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Karin Peschel (Ed.)

Infrastructure and the Space-Economy

Essays in Honor of Rolf Funck

With 58 Figures

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**Airline Network Structure and Regional Economic Development:
US Case Studies***

by

Aisling J. Reynolds and Geoffrey J.D. Hewings

1. Introduction

Professor FUNCK has had a long interest in the role of infrastructure in shaping the path of development for regions at different spatial scales. In this paper, we provide some empirical evaluation of the effects of a major change in the regulation of a transportation industry on the supporting spatial infrastructure in the United States. Contrary to many popular statements, the processes of change were evident before deregulation; while the deregulated system has moved at a more rapid pace, the network structure was evolving over the last several decades.

The process of change in the airline industry in the United States has been heralded as the dawn of a new era in the management of transportation systems. The initial enthusiasm that greeted the Airline Deregulation Act was borne out in the increase in the number of certified carriers, increased frequency of service, lower fares and often dramatic changes in the number of carriers serving any given airport. Recently, there has been a decline in the number of carriers, increasing fares (though, in real terms, these are still below the fares in existence prior to deregulation) and substantial evidence

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of movement towards oligopoly in the industry as a whole and spatial monopoly at several key airports in the national system. In the space of ten years, the pleas for deregulation have given way to more persistent calls for some form of re-regulation. At the same time, one might note that the process of deregulation is proceeding apace in Europe and several other countries (such as Australia).

In the next section of this paper, the process leading to deregulation is described. The major focus is on describing and documenting network changes by the airlines, and their effects on US airports over a 20 year period. The trends in the network structure for the airline system are revealed through the use of Gini indices of concentration. In the fourth section, an examination of two major airlines, Continental and American, is provided. Finally, some reflections are provided in the context of regional development theory.

2. The Deregulation of U.S. Commercial Aviation

2.1 The Process and Rationale for Regulation

For a period of 40 years, from 1938 to 1978, U.S. commercial aviation was regulated by various parts of the U.S. federal government. Airline regulation was imposed in 1938 in part to preserve the existence of 16 airlines ("trunk" lines) in operation at that time; it was felt that the unregulated free market might result in many of these firms moving to a state of bankruptcy. Hence, it was the fear of market failure and the feeling that few air traffic markets could support more than one airline that provided this initial regulatory trend (PANZAR, 1980). The allocation of federal subsidies in mail carriage provided a major cushion for airlines unable to survive by just transporting passengers. Thus, the airline markets could be considered to have been joint product natural spatial monopolies. All responsibility for the determination of mail rates and passenger fares was consolidated into one agency, the Civil Aeronautics Authority (and later, in 1940, the Civil Aeronautics Board, hereafter the CAB). This institution was given authority over routes, entry into the industry and entry into markets; it was also able to restrict the number of existing carriers that would compete in a given market. The net result

was that major long-haul markets were preserved for existing trunks, while new entrants were only able to serve regional markets. Hence, the system of control produced route and market specialization (GRAHAM, KAPLAN and SIBLEY, 1983). Until 1981, when CAB authority ended, an air carrier's certificate listed all routes it was authorized to serve. The CAB was required to apply a test of 'Public Convenience and Necessity' before awarding an interstate route authorization to a new or existing air carrier. The CAB selected the airline to serve the route from the applications tendered; the process was long and cumbersome, with the burden of proof falling on the applicant to demonstrate that other incumbent airlines would not be harmed in the process. Usually, two to three carriers were assumed to be sufficient on any route (CAB, 1984; GRAHAM, KAPLAN and SIBLEY, 1983). The CAB made a conscious effort to preserve all existing carriers and to narrow the differences between the strong and weak.

It was claimed that regulation allowed for service to a much larger number of cities than would have been the case in a deregulated environment; this assertion was promoted on the basis of the implicit cross-subsidy from the high volume (and hence high profit) markets to the thinner markets. However, in the 1960s and 1970s, questions began to be raised about the level and degree of cross-subsidization actually taking place, especially after empirical evidence was provided that some commuter/air taxi carriers (unregulated by the CAB) managed to provide profitable, unsubsidized service on many routes over which even the subsidized local carriers had not been able to break even (KEELER, 1972).

2.2 The Process of Deregulation

In 1978, the U.S. Congress passed the Airline Deregulation Act (ADA) and provided for a six year transition period. The ADA allowed the CAB to grant operating rights to any carrier applying to serve a route on which a minimum level of service was not being provided; although other carriers had authorization to provide service, they had chosen not to do so. Essential air transportation services were provided in the thinner markets through the continuation of subsidies for a ten year period. Without CAB approval, carriers could decrease fares by up to 50% or raise them 5% above standard industry

fares. CAB authority over routes ended in December 1981; a year later, authority over rates (fares), mergers and acquisitions ceased, with the CAB itself ceasing to exist in December, 1984. (MOORE, 1986; CAB, 1982, 1984; MEYER et al. 1981)

2.3 The Effects

How did an airline change its strategy in this post-regulatory environment ? Much depended on the niche held by the airline before regulation. Competition essentially focused on the battle between the existing trunks, characterized by high costs, union-dominated labor and the newer entrants that were low cost and non-union. The markets for which they competed contained a high percentage of discretionary passengers, many of whom found that flying could often prove to be cheaper than Greyhound Bus or AMTRAK rail. Competition focused first on fares and then on quality of service. Spatially, trunk airlines moved from point-to-point service (mainly non-stops flights) to hub-and-spoke oriented systems. The smaller trunk airlines contracted with their niche absorbed by the larger trunks or local service airlines. The latter carriers often entered into joint agreements with the trunks to provide service from smaller communities into the major hubs. It is interesting to note that the local carriers established the hub-and-spoke system because of the large proportion of passengers connecting to the trunk carriers. Their success led to experimentation by the trunks along the same lines (CAB, 1984; KORAN, 1983; MOORE, 1986; MEYER, 1986).

At first, there was an increase in the number of carriers - as predicted by the proponents of deregulation. However, this initial increase was not sustained with the result that the market under free entry and exit now resembles the market that existed under regulation in terms of the number of carriers and the market structure. Mergers and acquisitions in the airline industry are now treated not differently from similar processes in iron and steel or the automobile industries.

In the next section, some of the effects will be described in more detail for the whole U.S. system. Thereafter, the focus of attention will be on two large carriers, to provide specific examples of the patterns and processes of

change in the last two decades.

3. Network Structure: Trends in US Commercial Aviation

3.1 Introduction

Economic assessments of the industry since 1978 have failed to focus on the extent and nature of specific network changes, and secondly, the effect of these changes on the national airport system. In this section, both of these issues will be addressed. Specifically, the aims are to (i) describe the changes taking place in the national airways system and attempt to link these with patterns of change among air carriers' route systems; (ii) to ascertain whether the air carriers' propensity to concentrate traffic in their system at a small number of points (i.e. develop and emphasize so-called 'hub-and-spoke' systems) has occurred only since 1978, or if this trend was in place before deregulation.

The next sections begins with a description of the national airways system and the pressing spatial questions are emphasized. The subsequent sections describe the airport system, the traffic distributions over the system in the last 20 years, and the supporting air carrier industry. These carriers are then examined closely; industry characteristics are set out, and two airlines' traffic patterns are carefully analyzed for a 20 year period. The Gini index of concentration is used extensively in the following sections, and justification for its use is provided.

3.2 The National Airways System

The Federal Aviation Administration (FAA), under the Department of Transportation control the airway system, and categorize airports and airfields into two groups: (i) those airports used for air carrier operations which serve the needs of scheduled air carriers and (ii) those for general aviation, serving all other civil air carriers (air taxis, business, agriculture etc.). In this paper it is the former category only, which is the focus of attention. For

this category, the FAA developed its air traffic hub structure, and they use this classification scheme to measure the concentration of all civil air traffic, in their economic and operations research procedures (CAB, 1983). The FAA point out that social, economic and other factors influencing a community's ability to generate air carrier traffic are brought together in this one medium. The FAA air traffic hubs are not airports per se, rather, they are the cities and Standard Metropolitan Statistical Areas (SMSAs) requiring aviation services. These communities fall into a four hub classification scheme, depending on the community's percentage of the total enplaned passengers in all services and operations of U.S. certificated route air carriers within the 50 States and other designated areas. The hub classes are given below in Table 1.

Table 1:

FAA hub classification scheme

FAA hub type	Percentage of total US passenger enplanements
Large	1.00% or more
Medium	0.25 to 1.00%
Small	0.05 to 0.25%
Nonhub	less than 0.05%

Airline 'hubs', in comparison, usually refer to those key airports (typically two or three) around which the entire route system is organized. Airline hubs emphasize the transfer of passengers, and accordingly, at these airports, the airlines offer a large number of connecting flights to other areas. The airlines construct what they call 'complexes', which are large blocks of flights arriving at the hub airport within a very short period of time, and this is followed by an equally large number of departures, when passengers have made their connections. The hub airports usually have between 3 and 5 complexes in operation every day. The term 'hub' in the context of airline schedules is more loosely applied.

While most large cities began studies of new airports 20 or more years ago, very little progress has been made in the 1980s, in terms of designing and building new large airports. Since the completion of facilities at Dallas-Fort Worth airport over a decade ago, no major airport has been built in the U.S.,

though plans were recently outlined for a new 'superhub' at Denver, Colorado. Investment at the major airports in the recent period has been aimed more at upgrading facilities rather than expanding capacity.

At the lower end of the hierarchy, carrier network changes could involve a small community either loosing all of its service, or experiencing phenomenal growth in terms of demand for its facilities, but not being able to satisfy this demand. Given the volatile nature of the market and traffic patterns at smaller airports in particular, the investment and planning process aimed at maintaining and structuring the national airway system has been made considerably more risky. Some major carriers have been increasing their traffic feed to larger hubs by aligning themselves with small carriers, or by directly serving the smaller communities. The airlines have tended to select underused airports in expanding their systems, since these airports would be comparatively free of constraints that restrict many of the larger airport facilities, such as airside and groundside capacity, environmental concerns and airport policies that inhibit further growth. For the FAA, long term planning goals are difficult to formulate when projections of traffic need to be revised as carriers continue experimenting with new routes and connections, but fail to provide advance information to the FAA on their expansion or contraction plans. For the smaller airports being selected by the airlines, the grounds on which they may deny access are limited and difficult to establish now under deregulation. It is up to the community to make a case to the FAA, who are more likely to side with the airline. Deregulation allowed airlines to determine their own routes, rates and service frequency, but no mechanism was left for determining which airlines should get access when an airport has limited facilities (QUINONES, 1986).

The structuring of the air carrier's route system has wide ranging implications not just for the firm's profitability and competitive standing, but also for the nation's airways system. The stability and sustainability of this system depends on the air carriers' choice of airports, their service frequency and the possible connections that may be generated. The understanding of these relationships is important for federal agencies in order for future investments and planning to be effective and efficient.

3.3 Patterns in U.S. Commercial Aviation 1969-87

Since the early 1960s, U.S. passenger traffic has been growing steadily at an average annual rate of 5.8%, with minor declines in 1973/74 and 1980/81 due to the impact of the oil crises, and in the case of the 1980/81 drop, decline must also be attributed to a correction after the temporary but phenomenally high enplanement figures for 1978 and 1979, the deregulation year. Figure 1 shows the traffic trend for the period 1969-87, where traffic is indexed to 1977. International traffic has consistently accounted for between 3 and 5 percent of the total U.S. traffic over this period.

Figure 1: U.S. Passenger Enplanements
Traffic Index 1969-87

The increase in air traffic has not been equally distributed over the U.S. airport system. Some airports' traffic levels have grown at rates greatly exceeding the national average, while others have declined and indeed a substantial proportion have ceased serving the scheduled traffic market. The changing distribution of traffic can be very simply captured by computing rank correlation coefficients of the top 100 airport's ranks in 1987, with their ranks in 1985, 1981, 1977 and 1973. The vast majority of scheduled air traffic takes place at these top 100 'hubs'. Table 2 shows the percentage of U.S. traffic at these hubs in the four time periods mentioned above, and the proportion of all airports/communities certificated to receive scheduled service that the top 100 represent.

Table 2:

Proportion of traffic at top 100 U.S. hubs 1973-85, and correlation coefficients of the top 100 hubs' ranks in 1987 with other years.

Year	% Traffic	Proportion of CPs ¹	Total no. of CPs	Correlation with 1987 ranks
1969	96.9	27.9	524	-. ²
1973	92.5	13.0	772	0.707
1977	92.3	15.7	638	0.749
1981	94.7	15.9	627	0.848
1985	96.0	26.7	374	0.953
1987	97.7	26.2	477	1.000

Source: CAB/FAA *Airport Activity Statistics of the Certificated Route Air carriers*, Washington D.C..

¹ CPs refers to certificated points.

² The correlation coefficient was not computed for 1969, since it was not possible to determine the ranks of all hubs in that year.

The total number of FAA certificated points has dropped substantially since deregulation, so in effect, a smaller number of airports/communities are handling this substantially greater volume of traffic in the 1980s. Figure 2 shows the total numbers of large, medium and small hubs for the period 1969-87. In Table 3, the traffic proportions at all large, medium and small hubs for the period 1969-87 are summarized. The number of large and medium hubs in the system has remained relatively constant in the last 12 years, though the

number of small hubs has fallen noticeably, and accordingly so has the proportion of traffic at these nodes in a given year. US air traffic has become considerably more concentrated at a smaller number of centers. It is most likely that many of the smaller communities began receiving alternative service when scheduled service ceased, but these data are not as easily or readily available.

Figure 2: U.S. FAA Hubs 1969-87
Number of large, medium and small hubs

Table 3:

Traffic at large, medium and small FAA hubs 1973-85

Year	Large hubs		Medium hubs		Small hubs	
	No. ¹	% traffic ²	No. ¹	% traffic ²	No. ¹	% traffic ²
1969	22	69.7	38	20.4	86	9.9
1973	25	68.4	39	18.4	84	9.0
1977	25	68.1	39	18.4	92	10.2
1981	24	70.2	40	19.0	72	7.9
1985	26	72.8	37	18.1	61	6.7
1987	28	74.1	34	16.6	63	7.1

Source: CAB/FAA Data.

¹ Number of large, medium and small hubs (note: hubs refer to SMSAs and communities, *not* airports, so that there may be more than one airport at the FAA hub).

² % traffic refers to the proportion of U.S. domestic passenger enplanements at large, medium and small hubs.

Along with the reduction in the number of centers receiving scheduled air services, the spacing of the remaining airports has also changed over the recent decades. In Table 4, the average distances between large hubs and

Table 4:

Mean distances between U.S. hub types in miles

Year	Large to large hubs	Large to large and medium hubs	Large to large, medium and small hubs
1965	258	137	68
1969	256	145	72
1973	235	143	80
1977	236	139	79
1981	240	130	90
1985	216	127	101

Source: CAB/FAA Data.

Other large, medium and small hubs for the period 1965-85 are presented. Since the 1960s, it can be observed that the mean distance separating large hubs has been reducing gradually. A less stable trend is noted for the large to large or medium hub figures. The average mileage between large and all other hubs has been increasing over the period.

3.4. Traffic Patterns at FAA Hubs, 1969-87

In the previous section, the tremendous increase in passenger enplanements was traced for the U.S. over an eighteen year period. In this section, the traffic distribution at a sample of those airports are examined so that the pre-1978 patterns of service by carriers may be compared and contrasted with the patterns observed in the deregulated years. In the federal and academic literature on deregulation, many authors often refer to the noticeable change in carriers' routing strategy from predominantly linear, or point-to-point networks, prior to 1978, to 'hub-and-spoke' structures in the 1980s. Most of the evidence for this comes from visual inspection of route schedules and from examining traffic proportions at carriers' busiest airports. The aim in this section is to present data for a longer time period (i.e. 1969-87), and measure this propensity by the airlines to use hub-and-spoke routing systems, and in addition, to examine the effects of this hubbing phenomenon on the U.S. air system.

A random sample of five large, five medium and five small FAA hubs were selected from the 1987 *Airport Activity Statistics of the Certificated Route Air Carriers*. The total domestic scheduled and nonscheduled passenger enplanements were recorded for each certificated carrier serving the hub, and these traffic distributions were detailed for the years 1969, 1973, 1977, 1981, 1985 and 1987, (five year periods, with 1977 being used as a base year, since it was the last fully regulated year; 1987 was the most recent year for which data were available, and is included for this reason).

For the five large hubs (serving between 1.65% and 5.30% of total U.S. traffic), the average number of carriers increased from 8.2 in 1969 to 15.2 in 1987. This increase in the number of carriers is quite marked after 1977,

since the ADA allowed carriers to enter new markets freely after 1979. There was an average of 17 carriers serving the large hubs in 1985, though this number dropped in 1987, due most likely to the contraction in the total number of carriers serving the industry, because of mergers, takeovers/acquisitions or less typically, financial failure. The traffic distributions at one of the large hubs in the sample over the study period are illustrated in Figure 3.

Figure 3: Concentration at FAA Hubs
Traffic distribution at a sample large hub: Las Vegas, NV.

The Gini index, measuring the difference between actual traffic distribution and a traffic distribution where all carriers carried the same proportion of traffic, rose from an average of 0.526 in 1969, to an average of 0.701 in 1987 for FAA large hubs. A Gini index of 0.5 is quite high under any cir-

cumstances, so it must be stressed that almost a decade before deregulation, traffic patterns at large U.S. hubs exhibited a high degree of concentration, and after passage of the Act, this tendency became ever more marked.

The Gini index is positively and significantly correlated with the number of carriers serving each airport (the R-squared is 0.46). The Gini index is also positively and significantly correlated with the proportion of traffic at each airport ($R^2 = 0.44$). Regressing the Gini index on both of these variables gives an R^2 of 0.63. The relationship between the proportion of traffic and the number of carriers is very weak, the R^2 value being 0.19. Thus, the busiest airports do not necessarily have a large number of carriers serving them, but these airports are likely to have a more concentrated traffic distribution in comparison to the smaller airports. Those airports being served by a larger number of carriers are also likely to have a more concentrated traffic distribution.

The dramatic increase in concentration, particularly at the largest hubs, reflects the large airlines' consolidation of their "hubs" at these airports in the deregulated environment. The concentrated nature of the traffic distribution prior to 1978, indicates that many carriers had already selected and grown around a small number of key nodes in their systems, and, deregulation allowed this growth to continue in a more streamlined and efficient manner. The air carriers would logically have had a small number of major maintenance facilities at the airports they served, and aircraft rotation schedules would be planned around these nodes. The problem for the airlines with the regulations enforced by the CAB was that the ability to add and cut routes was very limited, and so, traffic flows and aircraft movements could not be channeled through such a narrow subset of nodes. The ADA did allow this streamlining to take place, and the hub-and-spoke networks currently being observed, are the logical progression for the airlines.

For all FAA hubs, it must be remembered that huge growth was taking place in the volume of traffic at these airports, in order for them to maintain their status (i.e. for medium hubs, they consistently needed to carry between 0.25 and 0.99% of total U.S. traffic). As with the large hubs, the increase in the number of carriers serving these airports is quite dramatic after 1977, though for the medium hubs, the increase is at a slower rate, with this trend being consistent for the 10 years since 1977. The Gini index for the medium hubs is consistently lower than for the large hubs. The index began increa-

sing substantially after 1977, rising from 0.361 in that year to 0.567 in 1987. The airlines select these nodes as obvious centers of growth and accordingly, have moved in and in many instances, used them as secondary hubs in their systems. Figure 4 plots the average Gini index for each hub type for the 18 year period, while Figure 5 shows the average number of carriers serving each hub type over the same period.

Figure 4: U.S. Commercial Air Traffic
Average Gini coefficient at each hub type

The number of carriers serving small hubs has increased also in the deregulated period. In 1969, there were an average of 2.4 carriers at the five small hubs in this sample. There were 2.6 on average in 1977 and 5.6 in 1987. However, looking at the traffic distributions at these airports, it is noted that only a small change has taken place in the concentration levels, in the 10 years since deregulation. Generally speaking, the Gini index continues to

reflect a more equitable distribution of traffic among carriers serving small hubs. This is good for these communities, since if their traffic load is being relatively evenly spread over an increasing number of carriers, they are also spreading their risks, giving them greater stability.

Figure 5: U.S. Commercial Air Traffic
Average number of carriers at FAA hubs

3.5. U.S. Air Carriers 1969-1987

Attention is now turned to the airline industry, and the size of that industry over the 18 year period, 1969-87.

Figure 6 plots the total number of certificated carriers for the selected time

period. Between 1969 and 1978, the number of carriers fluctuated between 33 (1974) and 37 (1970), dramatically rising to 52 in 1979, the first fully deregulated year. The industry continued to expand in the subsequent years. In 1983, the total count dropped by 9 carriers, and the general trend recently, has been a gradual fall-off in the number of carriers in the industry. The decline does not necessarily reflect financial failure of carriers, but rather the extent of mergers, takeovers and acquisitions by other airlines in the industry.

Figure 6: U.S. Air Traffic 1969-1987
Number of Certificated Carriers

Air carriers are allocated to one of four groups: The majors (with annual operating revenues of at least \$1 billion); the nationals (operating revenues of between \$100 million and \$1 billion); the large regionals (operating

revenues of between \$10 and \$100 million); and the medium regionals (with operating revenues of less than \$10 million). The number of majors has remained relatively constant over the period 1969-87. The greatest changes have occurred in the medium and large regionals categories. The number of medium regionals fell sharply from 26 in 1982 to just 4 in 1987, while the number of large regionals has varied up and down from a high of 23 in 1984, to 15 in 1987. Looking at the trends for the earlier period (1969-80), there were consistent numbers in all categories up until 1979. The categories were different to those listed above, focusing on carriers certificates rather than traffic volume; this older scheme broke down after passage of the Act. The major carriers served 77.4% of the total U.S. passenger traffic in 1987, and attention is now turned to examining two of these carriers in more detail.

4. Case Studies: Continental Airlines and American Airlines

4.1. Introduction

Both Continental and American existed before regulation was first imposed in 1938, and as was pointed out above, airlines in this position were given special attention and protection under CAB regulation. The economic status of air carriers in the current period was, to a large extent, predetermined by their status under regulation. The trunk carriers emerged in the late 1970s with by far the largest share of the air passenger traffic market, the most extensive aircraft fleet and gate ownership levels and with long standing public reputations. In the ten years since 1978 however, three of the 11 trunks of 1978 have declared bankruptcy and two were acquired by other trunks. In 1988/89, 9 of the 11 trunks were flying, many under different management and corporate frameworks. Table 5 summarizes the main changes taking place between 1978 and 1989.

Table 5:

Major changes in the U.S. trunk carriers 1977-1989.

1977 Trunks	Changes since 1977
American Airlines Braniff Airways Inc.	¹ Bankruptcy declared 1982. Re-entered as a national carrier 1984
Continental Air Lines Inc.	Acquired by Texas International 1981. Bankruptcy declared 1983. ³
Delta Air Lines Inc. Eastern Air Lines Inc.	Acquired by Texas International 1986 Bankruptcy declared 1989. ³
National Airlines Inc. Northwest Airlines Inc.	Acquired by Pan American 1979. ²
Pan American World Airways Trans World Airlines Inc.	Acquired Ozark Airlines
United Air Lines Inc. Western Air Lines Inc.	Acquired by Delta Air Lines 1986.

¹ American Airlines acquired Air California 1987

² Northwest acquired Republic in 1986 (Republic consisted of North Central, Southern and Hughes Southwest)

³ Texas Air (formerly Texas International) now consists of Continental Airlines (of which People Express (a post 1978 entrant), New York Air, Frontier, Rocky Mountain Airlines, Bar Harbor Airways, Britt Airways and Provincetown-Boston Airlines Inc are subsidiaries) and Eastern Airlines.

4.2. Continental Airlines and American Airlines Traffic Patterns, 1969-87.

In this section, two major U.S. airlines are focused, the aims being to (i) examine the effects of deregulation on the size and share of two carriers' operations, (ii) trace the characteristics of these carriers' networks for a roughly 20 year period, and examine the changes in these carriers' networks in terms of their size, features of the airports served, traffic, and, distribution of traffic and levels of concentration in the overall network system.

Table 6 shows a traffic index for Continental and American from 1969 to 1987 (1977, the base year, =100) and also the share of total domestic traffic handled by these airlines over the same period. American's volume of traffic has increased 240% since 1977, though it's share of the passenger market is almost exactly the same in 1987 as it was in 1969. This airline's market

share dropped in the 1970s and continued to decline initially under deregulation. American has managed to recapture its earlier share of the market via extension of its network and purchase of smaller feeder airlines (e.g. Air California Inc., and American Eagle). Continental Airlines was a smaller trunk, and its market share varied from 3.0% of total traffic in 1969 to 3.4% of traffic in 1973. The volume of traffic handled by Continental rose slowly after 1978. As seen in table 5, Continental was acquired by Texas Air (formerly Texas International) in 1981, and declared bankruptcy in 1983. After re-organization in 1984 and 1985, the company purchased People Express (and its subsidiary, Frontier), New York Air and Rocky Mountain Airways Inc., from its parent company. Continental rapidly increased its volume of traffic, 530% over the 1977 volume. Its share of the U.S. market grew from 3.04% in 1981 to 9.1% in 1987.

Table 6:

Continental and American Airlines' traffic indices and share of domestic U.S. traffic market 1969-87

Year	Continental Airlines		American Airlines	
	traffic index	share of U.S. market	traffic index	share of U.S. market
1969	63.68	3.009	86.99	12.642
1973	90.03	3.443	92.48	10.874
1977	100.00	3.293	100.00	10.125
1981	111.49	3.048	107.92	9.071
1985	208.50	4.153	181.98	11.145
1987	534.82	9.099	242.29	12.675

Source: CAB/FAA *Airport Activity Statistics of the Certificated route air carriers*, various editions.

In Tables 7 and 8, the number of domestic airports served by both carriers are recorded for the period 1969-87, and these are subdivided into the FAA hub classifications. Also given in this table, are the proportions of traffic at each hub type over the period. Both airlines have greatly expanded the size of their domestic networks since 1977, Continental increased its numbers from 33 airports in 1977 to 122 in 1987, while American increased its numbers from 50 in 1977 to 119 in 1987. Looking at the emphasis within the networks, American Airlines has consistently focused their operations on the FAA large hubs. The proportion of traffic at these large hubs increased in the deregulated period, when all FAA large hubs were served by this airline.

The proportion of traffic at medium hubs has declined even though the airline served a larger proportion of FAA medium hubs in 1985 and 1987 than it did in 1977.

Table 7:

Continental Airlines: traffic distributions and domestic system characteristics, 1969-1987

Year	Number of airports served	Number of hubs served				Proportion of traffic at each hub type			
		L	M	S	N	L	M	S	N
1969	28	10	9	8	1	63.35	23.37	13.09	0.19
1973	32	10	10	9	2	65.01	22.11	12.68	0.20
1977	33	12	9	9	2	67.81	20.49	11.92	0.07
1981	48	19	17	9	1	71.73	22.06	5.64	0.57
1985	54	23	16	6	3	83.37	11.84	3.89	0.89
1987	122	27	28	33	23	78.81	14.16	4.89	2.13

Table 8:

American Airlines: traffic distributions and domestic system characteristics, 1969-1987

Year	Number of airports served	Number of hubs served				Proportion of traffic at each hub type			
		L	M	S	N	L	M	S	N
1969	44	14	21	3	1	72.27	25.31	0.76	0.09
1973	47	15	22	6	0	71.47	25.46	1.43	0.00
1977	50	16	21	9	1	74.17	23.02	2.73	0.08
1981	67	23	28	14	0	79.85	17.94	2.22	0.00
1985	102	26	34	30	3	78.44	15.93	5.41	0.23
1987	119	28	32	39	10	72.69	20.98	6.01	0.32

Continental Airlines has significantly increased its traffic proportion at the large hubs it serves. In 1977, 67.8% of its traffic passed through large hubs, while in 1987, 78.8% of its traffic was channelled through these communities, when all but one of the FAA large hubs were served. As with American, the proportion of traffic at medium hubs has declined, along with a decline in the proportion of traffic at small hubs also. In 1987 however, this airline

dramatically increased the number of small hubs and nonhubs that it served: much of this increase in the network size is explained by the mergers and acquisitions mentioned above.

The traffic distributions over the airlines' systems were examined for each of the time periods selected. Scheduled and nonscheduled domestic passenger enplanements for each airport in the system were recorded for the six years. A series of summary statistics were computed for these traffic distributions for both carriers, and these are detailed in tables 9 and 10. The two most popular series of measures used in the economics literature to summarize traffic distributions are the Herfindahl index and the proportion of traffic at the top 1,2 and 3% most utilized airports. In Tables 9 and 10, these figures are recorded for both airlines.

The Gini index, Theil measure and coefficient of variation all have one obvious major advantage over the proportion of traffic measure, since they utilize the full distribution, and therefore take into account the increases in the number of airports served by both airlines. Looking at one example, the fact that 16.4% of Continental Airline's traffic was at one airport in 1969, and 18.1% of it's traffic was at its busiest airport in 1987, masks the 436% increase in the size of the system, as measured by the number of nodes. 18.1% of an airline's traffic at one airport, when it serves a total of 122 nodes, is intuitively more concentrated than having 16.4% of its traffic at one airport when only 28 nodes are served. In addition, any changes in the traffic distributions at the lower ranked airports, will not effect the summary statistics usually computed (i.e. the Herfindahl index and proportion of traffic indices).

Table 9:

Measures of concentration for Continental Airlines traffic distributions 1969-87

Year	C.O.V.	Theil index	Gini index	Traffic at top 1,2,3 & 4 airports				Herfindahl index
1969	1.185	-0.831	0.565	0.164	0.328	0.411	0.491	0.086
1973	1.220	-0.840	0.553	0.164	0.318	0.401	0.464	0.078
1977	1.255	-0.838	0.555	0.173	0.314	0.413	0.468	0.078
1981	2.252	-0.737	0.674	0.313	0.408	0.501	0.560	0.127
1985	2.382	-0.729	0.659	0.241	0.478	0.531	0.561	0.124
1987	2.763	-0.730	0.741	0.181	0.305	0.422	0.472	0.071

Table 10:

Measures of concentration for American Airlines traffic distributions 1969-87

Year	C.O.V.	Theil index	Gini index	Traffic at top 1,2,3 & 4 airport				Herfindahl index
1969	1.276	-0.844	0.589	0.139	0.244	0.350	0.417	0.061
1973	1.387	-0.829	0.603	0.142	0.253	0.353	0.423	0.062
1977	1.525	-0.816	0.618	0.160	0.278	0.372	0.446	0.066
1981	2.157	-0.748	0.705	0.198	0.356	0.430	0.504	0.084
1985	3.255	-0.704	0.713	0.278	0.448	0.492	0.523	0.114
1987		-0.731	0.718	0.235	0.377	0.424	0.459	0.085

The coefficient of variation, Theil's entropy measure and the Gini index show gradual increases in both American and Continental Airlines' traffic distributions between 1969 and 1987. These three measures are generally consistent in the trends they show. The Herfindahl index shows a different trend however, the change in this index is much smaller over the period. It suggests very slight increases in concentration of traffic for both airlines from 1969-85, and a drop in concentration between 1985 and 1987 (even though, in the space of two years, there were 126% and 17% increases in the number of airports served by Continental and American Airlines respectively). The proportions of traffic at the top 1,2,3 and 4 airports served by both airlines, show the same trend as the Herfindahl index.

The Gini index is proposed as a superior measure to those previously used in the economic literature, because it takes account of the entire distribution and makes unit free comparisons. In addition, it satisfies the axioms proposed by SEN (1976) which capture several intuitive properties of a good measure of concentration. In the context of air traffic for example, the Gini index is superior in measuring the effects of passenger transfer from one of the top ranked airports to one of the lower ranked airports in an air carriers system (REYNOLDS, 1989). The Gini index is also easily illustrated, and it is used now to highlight changes in both Continental and American' traffic patterns in the last c.20 years.

Figures 7 and 8 illustrate the changing nature of Continental and American Airlines' traffic distributions between 1969 and 1987. The high level of concentration in both airlines' traffic patterns in 1969 and 1977 indicate

that the recent phenomenon of hub-and-spoke networking is not so drastic a change in organization, but rather a refinement of a general trend among larger carriers, to concentrate flows from an increasing number of nodes in their system, through a small number of key airports or carrier hubs. The same comments were made earlier in section 3.4, when airport patterns were examined. These trends have become exaggerated since 1977, but were very definitely in place prior to deregulation.

Figure 7: Continental Airlines
Traffic distribution 1969-87

Figure 8: American Airlines
Traffic Distribution 1965-85

To summarize then, the major U.S. carriers examined here, have greatly expanded their networks (be it through natural growth or merger with/acquisition of other carriers) since 1977, and have maintained or increased their market shares by serving a very high proportion of the large and medium FAA hubs, and by streamlining their services through a small number of key hub-airports. The size of the national airways system serving the scheduled traffic market has contracted considerably since deregulation. This smaller national network which is handling a tremendously increased volume of traffic, is now being served by a greater proportion of the major carriers. The 11 trunk carriers in 1977 accounted for 77.86% of all U.S. traffic in that year. In 1987, the 12 major carriers accounted for 77.40% of U.S. traffic:

change in the industry structure has occurred among the smaller carriers: the large and medium regionals were the classes of scheduled carriers experiencing the greatest change, in terms of new entrants and subsequent exits.

In the final section of this paper, the implications of these changes for regional economic development and issues in regional development theory are outlined. Suggestions for further avenues of research are offered.

5. Implications for Regional Development Theory

What role do transportation systems play in conditioning the path, direction and pace of regional economic development? In particular, can one document a clear link between transportation improvements and economic change? How do changes in the organization of transportation systems affect regional development. The first two questions are ones that have occupied a great deal of attention in the literature at a variety of spatial scales as authors have struggled to relate transportation improvements to overall levels of national and regional welfare. The last question raises an issue that is far more difficult to answer since the effects of changes in spatial organization are often more difficult to trace. In the case of the airlines, the differences in organization have often come about in two important ways. First, there are the types of changes described in sections 3 and 4, the movement from point-to-point to hub-and-spoke systems. Secondly, and often complementing this reorientation are changes in the nature and character of the service provided. For example, the changes in the organization may increase the frequency of departures from an airport; the involvement with a hub in which interchange among several connecting flights might be possible will improve the indirect connectivity of the airports at the spokes with the rest of the system. Finally, one may note that the capital embodied in the service may change; greater frequency of service might be offered but in smaller aircraft and perhaps involving a substitution of non-jet for jet or narrow-bodied jet for wide-bodied jet aircraft. While these changes can be documented, the problem remains one of tracing the effects of these changes on other indicators within the regional economy.

The process of industrial restructuring that has characterized the economies of almost all western nations has resulted, in SCOTT's (1988) terms in the articulation of "flexible production spaces." This process has been accentuated by substantial, sustained vertical disintegration in the production process. Improvements in telecommunications and transportation in general have created opportunities for firms to expand the choice set of location possibilities. Factors that in traditional locational analysis appeared at the lower ends of the ranking now would appear to have been given greater prominence; the character of other factors, especially their form, would appear to have changed. This is particularly true in the case of access to transportation, first seen in terms of railroad access, then to highway/freeway access and most recently access to major airports.

As more and more commodities and inputs (especially human capital) with high value-to-weight ratios are being transported by air, proximity to major airports would appear to have become an important consideration. Yet, to date there would appear to be little documented evidence of the impact that the designation of community as a hub has had on its economic development. As with most transportation impact analysis, there remains the important distinction between cause and effect in a synergistic process of development; designation of transportation improvement as the cause or effect of economic development continues to prove intractable.

The process of hub creation has a major impact on a community in terms of jobs created and sustained over a period of incredible change and uncertainty in traditional, manufacturing enterprises. But to what degree have Raleigh-Durham (American Airlines), Dayton, Ohio (Piedmont, now USAir) or Denver (United and Continental) benefitted from the development of hubs at their airports in contrast to places like Columbus, Ohio or Indianapolis that are non airline hub airports?

It is interesting to note that there have been some serious discussions about the development of "Wayports," large airports located in the central part of the U.S. away from major urban concentrations. These airports would serve the role of transfer points rather than final destinations. Needless to say, the major airlines, with substantial infrastructure investments in major urban airports are not very excited about such propositions. The construction of wayports would involve disembodiment of the airport from the urban system

and represent a phenomenon that has not occurred in other transportation systems.

What has been the effect of changes in the spatial structure of the airline system on the process of regional development? The available evidence would seem to suggest that the airlines have responded to rather than anticipated economic development. The decrease in the number of carriers, through attrition but mainly mergers and acquisitions, may serve to further neutralize the potential impacts of the post regulated environment on regional development.

There are however, some major changes that are likely to require close monitoring. The first is the movement towards joint ventures between US airlines and carriers from other countries (e.g., SAS and Texas Air; Delta and Swiss-air, United and British). Closely associated with this is the degree to which US airlines are positioning themselves to take advantage of the increasing internationalization of the productive process. Penetration of the Pacific market has yielded substantial profit for those carriers fortunate enough to have authorization to serve points such as Tokyo, Hong Kong and Seoul. Across the Atlantic, US airlines are rapidly completing arrangements to serve European cities before 1992 when the fear of dealing with an unknown European Community agency might limit market penetration.

In the final analysis, the ability to offer substantial evidence for a clear link between changes in network structure and regional development remains elusive. Available data are not in a form to render the kinds of analysis and interpretation that would be necessary. On the other hand, the degree to which communities benefit from the presence of an airline hub may revolve more around the characteristics of the individual airline's total network rather than the presence or absence of the hub per se. In the United States, the absence of major developments of new airports over the next decade is likely to create additional opportunities for the specification of alternative, integrated systems of transportation. The spokes in the hub and spoke system may be served by high speed rail rather than short-haul jet and non-jet aircraft; if the development of magnetic levitation rail systems can be brought into economically viable reality, offering service at speeds up to 300mph, the character of the airline system will undergo a transformation that might be even more dramatic than the changes that have accompanied

the movement to the present hub-and-spoke system.

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