Airline Routes and Metropolitan Areas: Changing Access to Nonstop Service Under Deregulation

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As air transportation becomes more accessible to millions of Americans, the evolving network of airline routes continues to evoke both criticism and controversy. Some metropolitan areas are developing extensive nonstop air transportation networks, whereas others, often of similar size and economic status, continue to be served primarily by less desirable and more time-consuming connecting air flights. As shown by this study, these patterns are predictable and efficient market outcomes as carriers simultaneously attempt to minimize costs and cater to the diverging demands of consumers for high-quality and low-priced air service. Three aspects of airline route development are explored in detail: (a) why disparities in air route coverage have emerged among similarly sized metropolitan areas since deregulation, (b) which economic factors are acting to eliminate these disparities, and (c) in what cities consumers appear to be benefiting most from these arrangements. A computer-assisted survey of airline schedules and traffic volumes is conducted for each of the 60 largest population centers in the United States. The disparities in nonstop service among these cities are shown to be partly a result of economies of aircraft size, a factor that renders nonstop air service uneconomical compared with hub service in most city pairs. Market size, length of haul, and proximity to hubs are hypothesized as important determinants of the level of nonstop service provided. More recent trends suggest that other factors are encouraging carriers to move away from centralized hub operations—a reversal attributed to rising demand, falling costs, and varying pricing opportunities between cities.

The deregulation of airline prices and routes continues to have profound effects on U.S. metropolitan areas. In a turbulent marketplace marked by escalating competition and consumer demand, the prices of flights, schedules, and seat availability levels are shifting dramatically: since passage of the Airline Deregulation Act, prices have declined in real terms by 21 percent, new nonstop services have been added on 328 routes, and passenger miles have more than doubled (1).

As air transportation becomes more accessible to millions of Americans, however, the evolving network of airline routes linking the largest metropolitan areas in the United States continues to evoke both criticism and controversy. Some metropolitan areas are developing extensive nonstop air transportation networks, whereas others, often of similar size and economic status, continue to be served primarily by less desirable and more time-consuming connecting air flights. The effects of these disparities are borne primarily by time-conscious consumers such as those traveling for business or emergency purposes, for whom the absence of nonstop service means a costly loss of time, often exceeding 2 hr per trip. For even a relatively small metropolitan area, the collective value of this lost time can reach millions of dollars annually.

Prevailing public opinion often holds that the uneven development of nonstop air service under deregulation is a consequence of the oligopolistic structure of the industry—a factor alleged to encourage firms to tacitly collude to concentrate services at hubs to preserve regional market power or prevent costly product differentiation. Others misleadingly assert that the centralization of service is a function of hub "economies of scale." This study, which is supported by a unique computer-assisted survey of airline routes in the United States, is based on earlier academic research and illustrates that the uneven structure of nonstop service across metropolitan areas is an inevitable consequence of the market's response to varying passenger lengths of haul, market sizes, and pricing opportunities. The methodology allows the service disparities to be seen as predictable market outcomes as firms attempt to cater to the diverging demands of consumers for high-quality and low-priced air service. Technological and operational factors are shown to prevent nonstop air service from being provided in direct proportion to the quantity of service that consumers demand.

Three aspects of airline route development are explored in detail: (a) why disparities in the availability of nonstop service have evolved among similarly sized metropolitan areas since deregulation, (b) what economic factors are encouraging the elimination of these disparities, and (c) where time-conscious consumers are benefiting (or losing) most from these arrangements. By comparing the changing levels of nonstop service available from each of 60 major U.S. metropolitan areas, a useful perspective of how time-conscious travelers are being affected by the deregulation of air routes is provided. Evidence suggests that although the marketplace is eroding them, the disparities in nonstop air service among metropolitan areas remain a pervasive feature of the U.S. air transportation system.

The study is divided into four sections: important microeconomic factors affecting the development of nonstop air routes; their implications for metropolitan areas; the changing availability of nonstop air service from 60 metropolitan areas, based on changing commercial flight schedules; and general conclusions.

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The term "nonstop route coverage" (or simply "route coverage") is used to describe the network of routes operated by regularly scheduled air passenger carriers; for any metropolitan area, this is the system of routes radiating directly to other metropolitan areas (the terms "city" and "metropolitan area" are used interchangeably). Frequency of service, schedule convenience, and seat availability along each route, of course, are also important determinants of service quality; however, for this study, attention is focused exclusively on the structure of air routes themselves. This narrow focus offers new insights into the distributional consequences of route deregulation.

CONTRASTING PATTERNS OF NONSTOP AIR SERVICE DEVELOPMENT

Before enactment of the Airline Deregulation Act of 1978, the Civil Aeronautics Board (CAB) regulated and strictly controlled airline routes and prices. Firms were expected to comply with regulatory processes and legal requirements before initiating service and were restricted from entering markets that the CAB considered adequately served by others—a philosophical position the agency held until the late 1970s.

A specific objective of this regulation appears to have been to encourage a more evenly distributed, highly decentralized allocation of nonstop air routes between urban areas by suppressing the cost differences that exist in the supply of these services (2). Three aspects of the CAB's regulatory policy encouraged this outcome. First, the CAB employed rigid controls on route additions, which limited the development of private hub-and-spoke systems on a national scale and encouraged carriers to pursue more point-to-point route strategies (3). Second, passengers on short-haul routes (where price elasticity of demand was high) were systematically cross-subsidized by those on longer routes (where price elasticity was low), allowing much otherwise infeasible nonstop service to be provided (4). Finally, and most significantly, the CAB required both long-haul "trunk" operators and regional operators to voluntarily interchange passengers at intermediate points to facilitate coordinated route development. For example, a passenger traveling from Washington, D.C., to Los Angeles could make transfers between any two airlines at dozens of locations en route, such as Chicago, St. Louis, or Kansas City, for the same price as if the same carrier had been used for the entire trip. All cities were regulated "public" hubs, and homogeneity in air service between cities was preserved (5).

Under deregulation, the fare agreements necessary to continue such interline sales are being phased out gradually as airlines compete for the passenger's entire flight itinerary. Integrated, "private" hub-and-spoke route systems are allowing carriers to link major metropolitan areas with multiple frequencies in all regions of the country. Between 1978 and 1986, the share of the flights serving airline hubs expanded from 74 to 86 percent of the total, and the number of airline hubs doubled (1). In contrast to the regulated era when 20 percent of passengers used two or more airlines en route to their destinations, only 6 percent switched airlines en route in 1986. Private hub systems have become more pervasive, and many cities that served as vital connecting points in the regulated framework lost nonstop service.

The relatively even allocation of routes has given way to a system in which carriers have the operating flexibility to choose the combination of fares, aircraft size, load factors, and frequency to maximize profits in each market. On each route, carriers weigh the diverging demands for service quality and low ticket prices. Frequency of additional flights, for example, improves passenger convenience but leads to higher average costs because carriers must substitute smaller, higher-cost aircraft for such service. Similarly, nonstop service is preferred by consumers to connecting service, but is often more costly because it provides carriers less opportunity to exploit the economies of aircraft size. (Hub service generally is able to consolidate passengers bound for numerous destinations onto a few planes, thus enjoying lower seat-mile costs through the operation of larger aircraft.) Thus, when passengers value the improved frequency and lower ticket prices provided by hub services more than the costs of making an additional stop, carriers have incentives to dispatch passengers through centralized hub facilities.

A Brookings Institution study by Winston and Morrison concludes that the deregulated industry is more efficiently meeting these contrasting consumer preferences for service quality (a function of flight frequency, travel time, and average load factor) and low ticket prices (a function of aircraft size and price structure), with an estimated gain in social welfare of at least $8 billion during 1983 (6). Carriers under deregulation are substituting larger aircraft for smaller aircraft when passengers place relatively little value on flight frequency relative to ticket prices, such as in predominantly pleasure markets. Conversely, in business markets where a premium is placed on time and convenience, smaller aircraft are being employed to provide higher frequency and an emphasis is placed on offering nonstop service—with accompanying higher fares.

As this discussion attempts to show, however, the market's responsiveness to a time-sensitive consumer's demand for nonstop service is greatly affected by exogenous market factors. This is illustrated by considering the simple analogy between the development of air service and the economist's idea of a "lumpy good." "Lumpiness" occurs in a good—or service—that can be efficiently supplied only when output exceeds some minimum threshold; technology prohibits the efficient division of output into smaller units. The development of nonstop airline routes is similarly constrained. Nonstop service can be provided between cities that are not hubs only when demand is sufficiently large to allow nonstop service operators to exploit the economies of aircraft size necessary to compete effectively with hub service. To the extent that traffic levels do not permit the operation of an aircraft sufficiently large to achieve the least-cost scale of operation, the cost differential between nonstop and connecting service grows, increasing the necessary price differential between these competing services. Thus, where lumpiness is severe, less nonstop service tends to be available for time-conscious consumers, and the gains from deregulation primarily accrue to those less sensitive to the added travel time required by hub service.

Previous research has not explored this aspect of deregulation in sufficient detail to fully illustrate its potential significance for consumer welfare. Consider, for example, consumers in Omaha, Nebraska, who had nonstop service to numerous

West Coast markets until 1984. With the increased competition brought about by the added frequency of flights to hubs in Denver, Salt Lake City, and Phoenix, this service evidently became unprofitable and was abandoned. Nonstop service could no longer compete with the lower effective price of hub service. Collectively, consumers in the Omaha market might have benefited from the increased efficiency of the expanded hub operations, but the benefits are distributed unevenly. The improvement in network efficiency is shared by all passengers using the improved hub service, such as those traveling between Omaha and Denver or Salt Lake City, or connecting to other points. However, the costs are borne exclusively by time-conscious consumers desiring to travel between Omaha and the West Coast. If the value of the added hub frequency or lower fares does not offset the costs of the lost nonstop service (i.e., the lost consumer surplus), consumers are worse off under the new arrangement.

A welfare loss emerges whenever the total benefits to consumers of a nonstop service exceed its total costs, but carriers are no longer able to implement a fare structure that extracts sufficient revenue to pay for the service. Indeed, when carriers cannot operate profitably at any price, they can attempt to charge higher prices to those willing to pay for the added convenience of the nonstop service and allow more discretionary passengers to travel at lower fares. However, these efforts are problematic and often unsuccessful; they contributed to the elimination of nonstop service on more than 400 routes between 1977 and 1983 (*1*). This yields a paradoxical outcome: if the addition of new hub service undermines the profitability of nonstop service, time-conscious consumers in affected city pairs might well be worse off because of the hub's increased availability. Depending on the nature of consumer demand, the losses to consumers who are time conscious might well exceed the gains to those who are not.

The scope of this phenomenon can be appreciated by consideration of a few examples. There is sufficient passenger demand on less than 25 percent of the routes linking the 100 largest U.S. metropolitan areas to support profitable nonstop service. The lumpiness phenomenon is exemplified by the absence of nonstop service in city pairs such as Washington, D.C.–San Diego, California; Portland, Oregon–New York, New York; and Boston, Massachusetts–Seattle, Washington. All are markets in which forecast travel volume exceeds 200 passengers a day (*7*). Indeed, the costly absence of nonstop service to many business centers from cities such as Cleveland, Ohio; Oklahoma City, Oklahoma; and Louisville, Kentucky, has prompted municipal governments to initiate bold marketing programs to expand the scope of services, ranging from free gate space to tax incentives.

The technological relationship between aircraft size and flight distance heightens the lumpiness phenomenon on longer routes, further limiting the market's ability to provide cost-effective nonstop service. Fuel economy, labor, and maintenance render smaller aircraft less cost-effective (per seat-mile supplied) relative to larger aircraft as flight distance increases. On short routes, conversely, smaller aircraft are at a relative advantage over larger equipment because they provide greater ease in ground handling and more operational versatility.

The performance statistics of three common aircraft—the Fokker 28, McDonnell Douglas DC-9, and Boeing 747-200 (Figure 1)—illustrate this principle. Optimal aircraft capacity (i.e., that minimizing seat-mile costs) is shown to increase as a positive nonlinear function of length of haul (*8*). In the flight range of 200 mi or less, for example, the 80-seat aircraft (Fokker 28) is most cost-effective. On routes of 1,000 mi, the 325-seat aircraft (Boeing 747-200) is the most efficient, with direct operating costs as low as 2 cents/seat-mile (these estimates exclude nonvariable factors such as depreciation, managerial overhead, and administrative expenses). At intermediate distances, the 145-seat (DC-9) aircraft is the lowest-cost technological unit (*8*).

How does this affect route development? Consider a city pair between which 80 passengers travel daily. On a route of roughly 1,000 mi, nonstop service could be provided with an 80-seat plane at a cost of roughly 4 cents/seat-mile (Figure 1, Point *A*). However, if passengers were consolidated onto a larger 325-seat aircraft at an intermediate hub located 500 mi from each city, average costs would fall to nearly 3 cents/seat-mile (Point *B*), or approximately $10 less per passenger handled. In this example, the airline would have to operate an aircraft at least as large as a DC-9 with 145 seats to achieve cost parity per seat-mile supplied on the 1,000-mi nonstop route, as designated by Point *C*. Economies of aircraft size render nonstop service prohibitively costly relative to the hub service if market size is less than 145 passengers per trip; too much capacity would have to be made available to achieve cost competitiveness. However, if the length of haul in this example is reduced to 150 mi, nonstop service using 80-seat aircraft would be highly cost-effective relative to hub service. In this case, the economics are reversed: an airline seeking to establish hub service finds itself unable to compete effectively with the nonstop operator.

This simple principle suggests that the feasibility of nonstop service under deregulation is positively related to the size of the market and negatively related to the length of haul. A sample of 400 city pairs selected at random from among the 60 largest population centers in the United States supports this view. The city pairs were sorted into three categories on the basis of their relative sizes; large markets have 1987 traffic projections [published by the Boeing Commercial Airplane Company (*9*)] exceeding 200 passengers a day compared with 100 to 199 a day for middle-sized markets and 99 or fewer a day for small markets. Statistical estimates were made to assess the propensity for city pairs to have nonstop service, given forecast traffic and flight distance (Figure 2). City pairs in all three categories were found to exhibit a high likelihood (0.70 or higher) of having available nonstop service when separated by 400 mi or less. However, as length of haul increases, city pairs with higher passenger volumes fare disproportionately well relative to medium-sized and smaller city pairs. For large markets on long-haul routes (over 1,500 mi), for example, the probability of nonstop service is 0.37 compared with only 0.04 for smaller city pairs and 0.14 for medium-sized city pairs. Although traffic volume in small markets on long-haul flights averages about one-fifth that of large city pairs, only one-tenth as much nonstop service is provided. (In fact, when length of haul approaches 2,000 mi, the data suggest that the likelihood of
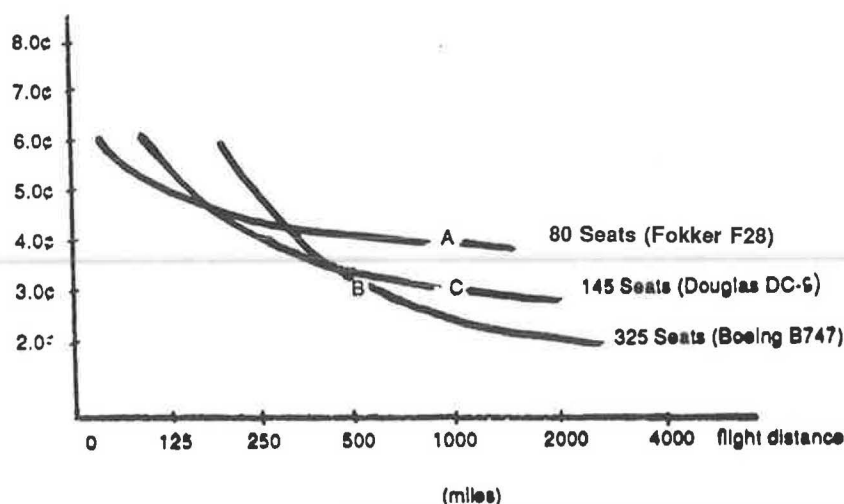
operating cost per seat mile

FIGURE 1 Length of haul and optimal aircraft size for three common aircraft.
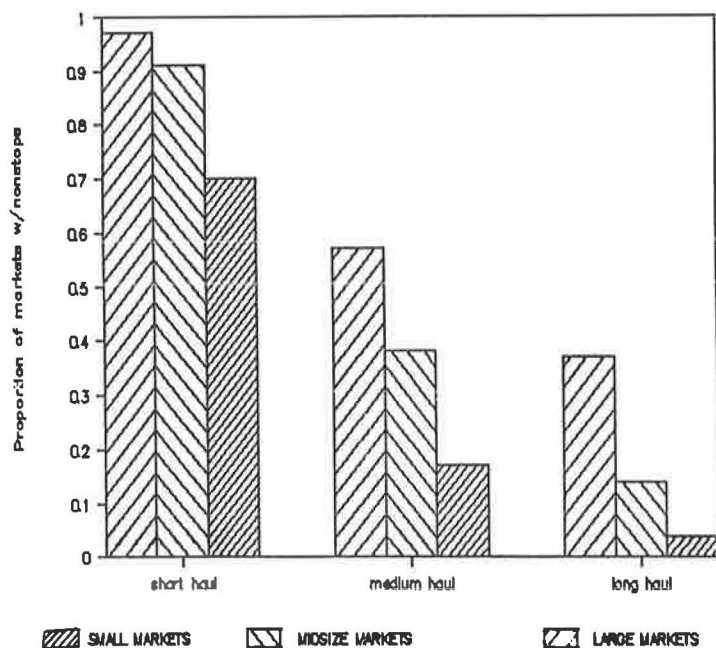

FIGURE 2 Likelihood of scheduled nonstop service: city pairs linking 60 largest U.S. metropolitan areas.

nonstop service in smaller city pairs approaches zero but levels off for larger city pairs at approximately 0.30 percent). Thus, the distribution of nonstop service is far from random—it is systematically related to the market's adaptation of least-cost transportation methods and will affect cities in profoundly different ways.

IMPLICATIONS FOR METROPOLITAN AREAS

These constraints on the development of nonstop air routes indicate that only a fraction of all city pairs will be linked by nonstop flights. Where quantity demanded is low or distance

between cities is great, nonstop service will develop sporadically and service often will be provided more profitably by dispatching passengers to central hub locations. Because the true profit-maximizing market allocation of routes might differ substantially from the regulatory allocation, certain metropolitan areas will experience dramatic service changes under this arrangement. Four aspects of this phenomenon might foster apparent inequities in nonstop service availability.

First, the smaller the city or the more distant the consumers' destinations, the more likely that cost-competitive nonstop service will be infeasible, worsening the market's responsiveness to consumer demand for nonstop service. Seemingly

minor differences in market demand and length of haul were shown in Figure 2 to foster potentially dramatic disparities in nonstop service availability. Consequently, cities located close to others will enjoy a wide range of nonstop service even though larger, more air-dependent cities in more isolated regions might be forced to rely primarily on connecting air service.

It is not surprising that relatively isolated cities such as Portland, Oregon, for example, now have less developed route structures than many smaller cities that are close to major business centers in the Midwest. Portland has nonstop service to only 16 of America's 60 largest business centers, comparing unfavorably with similarly sized eastern cities such as Indianapolis, Indiana (28); Baltimore, Maryland (38); and Columbus, Ohio (19).

This also suggests that consumers in metropolitan areas in which demand for air service is just high enough to mitigate the lumpiness problem will enjoy disproportionate advantages over metropolitan areas just below this threshold under deregulation. In the extreme case, consumers in certain cities will be provided with nonstop service to distant hub facilities even though far more passengers would prefer nonstop service elsewhere. For evidence of this tendency, consider the case of Fort Wayne, Indiana, where routes radiate to distant hubs such as Dallas, Texas; Denver, Colorado; and Atlanta, Georgia; whereas more heavily traveled destinations such as New York, New York; Philadelphia, Pennsylvania; and Washington, D.C., now are served only with connecting flights (7). Here many of the primary consumer destinations fall below the threshold at which nonstop service can effectively be profitably provided.

Second, cities with relatively poor hub service will enjoy substantially more nonstop routes than those with attractive hub alternatives. Heightened competition from hubs requires nonstop carriers to operate at increasingly favorable seat-mile costs—an objective often achievable only through the operation of larger aircraft. As a result, many relatively large city pairs with attractive hub alternatives (such as Indianapolis–Boston) remain without nonstop service, and smaller markets with fewer hub alternatives of similar length of haul (such as Billings, Montana–Seattle, Washington) are provided such service.

Third, a principal beneficiary of the lumpiness problem that exists under deregulation is the consumer in cities selected by carriers to function as airline hubs. If selected as a hub, a metropolitan area can acquire nonstop linkage to an entire network of cities that would otherwise not be available. Consumers in metropolitan areas selected as hubs accrue benefits from the lumpiness in supply that constrain the development of nonstop routes in other cities.

Hub selection, of course, is not an arbitrary process. A less-than-optimal hub location will lead to excessively long travel times for connecting passengers and unnecessarily high operating expenses—factors rendering geographical location of prime importance. However, carriers can compromise the geographical location of their hubs to the extent that gains (from the larger population located at the hub or other factors) equal or exceed the added costs. This will produce situations in which hub location is only loosely correlated with local population, encouraging what seems to be inequitable patterns of air-route development.

The fourth aspect is that metropolitan areas in which carriers can command premium fares for nonstop service will enjoy disproportionately high levels of nonstop service. The extent to which carriers will deviate from cost-minimizing hub systems described earlier depends on consumer willingness to pay fare premiums for nonstop service. Where consumers are willing to pay such premiums, it would be expected that route growth under deregulation would be higher than average. Nonstop service that would otherwise be economically less feasible than hub service will become feasible where such offsetting pricing opportunities exist.

Following deregulation, each of the foregoing aspects gave carriers incentives to restructure their route systems away from the relatively homogeneous regulatory allocation. This suggests that increased service "inequities" between cities have emerged. Two other factors, however, are simultaneously acting to lessen these disparities. First, lower operating costs are encouraging new nonstop service. Largely because of declining input costs and technological advancement, airline prices have dropped in real terms by 21 percent since deregulation (1). As prices fall, the quantity of air service demanded increases in a city pair, reducing lumpiness in supplying nonstop service. Second, rising demand is encouraging new nonstop service. The actual demand curve is shifting outward as population moves to more rural locations, income increases, demographics change, and levels of interstate commerce expand. This factor also stimulates the market's responsiveness in providing cost-effective nonstop service and might mitigate the incentives for a more uneven development of service cited earlier.

This hypothesis suggests that disparities in route coverage between cities will grow during the early years of deregulation as carriers reallocate their route systems away from the evenly distributed, decentralized distribution that existed under regulation. However, as the returns from investments in new hub-and-spoke systems diminish, it would be expected that countervailing forces such as rising demand and declining costs would eventually offset this trend toward centralization, reducing the scope of the disparities between cities. An empirical approach for testing this hypothesis is presented next.

MEASURING THE CHANGING AVAILABILITY OF NONSTOP SERVICE

Because nonstop airline routes will not develop in even proportion to the number of destinations to which consumers wish to travel, the traditional measures of the effects of deregulation on a city's air services—flight departures from a city, airlines participating in the market, or daily seats provided—are incomplete. It is also necessary to consider how well a city's system of air routes fits the distribution of consumer destinations. When the quality of service in a city pair is viewed as a dichotomous variable, classified as either nonstop or less desirable connecting service, the probability that randomly selected travelers from a metropolitan area will find daily nonstop service to their intended destinations can be calculated. This measure, entitled "nonstop route coverage," can be

thought of as the proportion of travelers from a metropolitan area for whom nonstop service is available.

The analysis begins with flight schedules published in late 1981 for travel in January 1982, the end of the national air traffic control crisis, which greatly constrained the development of airline routes. Before this date, the route system from the era of regulation remained largely intact, and airline hub development remained in a relatively embryonic stage (10). Moreover, the wave of consolidations, standardized pricing structures, and aggressive entry of low-cost operators had not yet taken place. By observing shifts in route coverage in 1-year increments from January 1982 to January 1987, a clear pattern in the effects of deregulation can be discerned.

Each of the 60 largest U.S. metropolitan areas is examined using a cross-sectional time-series econometric model. The first objective is to determine, as suggested by theory earlier, whether increased disparities in nonstop air service among cities have actually emerged under deregulation. Second, a more exploratory focus helps to develop a clearer understanding of how carriers use hubs to exploit the advantages of hub-and-spoke systems. In this second subsection the growing concentration of nonstop route coverage in hub cities at the outset of deregulation is explored and the changing significance of hubs across time is traced. Finally, a measure of the varying pricing opportunities facing operators of nonstop service is added to the model, helping to further explain the apparent inequities in nonstop service facing time-conscious travelers across metropolitan areas (see Appendix).

The 60 metropolitan areas were selected on the basis of 1984 Standard Metropolitan Statistical Area (SMSA) census data for the 48 contiguous states. Numerous technical adjustments were necessary to eliminate geographic factors that affect air service in ways not germane to the analysis (such as the construction of an airport location equidistant from two SMSAs). This process is described in greater detail in the Appendix.

Flight data on the itineraries of all nonstop flights from each of the SMSAs were taken from *Official Airline Guide* records and coupled with ridership forecasts made by the Boeing Commercial Airplane Company for all city pairs (9). For example, in 1987 the traffic forecasts are considered in 11,500 city pairs, whereas nonstop air service is found to be available in 1,043 pairs. These results were sorted by SMSA, and the probability that consumers will have access to nonstop service to their intended destinations was calculated and found to vary for 1987 from 0.122 (Scranton–Wilkes-Barre, Pennsylvania) to 0.981 (Dallas–Ft. Worth, Texas). The changing levels of route structure coverage for all 60 cities for each year studied are summarized in Table 1. Notice a high degree of variability between SMSAs functioning as major hubs, such as Minneapolis, St. Louis, and Pittsburgh, and less important air centers such as Indianapolis, Columbus, and Seattle.

Growing Disparities in Route Coverage

If deregulation has actually fostered a more uneven distribution of nonstop service across metropolitan areas, one would anticipate less association between a city's size and its route coverage under deregulation than under regulation. Thus, if population were used as an independent variable in predicting the route coverage of a particular city (or probability that

nonstop service to the desired destination of a randomly selected passenger would be available), its predictive power should deteriorate over time. To assess the changing relationship between population and nonstop route coverage, the multiple-least-squares model shown in Equation 1 was used:

$$\log [Pr_{xy}/(1 - Pr_{xy})] = a + bPop_{xy} + cPop_{xy}^2 + dSEC_x + u \qquad (1)$$

The log-linear structure linearizes the slope of the dependent variable, which by definition was bounded between zero and 1. Pr_{xy} denotes the route coverage in city x in year y (or the probability that a consumer would have access to nonstop service to his intended destination in SMSA x in year y). Pop_{xy} and Pop_{xy}^2 are functions of the population of SMSA x in year y. SEC_x is a dummy variable used to account for extreme values in the data caused by situations in which route development was affected adversely by the proximity of a larger SMSA. The use of the polynomial term reflects the nonlinear relationship between population and route coverage.

Separate regressions were run for each year from 1982 to 1987. The results confirm that the relationship between a city's population and its level of route coverage initially worsened over the period (Figure 3). The model exhibits significantly declining predictive power during 3 of the 4 years between 1982 and 1986; the proportion of variance in route coverage explained by the model (R^2) declined by nearly 30 percent, from .381 to .274. (Only between 1983 and 1984 was there no significant change in predictive power.) In 1987 a significant reversal of this trend took place, with the proportion of variation explained rising to .340. These findings are consistent with the theory that, following deregulation, carriers restructured their route systems away from regulatory allocation to a system that more properly considered the economic advantages of more centralized operations described earlier. Traffic in many city pairs simply was too light to sustain nonstop service that was as cost-effective as hub service. Not until 1987 did evidence indicate that this trend had reversed. The low coefficients of variation are not surprising; differences in market size, pricing opportunities, length of haul, and proximity to hubs—factors shown to be critical in route development—have been ignored to illustrate these general disparities in route coverage between cities.

Although the association between population and route coverage declined between 1982 and 1986, this, of course, does not necessarily indicate that cities have less nonstop service under deregulation. The growing disparities in route coverage (i.e., statistical heteroscedasticity) among cities might have offset a general, aggregate rise in nonstop route coverage. To assess this possibility, the model was run to consider data from all 6 years simultaneously, with dummy variables to denote incremental, year-to-year changes. If deregulation stimulated route growth beyond that explicable through population growth, the dummy variable's coefficients should rise with the passage of time. However, the data indicate that this was not the case. Although the coefficients for the population and SEC variables remained significant at a 5 percent level, the dummy variables were not significant, suggesting that deregulation itself has not significantly changed overall route coverage. (Statistical interaction terms also proved not significant:

TABLE 1   AIRLINE ROUTE COVERAGE BY SMSA

SMSA	1982	1983	1984	1985	1986	1987
Albany	48.83	47.58	46.44	48.31	47.44	50.27
Allentown/Bethlham	37.10	36.21	37.60	34.67	34.05	33.49
Atlanta	95.08	94.79	92.25	94.83	95.17	95.20
Austin	57.28	56.67	56.97	65.30	70.57	69.31
Birmingham	37.65	29.10	28.78	35.57	35.10	31.12
Baltimore	66.93	73.14	74.59	71.04	69.69	72.41
Boston	84.59	85.31	84.31	82.77	83.54	85.27
Buffalo	72.66	77.75	76.26	69.73	66.19	68.75
Chicago	94.76	93.58	93.64	93.53	95.71	95.33
Cleveland	84.63	84.57	81.11	83.34	81.12	80.55
Charlotte	72.69	76.78	79.87	81.12	84.41	86.49
Columbus	67.43	75.69	65.55	60.25	64.99	58.05
Cincinnati	63.59	75.51	81.31	79.13	78.62	65.90
Dayton	52.53	50.50	56.12	55.93	64.67	65.90
Denver	80.58	86.70	87.73	88.26	88.78	87.28
Dallas/Ft. Worth	98.08	98.09	98.10	98.11	98.11	98.12
Detroit	85.83	85.64	86.41	85.02	83.64	87.54
Ft. Lauderdale	87.01	89.12	88.27	86.09	82.20	84.14
Grand Rapids	25.78	34.97	27.27	26.66	26.10	25.62
Greensboro	67.81	69.97	65.77	63.94	64.81	64.51
Hartford/Springfield	57.19	58.58	57.40	60.78	60.61	58.93
Houston	78.85	81.47	85.29	74.91	70.45	79.52
Indianapolis	61.94	61.91	58.64	54.69	61.60	72.22
Jacksonville	60.68	53.98	35.64	32.28	37.42	60.35
Kansas City	71.16	76.87	71.88	81.15	80.12	81.48
Los Angeles	88.72	86.00	84.73	81.91	90.67	90.76
Louisville	65.22	67.41	67.10	61.69	63.90	64.35
Memphis	70.39	75.39	76.02	74.71	75.89	80.03
Miami	88.75	88.51	88.71	88.65	87.74	89.55
Milwaukee	76.07	67.13	68.83	65.22	71.08	57.78
Minneapolis/St. Paul	80.85	81.88	81.55	83.74	84.62	85.41
Nashville	61.11	57.36	54.52	55.32	55.57	62.16
New Orleans	73.39	76.02	76.42	74.48	74.43	72.88
New York City	83.36	84.70	83.26	83.17	83.00	84.92
Norfolk	68.48	65.05	68.25	71.24	67.34	67.37
Oakland	28.51	28.27	29.79	24.29	30.56	27.73
Oklahoma City	51.38	50.37	51.68	31.14	29.68	31.69
Orlando	83.97	83.33	84.22	85.99	84.53	85.69
Philadelphia	73.21	74.22	72.14	76.12	76.13	78.44
Phoenix	71.86	67.64	63.06	71.98	73.00	72.95
Pittsburgh	92.58	91.16	93.77	91.92	91.87	91.88
Portland	61.60	61.15	63.50	67.37	67.08	71.49
Providence	58.97	46.70	57.27	53.68	53.38	53.47
Raleigh/Durham	69.47	66.75	67.00	66.98	68.82	66.90
Richmond	62.87	83.82	63.97	64.11	64.26	64.42
Rochester.	71.79	71.40	72.98	68.72	68.52	66.19
San Diego	63.55	63.26	63.58	65.27	65.25	66.84
San Antonio	44.60	33.78	42.86	44.64	44.65	46.30
Scranton/Wilkes-Barre	21.21	20.21	19.64	19.16	18.77	12.26
Sacramento	65.83	65.11	64.46	68.95	68.45	67.99
Salt Lake City	66.44	66.09	70.75	74.50	72.25	75.65
San Francisco	65.97	65.64	62.59	59.90	59.14	61.12
San Jose	70.31	69.87	69.51	69.20	70.00	69.04
Seattle	64.42	63.71	58.92	59.79	62.35	63.76
St. Louis	97.29	99.03	94.06	94.78	99.87	95.73
Syracuse	69.02	74.95	76.50	73.62	74.20	70.95
Tampa/St. Petersburg	89.77	90.08	87.37	84.77	84.66	84.13
Toledo	49.15	49.99	40.60	40.36	30.76	30.55
Tulsa	32.20	53.06	55.68	53.80	26.83	28.87
Washington	79.01	80.96	80.75	80.59	80.44	80.31

NOTE: Figures multiplied by 100 to simplify interpretation.

changes in route coverage across time apparently were not highly dependent on SMSA population.) Indeed, although route coverage rose from an average of 0.65 to 0.69 over the period, this improvement only kept pace with the rise in SMSA population. The implication is that because so much of the route development apparently has centered around hub systems, consumers in zero-growth cities are no more likely to have available nonstop service to their intended destinations than they did 7 years ago, but increased variances among metropolitan areas evolved. To the extent that demand is proportional to city population, it is concluded that time-conscious consumers in certain cities are enjoying disproportionate gains—and losses—in route coverage.

Conclusions cannot be readily drawn about the reversal of this trend in 1987. The hypothesis suggests that, at this point, the incentives to concentrate operations at hubs must have been
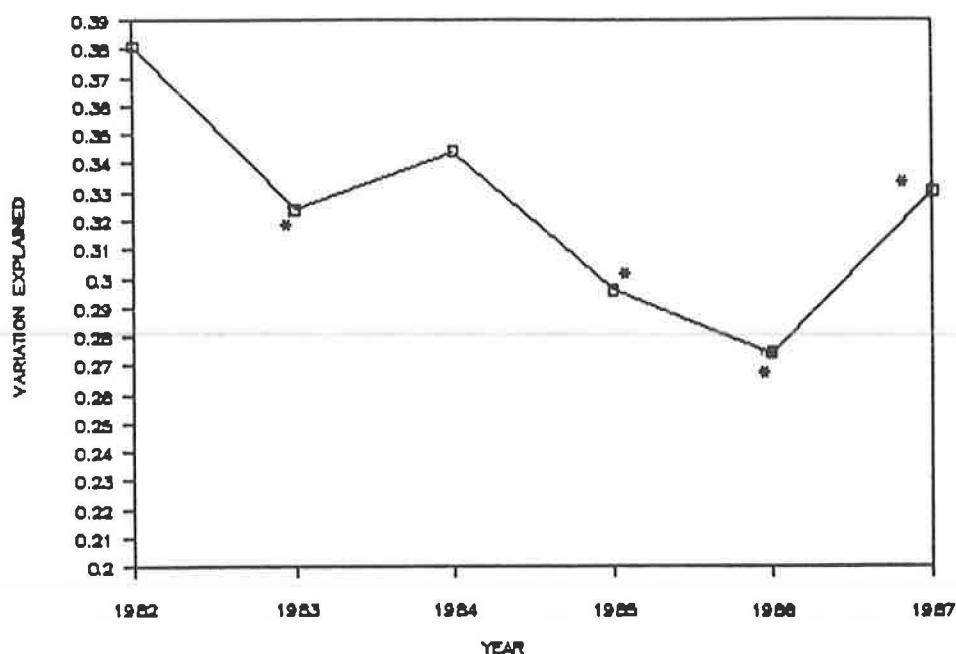
FIGURE 3 Proportion of variation explained by SMSA population. [Asterisk denotes statistically significant change from prior year (all variables significant at 5 percent level).]

offset by the incentives to decentralize made possible by rising demand, declining costs, or other factors. Although the model is unable to control for these exogenous factors, it suggests that after a half-decade of growing service disparities, all 60 metropolitan areas now appear to be participating in the establishment of new nonstop service.

Evolution of Hub Systems

Incorporating the status of metropolitan areas as privately operated airline hubs for air carriers improves the predictive capabilities of the model. The extent to which routes are increasingly allocated to hub systems—after the population of the metropolitan area has been fully considered—illustrates the scope of the disparities among metropolitan areas and provides a barometer of how incentives to centralize operations affect the development of routes. As hubs grow in importance, they bestow disproportionately high benefits to time-conscious consumers in those cities; as their importance declines, their ability to bestow more benefits than nonhub cities lessens.

Dummy variables designating a city's status as a hub were added to the model. Hub status, which frequently changed from year to year as airlines invested in or divested themselves of hub facilities, is presented in Table 2. Variable HB_{xy} denotes an SMSA designation as a minor ("regional") hub in year y. Variable SH_{xy} reflects SMSA x's status as a major ("super") hub in year y. [The definition of a hub here is considerably different from the CAB definition, and was based on the number of routes to the hub operated by an individual firm (see Appendix).] Of the 60 SMSAs in the study, 23 functioned as hubs during at least 1 year of the period; three grew from "minor" to "major" hub status over the period. Only one SMSA—Cleveland, Ohio—lost its status as a hub during this time period, whereas eight others gained such status. For

example, Nashville, Tennessee, did not serve as a hub until 1986 when American Airlines selected the city as a minor hub.

Incorporating hub status into the model helps explain the growing disparities in nonstop route coverage between metropolitan areas. The model indicates that, although there might have been a declining association between route coverage and population, SMSA hub status grew markedly more important. Major-hub status was highly significant throughout the model (Table 3), bolstering route coverage to a city in each of the 6 years studied. The proportion of variance explained between cities increased by 50 percent (from 0.4177 to 0.6206) with the addition of the hub variables.

Equally significant is the growing magnitude of the coefficients of the major-hub variables (SH) (from 1.396 in 1982 to 1.502 in 1985, and subsequently to 2.027 in 1986—changes significant at the 5 percent level). This is consistent with the popular prevailing belief that deregulation exacerbated the differences between the "winners" and "losers" in the competition for airline routes. However, the coefficients illustrate the same reversal for the year 1987 observed in the previous section, declining significantly between 1986 and 1987 (from 2.027 to 1.619, respectively). Why did this occur? With the growing market for air services, smaller hubs or nonstop operators appear to be achieving the scale of operation necessary to compete with major hubs on many routes, reducing the relative advantages of serving as a major hub.

The steadily increasing importance of the minor-hub variable (HB_{xy}) reinforces this hypothesis. During the early years of deregulation, the economic advantages bestowed on time-conscious consumers in cities serving as minor hubs were found to be largely inconsequential. This appears to be attributable to the higher degree of multicollinearity between minor-hub status and population, and the regional focus of most minor hubs during the early years of deregulation. However, at a 10 percent level of significance, minor-hub status (HB) became

TABLE 2   AIRLINE HUB STATUS

	Minor Hub Status						Major Hub Status						Private Operator[a]
	82	83	84	85	86	87	82	83	84	85	86	87	
Atlanta	0	0	0	0	0	0	1	1	1	1	1	1	Delta/Eastern
Baltimore	0	0	0	0	1	1	0	0	0	0	0	0	Piedmont
Boston	0	0	0	0	1	1	0	0	0	0	0	0	Delta
Chicago	0	0	0	0	0	0	1	1	1	1	1	1	United/American
Cincinnati	0	0	0	0	1	1	0	0	0	0	0	0	Delta
Cleveland	1	1	1	0	0	0	0	0	0	0	0	0	United
Charlotte	1	1	1	1	1	0	0	0	0	0	0	1	Piedmont
Dayton	0	0	0	1	1	1	0	0	0	0	0	0	Piedmont
Denver	0	0	0	0	0	0	1	1	1	1	1	1	United/Continental (Frontier)
Dallas	0	0	0	0	0	0	1	1	1	1	1	1	American/Delta
Detroit	1	1	1	1	1	1	0	0	0	0	0	1	Northwest
Houston	1	1	1	1	0	0	0	0	0	0	1	1	Continental
Kansas City	1	1	1	1	1	1	0	0	0	0	0	0	TWA/Eastern
Memphis	1	1	1	1	1	1	0	0	0	0	0	1	Republic
Minneapolis	0	0	0	0	0	0	1	1	1	1	1	1	Northwest (Republic)
Nashville	0	0	0	0	0	1	0	0	0	0	0	0	American
New York	0	0	0	1	1	1	0	0	0	0	0	0	Continental (People Express)
Phoenix	0	0	0	1	1	1	0	0	0	0	0	0	America West
Philadelphia	0	0	0	0	1	1	0	0	0	0	0	0	USAir
Pittsburgh	1	1	0	0	0	0	0	0	1	1	1	1	USAir
San Fran.	1	1	1	1	1	1	0	0	0	0	0	0	United/Pacific Southwest
Salt Lake C.	1	1	1	1	1	1	0	0	0	0	0	0	Delta (Western)
St. Louis	0	0	0	0	0	0	1	1	1	1	1	1	Northwest/Republic
Washington	0	0	0	1	1	1	0	0	0	0	0	0	Continental (NY Air)/United

[a]Names of hub operator before airline merger or acquisition shown in parentheses.

increasingly important in each of the final 4 years of the study, reaching its extreme level of significance in 1987.

In light of the general hypotheses outlined in the previous section, it has been shown that as the market expands, minor hubs have a higher propensity to develop new routes—previously constrained by lumpiness in supply—than larger hubs. One would expect minor hubs to become competitive initially on shorter routes where economies of aircraft size are less severe; only as the market further expands can they be expected to compete on longer routes where the operation of larger aircraft is the least-cost scale of operation. A similar pattern should ultimately emerge in the development of nonstop flights between cities that are not hubs.

Hubs most sheltered from this trend toward decentralization are those serving city pairs with the greatest lumpiness in supplying nonstop service relative to the volume of traffic handled. (One might expect predominantly high-density and short-haul hub operations, such as Pittsburgh, to be more vulnerable to new nonstop service than principally longer-haul hub operations such as St. Louis or Dallas–Ft. Worth.) The model discussed earlier is unable to confirm or deny these propositions. However, it serves as a useful foundation upon

which additional research will be conducted. Differences in average length of haul, passenger volume, and proximity to hubs undoubtedly explain much of the remaining variation in nonstop route coverage between cities.

Role of Price in Route Development

Carriers deviate from cost-minimizing transportation methods such as the hub-and-spoke system for a variety of reasons, ranging from competitive pressures to fleet considerations and capital constraints; the significance of these factors varies widely among carriers and regions. However, at least one factor can be expected to remain constant in its effect on route development and add considerable explanatory power to the model—the opportunity to demand higher prices for nonstop services. On many lightly traveled routes, nonstop service is less cost-effective than hub service but offers strong advantages with respect to passenger demand. Fare premiums of up to $100 are not uncommon for the convenience of nonstop service, often enabling carriers to profitably provide such service in city pairs that could otherwise be served only with connecting flights. It is expected that (a) certain cities will

TABLE 3 GROWTH OF HUB-AND-SPOKE SYSTEMS

$$\log(Pr_{xy}/1\text{-}Pr_{xy}) = a + bPOP + bPOPSQ + cSEC + dHB_{82} \dots + eHB_{87} + f\,SH_{82} \dots + g\,SH_{87} + u$$

$R^2 = 62.06$

descriptive variables:	intercept	POP	POPSQ	SEC
coefficient:	0.1890	0.00035	-1.639×10^{-08}	-0.8512
std error:	0.0729	0.0000424	2.671×10^{-09}	0.1158
prob > t:	0.0099	0.001	0.001	0.0001

major hub variables:	SH_{82}	SH_{83}	SH_{84}	SH_{85}	SH_{86}	SH_{87}
coefficient:	1.3955	1.5597	1.5183	1.5024	2.0268	1.6194
std error:	0.2509	0.2376	0.2522	0.2524	0.2695	0.2695
prob > t :	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

minor hub variables:	HB_{82}	HB_{83}	HB_{84}	HB_{85}	HB_{86}	HB_{87}
coefficient:	0.3099	0.1941	0.3939	0.3582	0.3556	0.4117
std error:	0.2651	0.2353	0.2356	0.2051	0.1846	0.1847
prob > t:	0.2431	0.4100	0.0955	0.0817	0.0550	0.0304

develop superior nonstop routes relative to other, similar-sized cities because market conditions permit substantial premiums to be charged, and (b) the degree of the price difference will partially reflect the extent to which nonstop service faces higher costs than hub service.

Factors affecting an airline's ability to offset the higher costs of nonstop service with higher fares include the proximity of competing airports, business climate, geographic location, and ground transportation alternatives. For example, most carriers have found it uneconomical to charge more for flights from Toledo, Ohio, than for service offered from nearby Detroit, a highly competitive market, because of the convenience of driving between the cities. In many nonindustrialized markets, soft levels of business traffic similarly prohibit premium charges for nonstop service. These types of considerations can profoundly affect a carrier's decision to establish new nonstop routes. Previous research underscores this observation (11).

Only the most time conscious of passengers will willingly pay such fare premiums. One study estimates that premiums can be extracted from only about 30 percent of the market (12). Business, emergency, and government travelers generally are considerably more time sensitive than their pleasure-oriented counterparts, and are among those willing to pay for the convenience of nonstop service. Because these passengers make advance reservations an average of less than 4 days in advance compared with 11 days ahead for pleasure-oriented passengers, the unrestricted fares typical of this portion of the market are used exclusively in the analysis (12). Excursion fares, fares with cancellation penalties, and those with special restrictions are excluded (fares with only capacity control restrictions are included).

Matching scheduling information from *Official Airline Guide* records with fare information from Airline Tariff Publishers Company allows measurement of the differences in nonstop and one-stop fares on routes from each of the 60 metropolitan areas as of July 1, 1987. For each of the 1,043 nonstop segments, the lowest nonstop unrestricted fare offered by a carrier with nonstop service was compared with the lowest one-stop unrestricted fare. The ratio of nonstop to one-stop fares was calculated for each of the city pairs in which nonstop service is available, and the results were sorted by city. For example, during July 1987, the lowest nonstop unrestricted fare between Chicago, Illinois, and Seattle, Washington, was $325 compared with the lowest one-stop fare (via Denver) of $179—an average fare premium of 82 percent. Nonstop premiums are found to vary substantially between cities (Table 4, Column 1), ranging from virtually no premium in Toledo to 99.6 percent in Chicago.

A significantly positive correlation between city size and price difference suggests that a strong business market is essential for maintenance of fare premiums. Furthermore, a random sample of 100 of these city pairs confirms that nonstop fare premiums become increasingly pervasive as the expected cost differences between nonstop and hub service increase. For city pairs separated by more than 1,000 mi, the average premium was 58 percent compared with 42 percent for city pairs separated by less than 1,000 mi.

The regression equation described earlier was used to assess the explanatory power of the price variable ($PRICE_x$) on route coverage (Table 5) (the SEC_x variable was deleted due to multicollinearity problems). As shown in Table 5, price differences between nonstop service and one-stop service are

TABLE 4 STATUS OF SMSA NONSTOP SERVICE DURING 1987

SMSA	Average Fare Premium	# Cities Served Nonstop	Infrastructure Status
Albany	41.4%	12	below
Allentown/Bethlham	25.6	8	below
Atlanta	86.6	57	signif. above
Austin	33.1	3	below
Baltimore	68.2	38	above
Birmingham	22.5	11	signif. below
Boston	57.0	39	signif. above
Buffalo	21.7	15	below
Chicago	99.6	59	signif. above
Cleveland	76.2	34	above
Charlotte	50.4	38	signif. above
Columbus	59.8	19	signif. below
Cincinnati	51.3	34	above
Dayton	38.1	29	above
Denver	72.4	42	signif. above
Dallas/Ft. Worth	71.8	54	signif. above
Detroit	70.1	44	above
Ft. Lauderdale	68.0	26	above
Grand Rapids	44.4	11	signif. below
Greensboro	28.9	13	below
Hartford/Springfield	94.7	20	below
Houston	85.9	45	above
Indianapolis	93.3	28	above
Jacksonville	28.9	13	below
Kansas City	21.1	32	signif. above
Los Angeles	29.6	39	above
Louisville	53.2	20	below
Memphis	29.6	32	below
Miami	97.1	32	signif. above
Milwaukee	57.0	22	below
Minneapolis/St. Paul	86.5	44	signif. above
Nashville	81.2	29	below
New Orleans	99.0	25	signif. below
New York City	52.1	62	below
Norfolk	38.6	16	signif. below
Oakland	17.6	9	signif. below
Oklahoma City	34.1	14	signif. below
Orlando	97.5	34	above
Philadelphia	32.0	38	below
Phoenix	87.8	29	above
Pittsburgh	81.8	46	signif. above
Portland	41.7	16	signif. below
Providence	48.0	9	below
Raleigh/Durham	58.5	17	below
Richmond	52.6	12	below
Rochester	26.5	13	below
San Antonio	38.6	14	below
San Diego	90.7	20	signif. below
San Francisco	98.8	32	below
San Jose	52.6	14	above
Salt Lake City	42.9	24	above
Sacramento	12.4	14	below
Scranton/Wilkes-Barre	0.0	4	signif. below
Seattle	69.8	15	below
St. Louis	64.5	43	signif. below
Syracuse	39.1	17	above
Tampa/St. Petersburg	60.5	30	above
Toledo	0.0	9	signif. below
Tulsa	69.7	12	signif. below
Washington	50.0	37	above

statistically significant in explaining disparities in route coverage during 1987. The proportion of variation explained rose marginally from .53 to .57 with the addition of the price variable to the population and hub variables. All other variables remained highly significant except minor-hub status (*HB*), the significance of which was only marginal. Although high standard errors limit interpretation, markets offering carriers the greatest opportunities for premium-price nonstop service appear to be better able to combat the tendencies that encourage carriers to provide hub-only service.

Critics of airline pricing under deregulation often dismiss fare premiums for nonstop service as an undesirable side effect of monopoly power. The methodology presented here does not allow this perspective to be fully discounted, but it provides convincing support for an alternative view that the ability to maintain fare premiums is often a necessary condition for the

TABLE 5   ROLE OF FARE PREMIUMS IN ROUTE DEVELOPMENT

model: $\log(Pr/1\text{-}Pr) = a + b\,POP_{87} + c\,POPSQ_{87} + d\,HB_{87} + e\,SH_{87} + f\,PRICE_{87} + u$

	Intercept	POP	POPSQ	HB$_{87}$	SH$_{87}$	PRICE
coefficient:	-0.9370	0.00041	-2.10065 X10^{-08}	0.3742	1.6951	0.5751
std error:	0.3917	0.00012	7.1239 X10^{-09}	0.2862	0.2895	0.2416
prob > t:	0.0203	0.0011	0.0047	0.1966	0.0005	0.0208

$$R^2 = 0.5718$$

development of nonstop routes. These conclusions, of course, must be tempered by the many aspects of airline pricing not considered in this exploratory model.

SUMMARY AND CONCLUSIONS

Considering the review of airline schedules from America's 60 largest population centers, it is clear that deregulation has unleashed powerful incentives for carriers to concentrate operations at centralized hub facilities, which in turn initially encourages widening disparities in the establishment and development of routes. These disparities were postulated to be partly a result of economies of aircraft size, a factor rendering nonstop air service analogous to the microeconomic "lumpy good," and uneconomical compared with hub service in most city determinants of the lumpiness problem. More recent trends suggest that other factors are lessening this phenomenon, encouraging carriers to move away from these centralized hub operations—a reversal attributed to rising demand, falling costs, and varying pricing opportunities.

Throughout the study, it has been speculated that the ramifications of the disparities depend on the time sensitivity of the consumer. A simple comparison of each city's level of route coverage with that of other similarly sized cities provides an interesting perspective of how such consumers have fared. Column 3 of Table 4 indicates the number of cities served by nonstop flights from each of the 60 largest areas studied. Column 4 illustrates how successfully this route network is providing nonstop service to these cities relative to other similarly sized cities. Entries in this column indicate whether a city's route coverage is significantly higher or lower than that expected from its population. (Cities designated as having significantly higher or significantly lower levels of route coverage differ by at least one standard deviation from their expected levels.) It will come as no great surprise to many that time-conscious consumers in cities such as Pittsburgh, St. Louis, and Charlotte fare disproportionately well, whereas those in Columbus, San Antonio, and Birmingham have much poorer access to nonstop service.

Differences in air transportation routes have important and largely unrecognized implications for the welfare of urban economies—factors beyond the scope of the paper. For consumers, poorly developed route systems are costly in terms of lost time, inconvenience, and fewer flight alternatives. Additional research is needed to quantify the economic impacts of these disparities. However, although certain cities and consumers might be found to suffer, it is important to reassert that these disparities do not necessarily reflect suboptimal allocations of resources. Hub-and-spoke systems reflect, among other factors, carriers' efforts to operate efficiently sized aircraft relative to the market's length of haul, carriers will deviate from this least-cost arrangement only to the extent that consumers are willing to pay premium prices for the convenience of nonstop service.

Accordingly, the "inequities" fostered by deregulation must also be put into the proper context. A compelling argument can be made that the geographic location of a city is itself a scarce resource, entitling that city to any rents from its utilization, such as its function as an airline hub. Chicago and St. Louis, for instance, have historically exploited their preferential location by functioning as domestic transportation hubs. Moreover, to the extent that hub locations are selected arbitrarily among numerous equally attractive substitute sites, competitive bidding systems emerge as cities seek to acquire the external benefits of hub status. Dayton, Ohio; Nashville, Tennessee; and Raleigh, North Carolina—cities in regions where many attractive alternative hub locations are available—are among the more recent winners of this competition for new air routes because they have offered attractive financial packages to incoming carriers. Although one might question the efficacy of this tactic, it is certainly worthy of increased analytic attention.

The quality of air service available to time-conscious consumers must ultimately involve such factors as flight frequency, reliability, and seat availability, which are beyond the scope of the exploratory model used in the study. Moreover, factors such as local economic conditions, landing and takeoff "slot" controls, technological advancement, and user fees were not considered. These factors were deliberately reserved for future analysis to help build a more solid conceptual framework upon which such research can proceed. The findings suggest that, even without considering these added complexities, disparities in routes among cities are a paradoxical and inevitable result of open market competition.

APPENDIX

The daily number of flights to all destinations in the contiguous 48 states was programmatically summarized for each city by using *Official Airline Guide* data. Four frequencies per week

were necessary for a city pair to qualify as having nonstop service. Multiple airports were considered for Houston; Chicago; New York; Washington, D.C.; Los Angeles; and Dallas. The following SMSAs were combined because carriers consider them "co-terminals" (common terminals) for ticketing and scheduling purposes: (a) Chicago, Illinois, and Gary-Hammond-Whiting, Indiana; (b) New York and Suffolk in New York State; and (c) Los Angeles, Ontario, and Orange County in California. Baltimore and Newark were maintained as separate SMSAs; even their airport facilities are commonly used by residents of neighboring SMSAs. The San Francisco Bay Area SMSA—San Francisco, Oakland, and San Jose—was also maintained separately.

Ridership forecasts published by the Boeing Commercial Airplane Company were used. Actual ridership statistics compiled by the CAB were also available. However, they do not provide unbiased estimates of the actual size of the market. As more supply is added to a market, ridership systematically grows because of factors such as added consumer convenience and increased price competition. The Boeing forecasts, conducted in 1981, are not subject to this problem and are a better barometer of the actual market size.

The *SEC* dummy variable ("secondary city diversion") was set equal to one in nine of the SMSAs: Toledo (60 mi to Detroit), Baltimore (45 mi to Washington, D.C.), Milwaukee (70 mi to Chicago), San Jose and Oakland (both less than 1 hr by car to San Francisco), Providence (55 mi to Boston), and Scranton (75 mi to Newark).

To qualify as a minor hub, a city must have a single, private firm offer nonstop service to a minimum of 17 destinations. A major hub requires service to a minimum of 35 nonstop destinations from a city. Services offered by "partner" carriers (generally commuter operators) were excluded for this purpose.

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