83.3	2.0	3.0	1875.0	2076.1	6666.7	4308.7
Harrisburg International	12	88	8.3	88.6	1.1	3.6	2781.1	1788.3	9583.3	3471.7
Honolulu International	13	97	38.5	88.7	1.8	3.9	1720.2	1690.5	7692.3	3289.2
Houston Intercontinental	52	59	23.1	96.6	1.3	4.0	4854.1	1184.1	8750.0	2412.8
Indianapolis International	35	76	34.3	97.3	1.4	5.6	2309.0	1064.9	8238.1	1959.3
Jacksonville International	20	90	25.0	96.6	1.3	4.7	1982.2	1347.9	8666.7	2513.3
James Cox Dayton International	30	80	3.3	91.1	1.0	3.7	5650.4	1680.0	9833.3	3065.7
John F. Kennedy International	39	72	35.9	88.6	1.5	3.6	2847.0	1565.3	8034.2	3077.8
John Wayne Airport (Santa Ana, CA)	13	89	23.1	77.1	1.2	2.4	2500.0	2701.9	8846.2	4928.8
Kansas City International	45	66	40.0	97.0	1.5	5.3	3261.9	964.4	7796.3	1932.6
Kent County International (Grand Rapids, MI)	9	88	22.2	87.5	1.2	3.8	1735.5	1595.0	8888.9	3524.5
La Guardia	43	68	39.5	95.5	1.5	5.3	1460.4	1158.7	7848.8	2060.1
Lamber-St. Louis International	72	39	27.8	94.9	1.3	3.7	5959.7	1125.2	8564.8	2165.1
Long Beach	13	89	30.8	73.3	1.5	2.9	1300.0	1739.7	8141.0	4528.0
Long Island MacArthur	10	89	0.0	68.3	1.0	2.1	4200.0	3156.5	10000.0	5643.1
Los Angeles International	53	58	50.9	96.6	2.2	5.6	1287.0	951.3	6670.3	1762.5
Lovell Field (Chattanooga, TN)	6	84	16.7	82.1	1.2	3.0	1836.7	2097.2	9166.7	4372.2
McCarran International (Las Vegas, NV)	40	71	42.5	94.4	1.7	5.2	1892.5	1059.9	7495.8	2224.5
McGee Tyson (Knoxville,TN)	14	95	14.3	91.5	1.2	4.5	1764.7	1480.4	9166.7	2804.2
Melbourne Regional (Melbourne, FL)	6	82	33.3	75.3	1.5	3.3	1851.9	1803.7	8055.6	4444.4
Memphis International	54	57	13.0	91.1	1.2	3.9	6206.1	1510.3	9259.3	2677.5

Table 4. (continued)

Airport [1]	Nonstop (all airlines) [2]	One-stop (all airlines) [3]	Percentage of Routes with Competition: Nonstop [4]	Percentage of Routes with Competition: One-stop [5]	Average Number of Airlines per Route: Nonstop [6]	Average Number of Airlines per Route: One-stop [7]	Herfindahl Index (overall service): Nonstop [8]	Herfindahl Index (overall service): One-stop [9]	Herfindahl Index (airport pairs): Nonstop [10]	Herfindahl Index (airport pairs): One-stop [11]
Metropolitan Oakland	17	85	52.9	63.4	1.6	2.6	1879.3	1739.8	7254.9	5015.6
Miami International	33	78	36.4	97.4	1.6	5.4	1248.3	1099.4	7848.5	2027.2
Michiana Regional (South Bend, IN)	10	91	10.0	81.3	1.1	4.1	1405.0	1437.6	9500.0	3729.4
Minneapolis-St. Paul	49	62	28.6	93.4	1.3	4.6	5183.7	1119.6	8469.4	2285.7
Mobile	8	94	12.5	78.3	1.1	3.0	2098.8	2097.1	9375.0	4501.7
Nashville Metropolitan	44	67	22.7	94.0	1.3	4.6	4185.6	1378.6	8674.2	2417.1
New Orleans International	30	81	16.7	98.8	1.2	5.4	1358.0	1138.9	9111.1	2083.7
Newark International	48	63	47.9	96.8	1.5	5.4	2710.0	1090.9	7500.0	1902.6
Ontario International (CA)	18	91	55.6	87.9	1.7	4.4	1288.9	1213.5	7037.0	3122.4
Orlando International	41	70	46.3	98.6	1.8	5.4	1551.9	1087.8	7243.9	1891.9
Palm Beach International	9	82	0.0	69.1	1.0	2.0	4321.0	3486.3	10000.0	5777.8
Pensacola Regional	8	84	12.5	81.7	1.1	3.0	2592.6	2088.5	9375.0	4313.0
Philadelphia International	48	63	29.2	95.2	1.4	5.4	3216.6	1096.4	8437.5	1968.1
Phoenix Sky Harbor	53	58	47.2	96.6	1.8	5.5	1918.1	936.6	7279.9	1806.5
Port Columbus International (Columbus, OH)	21	88	38.1	95.5	1.4	5.1	1533.9	1171.9	8095.2	2438.0
Portland International	21	88	42.9	87.5	1.8	4.0	1716.6	1439.2	7528.3	3181.3
Quad City (Moline, IL)	7	88	14.3	87.5	1.1	3.8	1562.5	1613.4	9285.7	3595.0
Raleigh-Durham	42	68	23.8	92.5	1.3	3.7	5233.1	1734.2	8690.5	2865.4
Richmond International Airport (Byrd Field) (VA)	13	94	30.8	80.2	1.3	3.1	3010.4	2171.1	8461.5	4211.5
Roanoke Regional (Woodrum Field)	10	97	0.0	78.7	1.0	2.7	3400.0	2694.6	10000.0	4631.4
Robert Mueller (Austin,TX)	13	98	46.2	88.8	1.6	4.2	1247.2	1417.0	7435.9	3301.9
Rochester--Monroe (Rochester, NY)	17	91	17.6	78.9	1.2	3.5	3950.0	1792.8	9117.6	3842.7
Sacramento Metropolitan	18	84	44.4	83.3	1.6	3.3	2117.3	1727.1	7638.9	3854.8
Salt Lake City International	35	76	22.9	86.5	1.3	3.5	5897.9	1632.3	8714.3	3245.5
San Antonio International	20	91	40.0	95.6	1.4	5.0	1201.0	1150.6	7916.7	2557.6
San Diego International	26	85	42.3	94.1	1.8	5.2	1171.9	1114.2	7426.7	2350.1
San Francisco International	44	67	59.1	97.0	2.0	5.7	1503.7	1016.5	6498.4	1831.1
San Jose International	20	82	65.0	86.6	1.8	3.6	1934.7	1513.9	6583.3	3421.8
Santa Barbara Municipal	10	92	30.0	58.4	1.4	1.9	3163.3	3264.7	8333.3	6212.1
Sarasota-Bradenton Airport (Sarasota, FL)	14	96	28.6	94.7	1.4	4.5	1450.0	1339.5	8392.9	2872.8
Savannah International	8	94	25.0	79.6	1.3	3.0	2400.0	2142.9	8750.0	4480.2

Table 4. (continued)

Airport [1]	Nonstop (all airlines) [2]	One-stop (all airlines) [3]	Percentage of Routes with Competition: Nonstop [4]	Percentage of Routes with Competition: One-stop [5]	Average Number of Airlines per Route: Nonstop [6]	Average Number of Airlines per Route: One-stop [7]	Herfindahl Index (overall service): Nonstop [8]	Herfindahl Index (overall service): One-stop [9]	Herfindahl Index (airport pairs): Nonstop [10]	Herfindahl Index (airport pairs): One-stop [11]
Seattle Tacoma International	34	77	47.1	98.7	1.9	5.9	1483.0	1058.2	7125.4	1802.8
Shreveport Regional (LA)	8	93	12.5	73.9	1.1	2.6	3827.2	2672.4	9375.0	5000.0
Southwest Florida Regional (Fort Myers, FL)	23	87	17.4	96.5	1.3	5.2	1177.2	1141.0	9021.7	2271.7
Spokane International	6	87	50.0	64.3	1.7	2.3	2600.0	2600.4	7222.2	5670.4
Standiford Field (Louisville, KY)	18	91	0.0	0.0	1.0	1.0	2107.4	1467.1	8888.9	2544.3
Stapleton International (Denver, CO)	56	55	22.2	95.6	1.2	4.7	3431.3	1013.3	6711.3	1852.3
St. Petersburg-Clearwater	3	89	60.7	100.0	1.8	5.3	10000.0	10000.0	10000.0	10000.0
Syracuse Hancock International	20	89	15.0	84.1	1.1	4.1	3988.7	1520.0	9250.0	3304.2
Tampa International	37	74	24.3	97.3	1.4	5.4	1463.2	1092.3	8545.0	1994.7
Theodore Francis Green State Airport (Providence, RI)	12	95	33.3	82.4	1.3	3.8	1953.1	1568.9	8333.3	3788.1
Toledo Express	9	99	22.2	79.8	1.2	4.0	1735.5	1546.7	8888.9	3781.1
Tucson International	15	92	33.3	83.7	1.7	4.4	1136.0	1259.2	8000.0	3335.9
Tulsa International	16	95	31.3	91.6	1.3	4.3	1519.3	1428.4	8437.5	3130.6
Washington National	57	54	18.0	96.7	1.2	4.6	3141.3	1102.8	8260.2	1984.8
Washington (Dulles)	50	61	31.6	96.1	1.4	5.1	5340.0	1344.5	9050.0	2343.0
Wichita Mid-Continental	13	95	23.1	90.4	1.2	4.5	1328.1	1195.8	8846.2	3163.0
Will Rogers World (Oklahoma City, OK)	15	96	26.7	90.6	1.3	4.3	1689.8	1415.2	8666.7	3128.8
William P. Hobby (Houston,TX)	28	83	14.3	92.8	1.1	4.7	2246.1	1220.9	9285.7	2650.2
Yeager Airport (Charleston, WV)	9	83	0.0	73.5	1.0	2.1	4074.1	3539.8	10000.0	5489.1
Mean	24.55	80.32	27.98	84.19	1.38	3.83	2926.79	1884.71	8470.13	3572.40
Standard Deviation	19.52	16.56	18.02	15.83	0.28	1.15	1716.86	1334.66	1005.82	1552.19
Coefficient of Variation	0.80	0.21	0.64	0.19	0.20	0.30	0.59	0.71	0.12	0.43

Sources: Various airline schedule guides, summer 1989, and authors' calculations.