

ESTIMATED REGIONAL IMPACTS FROM HUB-AND-SPOKE OPERATIONS
AT U.S. AIRPORTS

by

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ABSTRACT

Hub-and-spoke networking has grown steadily since route and fare regulations were lifted by the Deregulation Act of 1978. These operations were an economic response to higher aircraft operating costs and low load factors. The restructuring of non-stop route network into hub-and-spoke systems enabled airlines to serve more markets with a minimum of aircraft. However, these networks have major effects on the hub-and-spoke airport and the surrounding region.

This thesis establishes that hub-and-spoke operations have a significant effect on aviation activities, regional employment, regional income, state and local taxes, and airport expansion and financing. Regional employment and income are considered the major forms of regional impact and taxes and airport expansion are considered the major forms of local impact.

Among the airports studied, the estimated average employment impact from hub-and-spoke activity averaged 63 percent of total airport/airline employment while income generated from hub-and-spoke employment averaged 66 percent.

Fixed employment (not dependent on the number of hub-and-spoke flights or passengers) is a significant part of direct hub-and-spoke employment (3500-10,000), particularly major aircraft maintenance and system-wide management. Variable employment was also important (2,800-12,500).

Total regional induced and direct impacts were found to range from \$0.7 to 3.5 billion per year and tax impacts from \$56-200 million for the four large hub-and-spoke airports studied here.

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Chapter 1 INTRODUCTION

In the last 5--10 years there has been a dramatic increase in the number of hub-and-spoke operations at major airports. Today, there are twenty-eight major hub-and-spoke systems serving 75 percent of all enplaned passengers, compared with five hub-and-spoke systems used by major carriers before 1978. (Table 1)

Hypothesis

It is hypothesised here that 1) hub-and-spoke operations have a major impact on aviation activities, regional employment, regional income, state and local taxes; and airport expansion and financing, and 2) that these impacts are significant on the regional scale.

The thesis is divided into seven chapters. Chapter one introduces the concept and general pattern of hub-and-spoke networks prior to and following deregulation. Chapter two, Methodology, describes the choice of airports used to analyze hub-and-spoke airport operations and services, and defines the terms and measures employed in the thesis. Chapter three examines the hub-and-spoke impact on airport operations, markets and passengers. Chapter four explains the size and types of airport expansion and financing and the influence of hub-and-spoke operations on new construction. Airport expansion and taxes are considered the major forms of local impact.

Finally, since regional employment and income are considered the major forms of regional impact, Chapters five and six analyze the number of airport/airline jobs and income and estimate the direct and induced hub-and-spoke impacts on the region. Chapter seven summarizes the conclusions of the thesis.

1.1 History

In response to the lifting of route and fare restrictions imposed by the Civil Aeronautics Board (CAB), airlines began to consolidate operations at a few selected airports. Many of these airports served regions that were strategically located for route networking. In addition, airlines found it economically advantageous to shift markets and operations to these airports. These shifted markets and operations at a central distribution point and the emphasis on connecting service at this point is known as hub-and-spoke networking. This networking enables airlines to coordinate flights so that a passenger on any one of the planes arriving at the hub airport is able to transfer to any of the other planes to reach the ultimate destination..

Although hub-and-spoke operations existed prior to the passage of the Deregulation Act of 1978, they intensified when restrictive government control over route entry and fares was lifted. The important economic benefit deregulation gave airlines was the freedom to enter and exit markets based on profit maximization. Under regulation, airlines wishing to enter new markets were required by the CAB to justify service offered by their airline as essential to the public, and red tape prevented change of route structure.

Prior to deregulation when most routes were non-stop or point-to-point, two different airlines were frequently used to transfer from different city-pairs. Sensitive to the loss of revenues by having to share passengers along a route, airlines strengthened their services by gaining agreements from local carriers to coordinate short-haul feeder flights to connect with a their route system. In the new competitive environment, major airlines began to restructure their traditional non-stop routes into a few strategically positioned airports where they could service passengers from origin to destination by a network of routes served from one location.¹

Hub-and-spoke systems have existed since the 1940s. For example, Eastern and Delta began concentrating their fleets at Atlanta-Hartsfield in the early 1940s. Although Atlanta and much of the South remained economically stagnant during that period and thirty years following, the hub-and-spoke system at Atlanta grew independently. Today, an estimated 60 percent of the markets served out of Atlanta exist because of hub-and-spoke operations and although the city and surrounding region have experienced dramatic growth, the airport's main function still revolves around the connecting hub-and-spoke complexes built by Delta and Eastern.²

Table 1

Airlines Operating Hub-and-Spoke Operations in 1987			
<i>Airport</i>	<i>Airline</i>	<i>Airport</i>	<i>Airline</i>
Atlanta*	Delta, Eastern	Miami	Eastern
Baltimore	Piedmont	Minneapolis	Northwest
Cincinnati	Delta	Newark	Continental
Charlotte	Piedmont	Philadelphia	USAir, Eastern
Chicago/O'Hare*	United, American	Phoenix	AmericaWest
Chicago/Midway	Midway	Pittsburgh*	USAir
Dallas/Forth Worth*	American, Delta	Raleigh/Durham	American
Dayton	Piedmont	Salt Lake City	Delta
Denver*	Continental, United	San Francisco	United
Detroit	Northwest	San Juan	Eastern, American
Houston	Continental	St. Louis	TWA
Kansas City	Eastern	Syracuse	Piedmont
Las Vegas	AmericaWest	Washington, D.C. (Dulles)	United, Continental
Los Angeles	Delta		
Memphis	Northwest		

*Hub-and-spoke networks prior to 1978

Sources: 1985, 1986, 1987 Airline Annual Reports

Definition

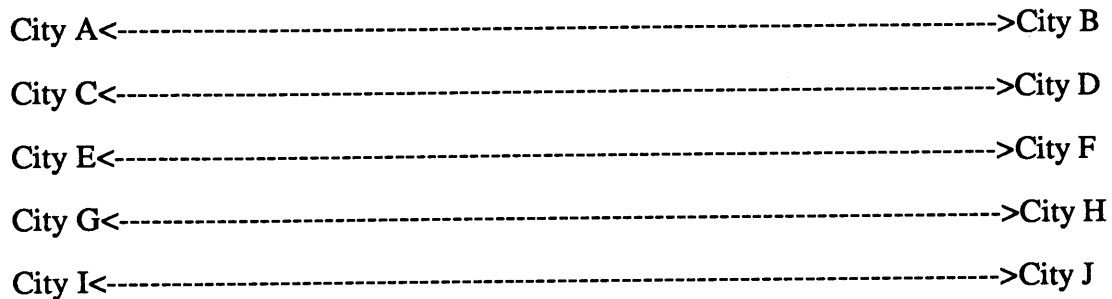
Hub-and-spoke operations involve the centering of operations for an airline. An airport serves as a "hub" or collection-distribution center where flights feed passengers into a central location and they are transferred to other flights. The benefits of this system is that it enables an airline to use fewer aircraft that serve more markets.

For example, Figure 2 illustrates that for every flight feeding **Hub K**, passengers would have 34 other cities to choose from. These connecting flights produce 35 city-pair combinations with a minimum of 5 aircraft. The connecting feed of passengers into a central location allows for an airline to redistribute passengers into larger departing aircraft on denser routes. The higher passenger volume from the combination of many routes into one allows an airline to achieve higher load factors and schedule greater frequencies of service to offset the extra time required by connecting service.³

In contrast, as shown by Figure 1, an airline using point-to-point networking could serve only 5 city-pairs and would require 5 aircraft. Another major problem with point-to-point networking that made it economically inefficient, was that an airline usually carried four different markets using the same capacity aircraft. Point-to-point networking encourages the use of different carriers to achieve the same market coverage as hub-and-spoke.⁴

Figure 1

Linear or Point-to-Point Networking Without Hub



Number of City Pairs Served: 5
Number of Aircraft Used: 5

Figure 2

Hub-and-Spoke Networking



Number of City Pairs Served: 35
Number of Aircraft Used: 5

Source: Brenner, et. al., Airline Deregulation. 1985
Market Penetration: Hub and Spoke Networks

Establishing a hub-and-spoke network allows an airline to concentrate operations and personnel at one airport. This can include major maintenance, flight and ground crews, and extra aircraft. In addition, hub-and-spoke configurations simplify the scheduling process. For example, a characteristic of hub-and-spoke operations are connecting complexes or banks. Here, airlines are able to schedule groups of flights in a short time span from one region into a hub airport⁵ where these aircraft depart later in the same day to connect with flights at another airport. The use of connecting complexes have been associated with delays at both the hub airport and airports feeding traffic to them.

1.2 General Pattern of Airline Operations Since Deregulation

Trunk carriers have generally found it profitable to establish their hub-and-spoke operations at large cities where their larger aircraft are best suited to operate. Conversely, some small carriers found it profitable to establish operations at smaller communities. Piedmont's Charlotte hub⁶ was developed as an alternative to Atlanta, as a connecting point in the southeast. Growth at Charlotte has been largely attributable to Piedmont. Traffic at Charlotte grew 125 percent between 1978 and 1981 and 325 percent between 1981 and 1987.⁷ Piedmont also developed hubs at Dayton, Baltimore, and gained a hub at Syracuse by its merger with Empire Airlines in 1986.

Another pattern of airline changes since deregulation is the growing evidence of declining non-stop service in favor of connecting service. One reason is that the economic rationale for hub-and-spoke operations has proven so successful, and it is more economical to provide connecting service to more markets with fewer aircraft, airlines have reduced the number of non-stop flights between airports that don't serve as their hubs.

The post-deregulation period saw the birth and demise of new airline entrants especially discount carriers. New entrants generally established hubs at underutilized airports primarily because they were unable to compete effectively in established hub-and-spoke airports, or obtain terminal space and slots⁸ at the four restricted slot airports.(JFK International, La Guardia, Chicago/O'Hare, Washington/National)⁹ The new hub-and-spoke airports grew in size and importance to the region as well as in the nation's air transportation system as new carriers began to compete in markets already saturated by the major established airlines. With fare wars and reduced load factors creating instability in the industry, most new entrants were removed from competition by merging with older, larger carriers.

The deregulation era has experienced a wave of mergers and bankruptcies after many airlines, especially new entrants, were unable to compete under a deregulated climate. Since creating new hub networks requires considerable time, capital and manpower, airlines have extended their networks and presence by merging with other carriers who operate in regions not served by the acquiring carrier. Many of these mergers were between direct competitors consequently several hub-and-spoke airports are now dominated by one airline.

2.0 METHODOLOGY

This chapter provides definitions of the terms and methods used in this thesis.

It is divided into ten sub-sections. These sub-sections are: Airport Selection; Definition of Impact Categories; Measurements of Primary Hub-and-Spoke Impacts; Hub-and-Spoke Airline Markets; Passenger Travel; Measurement of Direct Hub-and-Spoke Impacts; Calibration of the Equations; Direct Income Impacts; Induced Impacts, and Data Sources.

2.1 Airport Selection

The process of selecting sample airports started by identifying major airlines, then identifying the airports used by those airlines as large hub-and spoke operations. An airport's position in an airline's overall network was considered significant if it was the major connecting point for more than one-quarter of all markets served by a carrier. A final determination was guided by a geographic dispersion of the sample.

Six major hub-and-spoke airports met the criteria mentioned above and were selected for study in this thesis. Four of them, Hartsfield/Atlanta, Denver/Stapleton, Minneapolis/St. Paul, and Greater Pittsburgh International Airports were selected for availability of detailed data and these receive full analysis of regional impacts.

The remaining two airports, Newark and Charlotte/Douglas International, offer additional references to growth in employment and operations.

2.2 Definition of Impact Categories

The definition of impact categories is evaluated by a two stage impact analysis. The first, aviation impact, measures total growth at an airport from total operations. The second, the hub-and-spoke impact, measures the portion of the aviation impact that is attributable to hub-and-spoke operations. Hub-and-spoke operations have generated additional aviation activity and have added employment and income to base aviation activity.

For both these stages, there are three categories that define the economic impacts attributable to aviation. They are: (1) primary; (2) direct, and (3) induced.

(1) Primary economic impacts are defined as changes in operations and passengers of air transportation services for travelers and shippers of cargo.

(2) Direct impacts in the form of a change in resources used to produce airport and airline services are caused by changes in airport use (primary impacts) above. Airline/airport services include airlines passenger services, general aviation, airport administration, catering firms, janitorial firms, security firms, airport retail tenants, federal government agencies and parking.¹

Direct impacts are either regional or local. Employment and income are considered regional impacts while taxes, airport expansion, environmental and community impacts are considered local impacts. Environmental and community impacts are briefly mentioned below but are not the main focus of this thesis.

Economic Impacts from Aviation Activity

The economic impact to the region starts with the revenues received from passenger airlines created by the movement of passengers to and from an airport, catering firms, and airport tenants that sell retail merchandise to travelers. In freight transportation, revenue is received from the transport of cargo and mail. Ground transportation activities generate revenue from the transporting of travelers to and from the airport while contract construction are paid by the airlines and airport for structural improvements.

Revenue generated by the airlines is used to pay salaries, fuel, landing fees, taxes, new construction, rents, expenses incurred from the purchases of other goods and services. Similarly, airports pay employees salaries, infrastructure improvements as well as goods and services from revenues generated by airlines. (see diagram in Figure 2.1)

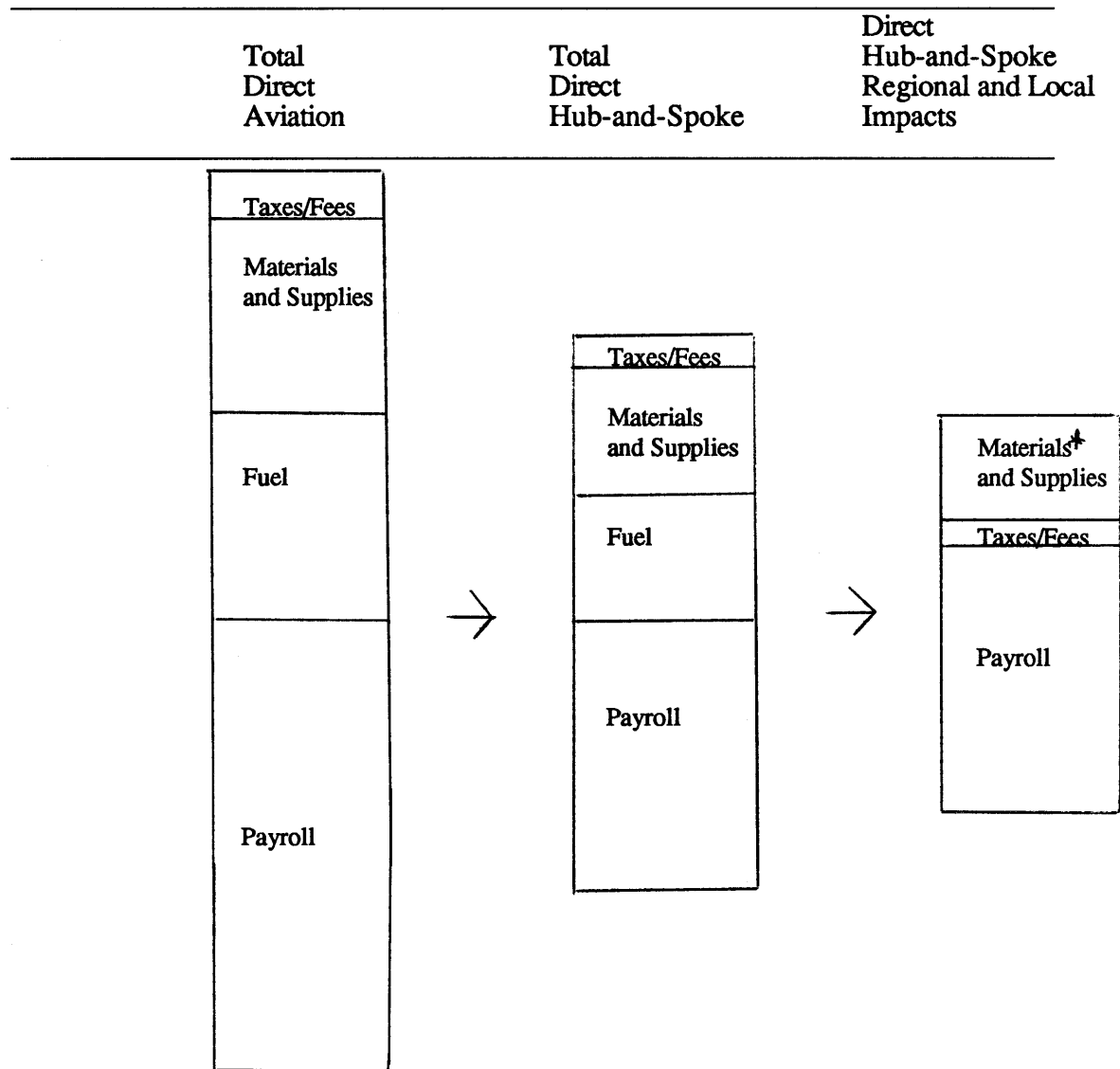
As shown in figure 2.1, hub-and-spoke activities directly contribute to only part of total airline and airport revenues. These include fuel, materials and supplies and payroll.

In addition only a fraction of these revenues can be used as direct impacts in the region, since major portions represent expenditures for materials and services procured outside the region. In economic terms these revenues for outside purchase are called "leakages," and do not benefit the regional economy.

The principal regional economic impact categories are payroll (personal income), taxes, fees and rents, and some purchases of local goods and services as indicated in the hub-and-spoke regional contribution are shown in the diagram. The first three of these categories were selected as the measures of regional impact in this thesis since they amount to 80-90 percent of impacts as shown in figure 2.1 and these were calculated at the four airports.

Of these regional impacts, payroll, (personal income) is the dominant one comprising approximately 50 percent of total aviation impact and up to 70 percent of hub-and-spoke airline expenditures. Of regional and local economic impacts, payroll represents approximately 80 percent while local impacts, taxes and fees (landing and etc.) are estimated to be under 10 percent the economic impact.

**Figure 2.1
Direct Aviation and Hub-and-Spoke Expenditures in the Region**



*Understated portion of the Regional Impact

Regional Impacts from Aviation Activity

Employment Impact represents the jobs required to provide airport and airline services. These jobs are directly dependent upon the level of airport activity, as well as corporate decisions of airlines with hub-and-spoke operations at the airport. This category includes a small amount of employment (eg., retail services) which could be classified as indirect or induced in an economic sense but are grouped with direct employment for the analytic purposes of this thesis.

Income Impact is the additional income entering the region due to airline and airport activities. In this thesis the major source of regional income are the wages and salaries paid to direct employees of the airport and airlines. Other types of income include purchases of the goods and services used by airlines and airports. Only a portion of which affect the regional economy. These are not quantified in this thesis and thus the total income impact is slightly under-estimated.

Local Impacts from Aviation Activity

Tax Impacts: Tax impacts represent federal, state, and local tax payments to the national, state and local governments by firms and by individuals whose jobs are directly dependent upon activity at an airport. For the purposes of this thesis, direct tax impacts are combined with induced taxes and so are discussed in Chapter 6, Induced Employment and Income.

Environmental Impacts: The most important environmental impact from aviation activity is noise pollution. Take-offs and landings create disturbing noise levels to residents living within prescribed traffic paths.

Hub-and-spoke networking exacerbates the situation by concentrating flight activity during the day through the use of connecting complexes. Noise impacts from hub-and-spoke operations are not discussed in this thesis, but is considered a topic for further research in Chapter 8.

Community Impacts: Communities are directly affected by aviation activity in the form of use of feeder roadways to and from the airport. The sharing of local roadways by travelers for access to airport facilities places a burden on the community's road system. Specifically, state and local governments are forced to repair, improve, or replace inadequate roadways. The funding for local improvements to the road system is accomplished by taxes either from the state or directly from airport revenues. Community impacts other than taxes are not discussed further in this thesis.

Airport expansion: Airports have undergone substantial expansion and improvements where hub-and-spoke operations exist. Much of this expansion has been terminal modification and gate additions and is primarily financed by the hubbing carrier (s). New terminal construction at hub-and-spoke airports is also being designed to conform to the needs of hub-and-spoke networking. Thus, the planning and construction of terminal space is being dictated by airlines rather than airport planners.

In some cases, airport expansion has reclaimed adjacent property where homes are purchased by the airport authority and residents relocated to other parts of the community. This has invoked political concerns over who the airport serves. Although political concerns are mentioned here, only financing and physical features of airport expansion are discussed in Chapter 4.

(3) Induced impacts are the ripple effects of the dollars and employment generated from primary and direct impacts. The use of airport services (primary) and the resources used to provide those services (direct) induce additional spending in the regional economy. These expenditures in the region by airport/airline firms and their payroll generate additional employment and spending which accumulates to create the total economic impact.²

The methods used to measure each of these impact categories are described in detail below.

2.3 Measurements of Primary Hub-and-Spoke Impacts

The major measure of hub-and-spoke impacts at an airport operations are defined in this thesis as (1) annual number of operations serving hub-and-spoke markets (combined number of departures and arrivals); (2) annual number of passengers that flow through the airport to and from these markets, and (3) the proportion of transfers broken down into intralining and interlining passengers. (Interlining is the transferring of passengers between two different airlines while intralining is the transferring to another aircraft with the same airline)

2.3.1 Hub-and-Spoke Airline Markets

In order to estimate the present proportion of hub-and-spoke operations at an airport, the change markets served at selected hub-and-spoke airports between 1967 and 1987 was assumed to be related to hub-and-spoke networking. In addition an estimated 20 percent of the 1967 markets were assumed to be converted to hub-and-spoke markets.

In mathematical terms this is represented as:

$$O_{HS} = \left(\frac{M_1 - M_0 + .2M_0}{M_1} \right) O_T = \left(\frac{1 - .8M_0}{M_1} \right) O_T$$

where

O_{HS}	is the number of hub-and-spoke operations
O_T	is total number of annual operations (arrivals and departures) at the airport
M_1	Number of markets served out of an airport in 1987
M_0	Number of markets served out of an airport in 1967

To compare and evaluate market and flight changes, the Official Airline Guides (OAG), North American Editions were utilized along with Boeing Quarterly DOT Data which provided specific information about the number and type of transferring passengers. From the OAG, for each city/airport selected for this study, destination cities were counted including those solely shown as connections, regardless of aircraft type. This was cross-checked by counting, for these same airports, the number of non-stop flights in all markets served by each airport for 1967 and 1987.

2.3.2 Passenger Travel

Hub-and-spoke passengers were estimated by assuming that the average number of passengers per operation was the same for hub-and-spoke and other flights for each airport. The proportion of transfer passengers, however, was expected to be much higher for hub-and-spoke flights. Mathematically, the expression for hub-and-spoke passengers is shown as:

$$P_{HST} = O_{HS} * p$$

Where P_{HST} is the number of total hub-and-spoke passengers
 O_{HS} is the number of hub-and-spoke operations
 p is the ratio of passengers to operations for all flights

For Hub-and-Spoke Origin-Destination (O-D) Passengers the equation for variable hub-and-spoke employment related to origin-destination passengers can be expressed in two steps: first transfers, then origin-destination passengers.

For Transferring Passengers : $T_{HS} = (M_{HS} * T_N) + \Delta I$ (1)

Where T_{HS} is the proportion of transfers that are hub-and-spoke

M_{HS} is the proportion of existing markets that exist as direct result of hub-and-spoke operations
 T_N Non-Intralining transfers
 ΔI is the percentage change in intralining passengers from 3Q77 to 3Q86

This assumes that the average number of passengers per hub-and-spoke flight is the same as for all flights.

For Origin-Destination Passengers : $P_{HSO/D} = (1 - T_{HS}) P_{HST}$ (2)

Where $P_{HSO/D}$ is the number of origin-destination passengers carried by hub-and-spoke flights.

2.4 Measurement of Direct Hub-and-Spoke Impacts

The three measurements used in this thesis of direct impacts are airport expansion, employment, personal income and taxes.

2.4.1 Airport Expansion

Hub-and-spoke operations present particular demands on existing terminals. In the past 10 years, many airports have had to reevaluate airport terminal design plans to accommodate the needs of the hubbing airline. There are two types of expansion generally found at airports. They are: (1) airside, and (2) landside expansion. Airside expansion involves the replacement, extension, or new construction of runways and navigation equipment. The hub-and-spoke portion of total airside expansion costs is funded by the Federal airport tax. Landside expansion covers terminals, gates, parking, and feeder roads into the airport. Landside expansion by hub carriers is identified in this thesis as a number of projects underway at hub-and-spoke airports.

2.4.2 Direct Employment

One of the measures of economic impacts to a region created by the airport is the employment impact. The direct employment impact are jobs directly generated by airport activity which would disappear should the airport be moved or closed.

The methodology used here is specifically designed to separate those jobs that are part of fixed employment: facilities, system-wide airline management and major maintenance and those that are dependent on the number of flights and passengers (variable). Mathematically this can be represented as:

$$E_D = E_F + E_V, \quad (3)$$

Where $E_{SM} + E_{MM} + E_{FM} + E_{BM}$ and (4)

$$E_V = F(O, P_T, P_{O-D}) \quad (5)$$

It is clear from various studies³ that growth in variable employment is related to the number of originating passengers, based aircraft and based employment. However there are a number of other (fixed) employees whose jobs are dependent on the number of system-wide flights, including pilots, flight crews, and maintenance personnel. These jobs will not necessarily increase or decrease with a change in the number of flights based at a particular airport, but only in response to airline management decisions for the system as a whole. Airlines tend to concentrate these jobs at hub-and-spoke airports.

Direct airport-airline employment is broken down into four major categories by all studies. They are airline/airport service, freight transportation, passenger ground transportation, and contract construction/consulting.⁴ Table 2 shows airport/airline job classifications within each service category.

Table 2
Airport/Airline Job Classifications

Airport/Airline Service

Passenger Airlines

General Aviation

Airport Employees

Catering

Sky Caps/P/Security

Janitorial

Aircraft Services

Airport Tenants/Concessionaires

Federal Government Agencies (Including Postal Service Employees)

Freight Transportation

Freight Airlines (excluding those jobs with passenger airlines; employees of passenger airlines that handle freight are included in passenger airlines direct jobs)

Freight forwarders

Trucking firms

Passenger Ground Transportation

Rental Cars

Buses, Taxis, Limo/Vans

Contract Construction

Contract Construction Firms

Using the methodology employed by Martin based on job classification⁵, direct employment was defined in this thesis as fixed employment (jobs in facilities management, airline management, and major maintenance) and variable employment (equipment service technicians and dispatchers).

The method for dividing direct employment into fixed and variable categories utilizes an estimate by Martin that 80 percent of airport/airline employees are fixed and 20 percent are variable for Minneapolis/St. Paul International Airport. His definition of fixed airline/airport employment based on interviews with airlines, determined that fixed employment is generally unaffected by the number of flights out of one airport. Rather, fixed employment is dependent on the technology (i.e. larger, fuel efficient aircraft) and can increase or decrease

depending upon and airline system-wide requirements. A number of key assumptions were used to estimate direct employment in a manner consistent with Martin's estimate.

The following job classifications are assumed to be totally fixed:

- Passenger Airline Major Maintenance, Facilities Management,
System-wide Management
- General Aviation
- Janitorial Services
- Miscellaneous (includes other airport support services)
- Freight Airlines

The following job classifications are assumed to be totally variable:

- Passenger Airline Line maintenance, Passenger Services
- Catering
- Sky Caps/Parking/Security
- Construction/Consulting

The following job categories were divided between fixed and variable employment:

- Airport Employment
- Federal Government Agencies.

Hub-and-Spoke Basing Strategy

As mentioned in Chapter 1, hub-and-spoke operations exist as an economic response to limited operating income, and the network configuration of hub-and-spokes allows an airline to service many markets with fewer aircraft. Therefore, it was appropriate that airlines consolidate personnel and operations at a few airports. The economic rationale of most hubbing airlines is to have at the main hub-and-spoke airport, essential aircraft and system-wide functions such as major maintenance, line maintenance, and reservation systems. In addition, hubbing carriers also tend to concentrate a major portion of their total passenger service staffs, at these airports. Conversely, airlines usually deploy a limited number of personnel at airports where they do not hub.

In examining several hub-and-spoke airports⁶, it was found that older hub-and-spoke bases contain approximately 3,500-6,000 personnel. New hub-and-spoke staffing is in the lower

range. (3,000 will be used here) including some form of major maintenance. If other operations existed prior to hubbing, additional hub staffing would be even lower, say 2,500 - 3,000 employees for the fixed jobs to be consolidated. Non-hubbing carriers were found in Pittsburgh and Atlanta to staff 50-100 persons per airline on average.

Personnel Related to Facilities Management

The number of personnel related to facilities management is airline-specific and may relate to the layout of gates and terminals. The range varies from 4-to-6 per gate excluding variable personnel. For the purpose of this thesis we will use 5 as an average and 6.66 with supervisory staff. These staff are treated as fixed since they do not vary in the short term with the number of flights.

Personnel Related to Base Management

Because of Atlanta's size and importance in the national air transportation system, it was calculated that a minimum of 100 employees are assigned to gates, line maintenance, and system-wide management there, while Pittsburgh, Denver, and Minneapolis have approximately 50 employees handling these jobs. The number of employees is used to estimate the fixed staff of non-hubbing major airlines.

Personnel Related to Systemwide Management

It was calculated that up to 18 percent of total national airline employment is systemwide management which may be based at a large hub. Using employment data from Minneapolis/St. Paul International Airport equation (2) was used to estimate the proportion of systemwide employment at Minneapolis. This was combined with Martin's conclusion that 80 percent of total airline employment at this airport is fixed.

$$E_F = E_{SM} + E_{MM} + E_{FM} + E_{BM}$$

$$E_F = 80\% \text{ of airline employment} = .8(13,974) \text{ since } E_{SM} \text{ is a proportion (p) of system-wide staffing for Northwest Airlines (33,500), then to solve for P}$$

$$= P * (33,500) + 4000 + 6.656G + 50a \text{ (for Northwest Airlines at Minneapolis/St. Paul)}$$

- where P is the percentage of system-wide employment at airports (in this case, Minneapolis/St. Paul)
- G is the number of gates at Minneapolis/St. Paul (100)
- a is the number of based airlines (12)

$$\text{Solving for P: } 11,179 = 33,500P + 4000 + 666 + 600$$

$$P = \frac{11,179 - 5266}{33,500} = \frac{5913}{33,500}$$

$$P = .18$$

Apparently eighteen percent of Northwest's airline system-wide employment is stationed at Minneapolis/St. Paul for system-wide management at that hub. This represents the high end of the range for large hubs. USAir, Eastern, Continental, and Delta are considered average at 15 percent. Although total system-wide staffing levels are known to vary from airline to airline, this proportion may not vary as widely.

Personnel Related to Major Maintenance

Major maintenance is considered fixed because it is a stationary facility dependent on the size of an airline's fleet. The maintenance to total employment ratio at American Airlines shows that 14,981 out of 54,300 employees or 27.5 percent were assigned to total maintenance at all hubs.⁷ Since American represents a high commitment to maintenance, 25 percent was taken as a representative proportion for other airlines. It was estimated that 50 to 60 percent of this 25 percent would be assigned to major maintenance while the remaining 40 to 50 percent would perform line maintenance at all airports served in an airline's system. Therefore, 15 percent of an airline's system-wide employment is used to represent major maintenance at all hubs. This employment was allocated to fixed employment at each hub. This is summarized in Table 4.

Table 4
Estimated Percentage of Total Airline System-Wide Personnel at Four Selected Airports

	Major Maintenance	System-wide Maintenance
<i>Atlanta</i>		
Delta	70 %	16%
Eastern	40 %	20%
<i>Denver</i>		
Continental	60%	23%
United	40%	20%
<i>Minneapolis/St. Paul</i>		
Northwest	70%	100%
<i>Pittsburgh</i>		
USAir	80%	50%

Major Maintenance was found at all four selected airports, although it is not automatically a part of hub-and-spoke staffing.

Personnel Related to Operations and Passengers

Variable employment are those jobs directly dependent on the number of plane movements or operations and passengers that flow through an airport. This employment is assumed to be the same per operation or per passenger, regardless of whether they are hub-and-spoke or not. Therefore the total variable employment in each airport was related to the total number of operations and passengers at the airport. Mathematically, this is shown as:

$$E_V = E_0 + E_P + E_{OD} \quad (6)$$

$$= aO_{HS} + bP_{HST} + cP_{HSOD} \quad (7)$$

Where E_V is variable employment, jobs dependent on the number of flights and passengers at an airport

E_0 is total variable employment related to airport-based line maintenance

E_P is total variable employment related to total passengers

E_{OD} is total variable employment related to total origin-destination passengers (O-D)

a is the coefficient calibrated for each airport using total variable employment related to airport-based line maintenance operations and total number of plane movements (operations)

b is the coefficient calibrated from total variable employment attributable to all passengers that flow through the airport including both connecting and origin-destination passengers, and total number of annual passengers

c is the coefficient calibrated from total variable employment attributable to only those passengers that are origin-destination (O-D) and total annual number of origin-destination passengers

O_{HS} is the number of hub-and-spoke operations

P_{HST} is the number of total hub-and-spoke passengers

P_{HSOD} is the number of origin-destination passengers carried by hub-and-spoke flights

This linear equation was derived for each of the selected airports and used to calculate total variable employment due to hub-and-spoke operations and passengers.

2.5 Calibration of the Equations

The linear expression is the simplest form of the possible relationships involved. However there is not yet evidence of a more complex relationship. (This may be a topic for further research) We could use a regression technique to estimate the coefficients, but the small number of airports studied here do not provide a large enough data set to consider a statistically valid analysis. Therefore, a more direct method was used following Martin's example.⁷

Calculation of the Coefficients

In order to calculate the present coefficients at each airport, it was necessary to separate jobs first into fixed and variable, then to divide variable employment into the coefficient categories related to: (1) line maintenance and other essential operations; (2) the service of total passengers, and (3) the service of origin-destination passengers.

The number of jobs in each category were then divided by the number of operations, total passengers and origin-destination passengers respectively in order to determine each coefficient.

Fixed and Variable Employees

For airline staffing, specific categories of fixed employment were identified and subtracted from total airline employment to find variable employment at each airport. (see table 4) The percentage of this airline variable employment was applied to certain categories of other employees (airport employees, airport tenants, federal government agencies, etc.) to determine the number of fixed and variable employees in these categories. This assumes that the relative proportions of employees in these categories are linked with the airlines and therefore their activities are related to fixed and variable airline activities proportionately. Other categories of employment were treated as all fixed. (janitorial, freight airlines, general aviation, and

miscellaneous). Construction and consulting were considered all variable.

Table 4
Percentage of Fixed and Variable Airline Employees

	Fixed	Variable
Atlanta	33%	67%
Denver	62%	38%
Minneapolis	72%	28%
Pittsburgh	30%	70%

Source: Tables 6-9

Line Maintenance Employees

To calculate the number of personnel responsible for line maintenance at each airport, a percentage of total airline employment less major maintenance was used. This percentage was derived from the calculation for major maintenance stated above. Of the total 25 percent maintenance employees, 40 percent are line maintenance or 10 percent of total system-wide personnel. Since 15 percent are major maintenance, line maintenance represents 11.8 percent (10/.85) of the remaining personnel.

This linear equation was derived for each of the selected airports (1) line maintenance; (2) total (originating and transfer) passengers, and (3) origin-destination passengers. The choice of the linear method is based on the fact that the variables chosen are co-variant, that is they are proportionally linked. We could use a regression technique, but the small number of airports studied here do not provide a large enough data set to consider a statistically valid analysis.

Passenger Service Employees

The number of passenger service employees was determined as a residual. Total airline employment at each airport was reduced by subtracting fixed employees as described above to obtain total variable employees. The line maintenance employees were subtracted from total variable personnel to derive the remaining passenger service employees.

These were divided into two parts in relation to the numbers of origin-destination passengers. This separation was made based on the percentage of transfer passengers using the following equation:

$$\frac{E_{O/D}}{E} = \frac{1 - T}{2 - T} \quad \text{and} \quad \frac{E_P}{E} = \frac{1}{2 - T}$$

Where

- E is total passenger service employees
- T is proportion of transfer passengers
- E_{OD} is total variable employment related to total origin-destination passengers (O-D)
- E_P is total variable employment related to total passengers

The equation above is based on a ratio of twice the number of passenger service employees per origin-destination passenger compared to the number of employees per transfer passenger.

All the variable airport employees by job category as described in section 2.4.2, were allocated as follows to coefficient categories.

**Table 5
Variable Employment Relationships by Job Category**

	Total Operations	Total Passengers	O/D Passengers
A. Airport Employees Maintenance Catering		100%	
B. Sky Caps, Parking, Security, Rental Cars, Buses			100%
C. Federal Gov't Employees Airport Tenants	50	50%	
D. Freight Forwarders, Trucking Firms Aircraft Services	100%		
E. Construction/Consulting	10%	90%	

The resulting employees and coefficients are given in chapter 5 for each airport.

2.6 Direct Income Impacts

As noted in section 2.2, personal income is used as the principal measure of regional income.

Direct income impact is a measure of personal income received by individuals directly employed by services offered at the airport.

In the four economic impact reports, for each airport direct income generated by direct airport/airline employment was established for each service category. By dividing the number of employees and total income for each service category, an average salary was obtained. These average salaries were used to convert employment into personal income.

Direct hub-and-spoke income impact was calculated by deriving weighted annual average salaries for employment categories from totals in each service category. These weighted averages were then applied to the number of fixed and variable jobs for each airport as shown in the following table.

Table 5
Weighted Average Wages and Salaries by Analytic Category

Airport	Fixed	Variable
Atlanta	\$46,545	\$36,934
Denver	\$31,002	\$24,351
Minneapolis	\$40,002	\$28,799
Pittsburgh	\$39,045	\$33,520

2.7 Induced Impacts

As noted above, induced employment is created as those individuals directly employed at the airport spend their wages locally on goods and services such as food, housing, entertainment, transportation, banking, and apparel.

In some sources⁸ the indirect employment impact, is defined as those jobs generated due to the purchase of goods and services by firms dependent upon airport activity and located on airport property. In some cases indirect employment is treated as direct and in some cases it is treated as an induced impact. In order to ensure consistency and economic accuracy, indirect impacts in this thesis are treated as a subset of induced employment and will be measured by using a state employment multiplier for the aviation industry. Those categories of employment where direct and indirect were not distinguishable (e.g. catering and restaurant employment) some employees may have been incorrectly included in direct employment. This is a relatively small fraction of direct employees.

A third category has also been employed in the literature, related employment impact. These are jobs with firms that would not have located in the region had the airport not existed. These jobs are not as directly dependent upon the airport as are the direct, induced and indirect jobs, but reflect the importance of an airport as a catalyst for economic development. These are also considered induced here.

The induced income impact is the respending of direct regional income in airport activities in the region. The purchase of goods and services generates additional employment and income and is estimated using an income multiplier calculated by using a regional input/output model.⁹ It is interesting to note that some regions have small income multipliers because they import more

goods and services and thereby cause income to escape into other regions. Conversely, a large personal income multiplier represents a significant percentage of respending of income within the region.

Induced employment and income are measured by input/output multipliers that are based on the Regional Input-Output Modelling System, RIMS-II, developed by the U.S. Department of Commerce and include the household sector as an added-on industry. The employment and income multipliers estimate the total changes in regional industries specific to the region.

Using Denver as an example, for every one dollar earned by residents of the Denver region, 46 percent is spent on goods and services within the region, while the remaining 54 percent is used to purchase items produced out-of-state to pay federal, state, and local taxes or held as savings. Of the \$.46 of purchases, another 46 percent, \$.21, will be used for the next round of purchases of goods and services. Of this \$.21, again 46 percent or about \$.10 will be used for further in-state purchases. These successive respending rounds will continue until an additional \$.85 of spending in the Denver region is generated for every dollar of earnings. At each stage of the respending, additional jobs and income are created.³

The principal multiplier in the RIMS II framework is the income multiplier, which converts direct income impacts into total income (direct plus induced). Since the major direct income category used here is payroll (personal income), the appropriate multiplier would be the one for the household sector. This multiplier is normally close to the average multiplier for the aviation industry (in the Pittsburgh region the aviation industry 2.27 and payroll is 2.30). The data on payroll multipliers was not available for this thesis, but a cross check was made on the magnitude of the multipliers used for income in the four studies city here.⁴ Only the Atlanta income multiplier appears out of line (see Table 6) and was modified.

In order to derive the employment multiplier, the induced income is converted to induced employment by using a ratio of jobs to dollars of induced income (final demand) in the household sector. This ratio was derived from statewide data, and used to cross check the employment multipliers in Table 7. It was found that the Pittsburgh employment multiplier was very close, while Denver and Minneapolis tended to under state the induced employment, and Atlanta tended to overstate the employment impact, (of course, these results depend on the ratio of jobs to income which might vary if calculated on a regional rather than state level.)

Due to the way the induced employment was calculated, employment multipliers will vary depending on the size of the base employment involved. The range is shown in Table 7.

The multipliers used here imply no difference between the regular operations (those airline operations that exist with or without hub-and-spoke activities) and hub-and-spoke operations. It is also assumed that a more detailed investigation of industries affected by hub-and-spoke operations would produce similar multipliers for those same industries.

Independent of the accuracy of the multiplier's themselves, some understatement is expected due to the understatement of direct impacts described previously in this chapter. Since these multipliers are applied to direct income to calculate induced impacts in this thesis, to the extent that the direct impact is understated the induced impact is understated as well.

**Table 6
Income Multipliers**

	Multipliers Used by Others ¹⁰	Multipliers Used Here	Variation
Atlanta	2.50	1.85 ^b	-26%
Denver	1.85	1.85	-a
Minneapolis/St. Paul	1.75	1.76	-a
Pittsburgh	2.27	2.30 ^c	+1%

a - no data available on payroll multiplier, but order of magnitude is correct

b - selected be indentical to Denver based on the close similarity

c - The Economic Impact of Aviation in Southwestern Pennsylvania , Wilbur Smith Associates, 1985. RMS II Multipliers averaged for 39 industries including households

The multipliers shown here are for total impact: direct and induced.

**Table 7
Employment Multipliers**

	Multipliers Used by Others ⁵	Range of Multipliers Used Here	Variation	Ratio of Jobs/Income*
Atlanta	2.50	2.16 - 2.23	-12%	35
Denver	1.85	1.85 - 1.89	+13%	36
Minneapolis/St. Paul	1.76	1.98 - 2.04	+33%	38
Pittsburgh	2.27	2.89 - 2.95	+ 8%	41

*Statewide jobs per million dollars final demand in the household sector.

2.8 Data Sources

Four studies were used as important data sources. The Minneapolis/St. Paul Economic Impact Study by John Martin Associates is the most definitive in its assessment of fixed and variable employment impacts. Only one other study, Denver/Stapleton International Airport Economic Impact Study (Booz, Allen & Hamilton Inc.), estimates the proportion of direct employment attributed to hub-and-spoke activities from total employment. The other two, Hartsfield-Atlanta Economic Impact Study and the Economic Impact of Aviation in Southwestern Pennsylvania (Pittsburgh), generalize most impacts.

This chapter has presented the methods used for measuring employment and income impacts, and the hub-and-spoke portion of the total economic impact from aviation activity in this thesis. The actual application of these methods for each airport is shown in the following chapters.

3.0 HUB-AND-SPOKE IMPACT ON AIRPORT OPERATIONS AND MARKETS

Since the inception of deregulation there have been many studies on the impact of hub-and-spoke networking on airport operations. Generally, there are four major impacts from hub-and-spoke operations: (1) number and frequency of flights; (2) total passengers and transfers; (3) delays from connecting complexes, and (4) changes in markets. In addition, there are secondary operational impacts discussed briefly below that are not the focus of this paper. Secondary impacts are related to network configurations of hub-and-spoke operations and include changes in the ratio of connecting passengers to origin-destination passengers and fleet mix of the hubbing carrier(s).

3.1 Number of Operations

Generally, flight operations that are hub-and-spoke related are associated with one or two carriers at an airport. At Atlanta, Charlotte, Denver, Minneapolis, Newark, and Pittsburgh, hub-and-spoke carriers utilize a significant portion of an airport's landside and airside facilities. Since deregulation, operations at airports where hub-and-spoke networking exist, (except at Pittsburgh which showed slower growth) , had significant percentage increases between the years 1980-1983 and 1983-1986 compared with non-hub-and-spoke airports.¹ Table 3 shows absolute growth between the years 1977 and 1987. The hub-and-spoke airports clearly experienced substantially more growth than non-hub-and-spoke airports.

Table 3

Comparisons of Increases in the Number of Annual Commercial Operations
for Selected Major Hub-and-Spoke Airports and Major Non-Hub U.S.
Airports for 1987, 1986, 1983, 1980, 1977**

Airport	1986	1983	1980	1977
Hub+Spoke				
Atlanta	787,301	612,791	N/A	N/A
Charlotte	359,527	204,912	228,779	91,290
Denver	476,046	383,280	371,861	359,308*
Minneapolis	302,458	204,032	158,652	141,376
Newark**	369,956	232,080	167,191	150,543
Pittsburgh	365,982	320,736	355,279	N/A
Non-Hub+Spoke				
Los Angeles	594,379	510,723	529,611	502,922
NY/JFK	266,907	286,818	282,759	294,114
NY/LGA	323,237	294,002	257,901	275,469
San Francisco	427,897	362,846	359,146	N/A

**Excluding Military and General Aviation

†Includes Military and General Aviation

*1979 Statistic

Source: Airport Survey, 1988, Airport Operating Statistics

3.2 Passenger Growth

Passenger growth has increased steadily at both hub and non-hub-and-spoke airports since 1982. Deregulation opened the way for a wave of new entrants, most offering discount fare structures. One of these discount carriers, People Express now part of Texas Air Corporation, opened up the market for air travel to a segment of population that previously limited travel and used primarily ground transportation. This encouraged greater frequency of service and entry into new markets. Prior to this change, air travel was used primarily by either business or high income travelers.

A comparison of passenger growth between the years 1977 and 1986 at the four airports used in this study (Tables 4-7) suggests that the number of passengers flowing through these airports is not leveling off.

Third quarter statistics between 1977 and 1986 for Hartsfield/Atlanta, (Table 4) shows total increases in passenger traffic since 1977 amounted to 39 percent; (Table 5), Denver/Stapleton International Airport, 116 percent, (Table 6), Minneapolis/St. Paul, 114 percent and table 7, Pittsburgh showing 87 percent.

**Table 4
Hartsfield/Atlanta International Airport
Passenger Growth**

3Q77	3Q82	3Q83	3Q84	3Q85	3Q86
43,160	44,524	47,959	51,657	55,473	59,947
Growth	+31.6%	+7.7%	+7.7%	+7.4%	+8.1%

Source: Boeing 100% Adjusted DOT Data

**Table 5
Denver/Stapleton International Airport
Passenger Growth**

3Q77	3Q82	3Q83	3Q84	3Q85	3Q86
22,688	35,164	33,039	40,273	42,861	49,108
Growth	+54.9%	-6%	+21.9%	+6.4%	+14.6%

Source: Boeing 100% Adjusted DOT Data

**Table 6
Minneapolis/St. Paul International Airport
Passenger Growth**

3Q77	3Q82	3Q83	3Q84	3Q85	3Q86
11,373	15,503	16,963	17,838	21,382	24,334
Growth	+36.3%	+9.4%	+5.2%	+19.9%	+13.8%

Source: Boeing 100% Adjusted DOT Data

**Table 7
Greater Pittsburgh International Airport
Passenger Growth**

3Q77	3Q82	3Q83	3Q84	3Q85	3Q86
12,304	13,237	15,184	18,061	20,578	23,037
Growth	+7.6%	+14.7%	+18.9%	+13.9%	+11.9%

Source: Boeing 100% Adjusted DOT Data

3Q = Third Quarter

3.3 Effect of Hub-and-Spoke Operations on Transfer Passenger Growth

The high number of transferring passengers at Atlanta, Denver, Minneapolis, and Pittsburgh is a result of an increase in the number of feeder routes converging at these hub-and-spoke airports and an overall decline in the number of non-stops from other destinations in their airlines' route system.

Use of the airports examined in this study by the local population or visitors as has grown in absolute value but declined as a percentage of total passengers except in Hartsfield/Atlanta which was experiencing an economic boom. As more routes are added to the hub, it is apparent that transferring passengers are becoming more dominant, especially if the regional population is growing at a slower pace and those industries located there are not primary users of air transportation. Conversely, a growing percentage of originating passengers indicates industries and population within an airport's service area are more likely to be service-oriented such as the business/finance industry which generate more trips per employee.

Hartsfield/Atlanta International Airport

The continued rise in transfers at Hartsfield/Atlanta are a result of Delta and to a lesser extent Eastern's hub-and-spoke operations as evidenced by Table 12, where intralining is increasing at a faster rate than total transfers. Between third quarter 1977 and third quarter 1986, transfers grew 27 percent compared to total passengers with 39 percent. Table 12 shows that although the percentage of total transfers declined slightly since third quarter 1977, this type of passenger still comprises almost two-thirds of total passengers.

Although the hub-and-spoke network operated by Delta and Eastern have contributed somewhat to this growth with more routes offered out of Atlanta, the increase in originating passengers reflects the number of industries and service oriented businesses as well as professionals that

have settled in the Atlanta region as well as Atlanta's vital position in the national air transportation system. In addition, Atlanta has become the choice city for conventions attracting origin-destination passengers.

Denver/Stapleton International Airport

The use of Denver as a transfer point in airline route systems has remained basically the same for the last five years. Most transfers at Denver are intraline or connecting flights on the same airline although this was not the case in 1977. By 1986, the dominating hub-and-spoke carriers, United, Continental, and Frontier (merged with Continental in 1987), were responsible for 94.3 percent of all transfers. While transfers represent over 50 percent of total passengers, Table 13 shows that intraline transfers represent a growing percentage of total transfer passengers using Denver been since 1977.

The growing percentage of origin-destination passengers from 1982-1986 suggests four factors: more of the regional population is willing to utilize air transportation; fare wars between Continental and United, Denver's two hub-and-spoke carriers that dominate the markets, entice residents with affordable fares, and access to more destinations; the ski industry in Denver draws tourists which are true origin-destination passengers and, the reduced emphasis of the Denver hub by Continental and United in favor of other western destinations.²

Prior to deregulation, the number of cities served out of Denver were limited. This aspect of airline routing was confirmed by the higher percentage of interlining by three of the four major carriers serving Denver. United had the highest intraline percentage because of its more extensive route system. By 1982, Continental, United, and Frontier had successfully networked their routes through Denver and were retaining passengers on connecting intraline flights. Non-hub-and-spoke carriers serving Denver had the lowest percentage of intralining because these airlines had hub-and-spoke operations at other cities.³

Minneapolis/St. Paul International Airport

Primarily used by origin-destination passengers in 1977 as shown in table 14, Minneapolis/St. Paul had 42.5 percent transfers as a percentage of total passengers in third quarter 1986 indicating more hub-and-spoke networking by Northwest. An indication of the the extent of hub-and-spoke networking here it the growth of intralining which stood at 12.9 percent in third quarter 1977 and 38.8 percent in third quarter 1986.

Greater Pittsburgh International Airport

While total transfers grew from 41.7 percent in third quarter 1977 to 60.5 percent in third quarter 86, intralining was 23.7 percent for third quarter 1977 and 58.7 percent for third quarter 1986 revealing a shift from a predominantly origin-destination airport.

**Table 12
Hartsfield/Atlanta International Airport**

	Number of Transferring Passengers	Total Passengers	Transfers as a Percentage of Total Passengers	Intralining as a Percentage of Total Passengers
3Q77	31,118	43,160	72.1	50.3
3Q82	30,790	44,524	69.2	60.4
3Q83	33,102	47,959	69.0	61.7
3Q84	34,980	51,657	67.7	63.3
3Q85	36,882	55,473	66.5	64.0
3Q86	39,490	59,947	65.9	63.9

Source: Boeing 100% Adjusted DOT Data

**Table 13
Denver/Stapleton International Airport**

	Number of Transferring Passengers	Total Passengers	Transfers as a Percentage of Total Passengers	Intralining as a Percentage of Total Passengers
3Q77	11,549	22,688	50.9	21.5
3Q82	20,464	35,164	58.2	48.7
3Q83	18,859	33,039	57.1	48.6
3Q84	22,199	40,273	55.1	46.8
3Q85	22,750	42,861	53.1	46.4
3Q86	25,862	49,108	52.1	45.6

Source: Boeing 100% Adjusted DOT Data

Table 14
Minneapolis/St. Paul International Airport

	Number of Transferring Passengers	Total Passengers	Transfers as a Percentage of Total Passengers	Intralining as a Percentage of Total Passengers
3Q77	3,178	11,373	27.9	12.9
3Q82	5,183	15,503	37.5	32.1
3Q83	6,996	16,963	41.2	36.3
3Q84	6,335	17,838	35.5	31.2
3Q85	8,845	21,382	41.4	37.7
3Q86	10,333	24,334	42.5	38.8

Source: Boeing 100% Adjusted DOT Data

Table 15
Greater Pittsburgh International Airport

	Number of Transferring Passengers	Total Passengers	Transfers as a Percentage of Total Passengers	Intralining as a Percentage of Total Passengers
3Q77	2,918	12,304	41.7	23.7
3Q82	5,155	13,237	47.3	38.9
3Q83	6,723	15,184	49.9	44.3
3Q84	9,199	18,061	54.6	50.9
3Q85	11,242	20,578	56.9	54.6
3Q86	13,562	23,037	60.5	58.7

Source: Boeing 100% Adjusted DOT Data

3.4 Airline Scheduling and Networking

An integral part of hub-and-spoke operations is the departure and arrival sequence called "banking" or connecting complexes. At major hub-and-spoke airports, in particular, Atlanta, Charlotte, Chicago, Denver, Minneapolis, and Pittsburgh, airlines send waves or banks of flights east to west or north to south destinations in order to provide connecting coverage in other regions. The justification for this system is to position an airline so it can service more domestic regional and international markets. Continental and United systematically schedules a high number of east to west and west to east connection banks at Denver.

There are two impacts from this type of scheduling. The first, involves the traffic controlling effort required to ensure that each bank leaves exactly on time. Denver frequently has delays as a result of tight or bunched scheduling and the inability of the hub carriers to allow for late departures from other cities. In fact, any weather related delays at Denver or at its receiving cities causes major delays in arrivals and departures for all travelers scheduled to connect there. Related to the first impact is the burden placed on the national air traffic control system that must direct the waves of incoming and outgoing flight. The air traffic control system is still not adequately staffed to handle the level of departures demanded by hub operations and frequently, controllers will hold flights on the ground if they are unable to handle the volume of flights safely.

A third impact is the tendency of hub-and-spoke carriers to monopolize slot times during the peak hours. Non-hub-and-spoke carriers also schedule flights during the same periods as hubbing carriers and are affected in a major way in planning their networks.

A fourth impact of hub-and-spoke operations is that the increased frequencies of service to accommodate connections tax an airport's peak hour capacity. At some hub-and-spoke

airports, delays due to capacity limits have prompted a growing avoidance of the airport as a destination. The beneficiaries are usually smaller hub-and-spoke operations near or within the same region.

3.5 Impact on Airline Routes and Markets

With hub-and-spoke networking intensifying in recent years, hub-and-spoke airports have seen an average doubling of the number of markets served by their airport. The onset of deregulation introduced new freedoms to airlines in expanding the number of markets they could serve. Table 20 reveals that hub-and-spoke airports had averaged a 106 percent increase in markets served between 1967 and 1987.

The number of new markets⁴ between 1967 and 1987 in the total 1987 number of markets for each airport, were attributed to hub-and-spoke operations. In addition it was assumed that an additional 20 percent of those markets that already existed were converted to hub-and-spoke which averaged 60 percent.

Table 20
Changes in the Number of Markets Served by Hub-and-Spoke Airports

City	Total Markets Served		Number of Markets Added From 1967-1987	Percent of New Markets in 1987	Percentage of 1987 Markets Attributed to Hub-and-Spoke Operations
	1987	1967			
Atlanta	293	137	156	53%	62%
Charlotte	198	62	136	69%	75%
Chicago/O'Hare	334	266	68	20%	36%
Dallas/Ft. Worth	286	163	123	43%	54%
Denver	302	141	161	53%	62%
Kansas City	216	119	97	45%	56%
Minneapolis	268	124	144	54%	63%
Pittsburgh	228	116	112	49%	59%
St. Louis	259	113	146	56%	65%

*Includes Commuter Service (turbo-prop)

Source: Official Airline Guide, North American Edition, 1967, 1987

Chapter 4 AIRPORT EXPANSION

Major U.S. airports in general, have experienced dynamic growth since deregulation and those airports serving as hub-and-spokes for carriers have had to respond to normal growth attributed to higher frequencies of service offered in many markets, and airside and landside capacity demands imposed by the high level of connectivity. While major non-hub-and-spoke airport level of activity are affected by twenty or more equally dominant carriers, hub-and-spoke airports are influenced by three or less dominant carriers. The use of an airport by a limited number of carriers and its use as a hub-and-spoke, raises some questions about the nature of financing expansion once capacity is near.

4.1 Size and Types of Expansion

There are two types of expansion generally instituted at airports. They are: (1) landside, and (2) airside expansion. Airside expansion includes replacement or extension of runways and navigational equipment. Airside expansion covers passenger terminals, parking, and access roads leading to the airport.

Airport construction is one of the most costly forms of infrastructure building and airport property itself is approximately in the range from \$75 to \$100 a square foot.¹ Reasons given range from the complexities of federal aviation regulations, to the specific needs of airlines financing the terminal. Since contracted airport construction is usually monitored by a governmental agency for primarily private concerns there are various avenues cities and authorities use to gain financial and community approval.

Since airlines committed much of their hub-and-spoke operations at a few main airports, infrastructure improvements have paralleled their expansion. One of the major changes in new

terminal design to accommodate the substantial numbers of connecting passengers has been the Midfield terminal. Atlanta/Hartsfield was the first airport to build a midfield in 1980. The location of the terminal in the middle of the airfield between the system of parallel runways facilitates the movement of aircraft between gates and runways, makes for short taxiing times and alleviates congestion. In addition, amenities are located on each concourse to anticipate small purchases by transferring passengers.

Charlotte/Douglas International Airport

During the last five years Charlotte has grown from medium hub to large hub status, ranking as the twenty-fourth busiest in the U.S. exceeded by only Miami and Atlanta in the Southeast. The Charlotte region and the use of its airport as a hub-and-spoke system by Piedmont have strained the airport's runway and terminal facilities, and have made previous master planning obsolete. The rapid growth of Piedmont have made it the largest carrier serving the airport, handling three out of every four passengers and eight out of ten flights.²

Piedmont, for example, is directly responsible for the International Facilities Expansion by obtaining permission to fly to London (Gatwick)³. Piedmont has prompted airport officials to plan permanent quarters for international flights. The new international terminal is planned to be more than 100,000 square feet, and includes an in-transit lounge, duty-free shopping and four international arrival gates for wide-bodied aircraft equipped with loading bridges⁴.

During 1986, new airport improvement at Charlotte was implemented by Piedmont who had acquired facilities vacated by another airline. In addition, Piedmont extended a second concourse, and with the City of Charlotte, plans to expand the existing main terminal facility to provide moving walkways to connect its existing concourses. Piedmont is also installing a computerized baggage system. Figure 1 provides an list of current and future improvements related to the hub-and-spoke activities of Piedmont.

Figure 1
1986-1990
Current and Future Improvements to Charlotte/Douglas Related to Hub-and-Spoke Operations

- Extension of Runway 18L-36R by 1,000 feet to the south
- Taxiway improvements to enhance airport capacity and ground circulation
- Extension of Concourse B of the terminal building to support five additional air carrier gates
- Expansion of main terminal building to create additional circulation and concession space, ticketing and baggage claim, and international arrival FIS facility
- Construction of a new Concourse D on the terminal building with five air carrier and eight regional gates
- Expansion of a four-level parking garage in the existing short-term lot
- Construction of Piedmont maintenance facilities
- Acquisition of 323 acres of land

1991-1995

- Extension of Concourse A to provide for a total 11 air carrier and 6 regional carrier gates
- Additional taxiway improvements
- Acquisition of 276 acres of land

1996-2005

- Construction of an 8,000 foot north-south runway 1,200 feet west of Runway 18R-36L
- Additional extension of Concourse A to provide a total of 14 air carrier gates
- Additional automobile parking improvements

Source: Charlotte/Douglas International Airport Master Plan Update and Part 150 Study
Howard Needles Tammen & Bergendoff in association with
Harris Miller Miller & Hanson, Inc. and Ken Koontz & Associates
January 1987

Another example, Greater Pittsburgh International Airport is the center of one of the nation's oldest hub-and-spoke systems. Presently, Pittsburgh ranks fifteenth airport in the U.S. and is USAir's base for 80 percent of its total systemwide operations. Based on forecasts of annual scheduled airline activity and average day, peak month, and peak hour passengers, that suggest greater connectivity at Pittsburgh, airport administrations have decided on a midfield configuration. While USAir has 40 of the 62 existing available gates at Pittsburgh, the new Midfield terminal will initially add 62 gates eventually reaching 94 gates. In addition, the airport has planned to accommodate the additional growth requirements from USAir. An example of this Greater Pittsburgh International's anticipated USAir employee parking needs for the years 1990-1995. The employee parking program underway by GPIA planners anticipates an increase from 1280 spaces projected in 1990 to 3200 spaces in the final update for the design year 1995.⁵

4.2 Influence of Hub-and-Spoke Operations

Prior to deregulation, airports constructed terminals and other airport facilities without the consulting the airlines who were to be financing them. In today's hub concentrated airport environment, airlines generally dictate new terminal construction.

The design of new terminals at hub-and-spoke airport has been influenced by the requirements of connecting passengers and aircraft. The major new airport design now in place is called the "midfield" configuration. Midfield configurations exist at Atlanta and are planned for Pittsburgh and Denver. A midfield configuration consists of a terminal(s) positioned between two runways for two reasons: (1) so that aircraft have access to all sides of it, and (2) facilitate quick movement of passengers from one gate to another.

Hub-and-spoke operations also affect existing peaking and create new peaking in terminal areas. As airlines schedule connecting banks, terminals can be busy for a few periods in a day or in use on a continuous basis as evidenced at Dallas/Fort Worth International Airport where American Airlines operates 11 banks, each lasting 1-1/2 hours.⁶

New Construction and Investment by Hub-and-Spoke Airlines at their Hubs in 1987

<u>American Airlines</u> ⁷	San Juan \$30 million on new terminal
Chicago/O'Hare \$60 million baggage facility	Nashville \$115 committed to new terminal complex
<u>United Airlines</u>	Chicago/O'Hare \$65 million airport lease revenue bonds guaranteed by UAL for baggage facility
<u>Delta Airlines</u> ⁸	Cincinnati Construction of additional 12 gates
Los Angeles Renovation of 14 existing gates	Salt Lake City New marking service/reservation/terminal facilities

4.3 Financing

The day to day operation of airports is funded by the operating revenues generated principally by landing fees, rentals, concession, parking fees and the Federal Government. All the airports studied in this paper, function within an "Enterprise System", where an airport operates either as a department of a city or county and is accounted for as a self-supporting enterprise fund at no expense to taxpayers. The agreements with users of the facilities provide for full payment of all cost including debt service on all bonds. Should an airport under the Enterprise system fall short of covering expenses after rates have been set, a review is conducted to establish new rentals, fees, and charges. An example of this policy is at Denver/Stapleton International Airport. The summary of Accounting Policies for 1986, states:

Stapleton's policy is to establish rentals, fees and charges (including surcharges) annually with a mid-year review. If established annual fees prove insufficient or excessive to recover calculated recoverable costs, Stapleton sets the next year's rate to cover estimated calculated recoverable costs plus or minus the deficit or surplus from the prior year. This policy effectively passes the costs of the airfield and rented space in the terminal directly to the airlines without net profit or loss to Stapleton.⁹

In Table 1, the selected hub-and-spoke airports showed that landing fees constitute less than one-third of total airport operating revenues except for Pittsburgh. Table 2 shows revenue is generated from concessionaires and parking is significantly greater than landing fees. Although landing fees are important to supplementing total revenue, the greater percentage derived from concessionaires and parking reveals that origin-destination passengers are contributing a substantial portion of airport operating costs rather than connecting passengers. Origin-destination passengers utilize parking facilities and have a propensity to spend at concessionaires because they stay for longer periods in an airport terminal prior to and after a flight.

The generally accepted method of financing new airport infrastructure has been through the issuance of general obligation bonds.¹⁰ Airlines are required to guarantee revenue bonds issued by municipalities to build or improve airport facilities leased to them. Under these lease agreements, airlines are required to make rental payments sufficient in amount to pay when the principal and interest comes due. In addition, payment of an airline's obligations is secured through standby letters of credit which must be guaranteed by the airline. All leases provide that the airline shall pay taxes, maintenance, insurance and certain other operating expenses applicable to the leased property.

**Table 1
Landing Fees as a Percentage of Total Airport Revenues**

Airport	Total Operating Revenues	Airline Landing Fees	Landing Fees as a Percentage of Total Operating Revenues
Atlanta**	\$106,932,000	\$25,466,000	23.8
Charlotte*	16,451,715	3,219,222	14.7
Denver**	95,751,309	16,117,651	16.8
Minneapolis	N/A	N/A	N/A
Pittsburgh*	37,171,870	13,755,055	37.0

*1985

**1986

Sources: Airport Annual Reports, 1985, 1986 N/A: Not Available

**Table 2
Parking and Concession Fees as a Percentage of Total Airport Revenues**

Airport	Total Operating Revenues	Parking & Concession Fees	Parking & Concession Fees as a Percentage of Total Operating Revenues
Atlanta**	\$106,932,000	\$33,621,000	31.4
Charlotte*	16,451,715	7,236,546	44.0
Denver**	95,751,309	35,697,947	37.3
Minneapolis	N/A	N/A	N/A
Pittsburgh*	37,171,870	13,755,055	37.0

*1985

**1986

Sources: Airport Annual Reports, 1985, 1986 N/A: Not Available

Charlotte/Douglas International Airport illustrates the complex financing involved in airport improvements.

Charlotte/Douglas International Airport

Charlotte/Douglas International Airport (Charlotte) requires that all funds used for airport expansion come from airlines, concessionaires, users of the airport and Federal Government. That is, the airport operates as a department of the City of Charlotte and is accounted as a self-supporting enterprise fund at no expense to taxpayers.¹¹

The agreements with users of the facilities provide for full payment of all costs including debt service on all bonds. Additionally, the agreement with the airlines provide for reserves which are similar to revenue bond covenants. Funding for infrastructure improvements from 1967-1985 is shown in table 3, were provided by issuance of approximately \$100 million in Airport Revenue Bonds which were sold by the end of calendar year 1985 and the issuance of an additional \$50 million in Airport Revenue Bonds spread out for the years 1986-1989.

The federal government still contributes the greatest source of funds for infrastructure improvements at Charlotte/Douglas. Table 3 shows that the FAA's contribution is 51.3 percent, slightly more than half of all sources.

Table 3
Funding Breakdown for Infrastructure Improvements at
Charlotte/Douglas International Airport 1967-1985

FAA	74.4 million
North Carolina DOT	5.4 million
Private	23.4 million
Airport	42.1 million
<i>Total</i>	<i>145.1 million</i>

Source: Charlotte/Douglas International Airport Master Plan Update and Part 150 Study Howard Needles Tannen & Bergendoff, in association with Harris Miller & Hanson Inc, and Ken Koontz & Associates

Direct employment as described in chapter 2, are jobs generated by airline/airport activity. This chapter first shows total airport/airline employment and income impacts, then hub-and-spoke impacts.

Total Airline Employment and Labor Costs

The direct airport/airline employment covers many services. Passenger airlines, and in particular carriers that use an airport for hub-and-spoke operations, comprise a major portion of the direct employment and income generated by an airport, and are considered major catalysts in attracting additional airport/airline services. As an airline concentrates more of its markets and operations at one airport, as in the case of hub-and-spoke networking, it also increases the number of personnel based there as well. In 1986, the nine largest U.S. airlines¹ employed from 15,000 to 63,000 and their salaries represented an average of 36% of total airline operating costs as shown in tables 1 and 2.

Table 1

Total Airline Employment for 1986

Rank	Airline	Number of Employees
1	Continental(1)	63,000
2	United(2)	58,000
3	American(3)	43,000
4	Delta(4)	38,901
5	Northwest(5)	33,500
6	TWA(6)	27,442
7	Pan Am	21,599
8	Piedmont(7)	21,000
9	USAir(8)	14,926

(1) Includes People Express and its subsidiary Frontier, and Eastern Airlines

(2) Includes Hertz, Westin Hotels

(3) Includes AirCal

(4) Includes Western

(5) Includes Republic Airlines

(6) Includes Ozark Airlines

(7) Includes Empire Airlines

(8) Excludes Pacific Southwest Airlines (PSA)

Source: Airline Annual Reports for 1986

Table 2

Labor Costs as a Percentage of Airline Operating Expenses for 1986

Rank	Airline	Operating Revenue (thousands)	Operating Expenses (thousands)	Labor Costs (thousands)	Labor as a Percentage of Operating Expenses
1	Delta (1)	\$4,460,062	\$4,425,574	1,963,575	44.4
2	USAir (2)	1,835,000	1,666,000	687,389	41.3
3	American (3)	6,018,175	5,607,252	2,157,864	38.5
4	Pan Am	3,038,995	3,362,574	1,249,318	37.2
5	TWA (4)	3,145,429	3,220,710	1,140,569	35.4
6	United (5)	7,105,141	7,031,860	2,531,470	36.0
7	Piedmont (6)	1,865,473	1,701,032	570,666	33.5
8	Continental (7)	4,406,897	4,169,519	1,352,798	32.4
9	Northwest (8)	3,589,174	3,422,529	1,028,478	30.1

(1) Includes Western

(2) Excludes Pacific Southwest Airlines (PSA)

(3) Includes AirCal

(4) Includes Ozark Airlines

(5) Includes Hertz, Westin Hotels

(6) Includes Empire Airlines

(7) Includes People Express and its subsidiary Frontier, and Eastern Airlines

(8) Includes Republic Airlines

Source: Airline Annual Reports for 1986

Given the number of people employed by airlines, it is no surprise that the direct employment and income for regions served by hub-and-spoke systems can be significant. For five selected hub-and-spoke airports, airport-airline direct, and regional employment for all industries is presented in table 3. At Hartsfield/Atlanta, employment in the region from hub-and-spoke activity by two carriers, Delta and Eastern, is a major economic force. Delta alone employs approximately 18,000 people including those employed at its major maintenance facility. Similarly, Eastern has an estimated 7,000 employees at Atlanta including major maintenance.² Should one of these carriers reduce their presence, or move to another location, total Atlanta regional employment would be lowered significantly.

Following Hartsfield/Atlanta is Denver/Stapleton with 140,000 related airline/airport jobs or 14.1 percent of regional employment. The two airlines operating hub-and-spoke networks at Denver, Continental and United have a large workforce deployed at and near the airport including those assigned there respective major maintenance² facilities. The other hub-and-spoke airports have smaller influences but they all represent at least three percent of regional employment.

**Table 3
 Airport-Airline Related Employment as a Percentage of
 Total Regional Employment**

Airport	Airport-Airline Related Employment	Total Regional Employment	Airport-Airline Employment as a Percentage of Regional Employment
Hartsfield/Atlanta (1)	93,028	1,318,000	7.0
Charlotte-Douglas (2)	17,292	542,000	3.2
Denver-Stapleton (3)	140,000	991,000	14.1
Minneapolis-St. Paul (4)	72,977	1,223,000	6.0
Greater Pittsburgh (5)	29,952	886,000	3.4

Sources: *Bureau of Labor Statistics, Geographic Profile of Employment and Unemployment
 (1) Hartsfield Atlanta International Airport Economic Impact Report, 1987
 (2) Charlotte Chamber Airport Economic Impact Study, 1987
 (3) The Economic Impact of Stapleton International Airport and
 Future Airport Development, 1985
 (4) The Economic Impact of the Minneapolis/St. Paul International Airport, 1988
 (5) Economic Impact of Aviation on Southwestern Pennsylvania Report, 1985

5.1 Airport and Airline Employment

Along with the increase in operations and passenger flows, airports supporting hub-and-spoke operations have seen a steady growth of direct airline-airport employment. The purpose of this chapter is to analyze that portion of direct airport-airline employment that is generated from hub-and-spoke activities. This is done in two steps: first employment is related to all operations and passengers. Then (in section 5.3) the hub-and-spoke employment element is separated out.

As defined in chapter 2, direct airline-airport employment is directly dependent on airport activity. That is, should the airport be moved, reduced in size, or disappear, these jobs would cease to exist.

More specifically, direct airline employment consists of employees of passenger and freight airlines⁹ that include: airline management and clerical staff, flight crews (pilots and stewardesses), and ground crews (baggage handlers, equipment mechanics and technicians, airline management)

ticket agents, dispatchers, custodial workers, sky caps, living in the region around the airport.

Direct airport employment also refers to employees of the airport and includes employees responsible for operating the airport, police/security, airport tenants (concessionaires), Federal Government Employees (FAA air traffic controllers, customs inspectors, and U.S. Post Office). Also considered as direct airport employment is passenger ground transportation and includes employees responsible for providing rental car service, private and public ground transportation.

Employment with passenger airlines represents more than half of all direct jobs at the four airports selected for this study. Table 4 shows the total number of direct airport-airline employees and those employees of passenger airlines. The remainder of employment is with freight and ground transportation and construction.

Table 4

Passenger Airlines as a Percentage of Total Direct Airport/Airline Employees

Airport	Total Number of Direct Airport-Airline Employees	Number of Employees with Passenger Airlines	Employees with Passenger Airlines as a Percentage of Direct Airport-Airline Employment
Atlanta	37,211*	29,743*	79.9
Denver	20,921**	13,786**	65.9
Minneapolis	19,421*	13,974*	65.9
Pittsburgh	10,620**	7,182**	67.6

*1986 Statistics
 **1985 Statistics
 N/A: Not Available

Source: Telephone Survey, Airport Annual Reports, Airport Economic Impact Studies

5.2 Direct Airport-Airline Employment at Selected Airports

The methods for estimating fixed and variable employment as described in chapter 2, were applied to Atlanta, Denver, Minneapolis, and Pittsburgh. Variable employment was then divided into three categories, aircraft operations, total passengers (Total Pax) and origin-destination (O-D Pax). The number of employees in each category were used to calculate a coefficient in a linear equation (equation 7, in chapter 2) in order to quantify the relationships between total operations, total passengers, and total origin-destination passengers and variable employment at each airport.

Hartsfield/Atlanta International Airport

Atlanta employment data has been categorized in a more summary form in the data source³ compared to the other airports. It separates direct airline/airport employment into the following subsets: (1) airlines; (2) all others (includes concessions, private security, maintenance, rental car agencies catering firms and other tenants), and (3) government agencies.

As shown in Table 6, the airlines sub-category includes 18,000 employees of Delta and 7,000 employees of Eastern, the hub-and-spoke airlines there. Delta employment covers jobs in its general office complex, central reservations center and technical operations base. The remaining 4,400 are employed by 38 passenger and cargo carriers.

The all others subcategory includes concessions, private security, maintenance, rental car agencies, catering firms, and other tenants not specified in the report. All these are considered variable employees but they cover more than one category specified in chapter 2. It contains rental car agencies, parking and security related to origin-destination passengers. Since the number of employees with car agencies is unknown, it was estimated that between 1,100 to 1,200 jobs exist to handle origin-destination passengers based on the average

proportion of jobs with rental cars parking and security at Denver and Minneapolis. This number was allocated to origin-destination passengers in Table 6 and the rest to total passengers.

For the government agencies sub-category, the Hartsfield/Atlanta study combines the 500 employees with the Federal Government including the Federal Aviation Administration, U.S. Customs and Immigration, and the U.S. Postal Service. Also included are 425 positions (police officers, firefighters, administrative staff) with the City of Atlanta who are responsible for operating the airport.

Denver/Stapleton International Airport

The Denver/Stapleton data⁴ is much more detailed and grouped into four categories:

(1) Airline/Airport Service; (2) Freight Transportation; (3) Passenger Ground Transportation, and (4) Contract Construction/Consulting. (see Table 7)

The airline/airport service category covers 12 sub-categories and totals 17,147 jobs or 82 percent of total direct employment. Within this category, are passenger airlines including jobs dedicated to air freight transportation, general aviation, airport city employees, catering, sky caps, janitorial, security, aircraft services, airport tenants, Federal government agencies, flight schools, and miscellaneous (not defined).

For the freight transportation category, the study was able to present employment and income for freight airlines (excluding 296 jobs with passenger airlines dedicated to air freight), freight forwarders, and trucking firms. Freight transportation amounts to 4.7 percent of total direct employment.

Passenger ground transportation consists of rental cars, buses, taxis, and limo/vans. The study was able to determine, through interviews and surveys, that 9.0 percent jobs are in this category. The last category is contract construction/consulting. Sixteen percent jobs of the total 858 total construction consulting jobs are directly related to consulting, architectural, construction and engineering firms providing infrastructure support to planning and construction department at Stapleton. The remaining 722 jobs are associated with major construction projects at Stapleton and should be considered short-term.

Minneapolis/St. Paul International Airport

The Minneapolis/St. Paul data⁵ is similar to Denver/Stapleton in organization and content. divides direct employment into four categories: (1) Airline/Airport Service; (2) Freight Transportation; (3) Passenger Ground Transportation, and (4) Contract Construction/Consulting. (see Table 8)

In the airline/airport service category, the majority of passenger airline employment is with Northwest Airlines. Here, airline employment includes jobs held by airline pilots, flight crew and maintenance facility employees who reside in Minnesota. Excluded from these figures is airline headquarters employment. While passenger airlines constitute 84 percent of direct airline/airport service jobs and 72 percent of all direct jobs impacts dependent on airport activity, the remaining direct jobs are with airport employees and Federal government agencies and represent only 2,593 jobs or 16 percent.

The freight transportation category represents 5.3 percent of total direct job impacts. The data exclude 106 freight jobs with passenger airlines from this category and instead combines them with passenger airline employment.

Passenger ground transportation represents the third category, and contains only 531 direct jobs. These jobs are split between rental cars having 246 jobs and a similar number, 285 in buses, taxis, and limo/van.

The last category presented in the Minneapolis/St. Paul Economic Study is contract construction/consulting and contains 6.6 percent of total direct employment. Compared with Denver, construction at Minneapolis/St. Paul plays a greater role in direct jobs and income.

Greater Pittsburgh International Airport

The direct employment data⁶ for Pittsburgh were disaggregated quite differently from the Denver and Minneapolis data. There are five basic categories: Airlines; Airport Tenants; Air Cargo (freight transportation); Department of Aviation (County airport employees), and others (Federal government agencies).

Within the airline category, the employees include air crews based in the Pittsburgh region, ticketing, baggage handling, and airline management. Of the total airline employees, USAir, Pittsburgh International's hub-and-spoke carrier, has 6,308 or 88 percent. The Department of Aviation of the County of Allegheny, has 326 employees and the airport tenants category amounts to 24 percent including jobs with rental cars, catering, and retail airport tenants. (see Table 9)

Direct employment at Pittsburgh was found to be far less in relation to the number of operations compared with the other three airports. This reflects the fact that USAir had significantly less system-wide employees than other airlines (before the merger with PSA and Piedmont) which could indicate high productivity. In addition, the airport itself does not employ many staff.

**Table 6
Hartsfield/Atlanta International Airport
Direct Employment* Analysis**

Airline/Airport Service	Total Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Delta	18,000		8,340	1,652	5,143	1,545
Delta Major Maintenance		4,000				
Delta Headquarters		4,000				
Delta System-wide Mgn't		1,200				
Delta Facilities Mgn't		360				
Delta Base Management		100				
Eastern	7,000		2,380	472	1,467	411
Eastern Major Maintenance		3,000				
Eastern System-wide Mgn't		1,200				
Eastern Facilities Mgn't		320				
Eastern Base Mgn't		100				
Other Airlines	4,743	1,765	2,979	560	1,861	559
Other Facilities Mgn't		265				
Other Airlines Base Mgn't (Dom)		1,200				
Other Airlines Base Mgn't (Int'l)		300				
All Others**	6,515		6,515	-----	5,365	1,150
Federal Gov't Agencies	953	314	639	639	-----	-----
Total	37,211	16,359	20,853	3,322	13,836	3,695
<i>Total Operations and Passengers</i>				<i>787,301</i>	<i>45,191,480</i>	<i>13,557,444</i>
<i>Calculated Coefficients for Variable Employment</i>				<i>.00421</i>	<i>.000306</i>	<i>.000273</i>

*1986

**Includes concessions, private security, maintenance, rental car agencies, catering firms, and other tenants

Source: Total Jobs, Hartsfield/Atlanta International Airport Economic Impact Report, Deloitte, Haskins & Sells/Martin, Murphy, Harps and Syphoe. 1987

Table 7
**Denver/Stapleton International Airport
 Direct Employment* Analysis**

Airline/Airport Service	Total Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Passenger Airlines	13,786		3,136	978	1,474	684
United Major Maintenance		2,600				
United System-wide Mgn't		1,700				
United Facilities Mgn't		350				
Continental Major Maintenance		2,900				
Continental System-wide Mgn't		2,200				
Continental Facilities Mgn't		350				
Other Airlines Base Mgn't		550				
General Aviation	301	301				
Airport Employees	454	281	173		173	
Catering	819		819		819	
Sky Caps/Pkg/Security	308		308			308
Janitorial	268	268				
Aircraft Services	346		346	346		
Airport Tenants	424	263	161		161	
Federal Gov't Agencies	337	209	128	128		
Miscellaneous	104	104				
Freight Transportation	Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Freight Airlines	770	770				
Freight Forwarders	171	106	65	65		
Trucking Firms	44	27	17	17		
Ground Transportation	Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Rental Cars	607		607			607
Buses/Taxis/Limo/Van	1,324	821	503			503
Construction/Consulting	Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Construction/Consulting	858		858	86	772	
Total	20,921	13,800	7,121	1,620	3,399	2,102
Total Operations and Passengers				437,252	29,905,270	12,350,871
Calculated Coefficients for Variable Employment				.00370	.000114	.000170

*1985
 Sources: Direct Airline Employment, The Regional Economic Impact of Stapleton International Airport and Future Airport Development, Booz-Allen & Hamilton Inc. 1985

**Table 8
Minneapolis/St. Paul International Airport
Direct Employment* Analysis**

Airline/Airport Service	Total Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
NW Airlines (estimated)	11,975		1,995	1,177	1,105	513
NW Major Maintenance		4,000				
NW System-wide Mgn't		5,280				
NW Facilities Mgn't		700				
Other Airlines (estimated)	1,999		800			
Other Airlines Base Mgn't		1,200				
General Aviation	72	72				
Airport Employees	320	230	90		61	28
Catering	785		785		785	
Sky Caps/Pkg/Security	319		319			319
Janitorial	85	85		85		
Aircraft Services	213		213			
Airport Tenants	249	179	70		70	
Federal Gov't Agencies	550	440	110	110		
Freight Transportation	Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Freight Airlines	501	501				
Freight Forwarders	412	297	115	115		
Trucking Firms	122	88	34	34		
Ground Transportation	Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Rental Cars	246	246		246		
Buses/Taxis/Limo/Van	285	43	242			242
Construction/Consulting	Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Construction/Consulting	1,288		1,288	129	1,159	
Total	19,421	13,070	6,351	1,822	3,180	1,349
Total Operations and Passengers				302,458	15,690,988	8,228,872
Calculated Coefficients for Variable Employment				.00602	.000203	.000164

*1986

NW: Northwest Airlines

Source: Total Jobs, The Economic Impact of the
Minneapolis/St. Paul International Airport, Martin Associates. 1988

Table 9
**Greater Pittsburgh International Airport
 Direct Employment* Analysis**

Airline/Airport Service	Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
USAir	6,303		2,903	520	1,721	663
USAir Major Maintenance		1,900				
USAir System-wide Mgn't		1,100				
USAir Facilities Mgn't		400				
Other Passenger Airlines	879	300	579	104	343	132
Other Airlines Base Mgn't		600				
Airport Employees	326	99	227		227	
Airport Tenants	2,505	626	1,879		1,356	522
Federal Gov't Agencies	140	42	98	98		
<hr/>						
Freight Transportation	Jobs	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Freight Transportation	467	467				
<hr/>						
Total	10,620	4,934	5,686	721	3,648	1,317
Total Operations and Passengers				362,793	15,058,178	6,053,388
Calculated Coefficients for Variable Employment				.00199	.000242	.000218

*1985

Source: Direct Airline Employment, The Economic Impact of Aviation in Southwest Pennsylvania, Wilbur Smith and Associates, December 1986

A Description of the Variable Coefficients for the Four Selected Airports

A comparison of the calculated coefficients reveals that the ratio of total variable employment to the total number of plane movements is the highest at Minneapolis/St. Paul International. (see Table 10) Although Minneapolis has the lowest number of plane movements compared with the other three airports in this study, the calculated coefficient indicates that Minneapolis has more employees assigned to line maintenance per operation than the other airports in Table 10. This probably reflects the major freight operations that are run by Northwest, and could not be separated from their passenger operations in these data, and in part to the wide variety of aircraft used by Northwest and the higher proportion of large aircraft.

Conversely, Pittsburgh has the lowest operations coefficient indicating that assigns fewer persons per operation. This is due in part to the more standardized fleet used by USAir.

The numbers here suggest that there is more variation in direct staffing between airlines, than there is any potential economies of scale.

The calculated variable total passengers coefficients indicate that the number of variable employees per 1000 passengers does not increase as the number of passengers that flow through an airport increase. Surprisingly, Atlanta, which is the second busiest airport in the nation in terms of passengers and first in operations⁷, has the highest coefficient followed by Minneapolis and Pittsburgh. Denver has the lowest coefficient and it is third in the nation in passengers and operations. This may represent the fact that very little construction work was being done in the year the data were collected. (a 3 or 5 year average would give a higher figure). On the other hand, the employees per origin-destination passenger group were in a tighter range. They also have no indication of any economies of scale, as was expected for a service industry.

Table 10

Comparisons of Coefficients Relating to Annual Number of Total Plane Movements (Operations) Annual Number of Total Passengers, and Annual Total Origin-Destination Passengers

Airport	Operations Coefficient (1) <i>a</i>	Total Pass. Coefficient (2) <i>b</i>	Pass. O-D Coefficient (3) <i>c</i>	1986 Total Operations (000)
Atlanta ⁴	.00422	.000306	.000272	787
Denver ⁵	.00370	.000114	.000170	476
Minneapolis ⁶	.00602	.000203	.000164	308
Pittsburgh ⁷	.00199	.000242	.000218	366
Average	.00353	.000216	.000206	

¹Total variable employees per 1,000 annual plane movements (operation).

²Total variable employees per 1,000 annual passengers.

³Total variable employees per 1,000 annual passengers.

⁴Based on Atlanta-Hartsfield Airport Statistics for 1986.

⁵Based on Denver-Stapleton Airport Statistics for 1985.

⁶Based on Minneapolis-St. Paul Airport Statistics for 1986.

⁷Based on Greater Pittsburgh Airport Statistics for 1985.

5.3 Direct Airport/Airline Income at Selected Airports

Direct airport/airline employment generates considerable income as shown in Tables 11-14. These figures were calculated by taking the total income per category (column 1) and dividing by total employees (column 1 of previous tables) to determine an average salary per employee in that category. This average salary was then multiplied by the number of employees in other columns of the previous tables.

Table 11
Hartsfield/Atlanta International Airport
Direct Income* Analysis (Millions of Dollars)**

Airline/Airport Service	Total Direct Income	Employment		Variable Maint. Operations	Variable Employment Related To:	
		Fixed	Variable		Total Pax	Pax O-D
Delta	\$837.8		\$388.2	\$98.9	\$222.8	\$ 66.8
Major Maintenance (DL)		186.2				
Headquarters (DL)		186.2				
System-wide Mgt (DL)		55.8				
Facilities Mgt (DL)		16.7				
Base Mgt (DL)		4.7				
Eastern	325.8		110.8	37.9	56.0	16.8
Major Maintenance (EA)		139.6				
System-wide Mgt (EA)		55.8				
Facilities Mgt (EA)		14.9				
Base Mgt (EA)		4.7				
Other Airlines	220.7	82.2	138.6	26.0	86.6	26.0
All Others***	\$116.0		\$116.0		\$89.2	\$26.8
Federal Gov't Agencies	24.7	8.2	16.6	16.6		
<i>Total</i>	<i>\$1,525.2</i>	<i>\$754.9</i>	<i>\$770.2</i>	<i>\$179.4</i>	<i>\$454.3</i>	<i>\$136.5</i>

*1986

**Figures may not add up due to rounding

***Includes concessions, private security, maintenance, rental car agencies, catering firms, and other tenants

DL: Delta Airlines

EA: Eastern Airlines

Source: Hartsfield/Atlanta International Airport Economic Impact Report, 1987.
 Deloitte, Haskins & Sells/Martin, Murphy, Harps and Syphoe

Table 12
Denver/Stapleton International Airport
Direct Income* Analysis (Millions of Dollars)**

Airline/Airport Service	Total Direct Income	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
United (Est.)	\$192.8		\$48.6	\$13.2	\$45.7	\$21.2
Major Maintenance (UA)		\$ 80.6				
System-Wide Mgt (UA)		52.7				
Facilities Mgt (UA)		10.8				
Continental (Est.)	217.6		48.6	15.1	22.9	10.6
Major Maintenance (CO)		89.9				
System-wide Mgt (CO)		68.2				
Facilities Mgt (CO)		10.8				
Other Airlines Base Mgt		17.0				
General Aviation	\$ 7.7	\$ 7.7				
Airport Employees	14.7	9.1	5.6		3.8	1.7
Catering	8.6		8.6		8.6	
Sky Caps/Pkg/Security	2.5		2.5			2.5
Janitorial	2.7	2.7				
Aircraft Services	7.9		7.9	7.9		
Airport Tenants	7.5	4.6	2.8		2.8	
Federal Gov't Agencies	7.8	4.8	2.7	2.7		
Miscellaneous	1.2	1.2				
Freight Transportation	Direct Income	Employment Fixed	Variable	Variable Employment Related To: Maint. Operations	Total Pax	Pax O-D
Freight Airlines	\$6.9	\$1.2				
Freight Forwarders	4.0	2.4	1.5	1.5		
Trucking Firms	.9	.55	.35	.35		
Ground Transportation	Direct Income	Employment Fixed	Variable	Variable Employment Related To: Maint. Operations	Total Pax	Pax O-D
Rental Cars	\$ 9.1		\$ 9.1			\$ 9.1
Buses/Taxis/Limo/Van	20.7	12.8	7.9			7.9
Construction/Consulting	Direct Income	Employment Fixed	Variable	Variable Employment Related To: Maint. Operations	Total Pax	Pax O-D
Construction/Consulting	\$ 26.9		\$ 26.9	\$ 2.6	\$24.2	
Total	\$556.5	\$383.1	\$173.4	\$43.7	\$88.3	\$41.3

*1985

**Figures may not add up due to rounding

Source: The Regional Economic Impact of Stapleton International Airport and Future Airport Development, Booz-Allen & Hamilton Inc. 1985

Table 13
Minneapolis/St. Paul International Airport
Direct Income* Analysis (Millions of Dollars)**

Airline/Airport Service	Total Direct Income	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Northwest	\$513.3		\$85.5	\$39.9	\$31.1	\$14.5
Major Maintenance (NW)		\$160.0				
System-wide Mgt (NW)		226.3				
Facilities Mgt (NW)		30.0				
Other Airlines (Est.)	\$85.7		\$34.3			
Other Airlines Base Mgt		51.4				
General Aviation	\$ 3.0	\$ 3.0				
Airport Employees	10.9	7.8	3.1		3.1	
Catering	10.2		10.2		10.2	
Sky Caps/Pkg/Security	3.3		3.3			3.3
Janitorial	1.3	1.3				
Aircraft Services	4.9		4.9	4.9		
Airport Tenants	3.6	1.8	1.8		1.8	
Federal Gov't Agencies	16.1	11.6	4.5	4.5		
Freight Transportation	Income	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Freight Airlines	\$14.7	\$14.7				
Freight Forwarders	9.2	6.6	2.6	2.6		
Trucking Firms	3.2	2.3	.89	.64		
Ground Transportation	Income	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Rental Cars	\$4.5		\$4.5			\$4.5
Buses, Taxis, Limo/Van	3.8	.57	3.2			3.2
Construction/Consulting	Income	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
Construction/Consulting	\$32.2		\$32.2	\$3.2	\$28.9	
Total	\$679.9	\$496.9	\$182.9	\$63.2	\$87.3	\$32.5

*1986

**Figures may not add up due to rounding

NW: Northwest Airlines

Source: Direct Income Figures, The Economic Impact of the Minneapolis/St. Paul International Airport, Martin Associates, 1988

Table 14
Greater Pittsburgh International Airport
Direct Income* Analysis (Millions of Dollars)**

Airline/Airport Service	Direct Income	Employment		Variable Employment Related To:		
		Fixed	Variable	Maint. Operations	Total Pax	Pax O-D
USAir	\$246.1		\$113.3	\$20.3	\$67.1	\$25.9
Major Maintenance (USAir)		\$74.2				
System-wide Mgt (USAir)		42.9				
Facilities Mgt (USAir)		15.6				
Other Passenger Airlines	25.9	8.8	17.0	3.0	10.1	3.9
Airport Employees	\$ 8.4	\$ 5.4	\$ 2.9		\$2.9	
Airport Tenants	68.6	17.1	51.4		37.1	14.3
Federal Government Agencies	4.2	2.7	1.4	.29	1.2	
Freight Transportation						
Freight Transportation	\$ 32.1	\$ 32.1				
Total	\$385.3	\$189.5	\$195.8	\$23.9	\$126.3	\$45.5

*1985

**Numbers may not add up due to rounding

Source: Direct Income Figures, The Economic Impact of Aviation in Southwest Pennsylvania, Wilbur Smith and Associates, December 1986

5.4 Direct Employment and Income Due to Hub-and-Spoke Operations

Direct Airport/Airline Employment

Hub-and-spoke direct employment was derived from overall airline/airport employment. Fixed hub-and-spoke employment was identified as all system-wide management, major maintenance and facilities management staff. For variable employment, it was assumed that hub-and-spoke operations and passengers generate the same amount of staff per aircraft movement or per passenger trip as other types of airline route management. Therefore, this employment was calculated from the coefficients obtained in section 5.2 from the number of hub-and-spoke operations and passengers at each airport.

The results are shown for each airport in Tables 15 and 16 with and without major maintenance. Since major maintenance is not required for a hub-and-spoke network, it is interesting to show the impact both ways.

The ranges of total hub-and-spoke direct employment are from 6,200 to 22,600 jobs, including major maintenance. The range is 4,300 to 15,600 without major maintenance. This is a wide range, but even the low end is significant as a portion of airport employment.

The importance of major maintenance is higher at those airports with more than one hubbing carrier. It varies from 31 to nearly 40 percent of hub-and-spoke employment.

Table 17 indicates that hub-and-spoke operations are responsible for between 57 and 68 percent of total airline-airport related employment. Moreover, hub-and-spoke variable employment for these same airports is estimated between 50 and 60 percent while fixed ranges from 56 to 82 percent including major maintenance. Consequently, should an airline choose to move operations, the airport stands to lose an estimated 63 percent of its direct employment and 66 percent of the personal income generated from those jobs.

Direct Personal Income from Hub-and-Spoke Airport/Airline Employment

Direct personal income from hub-and-spoke airport/airline employment was obtained by applying the weighted average salary figures for all job classifications that fall into either the fixed or variable employment categories. These job classifications vary dramatically in salary range with airline salaries the highest. For hub-and-spoke personnel 100 percent of the fixed employment are airline personnel and 70 to 80 percent of variable employment. Thus, fixed income from hub-and-spoke employment is higher than variable income.

Hub-and-spoke employment generates an estimated 66 percent of total airline/airport personal income as shown in Table 21. The closeness in the employment and income percentages (Tables 17 and 21) suggest that there is greater diversity from region to region (or airline to airline) than between hub-and-spoke in the direct airline/airport employment category and other employees.

Excluding major maintenance, the income generated from hub-and-spoke would range between 36 and 45 percent of total airport/airline income. (Table 22) The exclusion of a major maintenance from airline employment, reduces total hub-and-spoke income by almost half.

Table 15

**Estimated Total Employment Related to Hub-and-Spoke Operations
Including Major Maintenance**

	Fixed Employment Major Maintenance**	Facilities Management	Systemwide Management	Total Fixed Employment	Total Variable Employment*	Total Hub-and-Spoke Employment
Atlanta	7,000	700	2,400†	10,100	12,500	22,600
Denver	5,500	700	3,900	9,800	4,100	14,200
Minneapolis	4,000	700	2,600	7,300	3,800	11,100
Pittsburgh	1,900	400	1,100	,4100	2,800	6,200

*Totals are calibrated coefficients from table 10

**Totals from tables 6-9

†excluding headquarters personnel
(all figures are rounded to the nearest 100)

Table 16

**Estimated Total Employment Related to Hub-and-Spoke Operations
Excluding Major Maintenance**

	Fixed Employment Total Facilities Management	Systemwide Management	Total Fixed EmploymentE	Total Variable Employment	Hub-and-Spoke Employment
Atlanta	700	2,400	3,400	12,500	15,600
Denver	700	3,900	4,300	4,100	8,700
Minneapolis	700	2,600	3,300	3,800	7,100
Pittsburgh	400	1,100	1,500	2,800	4,300

*Totals are calibrated coefficients from table 10

**Totals from tables 6-9

(all figures are rounded to the nearest 100)

Table 17
Hub-and-Spoke Related Employment as a Percentage of Total Airline/Airport
Employment Including Major Maintenance

	Total Fixed	Total Variable	Total Hub-andSpoke
Atlanta	82%	60%	68%†
Denver	73%	58%	68%
Minneapolis	56%	60%	57%
Pittsburgh	69%	49%	58%
Average	70%	57%	63%

Table 18
Hub-and-Spoke Related Employment as a Percentage of Total Airline/Airport
Employment Excluding Major Maintenance

	Total Fixed	Total Variable	Total Hub-andSpoke
Atlanta	25%	60%	47%†
Denver	33%	58%	42%
Minneapolis	25%	60%	37%
Pittsburgh	30%	49%	40%
Average	28%	57%	38%

†excluding headquarters

Table 19

**Estimated Total Personal Income Related to Hub-and-Spoke Operations
Including Major Maintenance**
(Millions of Dollars)

	Major Maintenance**	<i>Fixed Employment</i> Facilities Income	Management Income	Total Fixed Income	Total Variable Income*	Total Hub-and-Spoke Income
Atlanta	\$325.8	\$32.6	\$111.7	\$490.1	\$461.7	\$931.8
Denver	\$170.5	\$21.7	\$120.9	\$313.1	\$ 99.8	\$412.9
Minneapolis	\$160.0	\$28.0	\$104.0	\$292.0	\$109.4	\$401.4
Pittsburgh	\$ 74.2	\$15.6	\$ 42.9	\$132.7	\$ 93.9	\$226.6

*Totals are calibrated coefficients from table 10

**Totals from tables 6-9

(all figures are rounded to the nearest \$0.1 million)

Table 20

**Estimated Total Personal Income Related to Hub-and-Spoke Operations
Excluding Major Maintenance**
(Millions of Dollars)

	<i>Fixed Employment</i> Facilities Management Income	<i>Fixed Employment</i> Systemwide Management Income	Total Fixed EmploymentE Income	Total Variable Employment Income*	Total Hub-and-Spoke Employment Income
Atlanta	\$32.6	\$111.7	\$144.3	\$461.7	\$606.0
Denver	\$21.7	\$120.6	\$142.6	\$ 99.8	\$242.4
Minneapolis	\$28.0	\$104.0	\$132.0	\$109.4	\$241.4
Pittsburgh	\$15.6	\$ 42.9	\$ 58.5	\$ 93.9	\$152.4

*Totals are calibrated coefficients from table 10

**Totals from tables 6-9

(all figures are rounded to the nearest \$0.1 million)

Table 21
Hub-and-Spoke Related Personal Income as a Percentage of
Total Airline/Airport Income Including Major Maintenance

	Total Fixed	Total Variable	Total Hub-andSpoke
Atlanta	83%†	60%	70%†
Denver	82%	58%	74%
Minneapolis	59%	60%	59%
Pittsburgh	68%	49%	59%
Average	68%	57%	66%

Table 22
Hub-and-Spoke Related Personal Income as a Percentage of
Total Airline/Airport Personal Income Excluding Major Maintenance

	Total Fixed	Total Variable	Total Hub-andSpoke
Atlanta	25%†	60%	45%†
Denver	37%	58%	44%
Minneapolis	27%	60%	36%
Pittsburgh	30%	49%	40%
Average	30%	57%	41%

†excluding headquarters

Chapter 6 INDUCED EMPLOYMENT AND INCOME

In the previous chapter, direct employment and income impacts from total and hub-and-spoke operations were examined. This chapter will introduce induced impacts which result from the ripple effect of airline/airport expenditures that lead to other economic activities throughout the region.

Of the direct income received by individuals directly employed due to airport activity a portion is spent on goods and services within the region which in turn creates additional employment and income. This is also accomplished from airline-airport related purchases which create induced employment in the firms supplying the goods and services. In addition, the airlines and airport-related services contribute to the regional economy by local purchases on maintenance, advertising and promotional services, commissions paid, passenger food and supplies, and other cash costs such as county and state taxes.

Of the possible induced impacts, only two major impacts were calculated: personal income and tax impacts. These were the most reliable figures available, but they do underestimate the total regional expenditures and therefore represent a conservative estimate of induced regional impacts.

6.1 Types of Industries Affected

The industries the most affected by airport activity are: Financial, Legal, Social Services; Food/Restaurant; Housing; Health Care; Entertainment ; Transportation, and Apparel. Economic studies on Atlanta, Denver, Minnesota/St. Paul and Pittsburgh airports indicate that induced employment impacts are greatest in the financial and business sectors followed by jobs with the retail and wholesale food and beverage industries.

6.2 Employment and Income Multipliers

The regional induced impacts of hub-and-spoke activities for the four airports in this study, were estimated from employment and income multipliers, and the direct impacts shown in the previous chapter. Employment multipliers estimate the number of jobs created in the local economy for each job at the airport. Personal income multipliers indicate the total spending in the regional economy. These multipliers were calculated by use of a regional input/output matrix developed for each state and modified to reflect a specific region. Multipliers are described in detail in chapter 2.

The size of the multiplier varies by state depending on the proportion of in-state goods and services purchased by individuals. The higher this percentage, the lower the income leakage out-of-state. The full income multiplier effects result from successive rounds of respending. At each stage of the respending additional jobs are created as well as income. These are the induced jobs which can also be calculated using a multiplier, as was done in the four airport studies.

As shown in Table 1, the employment multipliers for the four study airports range from 1.78 to 2.75. This means that for each employee of directly employed at the airports in this study, another 0.78 to 1.75 employees are hired in the regional economy.

The higher the multiplier reflects spending by state residents on more goods and services within the state. As shown in Table 2, the income multipliers for Hartsfield/Atlanta, Denver/Stapleton, Minneapolis/St. Paul, and Greater Pittsburgh International Airports induce from one-quarter to three-quarters the direct income generated by aviation activity.

6.3 Estimated Induced Employment and Income Impacts from Airport Activities

Employment impacts as shown by Table 1, generally increase by more than one-half of direct employment. Pittsburgh has the highest employment multiplier and this created induced impacts almost double that of direct employment. In Pittsburgh, for every one job at the airport almost two new jobs are created. Atlanta, Denver, and Minneapolis had slightly lower ratios of direct jobs to induced jobs.

Table 1
Estimated Induced Employment Impacts from Airport Activity

Airport	Total Direct Airline/Airport Employment Impact	Implied Regional Employment Multiplier	Induced Employment Impact	Total Direct and Induced Employment Impact
Atlanta ¹	37,211	2.21	45,360	82,571
Denver ²	21,921	1.78	17,028	38,949
Minneapolis ³	19,421	2.01	19,646	39,067
Pittsburgh ⁴	10,620	2.75	18,532	29,152

Sources:

- (1) Hartsfield/Atlanta International Airport Economic Impact Report, 1987
- (2) The Regional Economic Impact of Stapleton International Airport, 1985
- (3) The Economic Impact of the Minneapolis/St. Paul International Airport, 1988
- (4) The Economic Impact of Aviation in Southwestern Pennsylvania, 1985

Table 2
Estimated Total Induced Personal Income Impacts from Airport Activity
(Millions of Dollars)

Airport	Total Direct Airline/Airport Income Impact	State Income Multiplier	Induced Income Impact	Total Direct and Induced Income Impact
Atlanta ¹	\$1,525.	1.85	\$1,296.	\$2,821.
Denver ²	\$ 557.	1.85	\$ 473.	\$1,029.
Minneapolis ³	\$ 680.	1.76	\$ 517.	\$1,196.
Pittsburgh ⁴	\$ 348.	2.30	\$ 452.	\$ 800.

Sources:

- (1) Hartsfield/Atlanta International Airport Economic Impact Report, 1987
- (2) The Regional Economic Impact of Stapleton International Airport, 1985
- (3) The Economic Impact of the Minneapolis/St. Paul International Airport, 1988
- (4) The Economic Impact of Aviation in Southwestern Pennsylvania, 1985

6.4 Estimated Induced Employment and Income from Hub-and-Spoke Operations

The estimated induced employment and income from hub-and-spoke operations for the four airports (tables 3 - 6), reveals that an estimated 61 percent of employment and 65 percent of income exist from hub-and-spoke operations including major maintenance. Excluding major maintenance, this dependency is reduced to approximately 39 percent of employment and 41 percent of income. The percentage of induced hub-and-spoke income is slightly higher than employment because of airline salaries which average more than other airport employees.

Table 3
Estimated Induced Employment Impacts from Hub-and-Spoke Operations Including Major Maintenance

Airport	Total Direct Airline/Airport Employment Impact (H+S)*	State Employment Multiplier	Induced Employment Impact	Total Direct and Induced Employment Impact
Atlanta ¹	22,600	2.23	27,772	50,372
Denver ²	14,200	1.89	12,636	26,836
Minneapolis ³	11,100	2.04	11,590	22,690
Pittsburgh ⁴	6,200	2.95	12,095	18,295

Sources:

- (1) Hartsfield/Atlanta International Airport Economic Impact Report, 1987
- (2) The Regional Economic Impact of Stapleton International Airport, 1985
- (3) The Economic Impact of the Minneapolis/St. Paul International Airport, 1988
- (4) The Economic Impact of Aviation in Southwestern Pennsylvania, 1985

*Estimated from Table 15, Total Fixed and Variable Employment Related to Hub-and-Spoke Operations Including Major Maintenance

Table 4
Estimated Induced Employment Impacts from Hub-and-Spoke Operations
Excluding Major Maintenance

Airport	Total Direct Airline/Airport Employment Impact (H+S)*	State Employment Multiplier	Induced Employment Impact	Total Direct and Induced Employment Impact
Atlanta ¹	15,600	2.16	18,025	33,625
Denver ²	8,700	1.85	7,416	16,116
Minneapolis ³	7,100	1.98	6,954	14,054
Pittsburgh ⁴	4,300	2.89	8,118	12,418

Sources:

- (1) Hartsfield/Atlanta International Airport Economic Impact Report, 1987
- (2) The Regional Economic Impact of Stapleton International Airport, 1985
- (3) The Economic Impact of the Minneapolis/St. Paul International Airport, 1988
- (4) The Economic Impact of Aviation in Southwestern Pennsylvania, 1985

*Estimated from Table 16, Total Fixed and Variable Employment Related to
Hub-and-Spoke Operations Excluding Major Maintenance

Table 5
Estimated Induced Personal Income Impacts from Hub-and-Spoke Operations
Including Major Maintenance
(Millions of Dollars)

Airport	Total Direct Airline/Airport Income Impact	Income Multiplier	Induced Income Impact	Total Direct and Induced Income Impact	Hub-and-Spoke Percentage of Total Direct and Induced Income
Atlanta ¹	\$932.	1.85	\$792.	\$1,724.	61
Denver ²	\$413.	1.85	\$351.	\$ 764.	74
Minneapolis ³	\$401.	1.76	\$305.	\$ 706.	59
Pittsburgh ⁴	\$227.	2.30	\$295.	\$ 522.	65

Sources:

- (1) Hartsfield/Atlanta International Airport Economic Impact Report, 1987
- (2) The Regional Economic Impact of Stapleton International Airport, 1985
- (3) The Economic Impact of the Minneapolis/St. Paul International Airport, 1988
- (4) The Economic Impact of Aviation in Southwestern Pennsylvania, 1985

Table 6
Estimated Induced Personal Income Impacts from Hub-and-Spoke Operations
Excluding Major Maintenance
(Millions of Dollars)

Airport	Total Direct Airline/Airport Income Impact	Income Multiplier	Induced Income Impact	Total Direct and Induced Income Impact	Hub-and-Spoke Percentage of Total Direct and Induced Income
Atlanta ¹	\$606	1.85	\$515.	\$1,121.	40
Denver ²	\$242	1.85	\$206.	\$ 448.	44
Minneapolis ³	\$241	1.76	\$183.	\$ 424.	35
Pittsburgh ⁴	\$152	2.30	\$198.	\$ 350.	44

Sources:

- (1) Hartsfield/Atlanta International Airport Economic Impact Report, 1987
- (2) The Regional Economic Impact of Stapleton International Airport, 1985
- (3) The Economic Impact of the Minneapolis/St. Paul International Airport, 1988
- (4) The Economic Impact of Aviation in Southwestern Pennsylvania, 1985

6.5 Direct and Induced Tax Impacts at Selected Airports

Airport activity at the four airports generated Federal, state and local tax payments paid by individuals directly employed and firms engaged in airport activity. This is an important source of funds for state and local governments and it serves as funding for reinvestment in airport infrastructure. Tax impacts represent a portion of income earned by individuals and is described only for Denver and Minneapolis. For Hartsfield/Atlanta and Pittsburgh, only taxes from airlines are shown.

Hartsfield/Atlanta International Airport

Hartsfield/Atlanta International Airport resides in two counties, Fulton and Clayton, which benefit directly from an airline public utility tax. Between 1979 and 1984, Fulton County's public utility tax increased from \$453 million to \$523 and Clayton County's public utility tax revenues increased 119% from revenues of \$102 million to \$224 million.¹

Using Table 22, estimated hub-and-spoke personal income impact at Hartsfield/Atlanta comprises 60 percent the tax impact is estimated for the combined counties at \$448 million.

Denver/Stapleton International Airport

From direct and induced employment created from activity at Denver, a total of \$81 million in state and local taxes were paid by individuals and firms from activity the airport.² Of this \$81 million in taxes, an estimated 68 percent (Table 7) or 55 million is attributed to hub-and-spoke activities.

Table 7
Taxes Paid by Individuals Employed Due to Activity at
Denver/Stapleton(1985)

Tax	Tax Impact (Million of Dollars)
State sales tax	\$13.4
State personal income tax	28.1
Miscellaneous state tax	5.2
Local taxes	34.3
Total	\$81.0
<i>Hub-and-Spoke Impact</i>	<i>\$55.0</i>

For fiscal 1986, state and local tax revenue generated by activity at Minneapolis/St. Paul International Airport was based on state and local tax burdens developed from data supplied by the Minnesota Department of revenue and is shown in Table 8. Of \$110.7 million tax impact, 57 percent or \$63 million is generated from hub-and-spoke income.

Table 8
State and Local Tax Revenue Created by Minneapolis/St. Paul Airport
Activity Paid by Individuals and Firms (1987)³

Tax	Tax Impact (Millions of Dollars)
State personal income tax	\$32.1
State corporate income tax	5.5
State sales tax	20.2
State motor vehicle tax	3.1
Highway/gasoline tax	4.9
State airport fuel tax	2.5
Other state taxes	9.7
Local property taxes	32.7
Total	\$110.7
<i>Hub-and-Spoke Impact</i>	<i>\$70.8²</i>

6.6 Total Induced Impacts

The induced impacts above are substantially understated due to the fact that the regional income is only represented by payroll taxes and fees. The amount of this understatement is uncertain, but is in a range of 30 to 45 percent, as estimated from data in the four airport studies. Therefore the total impacts are estimated (Table 9) as follows:

**Table 9
Total Impacts from Hub-and-Spoke Activities**

	Hub-and-Spoke Calculated Impact	Range of Hub-and-Spoke Possible Impact
		1.30 - 1.45
<i>Atlanta</i>		
Income	\$1.72 bil	\$2.24 bil - \$2.49 bil
Employment	50,400	65,500 - 73,100
Taxes	\$140 mil*	\$180 mil - \$200 mil
<i>Denver</i>		
Income	\$0.76 bil	\$0.99 bil - \$1.10 bil
Employment	25,500	33,200 - 37,000
Taxes	\$55 mil	\$72 mil - \$80 mil
<i>Minneapolis/St. Paul</i>		
Income	\$0.71 bil	\$0.92 bil - \$1.03 bil
Employment	22,700	29,500 - 32,900
Taxes	\$63 mil	\$82 mil - \$91 mil
<i>Pittsburgh</i>		
Income	\$0.52 bil	\$0.68bil - \$.73 bil
Employment	18,300	23,800 - 26,500
Taxes	\$43 mil*	\$56 mil - \$62 mil

*Estimated as average percent of Denver and Minneapolis

Chapter 7 CONCLUSIONS

The prevalence of hub-and-spoke networking is a result of airlines taking advantage of strategically positioned airports to consolidate operations and to redirect the flow of passengers. By consolidating operations at one or more airports, airlines are able to enter more markets, and achieve higher load factors using connecting flights with fewer aircraft. This thesis concludes that hub-and-spoke networks have a significant impact on aviation activities, regional employment, regional income, state and local taxes, as well as airport expansion and financing.

Aviation Activity

The number of markets and passengers have increased dramatically (since deregulation) at the four airports studied and, virtually all of the increase can be attributed to hub-and-spoke networking. Hub-and-spoke operations at these airports now represents between 59 and 63 percent of 1987 markets, between 60 and 85 percent of all transferring passengers, and 15 to 40 percent of all origin-destination passengers.

Hub-and-spoke airports owe much of their growth to one or two airlines using their airport compared to non-hub-and-spoke airports where ten to twenty carriers have shared the growth. Evidence from airport administrators and airline publications suggest that hubbing airlines increase the number of operations to a hub-and-spoke airport and this tends to strengthen their position in the markets served by that airport by offering greater frequency of service than non-hubbing airlines. In addition, airlines have recognized the economic benefits of small feeder routes (extra spokes) into their hub-and-spoke operation by either merging or instituting some form of mutual arrangements with these regional carriers that operate these routes. This suggests two things: hub-and-spoke systems tend to attract small carriers, and more markets are added to the hub-and-spoke network as feeder airlines increase.

More than one airline can have a hubbing network at the larger airports, but smaller regional airports usually have only one dominant carrier. Some hubbing airlines even reinforce their dominance by exclusionary agreements.

One of the disadvantages of hub-and-spoke operations is that the hubbing carrier tends to control hub airport terminals and gates as well as dominate slot positions. The dominance of one hubbing carrier appears to reduce the attractiveness of some hub-and-spoke airports for other carriers wishing to offer service and how this affects airport revenues are interesting subjects for further research.

Regional Employment

The analysis of the four selected airports estimates that hub-and-spoke operations are responsible for more than 58 percent of all direct airport and airline employment and up to 61 percent of personal income generated by airport/airline employment.

Major maintenance and system-wide airline management staffing varies tremendously from one airport to another. Because major maintenance and system-wide management are not dependent on the number of flights out of a hub airport, these employees can be shifted to other regions. The size of this employment block can be as much as 43 percent of total direct airport/airline employment. (18-26 percent for major maintenance and 7-17 percent for system-wide airline management) This represents potential risk due to dependence that is very high.

The number of employees assigned to facilities management is also airline-specific but it amounts to much less than major maintenance or system-wide airline management. The total number of employees assigned to facilities management was between 2 and 4 percent of total

direct employment. Variable employment amounts one fifth to one third of total direct airport/airline jobs. Surprisingly, this is also a smaller employment impact of hub-and-spoke network staffing than the system-wide fixed job impact.

In terms of number of jobs, the four large hubs examined in this thesis, vary from 6,000 to 23,000. The fixed positions alone range from 3,500 to 10,000 including major maintenance.

There are important implications for existing hub-and-spoke airports and those airports who would welcome the chance of becoming a hub. First it is clear that an airport chosen to become a hub-and-spoke airport stands to gain direct employment estimated between 2,000 and 4000 jobs not including major maintenance. Major maintenance facilities were found at all of the hub-and-spoke airports studied in this thesis, and major maintenance facilities appear to be located at all other large hub-and-spoke airports with the exception of the American Airlines' major maintenance facility at Tulsa, Oklahoma. Including major maintenance, an airport chosen as a new hub-and-spoke operation stands to gain between 2,500 to 5,000 jobs; 3,500 to 6,000 jobs if an airline decides to shift a majority of operations to another airport.

The estimated low number of direct employees (50-100) per major airline not hubbing at an hub-and-spoke airport suggests that carriers tend consolidate a majority of their operations and employment at their own hubs. This is also indicated by the small market share held by non-hubbing carriers at each of the four airports.

Direct Income Impact

In terms of the direct personal income impact of hub-and-spoke networking, the range is \$227 million to \$932 million per year, including major maintenance. Other direct income increases this impact by 10-15 percent giving a total of up to one billion. This is a major contribution to the regional economy, which is even larger when induced effects are added in.

Induced Impacts

Regional Employment

At the four airports in this study, induced hub-and-spoke airport/airline employment accounts between 2.4 to 5.5 percent of total regional employment. (see Table 2) At 5 percent this is only barely significant as a proportion of regional employment. However it is still the size of a major industry, and in a smaller region this could become significant.

Table 2
Comparison of Total Direct, Induced, and Related Employment and Estimated Total Hub-and-Spoke Direct and Induced Employment as a Percentage of Total Regional Employment

Airport	Total Regional Employment (1)	Direct and Induced Employment from Hub-and-Spoke Operations (2)	Hub-and-Spoke Employment as a Percentage of Regional Employment
Atlanta	1,318,000	65,500 - 73,200	5.0 - 5.5
Denver	991,000	33,200 - 37,000	3.4 - 3.7
Minneapolis	1,223,000	29,500 - 32,900	2.4 - 2.7
Pittsburgh	886,000	23,800 - 26,500	2.7 - 3.0

(1) Bureau of Labor Statistics, Geographic Profile of Employment and Unemployment

(2) Total Direct and Induced Employment from Table 15

Regional Income

Total direct and induced personal income impacts vary from \$0.7 billion to \$2.5 billion. Total direct and induced tax revenues amount to another \$56 million to \$200 million or another 8 percent. Hub-and-spoke operations clearly contribute a significant amount of income to the regional economy, even if the number of visitors is not increased.

Airport Expansion and Financing

The concentration of air transportation activities from hub-and-spoke operations generally require more capacity than what exists at an airport and are primarily responsible for increasing airside and landside capacity at hub airports. The capacity crisis associated with

hub-and-spoke systems is slowly being alleviated by extended or new terminal construction, funded primarily by the hubbing airlines.

Airports are especially vulnerable in that these leasing agreements are contingent on an airline's financial situation and in some past instances, airlines have moved out of a hub airport, burdening a city or airport authority with excess capacity and lost revenue.

Topics for Further Research

Since estimates in this thesis have been made based on the number of airline employees in particular job categories, it may be important to refine the estimates of the assignment of fixed personnel, and especially major maintenance staff at hub airports. Airline dominance and instability or stability due to hub-and-spoke networking was also not established in this thesis and needs further research.

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⁵Ibid.

⁶The definition of a hub in this thesis differs from the one found in the FAA Statistical Handbook of Aviation. Calendar Year 1978, page 135. Within the context of this thesis, a hub is an airport that supports carriers who concentrate at least one-fourth of their routes there. Conversely, the FAA defines a hub actually as an air traffic hub. Not considered an airport, air traffic hubs are the cities and Standard Metropolitan Statistical Areas requiring aviation services. Communities fall into four classes as determined by each community's percentage of the total enplaned passengers in scheduled service of the fixed-wing operations of the domestic certificated route air carriers in the 50 States, the District of Columbia, and other U.S. areas designated by the Federal Aviation Administration. For example, Boston and Los Angeles are considered large hubs according to the FAA hub definition. This designation is invalid for these two cities if the true hub-and-spoke criteria is applied. Neither of these cities/airports contain significant hubbing operations.

⁷Bailey, Elizabeth E., Graham, David R., and Kaplan, Daniel P., Eds. Deregulating the Airlines. MIT Press. (Cambridge, Massachusetts: 1985). p. 78.

⁸The definition of slots is assigned periods during a day for takeoffs. For example, if an airport can handle 100 takeoffs an hour, these 100 are places or slots are assigned to the carriers wishing to utilize that hour during the day.

⁹JFK International, New York, LaGuardia, New York, O'Hare, Chicago, and Washington National have been since 1966 and still are designated as "high density terminal area" airports. Runway access to these airports is allocated among airline users through scheduling committees which meet twice a year. Access to these airports by commuter/air taxi operators and by general aviation aircraft is also rationed. (Cohen and Odoni, FTL, Massachusetts Institute of Technology. May 1985)

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APPENDIX

Airport Survey

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General Information

Size of Airport (square miles or acres)

Number of Runways

Maximum Number of Flights per Hour

Part I Airport Operations

Annual Summary Report of Airport Activities

(12 Month Commulative Period for the years 1987, 1986, 1985, 1984, 1983)

(Please insert or attach any existing printed sheets instead of filling out these sheets)

(1) Plane Movements

	Year	Cumulative from January	%CHANGE from previous year
Domestic	_____	_____	_____
Scheduled Passenger	_____	_____	_____
Scheduled Cargo	_____	_____	_____
Scheduled Non-Revenue	_____	_____	_____
Scheduled Commuter	_____	_____	_____
Air Taxi (Helicopter)	_____	_____	_____
General Aviation	_____	_____	_____
Military	_____	_____	_____
Total	_____	_____	_____
Overseas	_____	_____	_____
Scheduled Passenger	_____	_____	_____
Scheduled Cargo	_____	_____	_____
Scheduled Non-Revenue	_____	_____	_____
Military	_____	_____	_____

(1.1) General Carrier Information

(a) Please list the domestic carriers serving your airport.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____

(b) Please list the foreign carriers serving your airport.

1. _____
2. _____
3. _____
4. _____
5. _____

(2) Revenue Passenger Traffic

	Year	Cumulative from January	%CHANGE from previous year
Domestic Airline Total	_____	_____	_____
Scheduled	_____	_____	_____
Other	_____	_____	_____
Foreign Airline Total	_____	_____	_____
Scheduled	_____	_____	_____
Other	_____	_____	_____
Total	_____	_____	_____

(2a) Annual Number of Transferring Passengers

Could you provide an annual breakdown on Domestic Origin/Destination passengers that use your airport to transfer to other destinations for 1987, 1986, 1985, 1984, and 1983?

1987	1986	1984	1985	1984	1983
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Interlining

Could you provide an annual breakdown on those passengers listed above that use your airport to transfer to a different airline other than the one they arrived on for the years 1987, 1986, 1985, 1984, and 1983.

1987	1986	1984	1985	1984	1983
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

Intralining

Could you provide an annual breakdown on those passengers listed above that use your airport to transfer to a different airline other than the one they arrived on for the years 1987, 1986, 1985, 1984, and 1983.

1987	1986	1984	1985	1984	1983
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____

.....

(3) Revenue Mail (tons)

Domestic	_____	_____	_____
Overseas	_____	_____	_____
Total	_____	_____	_____

.....

(4) Revenue Cargo (tons)

Domestic	_____	_____	_____
Overseas	_____	_____	_____
Total	_____	_____	_____

(4a) The Significance of the Overnight Package Industry in Airport Cargo Activities

Does your airport have separate statistics on the overnight package industry? If yes, could you provide a breakdown on the following categories?

Annual number of flights _____

Number of firms _____

Firm name _____

Firm name _____

Firm name _____

Firm name _____

Firm name _____

At what hours do these firms operate flights?

Is any new or planned terminal construction geared to the overnight package industry?

.....

(5) Ground Activities

(Annual Number of Passengers using ground transportation to and from the airport)

Paid Parked Cars _____ _____ _____

Airport Coach Passengers _____ _____ _____

Bus _____ _____ _____

.....

Part II. Environmental Problems Associated with Airports

(1) Does your airport have night restrictions? (Please indicate if small commuter aircraft are permitted in place of jet aircraft)

If yes, please indicate the period when flights are restricted.

Have these restrictions been in place for the past five years or are they a recent response to increased activity at your airport?

(2) Number of Complaints from Aircraft Noise and Vibrations

Airports over the past few years have seen an increase in the number of complaints related to aircraft noise and vibrations during peak hours. Could you provide the number of noise complaints for the past five years?

1987 _____

1986 _____

1985 _____

1984 _____

1983 _____

(3) Aircraft Related Air Pollution

Do you know of any studies done on the level of air pollution attributed to aircraft operations?

(4) Road Congestion

Do you have any studies on airport-related road congestion?

Part III Economic Impacts on Adjacent Communities (Region)

(1) Airport operating budgets for the past five years

1987 _____

1986 _____

1985 _____

1984 _____

1983 _____

(2) Communities Directly Served by Your Airport

What is the estimated population served by your Airport?

Approximate Number of Communities Served

Name of Community Served _____

Proximity to Airport _____

Name of Community Served _____

Proximity to Airport _____

Name of Community Served _____

Proximity to Airport _____

Name of Community Served _____

Proximity to Airport _____

Name of Community Served _____

Proximity to Airport _____

Name of Community Served _____

Proximity to Airport _____

(3) Hotels Serving the Airport

Number of Hotels on and Adjacent to Airport

Name of Hotel _____ Number of Rooms _____

Name of Hotel _____ Number of Rooms _____

Name of Hotel _____ Number of Rooms _____

Name of Hotel _____ Number of Rooms _____

Name of Hotel _____ Number of Rooms _____

Name of Hotel _____ Number of Rooms _____

Name of Hotel _____ Number of Rooms _____

**(4) Revenue Compensation to Communities Directly
Affected by Airport Operations**

Does your airport have arrangements with adjacent communities where a percentage of airport revenue is returned to municipalities for compensation for flights over their properties or routes shared by airport bound traffic?

If yes, could you summarize the agreements or recommend a person or department who can?

(5) Airport-Airline Terminal Leasing Agreements

Do you have information about terminal leases?

If no, could you give them this part or recommend person(s) or departments that might handle aspects of leasing?

If yes, please indicate below if airlines operating at your airport are bound by tenent-at-will, 1 year, 5 years, 25 years, etc. agreements? Is there a corporation made up of number of airlines who collectively own terminal space and are responsible for maintenance?

name of airline

form of agreement

name of airline

form of agreement

Airline Leasing Agreements (Con't)

name of airline

form of agreement

name of airline

form of agreement

name of airline

form of agreement
