

**Pricing and Competition in US Airline Markets: Changes in  
Air Travel Demand Since 2000**

by

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## Abstract

Since 2000, the US airline industry has been in turmoil. The economic downturn, September 11 and other factors all have had a negative impact on the spending behavior of consumers, and consequently airlines have posted tremendous revenue losses.

The objective of this thesis is to analyze fare and passenger changes in the United States between 2000 and 2004 and to observe how air travel demand has changed recently. The Origin and Destination Survey of the US Department of Transportation is the main data source from which the Top 1000 Markets of 2004 were extracted and consistently matched back to 2000 in order to observe market changes.

First, an aggregate statistical analysis was performed to conclude that average fares had decreased 16.4% by 2004, whereas traffic rebounded to 2000 levels after dropping by 11%. As a result, revenues had dropped 17.3% by 2004 compared with 2000. The total market sample was then segmented by distance, hub versus non-hub, low-fare airlines' market share, and overall market competition to determine the impact of each factor. These analyses resulted in the following findings. New entry of low-fare airlines resulted in the greatest decline of 31.3% in average fare by 2004. Short-haul travel demand declined by 16% while fares remained stable; on the other hand, long-haul markets experienced a 29% decrease in fare which resulted in a 9% increase in traffic. The average fare of hub markets decreased by over 19% — a greater decline than for non-hub markets. The average fare for low concentration markets experienced a decrease of 24% resulting in a passenger stimulation of 13%.

Finally, regression analyses were performed to analyze the interactions between the different factors. These analyses further supported the previous findings and provided some new insights. The presence and growth of low-fare airlines in a market considerably decreases the average fare and increases the number of passengers. Hub premiums declined between 2000 and 2004, but are still evident for hub markets in which dominant carriers can exercise pricing power, and market concentration was shown to be positively correlated with slightly higher fares.

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# Chapter 1

## Introduction

The goal of this thesis is to better understand how different factors have contributed to the decrease in number of travelers and the lower prices they pay for their tickets on US airlines. Since 2000, the airlines have experienced major changes, which will be explained in greater depth in Section 1.1. Furthermore the objectives and methodology used will be presented in Section 1.2 and some relevant background concepts and definitions will be explained in Section 1.3.

### 1.1 Recent Changes in the Airline Industry

The Airline Industry has always been a turbulent one. The history of the airline industry is highly cyclical, where periods of losses are followed by periods of profit. The downturn of the current cycle is not over yet, and recent changes have dramatically redesigned the industry's landscape. According to the Air Transport Association [4], the US airline industry posted \$32.3 billion in cumulative net losses between 2001 and 2004.

The events of September 11th, 2001 had a dramatic impact on the industry, but it is not the sole reason for the airlines' losses. It could even be argued that these events represented

some form of diversion, as the public attention turned to the terrorist attacks instead of the declining health of the airlines. However, these attacks induced necessary actions by airlines in order to stay competitive: schedules were reduced by grounding airplanes and lay-offs became common practice. Since 9/11, passenger traffic followed a slow recovery path, and has now returned to levels before the terrorist attacks. More recently the average load factors have reached unprecedented heights, in part due to the fact that airline capacity has not grown. Despite the fact that most major US airlines are operating full flights, they still keep losing enormous amounts of money as the average fares are well below 2000 levels while fuel costs continue to rise.

Since 2000, the industry has endured an economic downturn, the primary result of which was the loss of business traffic. This has led to a serious decline in the average fare, as business passengers usually pay the highest fares. In addition, both fuel prices and labor costs surged which placed most major airlines in financial straits. Most of the largest US airlines sought bankruptcy protection, including Delta, Northwest, United and US Airways while American and Continental undertook major restructuring efforts. In May 2005 US Airways merged with America West to exit bankruptcy. The industry has now reached a point where changes occur in the form of consolidation, bankruptcy and liquidation for the US major airlines. The surviving airlines will have to reduce their costs and increase their revenues in order to return to times of profitability.

On the opposite end of the industry spectrum, the low-cost carriers (LCCs) have gained success with their alternative business models. Low cost carriers experienced a slow, constant growth since deregulation in 1978, even if they were only carrying a small portion of nationwide traffic. From the late 90s on, this growth has accelerated such that more recently a market share of nearly 25% can be attributed to the low-fare carriers group, including Southwest, Jet Blue, America West, ATA, AirTran, Spirit and Frontier [25].

With this alternative of lower fares for consumers, competition is fierce and the traditional network carriers are thus forced to change their cost structure and improve their productivity in order to be profitable.

Recently, passengers want to spend less money on flying, which affects their willingness-to-pay. There are some reasons to believe in this reduced willingness-to-pay of the consumers as the travel concept has changed over the last few years. Increased security and fuller planes negatively affect the perception of air travel. Furthermore, there are increasingly attractive alternatives to air travel, such as teleconferencing and rail travel. Also, business travelers are clearly less willing to pay fares many times higher than their fellow leisure travelers.

Considering the recent changes in the airline industry, there are many ways to explain the changing patterns of demand for air travel in recent years. Consumers are getting an increased amount of information through the internet, which makes it much easier for low-fare airlines to offer their discount fare. Because of the constant threat of low-fare airlines, legacy carriers must lower their fares to match and stay competitive in the affected markets.

Moreover, the volume of business travel has decreased due to such factors as lower travel budgets, the reduced quality of airline services and the increased security processing time and uncertainty. All of these factors forced the business sector to look for technologically feasible alternatives to air travel such as teleconferencing, or substitutes for premium air travel (incl. using low-fare airlines for business travel). Corporate traveling is thus increasingly supplanted by alternatives such as telecommunication or substituted with other modes of travel (such as driving for short haul markets).

Even for the general public, times have changed. The security "hassle factor" and threats of more terrorist attacks may influence people's decision-making process and encourage substitutes to air travel. Trains and automobiles may become viable alternatives. Measuring the factors that affect the air travel demand at the market level is thus critical in order to understand the full dynamics behind the current air transportation system.

## 1.2 Study Objectives and Methodology

### 1.2.1 Objectives

The key objective of this thesis is to determine how the air travel demand has changed in the United States and how different factors are affecting these changes. In more specific terms, the evolution of pricing and competition will be analyzed between 2000 and 2004 in order to identify relevant factors such as hub effects, low-fare airline competition and distance. Potential explanations for these changes will be developed, such as the economic downturn. Broader questions will be answered involving the changes in willingness-to-pay or price elasticity and the airline pricing power.

### 1.2.2 Approach

The primary data source for this thesis is the Origin and Destination Survey (DB1B) of Airline Passenger Traffic of the US Department of Transportation (US DOT). This collection of the data, mandated by the Federal Aviation Act of 1958, is a cooperative effort between the domestic air carriers, the Air Transport Association (ATA) and the Department of Transportation (DOT). This survey represents a 10% sample of airline tickets from reporting carriers (medium and large carriers). The DB1B Market raw data file includes items such as passengers, fares, and distances for each directional market as well as information on whether the market was domestic or international.

Access to the Origin and Destination Survey was obtained using O&D Plus, a commercial product distributed by Data Base Products, Inc. They provide the data and access software on CD-Rom. This product provides the true origin and destination of the sample passengers, but not their itineraries. However, the data distinguishes between passengers beginning a round trip at one end of a market and those traveling on the reverse trip, beginning at the other end.



Some noteworthy limitations should be addressed. The data set does not include smaller airlines with an annual revenue under \$100 million; nor does it include foreign registered carriers. The smaller airlines are not required to participate in the survey unless they operate aircrafts with more than 50 seats. However, the number of passengers carried by these small airlines represents a minor share overall and will thus not truly affect the US domestic markets. Some tickets sold on foreign carriers do slip through the data set, although these too represent very small percentages of passengers.

In order to analyze changes in fares and demand, a market focus was chosen. A market is a city-pair from origin to destination and will be explained more in depth in Section 1.3.1. As a first approach to the analysis, the Top 100 US Markets of 2004 were taken and these markets were consistently matched for the previous years back to 2000. A more detailed description of this process can be found in Section 3.1. This database was expanded to the Top 1000 US Markets. At this point it is worth noting that the Top 1000 Markets represent almost 70% of the US domestic passengers and can thus be considered representative for domestic travel.

The database created was further manipulated in order to group and categorize the markets by different factors such as distance and competition to obtain the results displayed in Chapter 3.

### **1.3 Key Concepts and Definitions**

This section first defines and illustrates the concept of the O-D market, which is the underlying base of the used data and performed analysis. This is followed by a discussion of demand market segmentation. In this subsection, several theoretical principles will be explained to understand how airlines price their products. Both subsections provide important background for the following Chapters.

### 1.3.1 O-D Market Definition

Throughout this thesis, O-D market data was analyzed. First, it should be noted that O-D stands for Origin and Destination. This market information should be addressed from a passenger's perspective, where a market is represented from the passenger's starting point to his final destination, independent of any stops. In other words, the passenger could have multiple stops on his way, but the journey is tracked over any connections even if it involves different carriers. As an illustrative example, a passenger could fly from BOS (Boston) to SFO (San Francisco) via ORD (Chicago). In that case, the passenger will be accounted in the BOS-SFO O-D market. This O-D perspective is opposed to a carrier's flight leg perspective, where each portion a passenger flies is counted as a separate leg. In our previous example this passenger is flying on the legs BOS-ORD and ORD-SFO. At this point, it is important to realize that airline pricing is predicated on an O-D Market and not on a flight leg, as the prices for traveling between BOS-SFO depends on the demand and supply characteristics in that specific market [7].

As used in this study, a market reflects the travel between two cities or a city pair. To clarify this statement, airports within the same metropolitan area are treated as one city by the software package O&D Plus. For example, when considering the metropolitan area of New York, the program combines the airports EWR (Newark), JFK (Kennedy) and LGA (La Guardia). This is primarily meant to compensate for local shifts in traffic from one airport to another, as passengers are willing to include more airport choices into their travel plans.

### 1.3.2 Market Demand Segmentation

Airlines try to segment the market demand such that they can capture the willingness-to-pay of each individual consumer in order to maximize their revenues. In practice, it is impossible to evaluate the willingness-to-pay of each individual, but the airlines can differentiate between segments with similar characteristics.

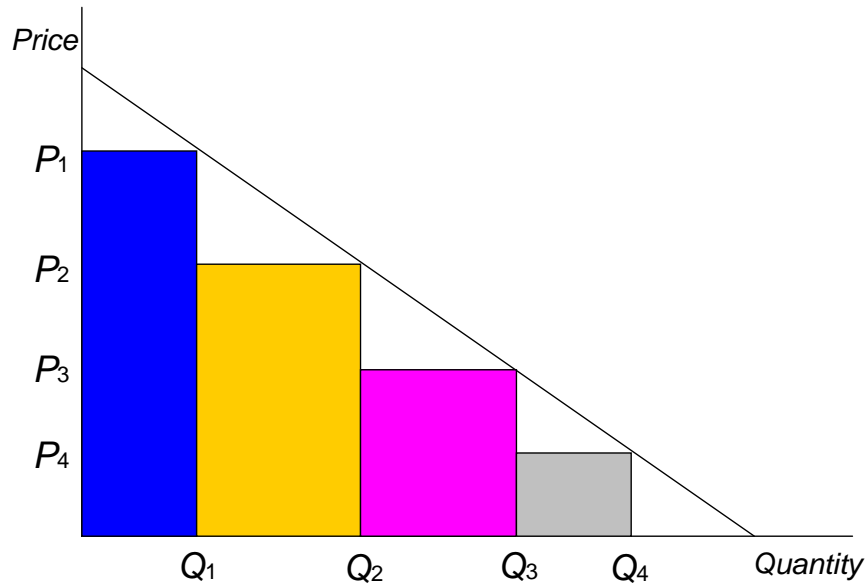


Figure 1-1: Market Segmentation

The unrestricted fare  $P_1$ , as illustrated in Figure 1-1, is offered to those with high willingness-to-pay, whereas the discount fare  $P_4$  is meant for the consumers with low willingness-to-pay. This fairly simple model assumes perfect segmentation of demand with respect to willingness-to-pay, which is the basis for differential pricing [7].

In the attempt to segment the business versus leisure passengers, airlines impose restrictions on the lowest fare products. Commonly used and effective restrictions include Saturday night stay, advance purchase, and cancellation and change fees. Other means of segmenting the market include offering different fares for the time or day of the week, for the season, for the status of the passenger (child, student etc) and for group tours. Yet, it is impossible to achieve perfect segmentation as more recently many business travelers do purchase restricted fares and some travelers with high willingness-to-pay can meet the imposed restrictions. Given the imperfect restrictions, some percentage of the higher demand segments will buy fares that are lower than their willingness-to-pay. This phenomenon is called diversion.

In order to prevent diversion and to maximize revenues, revenue management was developed. The main objective of revenue management is to protect seats for high fare business

passengers even if they book at the last minute, while at the same time filling the aircraft and avoiding flying empty seats. The revenue management systems control the airlines' seat inventory throughout the entire booking process.

As was shown in the theoretical discussion above, passengers in a certain market pay a variety of fares, ranging from highly discounted fares to the full-fare business product, dependent on restrictions such as Saturday night stay and advance purchase. This detailed information of different fare levels paid by passengers is unfortunately not available in the database used, which makes it impossible to analyze the distribution of fares purchased in greater detail. While this was a significant limitation on the database in terms of detailed information on fares, it should be noted that the previous discussion of segmentation is still applicable to the average fare, which will be used in the analysis.

A change in the average fare reflects all internal changes in the distribution of fares and also indicates a shift in demand. However, with the current database one can not entirely predict how well airlines are able to segment the market and how much passengers are willing to pay for a certain ticket.

## **1.4 Thesis Structure**

The thesis consists of three main parts: the Literature Review, the Empirical Analysis and a Regression Analysis.

Chapter 2 provides a literature overview. Relevant events in air transport economics and more in general changes in the airline industry will be addressed, and an overview of air travel demand studies is also included.

In Chapter 3, the empirical analysis that analyzes passenger and fare changes between 2000 and 2004 will be developed by first showing the general trends and aggregate patterns of the data. Consequently the markets will be segmented by using different key character-

istics such as distance, the presence of a major hub and competition with low-fare carriers. Resulting decreases in average fares and revenues will be displayed as well as explained.

Chapter 4 will then explain how a regression analysis was performed in order to obtain a better sense of how both demand and consumer willingness-to-pay are changing.

Finally, the conclusion (Chapter 5) will summarize the results obtained from both the empirical and the regression analysis, provide some explanations for these results, and propose some insights into the airline industry's current situation.



## Chapter 2

# Literature Review

Before the 1970s only a small number of studies covering specific air transport markets were conducted, but since then, the literature on air transport economics has clearly flourished. Still, until the 80s, studies of aviation economics tended to be more descriptive than analytical. After that, a wide number of publications were generated on topics such as revenue management and airline networks. Later on, with the growth of alternative business models and increased competition, these issues were addressed in the literature as well. Over the years, research orientation evolved as the modeling techniques, computing power and availability of data all improved and permitted detailed empirical analysis.

The more recent advances in air transport economics should be placed within their broader historical framework in order to fully appreciate what has happened over the past decades. In the subsequent sections, the literature review presented will contribute to a better understanding of recent changes in pricing and competition. First, deregulation of the industry will be briefly addressed, followed by a more detailed analysis of some noteworthy consequences that profoundly changed the structure of the air travel market. In the following section, recent changes in the industry will be discussed, as they are the underlying causes for the results presented in Chapter 3. Finally, an overview will be given of air travel demand studies, to serve as a basis for comparison in the analysis of Chapter 4.

## 2.1 The Airline Industry

### 2.1.1 Regulation and Liberalization

Before 1978, the airline industry was regulated in the United States. The Civil Aeronautics Board (CAB) determined which airlines could serve which cities, limiting the number of carriers serving each market and setting the corresponding fares by using a mileage-based formula that guaranteed carriers adequate profit margins. As a result, the only way airlines could compete for passengers was based on quality of service, in terms of in-flight service, departure times and frequency of their flights.

In 1978, the Airline Deregulation Act deregulated the US airline industry. The removal of economic regulations added several new dimensions to the airlines' competitive strategies. US airlines were given the freedom to enter or exit any domestic market they wished. Each airline also had complete freedom to determine the frequency of its flights and the number of seats it offered in any market; to set its own airfares; and to allocate as many seats as it desired to each fare class. Beyond that airlines put a lot of effort into increasing their network coverage by offering frequent flights and more itineraries.

Several studies found that deregulation resulted in airfares consistently lower than they would have been if the industry were still regulated. Morrison and Winston (1990) [29] found that on average deregulated fares were 18 percent lower than regulated ones, leading to an average annual saving on the part of travelers of roughly \$6 billion. However, deregulation had very different impacts on fares depending on the distance of the flight, as long-distance fares were deliberately set very high under regulation (and low for short routes) because of the mileage-based formula and resulted in cross-subsidizing of short-haul markets. Morrison and Winston state that deregulation reduced fares for trips over 900 miles (one-way) and increased them for trips less than 900 miles. They also point out that fares fall with increased competition.

Other important consequences of deregulation include:



- Fortification of hub and spoke networks by airlines, centered on one or more hub airports.
- Growth of computer reservation systems (CRS), which have a considerable impact on competition and airline marketing.
- Much more complex pricing structures, with many more discount fares offered. This leads to the widespread use of revenue management techniques.
- A high degree of airline market concentration following numerous bankruptcies, as well as mergers, alliances and takeovers.
- Appearance of new, successful business models leading to the growth of low-fare airlines.

Each of these changes is described in greater detail below.

### **Hub-and-Spoke Networks**

Developed in the early 1950s in the United States, the hub-and-spoke concept became the foundation of most US airline networks in the 1980s after the domestic market was deregulated. This concept enabled airlines to increase frequency in thin markets by connecting the smaller cities (spokes) to a central airport (hub). This is an effective way of serving more destinations; with the same number of flights, airlines are able to connect more cities and to serve more passengers. With this implementation the flight schedules are built with a focus on the hub airport with connecting flights in and out of the hubs. This led to banking of flight legs at the hub and resulted in periods of peak activity followed by more limited activity at the airport.

These hubs allowed the airlines to survive the post-deregulation competition by consolidating passengers departing from spoke stations and redistributing them at hubs on connecting flights. This way of expanding service is clearly less costly than adding cities with point-to-point service, but it requires a high degree of operating efficiency at the hubs.

Hub-and-spoke networks were considered to be efficient as they provide a lower-cost operation for airlines and higher frequency for passengers.

Borenstein (1990) [12] points out that hub-and-spoke networks also led to a decline in competition for passengers who want to fly to or from the hub airport. A comparison between airline fares on direct routes departing from a hub and by the same airlines' fares on routes not passing through the hub shows that the fares charged on the spokes of the system were significantly higher (by 15 to 40%) than those charged elsewhere.

## **Distribution Systems**

Until the 1970s, contact between airlines and distribution outlets was mainly by telephone, which was both time consuming and costly. As the 1970s proceeded, pioneering carriers automated the contact between the airline and travel agency via direct links into the airlines' reservations computer. These systems incited controversy almost from the beginning. It is estimated that 90% of reservations made by travel agents on these Computer Reservation System (CRS) are from the flights displayed on the first screen [20]. As CRSs were controlled by airlines these systems were a frequent source of manipulation as they could easily be used to favor the flights of the vendor carrier by rigging the display order. Computer Reservation Systems were first regulated by the CAB in 1984 in order to ensure display neutrality. A complete overview of airline reservations systems is provided by Copeland and McKenney (1988) [17].

Flights for a certain O-D market still appeared on the CRS display and were ranked by departure and total elapsed time. It was still important to be on the first screen listing for flights in order to have a significant number of bookings and thus market share. Hence competition was fierce and airlines scheduled flights at the most popular departure times and tried to reduce the planned connection time.

## Pricing and Revenue Management

Pricing and revenue management is an area that attracted much attention following deregulation. After deregulation, research emphasized how airlines could set prices to achieve a sustainable equilibrium. This field of study was rapidly expanded to address those problems confronted by airlines that operate schedules under uncertain demand conditions while facing stiff competition.

To increase total revenue and in an effort to better match the demand for each flight with its capacity, airlines offer a variety of fare products at different price levels for the same flight (differential pricing). Much of the rationale for price differentiation lies not in discrimination but rather in the different costs of serving passengers associated with different requirements. A leisure traveler who is willing to book well ahead when seats are more readily available is less expensive to accommodate than a business traveler who demands flexibility. Business passengers will often need to book a flight shortly before the departure, in the event of an unexpected business meeting, for example. Therefore airlines are obliged to have seats available at the last minute for a number of business travelers. This results in lower load factors on days when the actual (business) demand is lower than expected and must be accounted for when pricing different products. Fares thus must reflect the cost of providing different degrees of flexibility, even in economy class. Offering different fare products is also inevitably derived from the nature of airline market segmentation.

Revenue management is therefore the practice of determining the number of seats to be made available at each fare level, limiting low-fare seats and protecting higher-fare seats for late-booking passengers. The airline market has several niches, each with specific customer features. As a consequence, the price structure on a competitive route is not very transparent. A complete literature review dealing with revenue management and related problems can be found in Barnhart, Belobaba and Odoni (2003) [6] and McGill and van Ryzin (1999) [27].

## Competition

A crucial factor in the decision to pursue deregulation was the theory of contestability, which suggest that the threat of entry is sufficient to keep prices in a market at competitive levels. To be contestable, markets must meet several conditions, including an absence of barriers to entry, an absence of sunk costs on exit and the possibility of "hit and run" entry (entering the market, making a profit before the incumbent airline can react and, if necessary, leaving the market) [1]. However, by the late 1980s it was widely recognized that airline markets are not contestable, as potential competition appeared not to be a substitute for actual competition. Morrison and Winston (1987) [28], Borenstein(1989) [11] and other studies show that the number of airlines actually competing on a route has a significant effect on the price level, whereas the contestability theory suggests that the actual number of competitors should have no effect on prices. They also found through empirical analysis that a potential competitor has from one-tenth to one-third the competitive impact of an actual competitor in a market.

As a result of deregulation, new entry boomed and prices fell substantially on most routes, especially in long distance markets. In the early 1980s entry slowed considerably and subsequently many of the new entrants and the existing smaller carriers either merged with a major airline or declared bankruptcy and ceased operations. To a certain extent one could say that concentration was both horizontal (among the majors) and vertical (between the majors and small regional airlines). As Borenstein (1992) [13] found, concentration increased substantially between 1982 and 1990, even surpassing pre-regulation levels. Although there were fewer nationwide carriers, there was almost more competition at the city-pair route level than ever before, as competitors are effective substitutes in a market.

The airlines also successfully implemented marketing strategies to increase customer loyalty. Frequent Flyer programs (FFPs) and travel agent commission override programs (TACOs) were introduced shortly after deregulation. These programs created strategic advantages for airlines with large market shares while also reducing the threat of potential competition. In a way, FFPs encouraged travelers to choose the airline that they are most

likely to fly in the future.

In the 1990s the airline industry benefited from another innovation, namely the formation of international airline alliances. These alliances offered greater convenience to American and foreign passengers flying internationally. Furthermore, as airlines within an alliance enjoyed antitrust immunity, cooperative pricing of interline trips became possible. Brueckner and Whalen (2000) [16] found that the benefits of alliance membership resulted in a 25% reduction in interline fares compared with those charged by non-allied carriers.

### **Low-Fare Airlines**

The deregulation of the industry also allowed for the growth of low-fare, or low-cost airlines, which have rapidly gained market share from the major carriers. Franke (2004) [19] affirms evidence of the LCCs' sustainable growth and their development of an alternative business model that is better prepared to adapt to the changes in demand for domestic travel than that of the traditional carriers. However, he says that executives of major carriers were slow to challenge this new business model. It was initially seen as a regional phenomenon and restricted to a niche market sector, luring low yield passengers who would never have flown otherwise by offering the lowest service standards possible. After the invention of the low-cost business model by Southwest in the early 70s it took more than 15 years in the US and 20 years in Europe before major airlines began to take the challenge of this new business model seriously. The success of these low-fare, low-cost airlines is demonstrated by their phenomenal growth and financial performances.

In general, these airlines began providing point-to-point (non-stop), low-frill service in short-haul markets. However, some characteristics have evolved. Most low-fare airlines now offer coast-to-coast service within the United States and an increasing number of flights now connect at major cities, although that is not part of their primary scope.

The common denominator among all low-fare airlines is the deployment of streamlined operating processes and systems to keep productivity high and costs low. They have been

very successful in creating a business model with lean and efficient processes. One such example is the choice of a homogeneous fleet of cost-efficient airplanes (A320 or B737 families). Beyond that they consistently achieve record high employee and aircraft productivity that enables them to operate with minimum turnaround times. The cost gap with the legacy carriers can also be explained by lower wages, lower landing fees (by using smaller, less congested airports), reduced on-board amenities and lower costs associated with reservations (by selling paperless tickets through their websites).

Low-cost carriers have used their cost advantage to offer low fares to customers. Windle and Dresner (1995) [36] found that the entry of Southwest Airlines into a route decreased fares, on average, by 48% and resulted in an increase in passengers of 200%. In a subsequent study, Windle and Dresner (1999) [37] proved that this impact of entry can be extended to other LCCs, e.g. ValuJet's routing through an established carrier's hub. They also analyzed the pricing behavior of the legacy carrier on its non-competitive routes as means to compensate for lost revenues on its competitive routes; however, no evidence of increased fares was found.

Although low-fare airlines are having a tremendous impact on the airline industry, it should not be forgotten that many low-fare new entrants did not survive. As Gorin pointed out in his PhD thesis [22], numerous new entrants have either been acquired by a larger airline or have gone bankrupt. Examples are People Express and Midway. More recently, Independence air ceased operations. A different example consists of low-fare subsidiaries set up by legacy carriers in an effort to compete with independent low-fare airlines. Most of these subsidiaries were unsuccessful and closed down, with Song being one of the most recent examples.

### **2.1.2 Recent Impacts**

In the past few years, the airline industry has been hit by a series of unpredicted and uncontrollable non-economic factors, including major events such as terrorist acts involving commercial airplanes, the spread of the SARS virus and the increase in oil prices. All

have had measurable impacts on the airline industry. But even before these unprecedented events the industry was already undergoing fundamental and irreversible changes. They include but are not limited to the development of low-fare airlines, the transparency of fares provided by the Internet and a global downturn of the economy.

### **Emerging Distribution Systems**

The Internet Era profoundly changed the distribution landscape and impacted consumer choice behavior. With the success of their own websites, airlines were able to alleviate the firm control that travel agencies previously experienced over them. However, the build-up and growth of voluminous on-line travel agencies, such as Expedia is forming a new threat to the airlines. As Bakos (1998) [5] points out, electronic marketplaces enable new types of price discovery. He points out that airlines auction unsold seats at the last-minute to the highest bidders through Priceline, for example. He state that these intermediaries "allow consumers to specify product requirements and the amount they are willing to pay, and then make corresponding offers to the airlines, reversing the traditional functioning of retail markets".

With the increased availability of information on the Internet, customers are gaining more knowledge about their travel options and have the opportunity to become more sophisticated shoppers. They are able to comparison shop efficiently and to track prices over time, and they can learn to identify pricing patterns and delay or rush purchases based on anticipated price changes. But airlines can make it very difficult to compare the price of alternative product offerings by implementing complicated and changing fare structures. Eventually, airlines could attempt to collect information about buyers that allows more effective price discrimination.

Moreover, most Internet booking sites display itineraries in order of increasing fares and not necessarily by schedule of the flights. Not surprisingly, more and more tickets are sold over the Internet at lower fares, given the near perfect customer information about price.

## **September 11th, 2001 Terrorist Attacks**

The US airline industry greatly suffered from the terrorist attacks of September 11, 2001. As a direct result many travelers reduced air travel to the strict minimum. Still, there is some controversy about the long-term effects on the airline industry. Several studies were presented about this subject. Ito and Lee (2003) [26] used a monthly time-series analysis to find that September 11th resulted in a negative transitory shock of more than 30% as well as an ongoing negative demand shock amounting to roughly 7.4% of pre-September 11th demand that cannot be explained by economic, seasonal, or other factors. Blunk et al (2006) [10] also evaluated the long-term impacts using econometric and time-series forecasting methods and found that travel did not return to the levels expected in the absence of the attacks.

## **Global Economic Downturn**

The airline industry experienced the effects of the economic slowdown that began in early 2000. The recession and slow economic growth mainly affected business travel, on which airlines heavily rely to sell their high-fare seats. Rising unemployment levels decreased leisure travel, which was further affected by decreased household asset values; note Rubin and Joy (2005) [34], who have also extensively studied the consumer impacts of recent changes.

## **Pricing**

Borenstein 2005 [14] found that fares paid by passengers between 1995 and 2004 declined more than 20%. Some of the reasons for this were discussed above, but this thesis was undertaken to develop a better understanding of different drivers of these price changes, which have led to dramatic revenue declines for the airlines. Borenstein [14] also indicates that hub premiums fell by 24% over the same period. The effect of hubs in a market is one



of the factors that will be addressed in more detail in the empirical analysis in Chapter 3.

In the following section air travel demand studies will be presented, as these are of particular relevance to the regression analysis in Chapter 4.

## 2.2 Demand for Air Travel

Following the Deregulation of the US airline industry in 1978, many studies were produced about air travel demand. Several notable older studies will be discussed in the subsequent paragraphs followed by more relevant recent studies. The earliest studies focused mainly on the air traffic levels for a specified geographic area. After that, several other factors were taken into account to study the changes in air travel demand.

Both Abrahams (1983) [2] and Andersen-Kraus (1981) [3] developed an econometric model to estimate air travel demand in terms of quality of service. Both used a two-stage least squares procedure in order to determine their coefficients, and showed that air traffic is elastic with respect to airfares. Service quality has also been shown to be a significant determinant of demand.

Oum et al. (1992) [32] surveys the major empirical studies on the own-price elasticities of demand for transport of the previous ten years. First they present a theoretical introduction on the various concepts of elasticities used. This is followed by a summary of elasticity estimates for both passenger and freight demand. Looking at the demand elasticities of air passenger travel as surveyed in 13 studies, the estimates vary greatly between -0.4 and -4.51, with the majority falling between -0.8 and -2.0. They found that demand for business travel is less elastic than for leisure travel and that elasticity estimates from time-series data are generally lower than those from cross-section data.

Proussaloglou and Koppelman [33] presented a conceptual framework that analyzes air carrier demand in a competitive context to study the carrier choice of an individual traveler.

They found that membership and active participation in a frequent-flyer program results in the strongest impact on carrier choice. Travelers' perceptions of schedule convenience, low fares and on-time performance had a strong impact on carrier choice. Carrier market presence and the level of carrier service in a city pair market had the expected positive impact on carrier choice. The proven strength of frequent-flyer programs suggests that carriers with limited FFPs have to provide either substantially lower fares or a superior level of service to compete effectively.

In a study for the Canadian Department of Finance, Gillen et al. [21] gives the most complete and up-to-date overview of the literature on empirically-estimated price elasticities of demand. They used 21 Canadian and international empirical studies and found mean elasticity values ranging between -0.7 and -1.52 for domestic travel. The result differed significantly by distance and type of traveler (business/leisure) and therefore supports the concept of distinct air travel markets. Unique as well is their scoring of each study, which helps in judging the relevance of the elasticity values. Indeed, it should be noted that there is no single elasticity value that is representative of air travel demand, as there always is a range to consider to best forecast the impact of fare changes impacts. Most studies of air travel demand, as conducted, use a linear or log-linear functional specification. Therefore, both of these forms will be tested in the regression analysis performed on our database (Chapter 4).

Another comparative analysis of a large number of empirical studies in the field of price elasticities was performed by Brons et al. [15]. They collected 37 studies for a total of 204 observations and found a mean price elasticity of -1.146 with a standard deviation of the distribution of 0.619. They went on to discuss the importance of a number of driving forces. They reaffirmed that business passengers are less price-sensitive, that price elasticities are higher when viewed in the long-term and that if the income variable is omitted in a study, the price sensitivity is higher.

Finally, an MITRE Corporation study presented by Bhadra (2002)[9] estimates price elasticity of demand between -0.56 and -1.82 depending on O-D distance. Their results demonstrate that demography and local income affect travel in a positive manner. They also

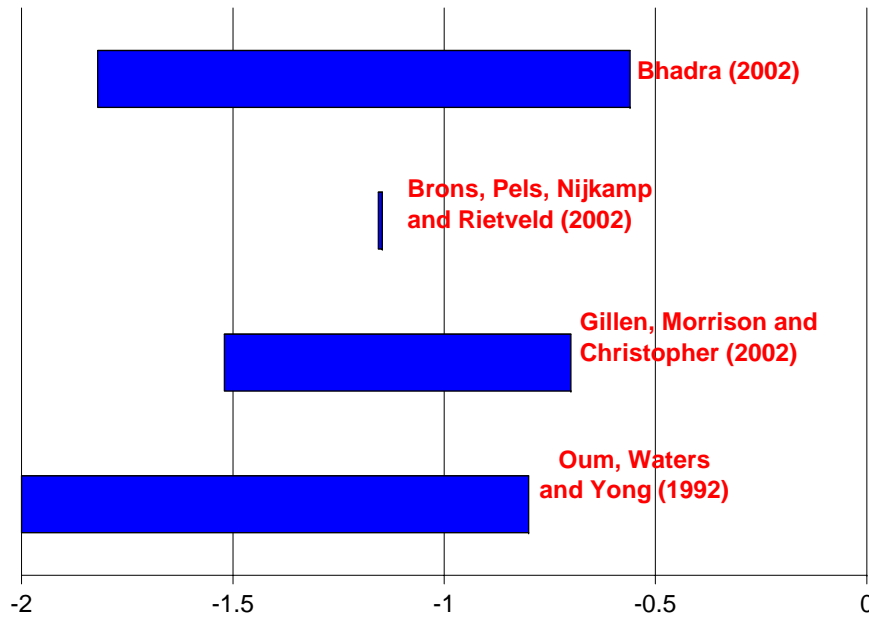


Figure 2-1: Summary of Price Elasticity of Demand Estimates

found that longer distance travel is more fare-elastic than shorter travel and that overall, the average fare tends to affect passenger travel negatively. Finally they identify the importance of large hubs and the higher market share of established airlines for passenger travel.

Figure 2-1 shows the range of price elasticity estimates for all air travel demand studies discussed. It can be concluded that the majority of estimates lie between -0.75 and -1.75. Considering the mean elasticities of all these studies, it can be said that air travel demand is elastic, meaning that a decrease in price will lead to an increase in passengers.

## 2.3 Summary

This chapter showed that the airline industry underwent major changes after the deregulation as well as more recently.

Deregulation led to the fortification of hub networks, complex pricing structure, airline concentration and the growth of low-fare airlines. As discussed, most of these consequences

generated significant impacts in terms of fare changes.

Since 2000, September 11th, the global economic downturn and the success of the Internet resulted in a second important wave of changes that will further be observed and analyzed in this thesis.

Finally, air travel demand studies were reviewed. Of the studies discussed, most price elasticity estimates are located between -0.75 and -1.75, with the majority being on the elastic side. Air travel demand has generally been accepted to be elastic, meaning that a price decrease results in a passenger increase.

## Chapter 3

# Empirical Analysis of Pricing and Competition in Top US Markets

The goal of this Chapter is to analyze recent changes in fares and traffic in the United States between 2000 and 2004, in order to better understand changes related with several factors such as distance, competition and hub effects. The focus lies on an empirical analysis performed on the Top 1000 US Markets. The approach used to obtain the total market sample is explained in Section 3.1. First, aggregated patterns of changes in fares and traffic are presented in Section 3.2. This is followed by a more detailed analysis (Section 3.3), where the total market sample will be segmented according to various factors. This is done to understand the individual effects of relevant factors on the changes in fares and traffic by looking at smaller portions of markets. Finally, this Chapter's findings will be summarized in Section 3.4.

### 3.1 Methodology

As already explained in Section 1.2.2, the main data source is derived from the Origin and Destination Survey of the US Department of Transportation (USDOT), which is a 10%

sample of airline tickets from reporting carriers. For this study, the processed data from O&D Plus of Data Base Products, Inc. was used.

The methodology used was to first filter out the Top 1000 US Markets for the years 2000 until 2004 from the O&D Plus package. Subsequently, the markets were matched, based on the market rank of the 2004 data. For example, the 4th biggest market in 2004, Los Angeles - New York was ranked as the 1st market in 2000. However, this market was matched on the 4th place through all the years, thus independent of its original position in a specific year. To create a better understanding of this procedure, a visualization of the data set after this matching process can be found in Appendix A-1 in the form of a snapshot.

At this point, some markets could not be matched through all the consecutive years, as data for only the Top 1000 Markets were available for each year. This caused the number of markets in each year to be unbalanced from 1000 in 2004 up to only 901 matching markets in 2000. For consistency, all markets with incomplete data were left out. The dataset of the Top 1000 US Markets therefore shrank to 873 consistent markets over the 5-year period. From now on, this dataset will be referred to as the *Total Market Sample*. It thus consists of 873 matching markets from the Top 1000 US Markets, consistent over the study period. The total market sample includes items such as passengers, revenues and distance aggregated per market and broken down by carrier within a market.

## 3.2 Aggregate Patterns

A first analysis is conducted on the aggregated total market sample in order to be able to discuss the trends and changes at an overall market level. This means that the numbers (passengers, revenues) used, are summed over all the carriers in each market. More specifically, all numbers presented in this section are not carrier specific but totals over the complete sample.

### 3.2.1 Metrics

Our main parameters of interest for this study are the number of passengers and revenues in a specific market. Then the average fare can be calculated with the following equation for each market or overall:

$$\text{Market Revenue} = (\text{Market Passengers}) \times (\text{Market Average Fare}) \quad (3.1)$$

At this point it should be noted that throughout this chapter, all calculated and presented average fares are weighted averages over all concerned markets. This weighted average fare is obtained with Equation 3.2 and is considerably different than taking the average of all Market Average Fares, as one can imagine due to different market sizes.

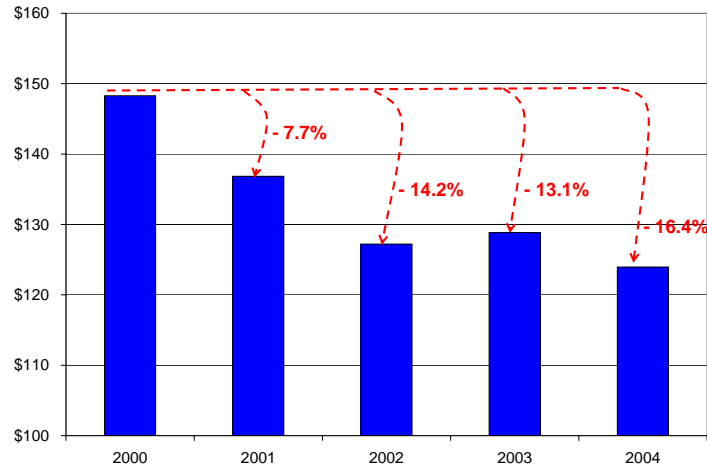
$$\text{Average Fare} = \frac{\text{Total Revenues}}{\text{Total Passengers}} \quad (3.2)$$

In the dataset both the number of passengers and revenues are given for each market in PDEW or Per Day Each Way, it is essentially to keep this in mind for the entire study in order to interpret the numbers correctly. Other parameters, such as distance, yield etc., are either readily available in the data set or they can be computed using simple formulas. These other metrics will be of importance at a later stage.

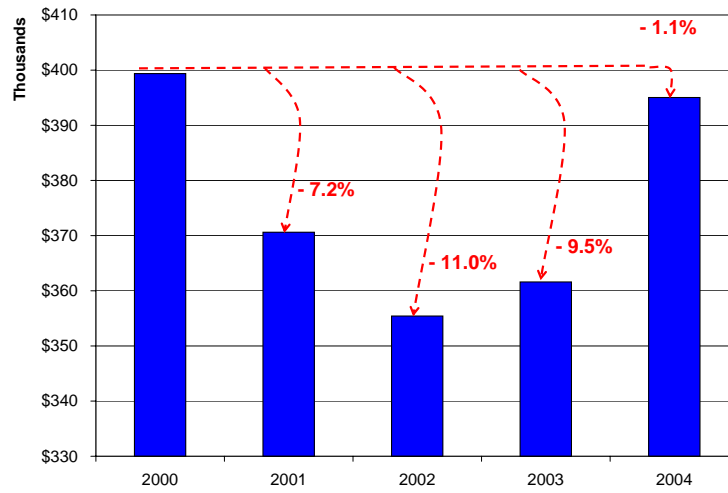
### 3.2.2 Aggregate Analysis

The above described variables (average fare, passengers and revenues) were calculated for the total market sample, comprising 873 markets from the Top 1000 US markets, for each year between 2000 and 2004. Figure 3-1 shows the changes in average fare, passengers and revenues for the 5-year period of the total market sample.

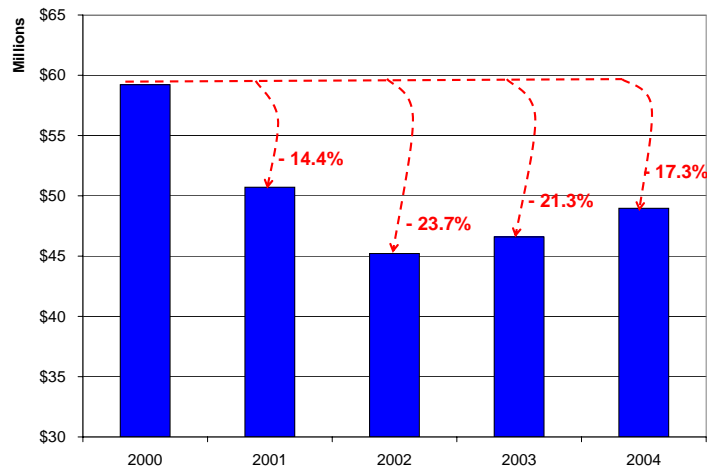
Analyzing the first figure, one can see that the (weighted) average fare over all markets dropped by 16.4% between 2000 and 2004. The evolution of the change in average fare from one year over another clearly was not gradual. Between 2000 and 2001, the average



(a) Average Fares - Total Market Sample



(b) Total Passengers PDEW - Total Market Sample



(c) Total Revenues PDEW - Total Market Sample

Figure 3-1: Changes between 2000 and 2004 of Total Market Sample



fare fell 7.7%. The following year, the average fare again decreased approximately the same amount to yield to a 14.2% drop between 2000 and 2002. After that, the average fare slightly increased (little over 1%) but was still 13.1% down in 2003 compared with 2000. Finally, the average fare dropped 3% more to lead to the steepest decline in the last five years of 16.4%.

The passenger volumes almost followed the same pattern as the average fare between 2000 and 2002, with the biggest decline in passengers of 11% in 2002 compared with 2000. However after that, traffic started to rebound. A huge increase in passengers is noted between 2003 and 2004 of 8.4%, to almost achieve the 2000 levels in terms of passengers. The number of passengers in 2004 was still 1.1% lower than in 2000.

Finally, the revenues can be looked at, as a combination of the patterns as experienced by both the average fare and passengers, as illustrated by Equation 3.1. Total revenues experienced a huge decline of over 14% by 2001 and over 23% by 2002. After that, a slow recovery is observed. In 2003, as both the average fare and total passengers slightly increased, the total revenues also increased by about 2.5% between 2002 and 2003, but were still more than 20% lower than they were in 2000. As in 2004 the total number of passenger grew substantially, the total revenues also grew 4% despite the fact that the average fare touched upon a new minimum. But there is still a long way to go, to achieve the same revenue levels as 2000, as they were still 17.3% lower in 2004.

In short, the average fare over all markets dropped 16.4%, whereas the passenger volumes almost rebounded to 2000 levels after dropping by 11%. At the same time, total revenues experienced a huge decline of over 23% by 2002, followed by a slow recovery since then. But the revenues are still 17.3% lower than in 2000. These very interesting patterns, are probably due to a combination of effects, such as the economic downturn, the events of September 11 (2001) and increased competition.

### 3.2.3 Effect of Sample Size

In order to determine how representative these changes and patterns are compared with the total domestic O-D traffic, it might be helpful to investigate the effect of the sample size. One way of to create a better understanding of how the changes relate to the sample size, is by looking at specific subsets of the total market sample. The total market sample was condensed to the Top 100 and Top 500 US Markets respectively and again the relevant parameters and percentage changes between 2000 and 2004 were calculated. These results combined with the results of the Top 1000 US Markets (as presented in Section 3.2.2) are displayed in Table 3.1.

Table 3.1: Aggregate Changes between 2000 and 2004 for different Subsets

<i>Top 100 Markets</i>			
	2000	2004	% change
number of markets	99	99	-
Avg Fare	\$144.6	\$116.6	-19.4
Passengers	147,113	146,547	-0.4
Revenues	\$21,272,990	\$17,088,749	-19.7
<i>Top 500 Markets</i>			
	2000	2004	% change
number of markets	491	491	-
Avg Fare	\$145.3	\$120.4	-17.2
Passengers	325,794	325,892	+0.03
Revenues	\$47,332,334	\$39,225,785	-17.1
<i>Top 1000 Markets</i>			
	2000	2004	% change
number of markets	873	873	-
Avg Fare	\$148.3	\$124.0	-16.4
Passengers	399,367	395,033	-1.1
Revenues	\$59,221,873	\$48,968,668	-17.3

It can be inferred from the table that the larger the number of markets, the more attenuated the results are for the average fare. As concentrating on the Top 100 US Markets, a drop of 19.4% in average fare is experienced by the 100 biggest US Markets, which is a greater decrease than the 16.4% as experienced by the Top 1000 US Markets. By increasing the sample size, the average fare itself slightly increases but the change in average fare between 2000 and 2004 becomes smaller.

The change in total number of passengers per day each way stays approximately stable for all three sample sizes, even if the number of passengers in the subset increases substantially, as more markets are involved in the analysis.

These results should be compared with the proportion of total US domestic traffic it represents, in order to know how representative they are. The total number of US domestic passengers in 2004 equalled 629,739,062 passengers, based on data from the Bureau of Transportation Statistics (BTS). One caution that should be exerted is that this number reflects the total number of enplaned passengers and not the total number of O-D passengers. The number of total O-D passengers can be extracted from O&D Plus and equals 434,868,840 passengers. Recall that the total number of passengers are given per day each

Table 3.2: Traffic for different Subsets in terms of Total O-D Passengers

	Total Passengers in 2004	% of Total O-D Passengers
Top 100 US Markets	106,979,310	24.60%
Top 500 US Markets	237,901,160	54.71%
Top 1000 US Markets	288,374,090	66.31%
Total O-D Markets	434,868,840	100%

way, whereas our total number of O-D passengers is based on a yearly basis. Multiplying the total PDEW Passengers in 2004 by 2 (directions) and by 365 (days) the yearly number of passengers can be found for the three subsets. Finally, one can find the percentage it represents of the total number of O-D passengers. The Top 100 US Markets represent 25% of the total O-D domestic traffic whereas the Top 500 and the Top 1000 represents respectively 55% and 66% of the total US O-D traffic as is displayed in Table 3.2.

### 3.2.4 Statistical Significance

In order to verify the reliability of the presented statistics, especially of the differences in average fare observed between 2000 and 2004, statistical tests were performed on the data set.

As the average fare of 2000 and 2004 had to be compared in order to determine if the

change is statistically significant, a t-test was performed. The t-test assesses whether the means of two groups are statistically different from each other, and is thus appropriate when a comparison of means is needed. The formula for the t-test for the average fare is:

$$\begin{aligned}
 t &= \frac{Mean_{04} - Mean_{00}}{\sqrt{\frac{Var_{04}}{N_{04}} + \frac{Var_{00}}{N_{00}}}} \\
 &= \frac{131.14 - 157.44}{\sqrt{\frac{1894}{873} + \frac{4483}{873}}} \\
 &= -9.732
 \end{aligned} \tag{3.3}$$

As can be derived from Equation 3.3, the t-value will be positive if the first mean is larger than the second and negative if it is smaller. Once the t-value has been computed, it should be looked up in a table of significance to test whether the ratio is large enough to say that the difference between the groups is not likely to have been a chance finding. To test the significance, one needs to set a risk level (called the alpha level). As a rule of thumb, the alpha level is set at .05. This means that five times out of a hundred one would find a statistically significant difference between the means even if there was none. The degrees of freedom (df) for the test also need to be specified, which equals the sum of the observations in both samples minus 2. For this test, the degrees of freedom thus equal 1744. Given the alpha level (.05), the degrees of freedom (1744) and the t-value (-9.732), one can look up the t-value in a standard table of significance to determine if the t-value is large enough to be significant. Every t-value greater than 1.96 is significant for this example. This condition is largely met thus the difference between the means of the two average fares is different (even given the variability in average fare over the markets).

At no surprise, the t-statistics turned out to be highly significant for the difference in average fare. One of the reasons is the large sample size ( $N = 873$  markets). As the average fares are highly significant it is very sure that this difference is real and that it did not happen by accident. Other t-tests were performed on the total market sample and as expected, the presented results for the aggregate analysis turned out to be statistically significant.

### 3.3 Segmentation of O-D Markets

Considering the aggregate patterns the general trends were analyzed, but as can be imagined there are great variations in metrics across markets. One illustration of this statement can be given by looking at the distribution of changes in average fare between 2000 and 2004 for all markets. This is plotted in Figure 3-2 and as expected, the change in fare is not uniform across markets as 673 markets experienced a decrease in average fare, whereas 200 markets actually experienced an increase in average fare.

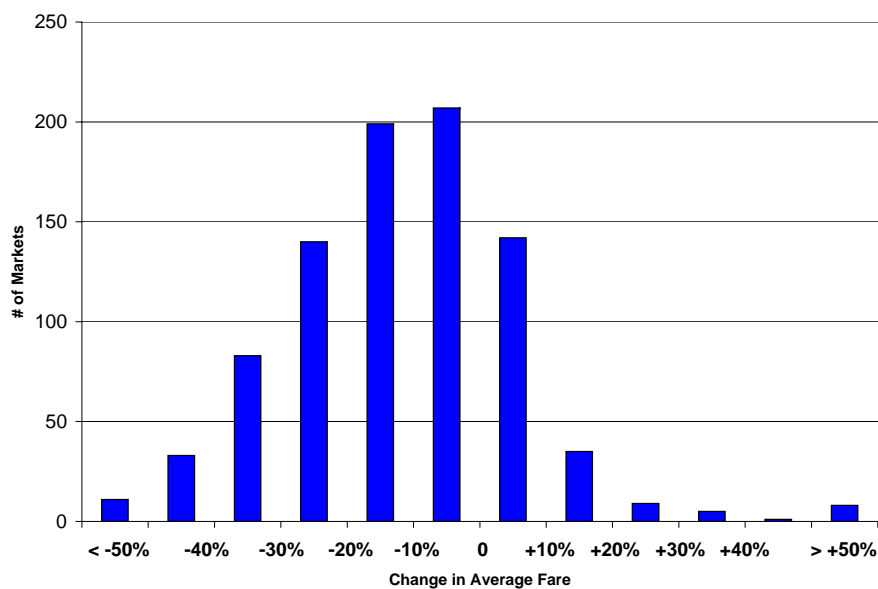


Figure 3-2: Distribution of Change in Average Fare between 2000 and 2004

In order to better understand these variation, this Section will explore various factors that are considered to be relevant to explain which markets grew i.e. in terms of passengers, which markets experienced the biggest fare declines and which markets lost the most revenues. According to one factor, the total market sample will then be segmented into several categories and changes in performances will again be analyzed. The actual segmentation of the markets is always based on a market's position in 2004, except if otherwise stated. The factors that will be used as criteria to segment the total market sample are:

- Carrier and Type of Carrier

- Distance
- Hub versus non-Hub
- Competition by Low-fare Airlines
- Concentration

These factors will be presented one by one in the following subsections in order to better capture the effects of each element individually.

### **3.3.1 Analysis by Carrier and Type of Carrier**

After looking at the big picture of trends in fare and passenger changes, the data is inspected at a more detailed level in this section. One level of detail is to look at individual carrier's behavior in the aggregate sample. This can be done by analyzing their respective market and revenue shares and changes of these in the period studied.

#### **Analysis by Carrier**

In Table 3.3, the market and revenue shares are presented of the major carriers that were both present in 2000 and 2004, ordered from the biggest winners in market share down to the greatest market share losers (in terms of passengers). The market share represents the number of passengers each carrier transported compared to the total number of passengers in the Top 1000 Markets. Similarly the revenue share is computed by comparing the carrier's individual revenue to the total revenue.

When taking a closer look at the table, it is obvious that most low fare airlines gained both market and revenue share while most legacy carriers lost market and revenue share. Overall, Southwest is market share leader both in 2000 and in 2004 and they are still expanding their services. Recalling that this sample only considers domestic markets, it

Table 3.3: Market and Revenue Shares per Carrier of Total Market Sample

Carrier	MS in 2004	MS in 2000	change	RS in 2004	RS in 2000	change
Jet Blue	2.80%	0.28%	+2.52	2.34%	0.18%	+2.17
American	13.13%	10.87%	+2.26	15.90%	15.03%	+0.87
Southwest	20.30%	18.47%	+1.82	13.37%	10.15%	+3.21
Airtran	2.38%	1.32%	+1.06	1.83%	0.89%	+0.94
ATA	2.44%	1.50%	+0.94	2.11%	1.23%	+0.88
Frontier	1.37%	0.64%	+0.73	1.31%	0.68%	+0.62
Spirit	1.37%	0.71%	+0.66	0.91%	0.49%	+0.42
America West	3.97%	3.41%	+0.56	3.92%	2.82%	+1.09
Alaska	3.18%	2.91%	+0.27	2.74%	2.06%	+0.68
Continental	6.50%	6.78%	-0.28	8.62%	8.98%	-0.36
Sun Country	0.31%	0.60%	-0.29	0.27%	0.41%	-0.14
Northwest	4.78%	5.18%	-0.40	6.05%	6.07%	-0.02
Delta	11.80%	13.25%	-1.45	12.08%	13.64%	-1.56
United	10.16%	11.75%	-1.59	13.00%	16.40%	-3.41
US Airways	5.30%	8.17%	-2.87	5.67%	8.29%	-2.62

makes perfect sense that Southwest is the leader. The biggest winner over these 5 years, both in market and revenue share is Jet Blue, this is mainly due to the fact that Jet Blue started its operations early 2000 and since then it has been very successful in growing. American takes the second place. This is primarily a result of its acquisition of Trans World Airlines in 2001. Behind Southwest, there is a middle category of airlines that are mostly low-fare airlines and that did not see any major changes in market and revenue share. At the bottom of the table, US Airways, United and Delta lost between one and four percent in market and revenue share, which is a clear indication of their recent difficulties.

Table 3.4: Average Fare and Average Haul per Carrier of Total Market Sample

Carrier	Avg Fare in 2004	Avg Fare in 2000	% change	Avg Haul in 2004	Avg Haul in 2000	% change
Jet Blue	\$103.78	\$91.97	+12.84	1,408	1,158	+21.61
Sun Country	\$107.98	\$102.70	+5.14	1,300	1,232	+5.52
Alaska	\$106.82	\$104.94	+1.79	1,017	736	+38.23
Southwest	\$81.64	\$81.57	+0.08	1,017	1,010	+0.76
America West	\$122.26	\$122.98	-0.58	1,605	1,495	+7.33
Airtran	\$95.36	\$100.17	-4.80	954	724	+31.80
Northwest	\$156.87	\$173.77	-9.73	1,422	1,473	-3.49
ATA	\$107.64	\$122.06	-11.81	1,392	1,368	+1.74
US Airways	\$132.66	\$150.66	-11.95	1,124	1,099	+2.25
Continental	\$164.48	\$196.59	-16.34	1,329	1,399	-5.04
Delta	\$126.88	\$152.78	-16.95	1,349	1,324	+1.95
Spirit	\$82.27	\$100.97	-18.52	1,071	1,034	+3.61
United	\$158.62	\$207.18	-23.44	1,474	1,567	-5.95
Frontier	\$118.05	\$159.8	-26.11	1,223	1,068	+14.52
American	\$150.06	\$205.10	-26.83	1,447	1,462	-1.07

Another parameter of interest is the change in average fare per carrier. Table 3.4 summarizes the absolute average fares in 2000 and 2004 as well as the percentage change per carrier. This table also presents the average haul of each carrier in 2000 and 2004 and the

respective percentage changes, as on average longer hauls tend to have higher fares.

Overall, most carriers experienced a huge drop in average fare, with American clearly taking the lead with a reduction from over \$205 to \$150, which is a 26.8% change. Some low-fare carriers slightly increased their average fare. Jet Blue however, should be considered as an exception as in 2000 their operations were limited and included much shorter routes. Southwest managed to hold their average fare constant over this 5-year period. The airlines with the largest decrease in average fare are almost solely legacy carriers, but both Spirit and Frontier stand out. Both carriers entered new markets between 2000 and 2004, which increased their number of markets in which they compete and also resulted in an increased average haul. These factors also contributed towards their lower average fare as will be explained more in depth in subsequent sections.

### **Carrier Categorization**

At this point, the carriers can be grouped into separate and distinct categories in order to provide results per type of carrier. One common way of categorizing is based on the business model of network/legacy and low cost carriers. However, for the scope of this thesis, this classification was reviewed, in order to reflect the airlines' pricing practices. Therefore the term low-fare airline will denominate an airline offering low fares throughout the booking process. In most reports low cost carriers are also considered as low-fare airlines but for this thesis specifically it is of primary importance to define the low-fare carriers.

First, the yield versus average haul was plotted in Figure 3-3 for the major carriers using the data available from the total market sample. The figure shows the evolution between a carrier's position in 2000 and in 2004, with the arrow pointing towards the carrier's most recent situation, as of 2004. Within the graph, one can draw a separation between the high and low fare airlines. The presented line has been plotted first based on a power trend line for the 2004 data and has been further modified to reflect the discussion of the next paragraphs.



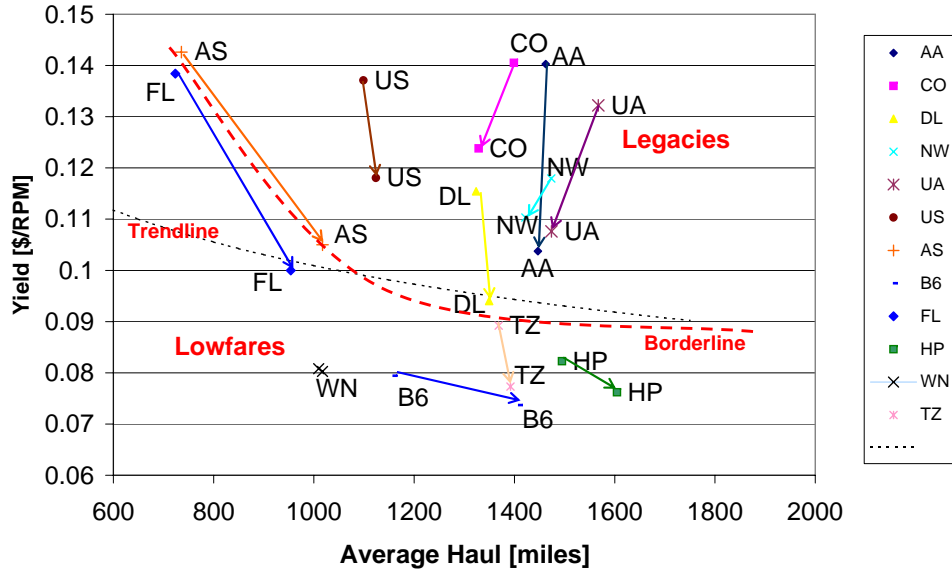


Figure 3-3: Carrier Analysis of 2000 and 2004 data, Yield versus Average Haul

Analyzing the figure more closely logically indicates major carriers such as Continental (CO), Northwest (NW), United (UA), American (AA) and US Airways (US) as high-fare airlines. Surprisingly, Delta (DL) is right under the border line for 2004 as it recently simplified its fare structure. But when inspecting Delta's 2000 position, it clearly belongs in the high-fare carrier zone. Historically, Delta has always been considered as one of the big six legacy carriers and therefore it will still be accounted as a major high-fare carrier.

Under the trend line there are the well established low-fare carriers such as Southwest (WN), JetBlue (B6), America West (HP) and ATA (TZ). From now on, these carriers are all grouped in the low-fare category.

In between the two clear zones, there is a gray area including Alaska (AS) and AirTran (FL). When taking a closer look at AirTran, its 2000 data point is in the upper left corner but it is actually situated under the curve for the 2004 data. AirTran grew which is indicated by their increase in average haul and their number of competing markets and passengers that approximately doubled over these 5 years. Moreover, AirTran is commonly accepted to be a low cost carrier, and it is thus uncontroversial to categorize it as a low-fare airline. Alaska however, is in a more complicated situation. It claims and market itself to be a low cost carrier, but their fare structure clearly does not follow the general low cost carrier

patterns. Above that, Alaska falls above the dividing curve and several previous studies reported Alaska as a network carrier, including the GAO Report [31] and Bhadra study [9]. All these reasons combined suggest Alaska should be categorized as a high-fare airline.

In order to group all the airlines appearing in the total market sample, an extra category "Others" was created to accommodate regional (incl. Legend, Midway, Midwest) and Hawaiian (Aloha and Hawaiian) carriers, as well as the Off-line Connects, Other Locals and Unduplicated Commuters as reported by the O&D Plus package.

The final segmentation of all carriers included in the dataset between 2000 and 2004 between the traditional network or legacy carriers, low-fare airlines and others (including Regional and Hawaiian carriers) can be found in Table 3.5. This categorization will be used throughout the study.

Table 3.5: Carrier Segmentation

Legacy Carriers	NC	Low-Fare Airlines	LFA	Others	-
Alaska Airlines	AS	Airtran/Frontier	FL	Allegiant Air	G4
American Airlines	AA	America West Airlines	HP	Aloha Airlines	AQ
Continental Airlines	CO	American Trans Air	TZ	Chautauqua/Precision Val	RP
Delta Air Lines	DL	Frontier Airlines	F9	Hawaiian Airlines	HA
Northwest Airlines	NW	Jet Blue	B6	Legend	LC
Trans World Airlines	TW	National Airlines	N7	Midway Airlines	JI
United Airlines	UA	Pro Air Services	P9	Midwest Express Airlines	YX
US Airways	US	Southwest Airlines	WN	Off-line Connects	Offline
USAir Shuttle	TB	Spirit Air Lines	NK	Other Locals	Other
		Sun Country Airlines	SY	Sun World Int'l Airlines	SM
		Vanguard	NJ	Unduplicated Commuter	XX

### Analysis by Type of Carrier

As different types of carriers were defined above, the previous analysis by carrier is now performed again on a more aggregated level. Table 3.6 shows the market and revenue shares per type of carrier of the total market sample. The market share gained by the low-fare carriers directly comes from the loss of the legacy carriers, the same holds for the revenue shares. In a sense these two types of carriers are complimentary and directly competing with each other as the "Others" category remains fairly constant.

Table 3.6: Market and Revenue Shares per Type of Carrier of Total Market Sample

Carrier	MS in 2004	MS in 2000	% change	RS in 2004	RS in 2000	% change
Legacy Carriers	54.84%	61.65%	-6.80	64.05%	73.46%	-9.40
Low-Fare Carriers	34.94%	27.86%	+7.08	26.06%	17.51%	+8.55
Others	10.22%	10.50%	-0.28	9.89%	9.03%	+0.86

Analyzing the breakdown of average fares per type of carrier reveals that the legacy group underwent the biggest decrease in fare of over 18%, while the low-fare carriers were able to hold their fares constant over the 5-year period. The biggest decrease in fare is also linked with their longer average haul. Moreover, the low-fare carriers are still growing and expanding towards longer haul markets, as is reflected in the largest increase in average haul for this specific group.

Table 3.7: Average Fares per Type of Carrier of Total Market Sample

Carrier	Avg Fare in 2004	Avg Fare in 2000	% change	Avg Haul in 2004	Avg Haul in 2000	% change
Legacy Carriers	\$144.77	\$176.81	-18.12	1,309	1,202	+8.84
Low-Fare Carriers	\$92.47	\$93.27	-0.86	1,246	1,097	+13.65
Others	\$119.94	\$127.70	-6.07	1,067	951	+12.12

### 3.3.2 Analysis by Distance Category

Another factor to be considered in the segmentation analysis is the market distance, as short and long haul markets have very distinct characteristics. Therefore, one can imagine observing different changes in fares, passengers and revenues for markets with different distances.

Three categories were chosen that best reflects the differences between short and long haul markets, keeping in mind that the categorization reflects a real distribution of number of markets in each category. Short haul markets are markets with a non stop mileage under 500 miles, Medium Haul between 500 and 1500 miles and Long Haul markets are defined over 1500 miles. This gives an approximately 25-50-25% distribution of number of markets across the different data sets (Top 100, Top 500 and Top 1000), which is detailed in Figure 3-4 for the total market sample.

Figure 3-5 displays the changes between 2000 and 2004 by distance category (short,

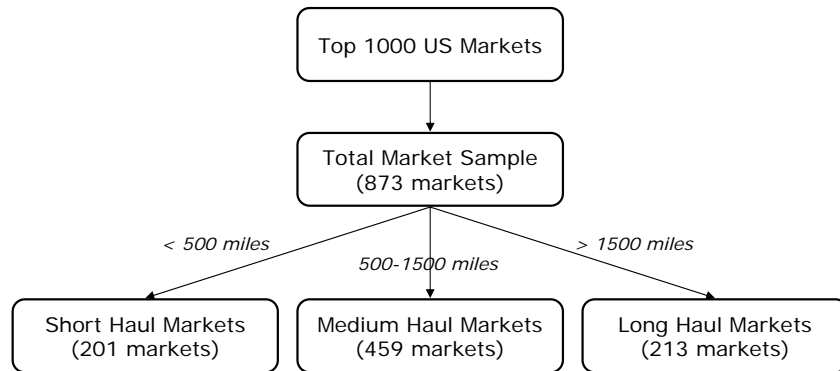
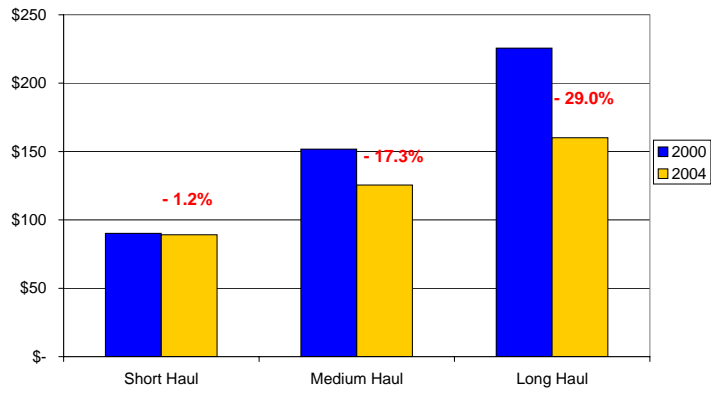


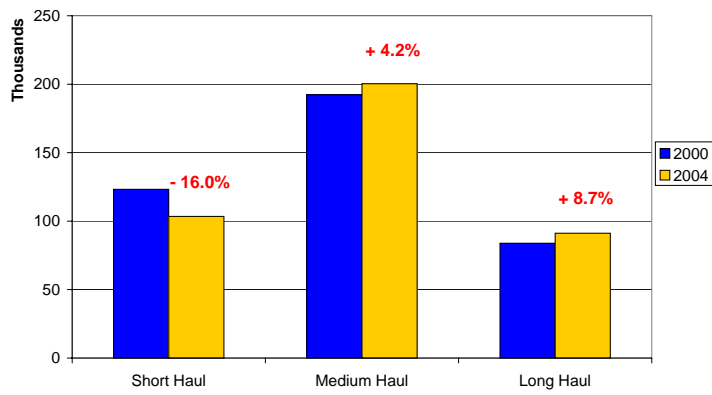
Figure 3-4: Distribution of Markets by Distance Category

Table 3.8: Changes between 2000 and 2004 per Distance Category of Total Market Sample

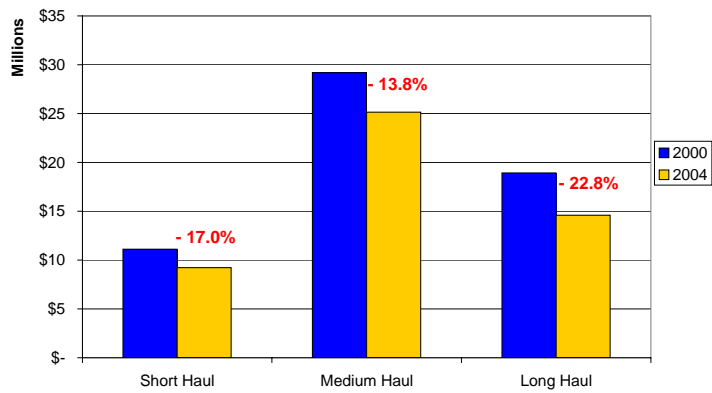
<i>Short Haul (&lt; 500 miles)</i>			
	2004	2000	% change
Avg Fare	\$89.13	\$90.20	-1.2
Passengers	103,463	123,228	-16.0
Revenues	\$9,221,315	\$11,115,480	-17.0
<i>Medium Haul (500-1500 miles)</i>			
	2004	2000	% change
Avg Fare	\$125.50	\$151.79	-17.3
Passengers	200,379	192,274	+4.2
Revenues	\$25,147,833	\$29,184,609	-13.8
<i>Long Haul (&gt; 1500 miles)</i>			
	2004	2000	% change
Avg Fare	\$160.10	\$225.62	-29.0
Passengers	91,191	83,865	+8.7
Revenues	\$14,599,520	\$18,921,784	-22.8



(a) Average Fares - Total Market Sample



(b) Total Passengers PDEW - Total Market Sample



(c) Total Revenues PDEW - Total Market Sample

Figure 3-5: Changes between 2000 and 2004 of Total Market Sample by Distance Category

medium and long haul) for the total market sample, whereas Table 3.8 presents the same information in numerical values for the relevant metrics. A first observation is that the average fares in the short haul markets remained constant over the years, whereas the long haul markets experienced a 29% decrease in average fare. Moreover, the short haul markets saw a decline of passengers of 16%, whereas the longer haul markets increased their passengers up to almost 9%. One possible explanation for these statistics is that more recently the low-fare airlines have been expanding into longer distance flights which resulted in a decline in fare and a stimulation of passengers especially for these markets. Still, revenues are down between 14 and 23%, which shows that even with passenger stimulation airlines are not able to generate the same revenues.

### 3.3.3 Hub versus non-Hub Markets Analysis

As has extensively been treated in the literature, a hub can lead to fare premiums for the major carrier. In order to better understand these effects, an analysis based on the presence of a hub is performed on the total market sample.

#### Hub Definition

A hub is defined in this thesis, as a major airport with a significant portion of connecting traffic in its domestic operations. Therefore the percentage of connecting passengers is calculated by applying the following formula:  $CON = (OUT - LOC)/OUT$ , where  $CON$  means the percentage of connecting passengers,  $OUT$  represent the number of outbound passengers and  $LOC$  stands for the local O-D traffic. Airports with more than 50% connecting traffic are considered as a major hub. In this thesis international entry airports into the United States, such as Miami, New York Kennedy and San Francisco, are excluded as they do not reflect true domestic hub operations. Table 3.9 summarizes the airports with the corresponding data from Airport Daily [18] that will be denoted as a hub for further analysis.

Table 3.9: Hub Airports

Airport	Outbound Passengers	Connecting Passengers	% Connecting Traffic
Cincinnati	10,941,264	8,820,354	80.62%
Charlotte	12,385,716	9,557,456	77.17%
Atlanta	41,027,910	28,615,360	69.75%
Houston	17,158,638	11,611,568	67.67%
Dallas/Fort Worth	27,973,290	18,332,740	65.54%
Memphis	5,390,876	3,522,746	65.35%
Chicago O'Hare	35,962,573	23,282,563	64.74%
Detroit	17,003,890	10,244,160	60.25%
Minneapolis/St.Paul	17,383,298	10,463,578	60.19%
Pittsburgh	7,076,990	3,831,010	54.13%
Denver	20,347,706	10,751,636	52.84%

### Hub versus non-Hub Markets Analysis

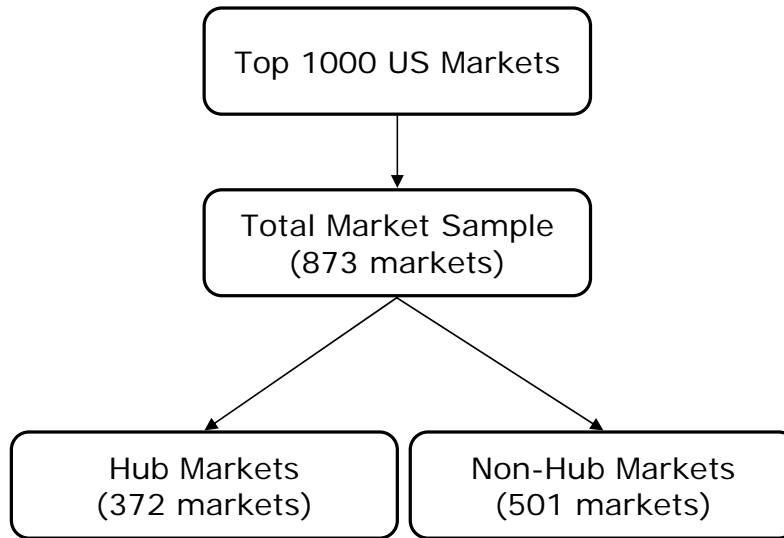


Figure 3-6: Distribution of Markets by Hub presence

Now that the hub airports are defined, the total market sample can easily be separated in hub and non-hub markets. The sole criterion is, that if one market has either the origin or the destination being a hub, the market will be categorized as such. Figure 3-6 shows the proportion of the total market sample that thus has at least one hub.

Table 3.10 and Figure 3-7 display the changes in the studied period of the total market sample by hub presence, by separating out the hub and non-hub markets. Looking at the results, the average fare is notably higher for hub markets than for non-hub markets, despite the fact that they have a shorter average distance. As a result, they tumbled further leading

to an average fare change of almost 20%. The number of passengers diminished more for the hub markets, which also results in an important loss of revenue of 21.4%. Hub markets are mainly operated by legacy carriers, as low-fare airlines are developed around point-to-point network, which in part explains these results.

Table 3.10: Changes between 2000 and 2004 by Hub presence of Total Market Sample

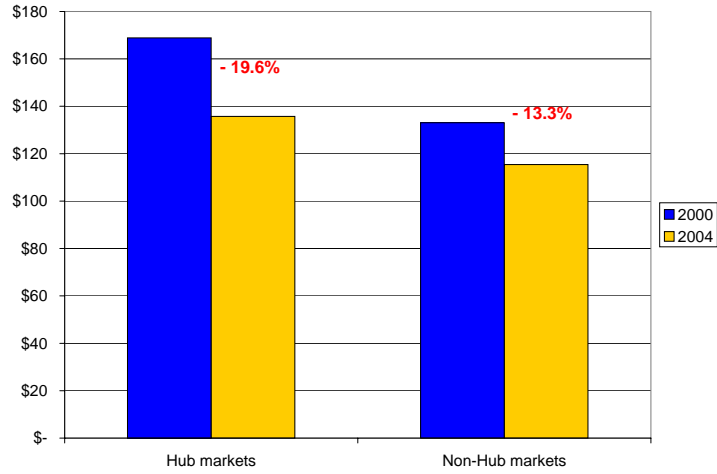
<i>Hub markets</i>			
Average Distance = 985 miles			
	2004	2000	% change
Avg Fare	\$135.7	\$168.9	-19.6
Passengers	166,205	169,869	-2.2
Revenues	\$22,558,724	\$28,682,681	-21.4
<i>Non-Hub markets</i>			
Average Distance = 1,133 miles			
	2004	2000	% change
Avg Fare	\$115.4	\$133.1	-13.3
Passengers	228,828	229,498	-0.3
Revenues	\$26,409,944	\$30,539,192	-13.5

### 3.3.4 Analysis of Competition by Low-fare Carriers

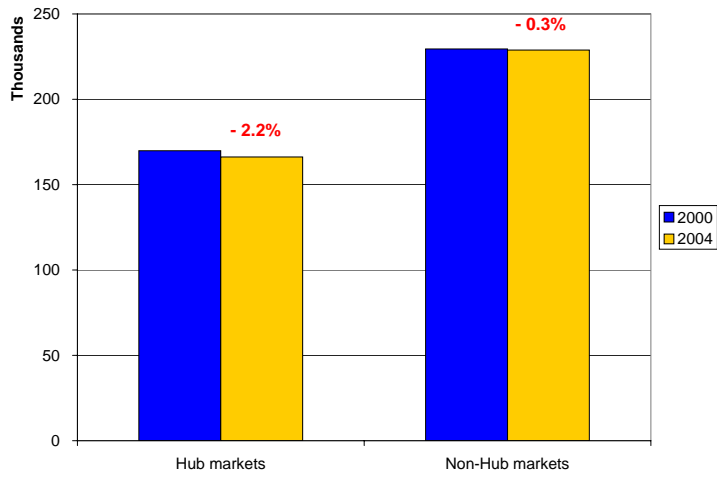
One of the most interesting segmentation of the total market sample is by low-fare carriers' competition. For a certain market, the total market share of the three previously defined types of carriers can be computed in terms of passenger share. As within a certain market the total market share of the legacy, low-fare airlines and others are known it is possible to look at the changes in the respective markets. Significant low-fare carrier competition has been defined if in a certain market the market share of low-fare airlines greater is than 10%. This segmentation by low-fare carriers market share was performed twice, once based on the 2004 data and then on the 2000 data. This made it possible to get a better view of the evolution of the respective markets and to capture other effects such as new significant entry of low-fare airlines into markets.

Figure 3-8 shows the distribution of the number of markets that either have significant LFA market share or not. For example, when looking at the 2000 data, 365 markets had no significant LFA presence, while in 2004 this number decreased to 283. There is a difference

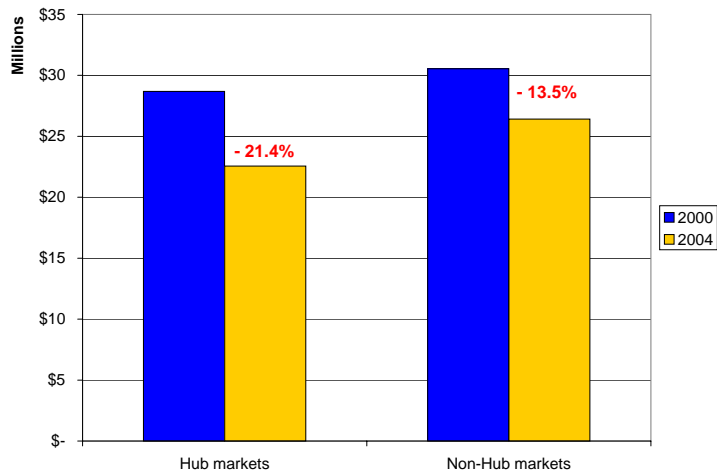




(a) Average Fares - Total Market Sample



(b) Total Passengers per day - Total Market Sample



(c) Total Revenues per day - Total Market Sample

Figure 3-7: Changes between 2000 and 2004 of Total Market Sample by Hub presence

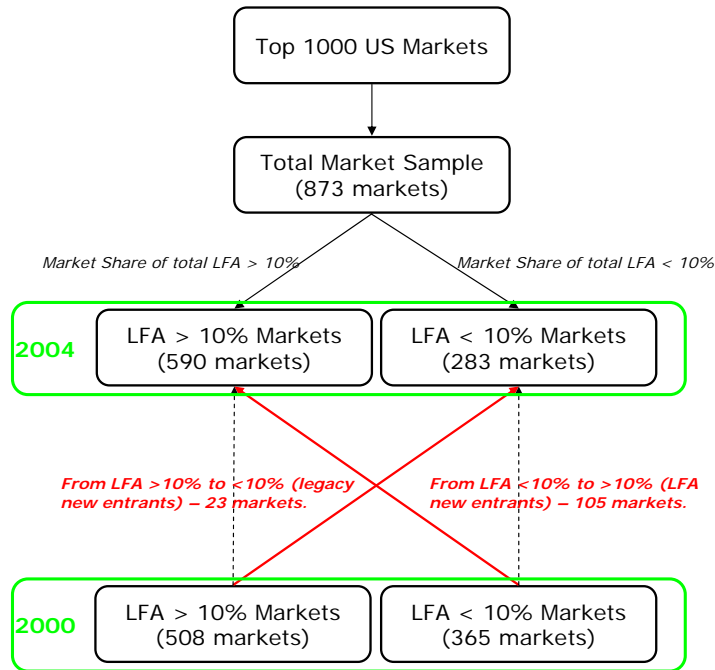


Figure 3-8: Distribution of Markets by LFA presence

of 82 markets that moved to the category with significant LFA competition. However, 105 markets experienced low-fare new entry, which basically is measured by a change in market share of the LFAs from less than 10% to more than 10% between 2000 and 2004. Consistently, 23 markets experienced a legacy new entry or LFA reduction as the low-fare airlines' market share decreased from more than 10% to less than 10%.

The following paragraphs will first look at the LFA presence in 2004, then 2000 and finally the interesting groups of LFA and Legacy new entry.

### Analysis by LFA presence in 2004

Table 3.11 and Figure 3-9 again shows the changes in average fare, passengers and revenues for the categories with significant and non-significant LFA market share. The average fare decreased slightly more for markets with well-established LFA market share than for the markets with non-significant LFA presence. But this difference of 1.4% is surprisingly very

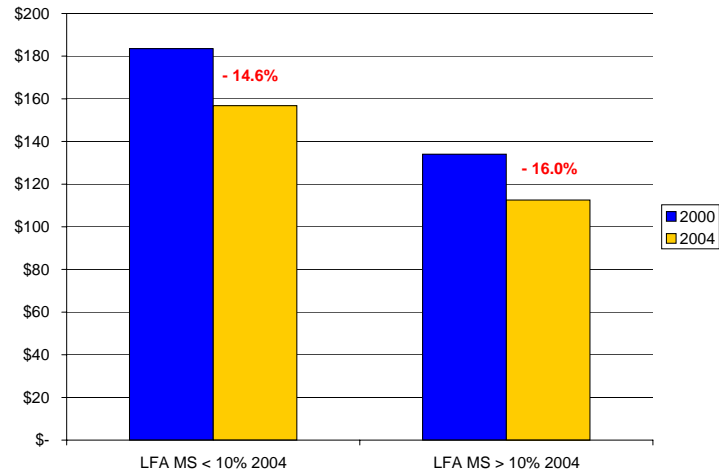
small, as it is not obvious that markets without LFA presence would drop that much in average fares. This is a clear indication that there is more going on in the airline industry than just the increased competition of low-fare carriers. Moreover, markets with LFA presence showed an important traffic growth of 3% whereas in O-D markets with small LFA market share traffic is still 11% below the 2000 level. This clearly shows a disparity between low-fare airlines that are able to capture extra demand by lowering their fares, while the legacy airlines are struggling to survive with their lowered fares and unable to keep their number of passengers at the same previous level. As a result, the markets with a combined low-fare airlines' market share smaller than 10% revenues overall experienced a 24% drop, while the markets where low-fare airlines' market share greater are than 10% could moderate their decrease of revenues to only 13.5%.

Table 3.11: Changes between 2000 and 2004 by LFA presence in 2004 of Total Market Sample

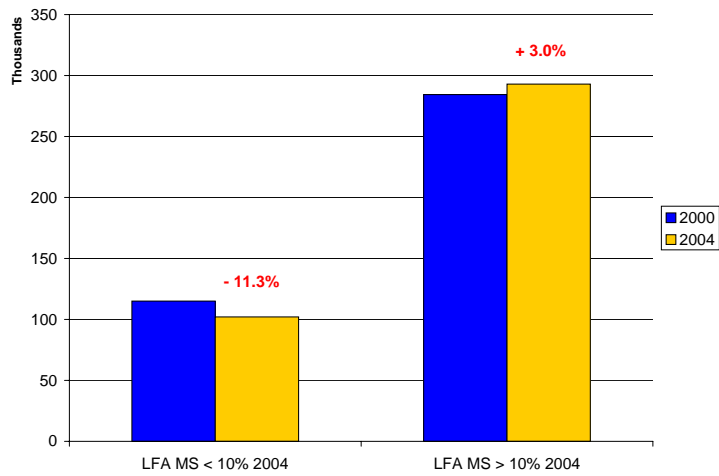
<i>LFA &lt; 10% in 2004</i>			
	2004	2000	% change
Avg Fare	\$156.8	\$183.5	-14.6
Passengers	102,030	115,009	-11.3
Revenues	\$15,994,816	\$21,108,989	-24.2
<i>LFA &gt; 10% in 2004</i>			
	2004	2000	% change
Avg Fare	\$112.5	\$134.0	-16.0
Passengers	293,003	284,357	+3.0
Revenues	\$32,973,853	\$38,112,884	-13.5

### **Analysis by LFA presence in 2000**

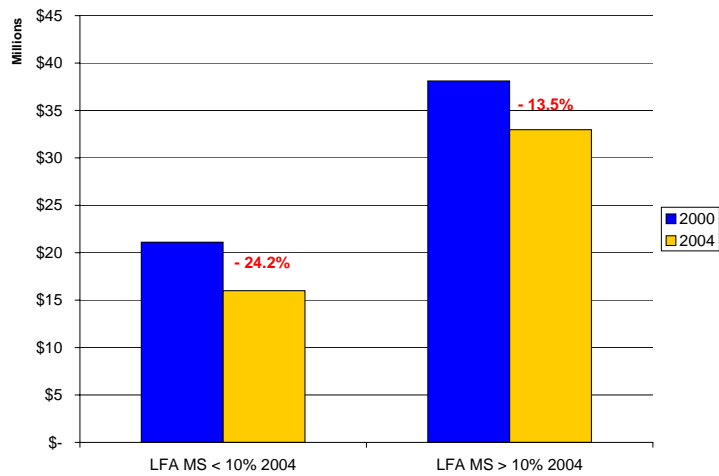
The same analysis is again performed, but now by sorting the markets based on their 2000 position and subsequently looking at their matching markets up to 2004. When looking at the markets with small, non-significant LFA presence it should be kept in mind that in a large part of these markets LFA either entered or grew considerably. Therefore, the average fare dropped 21.6% as can be seen in Table 3.12. On the other side, markets with significant LFA market share only lost 11.4% in average fare, while their passengers stayed at a more or less constant level. It should be noted that this analysis is less explanatory but serves as an introduction to the concept of new entry and is needed to form a good understanding of



(a) Average Fares - Total Market Sample



(b) Total Passengers PDEW - Total Market Sample



(c) Total Revenues PDEW - Total Market Sample

Figure 3-9: Changes between 2000 and 2004 of Total Market Sample by LFA presence in 2004

the complete picture.

Table 3.12: Changes between 2000 and 2004 by LFA presence in 2000 of Total Market Sample

<i>LFA &lt; 10% in 2000</i>			
	2004	2000	% change
Avg Fare	\$147.4	\$187.9	-21.6
Passengers	151,484	153,633	-1.4
Revenues	\$22,326,218	\$28,870,702	-22.7
<i>LFA &gt; 10% in 2000</i>			
	2004	2000	% change
Avg Fare	\$109.4	\$123.5	-11.4
Passengers	243,550	245,734	-0.9
Revenues	\$26,409,944	\$30,539,192	-12.2

### Analysis of New Entry

New entry in a market is generally defined as a new player that enters a market. Here this definition is taken more widely and defined as a change in status of LFA MS between non-significant and significant. Therefore, low-fare carriers' new entry is demarcated as a change in market share between 2000 and 2004 from smaller than 10% to greater than 10%. This category, as can be imagined, has by far experienced the greatest drop of 31.3% in average fare. Actually this number can be slightly boosted by taking a stricter definition of low-fare entry as the markets with zero LFA market share in 2000 to more than 10% in 2004. A decrease of 31.8% is observed for these 64 markets. Not surprisingly, the number of passengers increased 19.2%, as a result of passenger stimulation, but apparently this stimulation was not sufficient to break even with the revenues as they are down 18.1%.

Taking a look at the other side of the coin, a category has been defined as legacy new entry. This means that the low-fare market share actually has decreased between 2000 and 2004, in favor of the legacy carriers. These 23 markets were able to increase their average fares by almost 5%. However, they experienced a huge loss in passengers of almost 20% and therefore also a loss in revenues of 16%.

Table 3.13: Changes between 2000 and 2004 by LFA and Legacy New Entry of Total Market Sample

<i>LFA New Entry (LFA MS &lt;10% to &gt;10%)</i>			
	2004	2000	% change
Avg Fare	\$131.5	\$191.3	-31.3
Passengers	56,474	47,375	+19.2
Revenues	\$7,426,731	\$9,064,095	-18.1
<i>Legacy New Entry (LFA MS &gt;10% to &lt;10%)</i>			
	2004	2000	% change
Avg Fare	\$156.0	\$148.8	+04.8
Passengers	8,752	7,020	-19.8
Revenues	\$1,095,329	\$1,302,382	-15.9

### 3.3.5 Analysis of Competition by Concentration Level

Another factor of interest is the level of competition in general in markets independent of low-fare and legacy airlines shares. One way to look at this factor is by analyzing the concentration in a market, and finally segmenting the total market sample by concentration, which is an inverse indicator of competition. When a market is heavily concentrated, this means that there is little competition, whereas a low concentration indicates that there is a high degree of competition between the airlines.

#### Concentration Definition

A commonly accepted measure of market concentration is the Herfindahl-Hirschman Index (HHI) proposed by both Herfindahl (1950) [23] and Hirschman (1945) [24]. It is calculated by squaring the market share of each airline competing in a certain market, and then summing up the resulting numbers. The HHI number can range from close to zero to 10,000 and is expressed as:

$$HHI = s_1^2 + s_2^2 + \dots + s_n^2 \quad (3.4)$$

where  $s_n$  is the market share of the  $i$ th airline. The closer a market is to being a monopoly, the higher the market's concentration (and the lower its competition). If, for example, there were only one airline in a market, that airline would have 100% market share, and the HHI

would equal 10,000 ( $100^2$ ), indicating a monopoly. Or, if there were thousands of airlines competing, each would have nearly 0% market share, and the HHI would be close to zero, indicating nearly perfect competition. Also it should be noted that the HHI increases both as the number of airlines in a market decreases and as the disparity in size between those airlines increases.

The Department of Justice (DOJ) in 1984 [30] established a fundamental threshold to separate an unconcentrated market from a moderately concentrated market at the level of a HHI of 1000. This level of concentration would be achieved in a market of 10 equal size competitors. The DOJ established a second threshold at an HHI of 1800. Above this level, the market is considered highly concentrated. This is roughly equal to a market with fewer than six equal sized competitors as a market with six, equal-sized firms would have a HHI of 1667. Using these definitions, airline markets are considered as highly concentrated. As an illustration for this statement, the HHI of the total market sample in 2004 ranges between 1390 and 10,000, with an average of 4,681. This shows that using the DOJ categories with cutoffs at 1000 and 1800 would not be a good choice for this application. Instead, another categorization should be used. One that can be used for this model is described as a rule where HHI smaller than 2000 is considered as low concentration and an HHI greater than 4000 is a highly concentrated market [8].

### **Analysis by Concentration Level**

With this definition and categorization in mind, the total market sample can be segmented according to the HHI index in 2004. Figure 3-10 shows the number of markets that are present in each category, ranging from low to a high level of concentration.

Figure 3-11 and Table 3.14 present the results of the analysis by level of concentration (low, moderate or high). The average fare decreased most within markets with a low and moderate concentration. When only considering the markets with low concentration, and thus representative for markets with high competition, the average fare dropped 24%. This clearly shows that competition in general, independent of the type of carrier is a

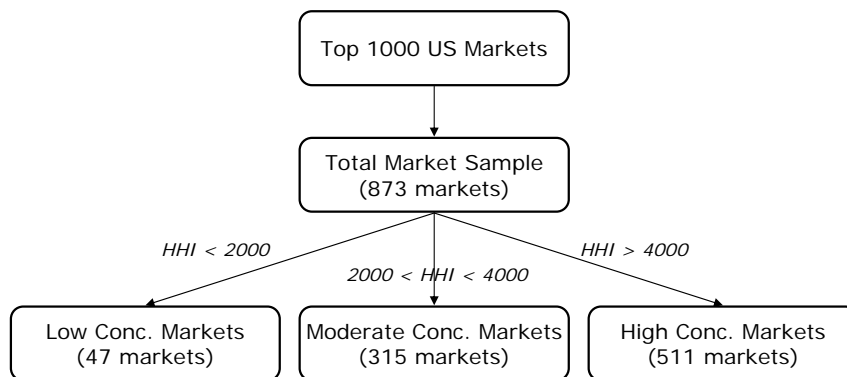


Figure 3-10: Distribution of Markets by level of Concentration

Table 3.14: Changes between 2000 and 2004 by level of Concentration of Total Market Sample

<i>Low concentration (HHI &lt; 2000)</i>			
Average Distance = 1,937 miles			
	2004	2000	% change
Avg Fare	\$126.6	\$166.6	-24.0
Passengers	18,031	15,981	+12.8
Revenues	\$2,283,469	\$2,661,748	-14.2

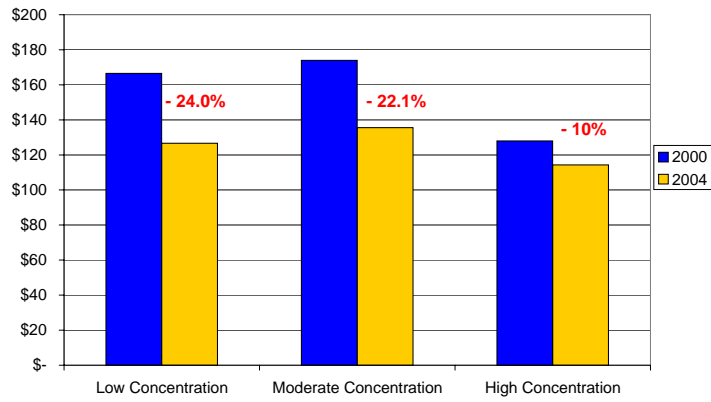
  

<i>Moderate concentration (2000 &lt; HHI &lt; 4000)</i>			
Average Distance = 1,311 miles			
	2004	2000	% change
Avg Fare	\$135.5	\$174.0	-22.1
Passengers	169,418	162,869	+4.0
Revenues	\$22,963,028	\$28,335,206	-19.0

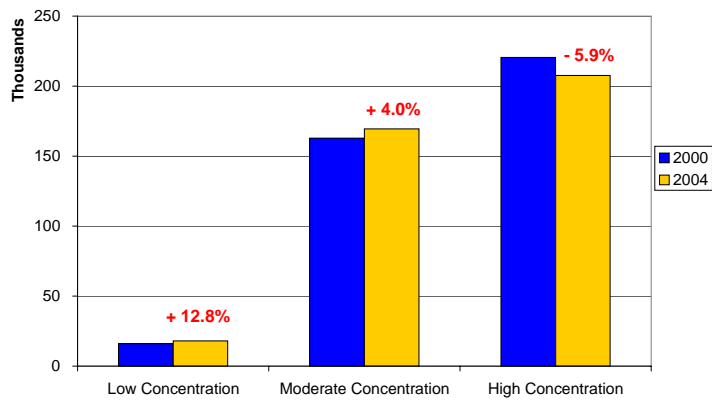
  

<i>High concentration (HHI &gt; 4000)</i>			
Average Distance = 842 miles			
	2004	2000	% change
Avg Fare	\$114.3	\$128.0	-10.7
Passengers	207,585	220,517	-5.9
Revenues	\$23,722,171	\$28,224,920	-16.0

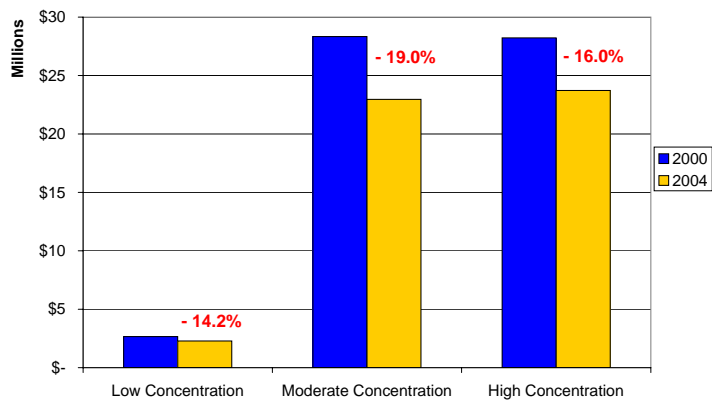




(a) Average Fares - Total Market Sample



(b) Total Passengers PDEW - Total Market Sample



(c) Total Revenues PDEW - Total Market Sample

Figure 3-11: Changes between 2000 and 2004 of Total Market Sample by level of Concentration in 2004

real indication for enormous fare declines. In markets with a high concentration (or low competition), fares only decreased 10%, which is a much smaller decline. Nested within these results, are the relative average distance associated with each category. As was previously noted, short-haul markets tend to experience a more attenuated decline in average fares, as can also be seen in these results.

Logically, the traffic within low concentration markets grew considerably, achieving a 12.8% increase in number of passengers. This is again because of stimulation due to the lower fares. These markets either attracted 'new' passengers that would otherwise not have flown, or simply diverted travelers from other markets. The same passenger stimulation trend is followed in the moderate concentration group, however this effect is moderated. Surprisingly, the average fare fell almost as much as that of the low concentration category, but the number of passengers only increased a mere 4%. One reason, is that although the average distance lower is in the moderate concentration segment compared with the low concentration category, the average fare in dollars still higher is in the moderate concentration segment. This implies that the average fare not that low is compared with the low concentration markets and consequently one can understand that the passenger stimulation less pronounced is.

Observing what happened in the markets with high concentration, different conclusions arise. As the average fare only moderately decreased, the number of passengers flying these markets declined with almost 6%. Recall that the total market sample overall lost 1% of passengers between 2000 and 2004, and when looking at the concentration levels, this lost is entirely attributed to the high concentration segment, which experiences the least competition. Due to this lack of competition, these markets were unable to effectively capture or stimulate traffic. This causes this segment to lose 16% of revenues, whereas the markets with low concentration and thus high competition only experienced a 14.2% loss in revenues.

### 3.4 Summary

Recently air travel patterns changed significantly in US domestic markets. Over the total market sample, fares continue to decrease over the sample period, on average they were 16.4% lower in 2004 compared to 2000. Passenger volumes have almost rebounded to 2000 level after dropping by 11%. As a result, there was a huge revenue drop of 23.7% by 2002 followed by a slow recovery since then, but the revenues are still 17.3% below 2000.

However, these trends are not uniform across all markets. In order to reflect part of the variations and to understand which factors drive which changes, the total market sample was segmented according to different criteria. Some of the most striking results are summarized here, where the mentioned percentage changes are always given between 2000 and 2004:

- In markets where low-fare airlines entered, which is defined as a market share increase from smaller than 10% to greater than 10% between 2000 and 2004, the average fare dropped by 31.3%, which is the greatest drop observed.
- In long haul markets, the average fares dropped by 29% while short haul fares almost remained constant when compared with 2000. Linked with these fare changes, traffic in short haul market dropped 16%, while increasing 4-9% in medium and long haul markets. Total revenues decreased 22.8% in long haul markets, despite the traffic growth.
- The markets with both low and moderate concentration (thus facing a higher degree of competition) experienced a 22-24% decrease in average fare. These markets saw an increase in traffic of 4-13%. On the other hand, the average fare in markets with high concentration only dropped by 11%, while the total number of passengers decreased by 6%.
- Hub markets clearly had a bigger impact on the decline in average fare than non-hub markets. The average fare of hub markets decreased over 19%, while non-hub markets had an average decrease in fare of 13%. The hub/non-hub segmentation

had no difference in traffic growth as both segments experienced a passenger decline between 0.3-2%.

- Focusing on the legacy carriers, their average fare dropped over 18%, while the average fares of the low-fare airlines decreased less than 1%. Above that, the legacy lost almost 7% in passenger share, which has entirely been picked up by the low-fare airlines.
- The Top 100 US Markets experienced a 19.4% decrease in average fare, whereas the average fare of the Top 1000 US Markets declined 16.4%. The size of a market thus shows a relationship with the change in average fare as the bigger the markets are, the more the average fare will decrease.
- Looking at all different segmentations, one can observe that all market segments lost at least 12% of revenues and in several markets the revenue losses decreased more than 20% with the biggest decrease of 24.2% for markets with non-significant low-fare airlines competition.

## Chapter 4

# Regression Analyses

In the previous chapter, a better understanding was created of how factors such as distance and hubs impacted specific segments of the total market sample (e.g. hub versus non-hub markets). With this first empirical analysis the effects of fare and passenger changes within a specific market were tracked for each factor separately. In this Chapter, we perform an econometric analysis on the total market sample in order to explain the observed changes by the combination of all factors. It is also a way to analyze the interactions between the factors and their relationships.

In order to analyze these changes accordingly both fare and passenger regressions will be constructed in this Chapter. Before that, the next section will describe different models and the variables that will be used for these regressions as well as address some econometric issues.

## 4.1 Models and Variables

### 4.1.1 Linear and Log-Linear Models

The linear models used throughout this chapter are based on the following equation

$$y = \alpha + \beta_1 * x_1 + \beta_2 * x_2 + \dots + \beta_i * x_i + \epsilon \quad (4.1)$$

where  $y$  is the dependent, response or endogenous variable, and  $x_i$  represents the independent, explanatory or exogenous variables (also including dummy variables). Finally  $\epsilon$  represents the error term which consist of an unpredicted or unexplained variation in the response variable. The parameters  $\alpha$  and  $\beta_i$  are estimated by the method of least squares, which is obtained by minimizing the sum of the squares of the residuals.

Log-linear models will also be used in this Chapter. The exponential model is as follows using the same notations:

$$y = \alpha \times x_1^{\beta_1} \times x_2^{\beta_2} \times \dots \times x_i^{\beta_i} \quad (4.2)$$

This can also be expressed as

$$\ln(y) = \ln \alpha + \beta_1 \times \ln x_1 + \beta_2 \times \ln x_2 + \dots + \beta_i \times \ln x_i + \epsilon \quad (4.3)$$

The model in Equation 4.3 is called a log-log, double-log or log-linear model. A nice feature about this model is that the slope coefficient,  $\beta_i$  measures the elasticity of  $y$  with respect to  $x_i$ , that is, by the percentage change in  $y$  given a percentage change in  $x$ . The formula used to calculate the price elasticity of air travel demand for example, can be expressed as:

$$\begin{aligned}
E_d &= \frac{\text{Percentage Change in Passengers}}{\text{Percentage Change in Price}} \\
&= \frac{\delta Pax}{\delta Fare} \cdot \frac{Fare}{Pax} \\
&= \frac{\delta \ln Pax}{\delta \ln Fare}
\end{aligned} \tag{4.4}$$

In general, a fall in fares is expected to increase the number of passengers, so the price elasticity of air travel demand is negative. Because both the denominator and the numerator of the fraction are percent changes, price elasticities of demand are dimensionless numbers and can be compared without ambiguities even when using different currencies or goods.

When the price elasticity of air travel demand is elastic ( $|E_d| > 1$ ), the percentage change in passengers is greater than that in price. Hence, when the fares are raised, the total revenue of the airlines falls, and vice versa. When the price elasticity of air travel demand is inelastic ( $|E_d| < 1$ ), the percentage change in passengers is smaller than that in price. Hence, when the fares are raised, the total revenue of producers rises, and vice versa. The essential idea is that elasticity measures how sensitive we are to changes in price. If prices matter very little, changes in price only will have small impacts on our willingness to buy. Because the percentage changes will be small, the calculation of elasticity will also be small and inelastic results will be found.

### 4.1.2 Variables

The sample that is utilized is the aggregated total market sample of the Top 1000 US Markets, constructed as explained in Chapter 3. This sample can be considered as panel data that includes both time series and cross-sectional data, as all variables are given for 5 consecutive years. Each observation in the sample is thus an origin-destination market for a certain year. As our primary interest is to model changes over the data set between 2000 and 2004, the variables of these specific years will be most widely used in our regression

models. The following variables were constructed for the econometric analysis.

*CONC* represents the concentration level in each market in a certain year. It represents the Herfindahl-Hirschman Index (HHI) of O-D passengers for each market as defined in Section 3.3.5. The HHI ranges between 0 and 10,000. In the regression models, the concentration is defined for a certain year, e.g. *CONC04* which is the concentration level for the year 2004.

*DIST* represents the distance in non-stop mileage from origin to destination of each market. This variable is thus independent of the year of observation.

*FARE* represents the average fare observed for each market in a specific year (e.g. *FARE04* and *FARE00*).

*HUB* represents a dummy variable that takes on value 1 if either the origin or destination airport defined is as a hub, and takes the value 0 otherwise. Hub airports are defined in Section 3.3.3. This variable is also independent of the year of observation.

*LFA* represents the combined market share of low-fare airlines in each market, as defined in Section 3.3.1 for a specific year (e.g. *LFA04*). It ranges from 0 to 1.

*PAX* represents the number of passengers transported per day each way for each market in a specific year (e.g. *PAX04*).

Furthermore several of these variables do change between 2000 and 2004. Therefore, additional variables can be constructed in the form of absolute, ratio and percentage changes. The notations are as follows:

*CHG* before the variable name (e.g. *CHGFARE*), represents the absolute change between 2000 and 2004 and is defined as e.g.  $CHGFARE = FARE04 - FARE00$ . It thus takes a positive value for a fare increase and a negative value for a decrease in average fare.

*RATIO* after the variable name (e.g. *FAREERATIO*), represents the ratio of a variable between 2004 and 2000. This construction is especially important to estimate log-linear



models. It is defined as e.g.  $FARE\text{RATIO} = FARE04/FARE00$  and is thus greater than 1 for a fare increase or smaller than 1 for a decrease in average fare. Note that this ratio a measure is for the percentage change of a variable, but centered around 1 instead of 0.

$\%CHG$  before the variable name (e.g.  $\%CHGFARE$ ), represents the percentage change between 2000 and 2004 and is thus defined as e.g.  $\%CHGFARE = (FARE04 - FARE00)/FARE00$ . A positive value indicates a fare increase, whereas a negative value signifies a decrease in average fare.

Summary statistics (sample mean and standard error) for all variables described above for the total market sample can be found in Table 4.1.

Table 4.1: Summary Statistics of Total Market Sample

Variable	Sample Mean	(Standard Error)
HUB	0.4261	(0.0167)
DIST	1070.06	(23.95)
PAX04	452.50	(16.41)
PAX00	457.46	(16.82)
FARE04	131.14	(1.47)
FARE00	157.44	(2.27)
LFA04	0.3287	(0.0107)
LFA00	0.2705	(0.0103)
CONC04	4681.36	(65.86)
CONC00	4573.12	(65.48)
CHGFARE	-26.30	(1.28)
CHGLFA	0.0582	(0.0045)
CHGCONC	108.24	(38.75)
PAXRATIO	1.0452	(0.0112)
FARERATIO	0.8842	(0.0064)
$\%CHGPAX$	0.0452	(0.0112)
$\%CHGFARE$	-0.1158	(0.0064)
$\%CHGCONC$	0.0600	(0.0094)
Sample Size N	873	

### 4.1.3 Multicollinearity

Before constructing specific models one should take a look at potential econometric issues such as multicollinearity. Multicollinearity is a result of strong correlation between inde-

pendent variables and this existence inflates the variances of the parameter estimates. That may in turn result in lack of statistical significance of individual independent variables while the overall model may be strongly significant. It may also result in incorrect magnitudes and signs of regression coefficient estimates, and thus in wrong conclusions about relationships between variables.

To detect multicollinearity, correlations should be analyzed between variables. The correlation matrix of all possible variables can be found in Appendix B.1. Analyzing this table, only the most closely related variables are highly correlated such as *PAX04* versus *PAX00* and *CHGFARE* versus *FARE RATIO*. As these variables would never be used in the same regression model, there is no critical issue here. However, there is a second group of relatively high absolute correlation factors of around 0.6, for *DIST* versus *FARE* and *FARE* versus *LFA*. This clearly indicates that the average fares are correlated to some extent with both the distance and the market share of low-fare airlines. These correlations should not be forgotten while constructing the regression models.

## 4.2 Average Fare Regression Model

This section presents a description of the determinants of the average fare in a market. Using the data available, a linear regression is developed to better understand the interaction of factors upon the average fare. This regression was performed both for the year 2004 and 2000, such that relative changes in factors can be identified. The regression model to be estimated is specified as follows, which includes all explanatory variables described above.

$$FARE = \alpha + \beta_1 * DIST + \beta_2 \times PAX + \beta_3 \times LFA + \beta_4 \times CONC + \beta_5 \times HUB \quad (4.5)$$

This regression is performed on cross-sectional data both for 2004 and 2000. Results for this linear regression of the year 2004 can be found in Table 4.2. The first observation is that

all coefficients are highly significant at the 1% level and that the adjusted R squared reached the acceptable value of 0.65. This means that all included variables are able to explain the average fare up to this level, but that 35% of the average fare remains unexplained by other variables that are not included in this model. The intercept of the regression is \$106.5 which can be interpreted as the average fare of the total market sample all else equal.

Table 4.2: Average Fare Regression of 2004

Variable	Coefficient	Standard Error
Intercept	106.5096	3.0925
DIST	0.0303	0.0014
PAX04	-0.0077	0.0018
LFA04	-70.6190	3.1524
CONC04	0.0025	0.0005
HUB	16.4926	1.8701
R squared	0.65	

Note: All coefficients are significant at 1 % level

The most significant variable of the regression is *LFA04*. The highly negative coefficient can be explained as follows. The higher the low-fare airlines' total market share the lower the average fare will be. Each 10% of low-fare airlines' market share is associated with a \$7 lower fare. This is clearly as expected, as it already was showed that new entry or an increased market share of low-fare airlines a big downward impact has on the average fare.

The next most significant variable turned out to be distance (*DIST*). The coefficient means that for a one-mile longer market (than the average distance), the average fare of \$106.5 increases by 3 cents. Thus the longer the distance, the higher the average fare will be which is intuitively correct.

Next, is the hub variable. Recall that *HUB* a dummy variable is, thus in the case that a certain market includes at least one hub, the average fare will increase by \$16.5. This increase of average fare is related to the concept of hub premium. The hub premium that is generally charged by hub airlines can be explained by lack of competition in hubs on one side and the advantages of operating a hub on the other hand. Higher hub fares are thus because of lack of effective competition as either there is no competition from non-hub airlines or if they face competition, hub airlines can usually respond by expanding service

and drastically cutting fares on specific markets, without suffering as a hub, to finally repress their competitors.

After that, and related to the previous variable is the variable concentration (*CONC04*) from where the level of competition can be inferred. As indicated by the coefficient, a higher concentration in a certain market will cause the average fare to be slightly higher (0.25 cents per unit of HHI). A higher HHI or concentration means that there is less competition in that market, and thus logically the average fare will increase.

Finally, *PAX04* indicates the size of the market. The sign of the coefficient tells us that for bigger markets (in terms of passengers) the average fare slightly lower is. However it should be noted that this effect moderate is as the magnitude of the coefficient corresponds to -0.77 cents per passenger (*PDEW*). One explanation for this is that markets with more passengers may experience more competition, which in turns lead to lower fares. Related to this is the explanation that smaller markets also operate on a fare premium as service is less frequent and the competition is not very strong, leading to much higher fares. Finally, one can think of the biggest markets to be primarily oriented to leisure passengers which can itself lower the average fares.

Exactly the same linear regression is now performed for 2000 and the results can be found in Table 4.3. In this regression almost all variables are significant at the 1% level, except *PAX00* is only significant at the 10% level. This is not that surprising as already in the 2004 analysis, this variable turned out to be the least significant. Overall, the adjusted R squared reached 0.64 which can be considered to be equal to the R squared of 2004 and thus as both models have the same variables they also explain the same portion of average fare between 2000 and 2004. The intercept of this regression model is \$95.5 which can again be interpreted as the average fare of 2000 all else equal.

The most significant variable in this model is distance (*DIST*). The corresponding coefficient shows that the average fare is increased with 5.3 cents for a one-mile longer market than the average distance. This shows again that longer markets will have higher average fares, which is as expected.

Table 4.3: Average Fare Regression of 2000

Variable	Coefficient	Standard Error
Intercept	95.5416	6.1486
DIST	0.0530	0.0023
PAX00	-0.0053	0.0028
LFA00	-88.5958	4.9369
CONC00	0.0042	0.0008
HUB	32.3041	2.8734
R squared	0.64	

Note: All coefficients are significant at 1 % level, except PAX00 which is significant at 10 % level.

The next most significant variable of the regression is *LFA00*. The interpretation of the coefficient is that for each one percent of low-fare airlines' market share the average fare will be 88.6 cents lower (as *LFA* is defined between 0 and 1). This is again consistent as low-fare airlines have a strong downward effect on the average fare.

This is followed by the *HUB* variable. The presence of a hub will increase the average fare by \$32 on average. This is a large increase for the sole presence of a hub and it is a 33% augmentation if compared with the average fare (intercept). This is mainly due to the strong presence of a hub premium as was explained above.

Next is the concentration (*CONC00*) variable. For a higher concentration in a certain market (meaning less competition) the average fare is slightly higher. Looking at the magnitude of the coefficient it can be interpreted that the average fare increases 42 cents for every unit of HHI. This is again intuitively accurate as less competition will tend to increase the average fare.

To conclude this average fare analysis of 2000, the *PAX00* variable means that markets with more passengers will see a .53 cents decrease in average fare. Again, bigger markets experience more competition and thus have lower average fares.

More relevant to the analysis are how these coefficients changed over the 5-year period. The coefficients of all the variables of both the 2000 and 2004 model are displayed in Table 4.4 to be able to compare them mutually.

Table 4.4: Comparison of 2000 and 2004 Coefficients

Variable	Coefficient00	Coefficient04
Intercept	95.5416	106.5096
DIST	0.0530	0.0303
PAX	-0.0053	- 0.0077
LFA	-88.5958	-70.6190
CONC	0.0042	0.0025
HUB	32.3041	16.4926

The intercept of the average fare slightly increased, but this is not regarded as that important. However, all other coefficients significantly changed between 2000 and 2004 in magnitude and are discussed in the next paragraphs.

The coefficient of the distance (*DIST*) decreased from 0.0530 to 0.0303 between 2000 and 2004. This means that longer distance markets were charging more per mile in 2000 compared with the 2004 data.

The size of the market, as indicated by *PAX*, shows an increase in impact on the average fare. This means that the average fare will decrease more per passenger for bigger markets in 2004 than in 2000. However, reminding the lower significance of this variable the size of the market is less relevant than other variables in explaining as a determinant of the average fare.

Interesting results are that both the low-fare airlines' market share (*LFA*) and the concentration (*CONC*) had a higher impact on the average fare in 2000 than in 2004. This effect can be explained by the fact that there were less low-fare airlines and less competition in 2000, which yielded to a higher effect per effective LFA market share or competition. But, in the markets where they entered successfully, they had a bigger impact and lowered the average fare further.

Finally, the *HUB* variable almost halved from \$32.3 in 2000 to \$16.5 in 2004. This clearly indicates a much lower hub premium for 2004 compared with 2000. This is another proof of the weakening effect of hubs to charge higher fares.

To conclude, this simple linear regression gives some insights on the evolution of the interdependent factors that affect the average fare. The comparison of the coefficients between 2000 and 2004 specifically shows that recently the impact of longer markets, hubs, LFA and concentration are all reduced.

### 4.3 Models of Change in Average Fare

In this section, the impact of various factors on the change of average fare in each market between 2000 and 2004 are analyzed. When considering all relevant available factors, the following linear equation will first be assessed for the absolute change in fare:

$$CHGFARE = \alpha + \beta_1 \times HUB + \beta_2 \times DIST + \beta_3 \times PAX00 + \beta_4 \times FARE00 + \beta_5 \times LFA00 + \beta_6 \times CHGLFA + \beta_7 \times CONC00 + \beta_8 \times CHGCONC \quad (4.6)$$

Results of this linear regression are presented in Table 4.5. The first observation is that this regression attained a relatively good adjusted R square of 0.71. However it should be noted that some portion (29%) of the change in average fare remains unexplained by these variables. The t-statistics turned out to be significant for all variables, meaning that these variables have a non-zero impact on the change of average fare.

Table 4.5: Change in Fare Linear Regression Results

Variable	Coefficient	Standard Error
Intercept	63.4180	3.6993
HUB	3.3960	1.5691
DIST	0.0095	0.0015
PAX00	-0.0046	0.0014
FARE00	-0.5974	0.0173
LFA00	-33.6673	3.0906
CHGLFA	-59.1282	5.2662
CONC00	0.0016	0.0005
CHGCONC	0.0019	0.0007
R squared	0.71	

Note: All coefficients are significant at 5 % level.

Taking a closer look at the regression coefficients, the statistically most significant variable turned out to be the average fare in 2000 (*FARE00*). The higher the average fare was in 2000, the more it dropped by 2004, which is logical. The higher the average fare was in 2000, the more the carrier was — potentially — able to lower it in absolute terms with the coming of low-fare airlines and increased fare availability of information over the Internet.

The next most statistically important variable is the change in low-fare airlines' market share (*CHGLFA*). In markets where low-fare airlines entered or increased their market shares, the average fare clearly goes down, which is consistent with the empirical analysis as discussed in Section 3.3.4.

After that and related to the previous variable, the actual level of low-fare airlines' market share in 2000 (*LFA00*) also revealed itself to be highly significant. The negative sign shows, as predicted, that the higher the low-fare airlines' market share was in 2000, the more the fare dropped by 2004. At this point it should be noted that both the variables *LFA00* and *CHGLFA* are highly significant and relevant to the explanation of changes in average fare, but that the change in LFAs' market share is more influencing these changes in average fare, as can be concluded from the magnitudes of the coefficients.

A similar story can be said about the concentration variables. The change in concentration over the years is slightly more important than the actual level of concentration in 2000. The sign of both coefficients is positive. For *CONC00*, this means that the higher the concentration, the more the average fare increased over the years. For the variable *CHGCONC*, the more the concentration increased (meaning less competition), the more the fares also increased over the period. This again, is intuitive and consistent with what was presented in the segmentation analysis.

The variable *PAX00* gives some insights about how the size of a market is related with the change in average fare. As can be concluded from the coefficient, larger markets, thus with more passengers in 2000, are leading to a small reduction in average fare over the years. This is again instinctive as the higher the number of passengers is, the lower the average fare tends to be, as was already explained in Section 4.2.



Having a hub in the market still means that the average fare is higher for these markets and the change tends to be more attenuated by this factor than others. As *HUB* is a dummy variable (0 or 1), the interpretation is a little more subtle. The change in fare is positive with respect to hubs. This means that for hub markets, the average fare is higher than for non-hub markets as well as the change in average fare goes up more for hub markets between 2000 and 2004. The latter part is somewhat contradictory with the segmentation analysis, as there it was shown that hub markets experienced a relatively bigger decrease in average fare both in absolute and percentage terms than non-hub markets. The fact that hub is positive here, shows that the presence of a hub positively boosts the average fare compared with the other factors, which is logical recalling the hub premiums. Added to this discussion is the fact that while the variable hub is significant at the 5% level, it is the least significant variable of this regression.

Looking at the distance variable, one can conclude that the greater the distance, the higher the absolute change in average fare is. This again, is a little contradictory with the previously performed segmentation analysis where the conclusion was that longer haul markets experienced the biggest decline in average fares in percentage terms. But considering the other factors, it is again reasonable to accept that the absolute change in distance has a somewhat moderated impact on the change of the average fare compared with other factors such as low-fare airlines' market share. It is very plausible that, as fare and distance are somewhat correlated that the change in absolute fare positively is affected by longer distances. This should be opposed to the fact that the segmentation analysis showed that the percentage change in average fare should decrease more for longer distances.

A second regression analysis of the change in fare was obtained by transforming Equation 4.6 into a log-linear one. By implementing this transformation the *HUB* variable revealed itself to be insignificant, which is not an entire surprise as it was already marginally significant in the first change in average fare analysis.

The following log-linear equation is the one to be estimated:

$$\ln FARERATIO = \alpha + \beta_1 \times \ln DIST + \beta_2 \times \ln PAX00 + \beta_3 \times \ln FARE00 + \beta_4 \times \ln CONC00 + \beta_5 \times \ln CONCRATIO + \beta_6 \times LFA00 + \beta_7 \times CHGLFA \quad (4.7)$$

Note that this equation contains two factors, *LFA* and *CHGLFA*, which are not presented in the log-form. The reason that these variables are entered as a linear form, rather than its natural logarithm, is apart from practical reasons (as *LFA* ranges between 0 and 1) also based on a legitimate justification. As Borenstein (1989) [11] already pointed out it is unlikely that the effect on fares the same is when an airlines' market share changes from 1% to 2% as when it share increases from 30% to 60%. The potential inclusion of *HUB* in future log-linear models as a linear form requires less justification as it is constructed as a dummy variable.

Table 4.6: Change in Fare Log-Linear Regression Results

Variable	Coefficient	Standard Error
Intercept	1.5775	0.1584
ln(DIST)	0.0609	0.0100
ln(PAX00)	-0.0156	0.0063
ln(FARE00)	-0.4756	0.0180
ln(CONC00)	0.0488	0.0132
ln(CONCRATIO)	0.0605	0.0204
LFA00	-0.2331	0.0209
CHGLFA	-0.4600	0.0342
R squared	0.60	

Note: All coefficients are significant at 5 % level

Table 4.6 shows the results of this log-linear regression. Again, the first observation is that this regression attained a lower adjusted R squared of 0.60. This indicates that there is a large part of 40% that remains unexplained by other factors not included in this regression model.

When comparing this log-linear model with the previous linear model, similar interpretations can be given as the signs remained unchanged. The most significant variable is again *FARE00* and the coefficient indicates that the higher the average fare in 2000, the

more it dropped by 2000, which is as previously noted.

This is followed by the change in low-fare airlines' market share (*CHGLFA*) that shows that the average fare decreases for markets where the low-fare airlines' market share increases over the sample period. Related with that, is the variable *LFA00*, that again indicates that the level of low-fare airlines' market share also negatively influences the change in average fare, as the higher the market share is in 2000, the more the fare dropped by 2004.

The coefficient of the *DIST* variable indicates that longer distances will experience a higher change in average fare, and the same explanation for this result applies as for the linear model.

For either a higher value of the original concentration level (*CONC00*) or an increase in concentration level (*CHGCONC*) the average fare increased over the sample period. This is consistent with the fact that less concentration will result in lowered fares.

Finally, the *PAX* variable, which is the least significant variable, indicates that the larger the size of the market the more the average fare decreased. This was also shown in the empirical analysis as for the Top 1000 markets (which includes smaller markets) the average fare decreased less than for the Top 100 markets (the biggest markets in terms of passengers).

To conclude, a comparison with the linear model shows that all relative magnitudes of coefficients are similar. The advantage of this log-linear model is that the coefficients represent elasticities. For example, the elasticity of the change in average fare with respect to the change in concentration is estimated to be 0.0605. This can be interpreted as follows: a 1% increase in change in concentration increases the change in average fare by 0.0605%. Therefore, this model is somewhat easier to interpret.

## 4.4 Model of Change in Traffic

In this final section, a second type of regression analysis is tested to try to estimate the impact of the variables on the change in passengers from 2000 to 2004. For this type of regression, a logarithmic form is preferred as it is convenient to read the fare-elasticity directly from the coefficients, as explained in the previous paragraph. In order to estimate the elasticity with respect to fare, the variable of change in fare is added to the other available variables. After a trial with all the available variables, the variable  $\ln CONCRATIO$  (log of concentration level in the year 2000) turned out to be extremely insignificant and was therefore removed from the model. The following equation is the tested regression model:

$$\ln PAXRATIO = \alpha + \beta_1 \times \ln FARERATIO + \beta_2 \times \ln DIST + \beta_3 \times \ln PAX00 + \beta_4 \times \ln CONCRATIO + \beta_5 \times LFA00 + \beta_6 \times CHGLFA + \beta_7 \times HUB \quad (4.8)$$

Table 4.7: Change in Passengers Log-Linear Regression Results

Variable	Coefficient	Standard Error
Intercept	-0.1827	0.1076
$\ln(FARERATIO)$	-0.5716	0.0412
$\ln(DIST)$	0.0642	0.0120
$\ln(PAX00)$	-0.0667	0.0098
$\ln(CONCRATIO)$	-0.0720	0.0302
LFA00	0.1984	0.0264
CHGLFA	0.4443	0.0559
HUB	-0.0412	0.0154
R squared	0.40	

Note: All coefficients are significant at 5 % level

When analyzing the results, as presented in Table 4.7, the first noticeable result is a very low adjusted R squared of only 0.4.

The statistically most significant result is the change in fare from 2000 to 2004. The associated estimated elasticity of the change in passengers with respect to the change in average fare is -0.57. The elasticity can be translated as follows; a 10% decrease in average

fare would lead to 5.7% increase in passengers. This would mean that price is inelastic, as the elasticity is smaller than 1 which is not intuitive considering the general belief that air travel demand is elastic.

Comparing this number with other studies, as described in Chapter 2, reveals that this value is significantly lower. Recall that the Canadian study for example, found mean elasticities between -0.7 and -1.52 for domestic travel. The comparative study of Brons et al. found a mean elasticity of -1.146 and they also found that when omitting the income variable, as is the case in this regression, that the price sensitivity is higher. Combining all air travel demand studies that were discussed in Section 2.2, the elasticity estimates fall between -0.4 and -4.51 but with the majority falling between -0.75 and -1.75. This evaluated elasticity is thus clearly on the lower side and was expected to be much higher.

One explanation for this lower price elasticity as estimated could be because of multicollinearity effects between the other explanatory variables, especially the inclusion of both fare and the low-fare airlines' market share. However, removing some of these variables and testing different models never resulted in an elasticity lower than -0.7. This indicates that there is something else going on over the sample period and more precisely that all other factors explain the passenger demand.

Furthermore, it can be argued that air travel demand is indeed inelastic over the sample markets and period when considering the results of Chapter 3. The estimated elasticity of -0.57 would mean that price is inelastic and that demand is not very responsive to changes in price, indicating a somewhat weakened demand. Looking at all recent changes in the airline industry between 2000 and 2004, it is plausible to accept that the passenger stimulation not that great is even considering the extreme decline in average fares. As was shown in the aggregate statistical analysis the average fare decreased by 16.4% between 2000 and 2004, whereas passenger volumes fell by 1.1%. Over all markets, air travel demand showed to be rather inelastic as extreme passenger stimulation was not observed. However, several markets experienced great traffic increases, but in these specific markets the average fare decreased much more, as was shown in the segmentation analysis and thus also leans towards the acceptance of inelastic air travel demand.

Distance (*DIST*) had a positive impact on traffic. For longer markets, other things being equal, the number of passengers increased more over the sample period, which is consistent with the findings of the segmentation analysis.

Looking at the size of the market (*PAX00*), the bigger the market, the more the number of passengers decreased. Similarly, markets with a hub are associated with a drop in passengers. Both coefficients carry a logically correct sign and the decrease in number of passengers for hub markets can also be found in the previously carried out segmentation analysis.

The relationship of change in passengers to the change in concentration is negative. This implies that markets with a higher change in concentration (or thus facing less competition over the years) experienced a decrease in number of passengers. This is again intuitively acceptable as markets with increased competition (less concentration) generally attract more passengers.

Low-fare airlines' market share and change in market share had both an extremely positive effect on the number of passengers. This shows again that the presence of low-fare airlines positively affects air travel demand. This also means that for markets where low-fare airlines entered or significantly grew in term of market share, the number of passengers increased by a significant amount, as was also shown in the segmentation analysis.

## 4.5 Summary

All together, the performed analyses contributed to the understanding of changes in average fares and passengers. The different regressions showed that:

- The market share of low-fare airlines in itself and especially the increase in low-fare airlines' market share played a very important role in decreasing the average fare in absolute terms. An increase in low-fare airlines' market share over the sample period

caused a bigger drop in average fare by 2004. The presence and growth of low-fare airlines also results in an increased number of passengers.

- Similarly, a higher concentration or increase in concentration leads to fare increases and a drop in passengers.
- The level of the average fare, also affects the change in average fare. The higher the average fare was in 2000, the more it decreased by 2004.
- Hubs showed to have lost some part of their fare premium between 2000 and 2004. However, when looking at the model for change in average fare, it appears that the absolute change in average fare increased for hub markets. Hub markets are also associated with a drop in passengers over the sample period.
- For longer markets, the average fare increases as is expected. The change in average fare regression showed that the greater the distance, the higher the change in average fare is. This should be placed in context with the explanations of the other variables. Increasing the distance also causes the number of passenger to increase over the sample period.
- The bigger the size of a market, the more in absolute terms the number of passengers decreased. For bigger markets the absolute fare will be slightly lower and a larger number of passengers in a market lead to decreasing average fares.

The analyses itself mostly confirmed and supported the findings of the segmentation analysis, however in some regressions variables such as distance and hub had to be looked at from another dimension.

These models helped in the comprehension of the relative changes. Due to data limitations a number of potentially relevant parameters (such as income, business/leisure index, service quality, plane changes or number of coupons and load factors) were not included but should be considered and eventually added in the regressions analyses in order to fully capture and improve the demand dynamics.





## Chapter 5

# Conclusions

Since 2000, the US airline industry has faced several challenges, one of the most important being a serious drop in revenue. Both the economic downturn and the terrorist attacks of September 11, 2001 had a negative impact on the spending behavior of consumers, and as a result airlines reported tremendous losses between 2000 and 2004.

The main objective of this thesis was to analyze the fare and traffic changes in the United States that happened between 2000 and 2004. Competition, hubs, low-fare airlines, size and distance are all factors that affect these changes, and all were investigated in this thesis. The main data source was the Origin and Destination Survey, a census reported by carriers to the US Department of Transportation. From this Survey, the Top 1000 US markets in 2004 were extracted and systematically matched back through 2000 in order to observe changes in markets.

Overall, average fares in these Top Markets declined 16.4% between 2000 and 2004, whereas traffic rebounded to 2000 levels after dropping by 11%. Revenues dropped 17.3% by 2004 compared with 2000.

## 5.1 Summary of Findings

### The impacts of Low-fare airlines

From a market share of 28% in 2000, low-fare airlines have grown substantially to carry 35% of all passengers of the total market sample in 2004. With the growth of low-fare airlines these fares are becoming the standard for consumers. As low-fare airlines steal more and more of the market share from the legacy carriers, they are steadily increasing their market power. This is having a visible impact on the pricing decisions of legacy carriers. One such example is the recently introduced Simplified Fare structure from Delta, which follows the trend of low-fare airlines by cutting fares and removing restrictions on the fare products.

The empirical analysis showed that markets in which low-fare airlines entered between 2000 and 2004 (entrance is defined as a shift in market share from less than to greater than 10%), the average fare decreased by 31.3%, which is the greatest decline observed for a specific subset of markets over all segmentations considered. This substantial decrease in fare indicates that incumbent carriers in the markets take the threat of low-fare airlines seriously. As a result, incumbent carriers match some of their low-fare competitor's fares, which lowers the average fare significantly.

Another finding was that as the low-fare airlines grew in long-haul markets over the sample period, the average fare dropped by 29% in these markets. Low-fare airlines pose a real threat to legacy carriers, which have no choice but to cut back the average fares.

The regression analysis confirmed the importance of low-fare airlines. For each one percent of low-fare airlines' market share the average fare was 70 cents lower in 2004, which shows the downward fare impact of low-fare airlines. It was also shown that as the low-fare airlines' market share increased over the sample period, the average fare decreased by a consistent amount. Above that, both the presence and growth of low-fare airlines resulted in an increased number of passengers.

It was previously believed that low-fare airlines were leisure-only airlines. However, more and more business travelers are choosing them as viable alternatives due to their competitive fares and service. This clearly shows the growing importance of low-fare carriers in capturing a segment of air travelers that previously would never thought of flying them. Low-fare airlines are still growing and undoubtedly impacting the airline industry.

### **Declining Short-Haul Travel Demand**

The empirical analysis demonstrated that the demand, and thus the passenger volumes for short-haul travel has declined by 16% between 2000 and 2004, while fares remained relatively stable. This means that at the same fare level, fewer people are willing to fly. This clearly indicates a weakened demand for this segment. The decline in demand for short-haul flights can be attributed to both the decrease in business demand due to the economic downturn as well as the existence of alternative modes of transportation for short distances (car, rail, bus) for both business and leisure travelers.

In contrast, longer-haul markets experienced a fare reduction of 29% and as a result demand went up by almost 9%. This shows that this fare reduction did stimulate passenger interest, but considering this enormous fare reduction one would have expected to see a larger passenger growth. Thus, it may be the case that despite fare reductions there is a weakened demand in long-haul markets as well. The moderate growth of long-haul travel can also be explained by the expansion of low-fare airlines into longer haul markets. These low-fare airlines have collectively lowered the average fares for business and leisure passengers in this segment.

The regression analysis showed that distance has a slightly positive impact on the absolute change in average fare, while also confirming the statement that longer distances are associated with higher average fares.

Over the entire sample, the estimated price elasticity of demand equals -0.57. This would mean that the price is inelastic and that demand is not very responsive to changes in price.

With this estimate a 10% decrease in price would lead to a 5.7% increase in passengers. This means that over the entire database, the stimulation of passengers does not exceed the decrease in fare. Usually air travel demand is considered to be elastic (with an elasticity greater than 1), but considering the time frame studied with all associated changes it is credible to accept that the demand has weakened. This was caused by factors such as the terrorist attacks, the economic downturn and the reduced willingness-to-pay of passengers.

### **Declining Hub Premiums**

Literature has shown that hub airlines are able to charge a premium for their flights. This premium may be due to the quality of the product, or it may be considered a mere exercise of market power. This thesis demonstrated that hub premiums weakened between 2000 and 2004. One indication is that the average fare of hub markets decreased by over 19%, which is more than for non-hub markets, which experienced a fare decline of 13%. The regression analysis of the average fare showed that the effect of a hub was halved from a hub premium of \$32 in 2000 to \$16 in 2004, and illustrates the decreasing ability of hub airlines to charge higher fares.

Furthermore, the hub segment saw a decline in passengers of 2%. Hub markets are thus lowering their fares but are unable to capture more demand. Hub markets are generally in large cities and mainly operated by legacy carriers, which in part explain these results. Furthermore, low-fare airlines have appeared in dominant hubs, increasing the competitive pressure in some hub markets.

### **Competition and Information Availability**

Competition not only from low-fare airlines but in general has had a real impact on fares. One illustration of this statement is that markets with both low and moderate concentration experienced a 22 to 24% decline in the average fare. As was shown in the different regression models, a decrease in concentration (signaling more competition) causes the average fare to

decrease and stimulates passenger traffic.

Key to this fierce competition is the information available to consumers. Prior to the Internet, consumers could not access the fare information of all possible choices, because bookings were manipulated by travel agents. The Internet now makes it possible for consumers to browse a broad range of options and gives them the flexibility to choose between options according to certain pros and cons (price versus schedule and/or brand loyalty). This availability of information also affects the customer's view on the reference price. The low-fare airlines benefited from this as they are becoming the new benchmark for fares. Moreover, consumers are starting to notice cheaper alternatives, such as traveling from nearby smaller airports. This availability of information greatly influences the consumer's willingness-to-pay and in general one can say that travelers are getting more price sensitive because of this dynamic knowledge provided by the Internet.

## **5.2 Implications**

Now that passengers seem to have taken full advantage of pricing information, discovered alternatives to air travel, and noticed the benefits of low-fare airlines, there is little hope of returning to the fares of 2000.

### **Pricing**

In price-competitive markets, airline managers are faced with an increased number of decisions concerning their responses to the pricing initiatives of competitors. Appropriate actions are often dependent on the competitor's position in the market (a dominant versus weak player). In general, airlines are cutting fares either because they need cash, just started service or have an overcapacity problem. In most of the cases airlines will compete with one another by offering a limited number of tickets at matching fares. This is one of the major reasons for the lower average fares.

As can be inferred from the overall fare declines, airlines are also less effective in segmenting their passengers, especially the high-fare passengers. If airlines want to continue to practice differential pricing, they will need to justify higher fares with a product that passengers are willing to pay for. This differentiation could involve schedule, service or any other plan that the public might find attractive. In fact, this is exactly what is happening at the time of writing; some carriers are charging higher fares for exit row seats. This is a perfect example of a differentiated product that is perceived by airlines to have a high value for a group of customers. But the challenge in this case is to find that group of travelers who are willing to pay the higher fares.

Eventually, fares will have to increase in order to compensate for rising fuel costs. Travelers might experience fare increases in several ways. Fewer seats might be available in the lowest-price categories. There may be small increases in leisure fares and big increases in business fares. This may result in a break-even or perhaps profit for the airlines in the coming years. [35]

## **Demand and Profitability**

As was shown throughout the thesis, declines in fare stimulate passenger demand. However, it is very important to note that in none of the cases studied did the revenues actually increase. As at the lower end of the demand curve, additional passenger growth will generate very little extra revenue. To generate some extra revenue from a fare decrease, the airlines should limit the lowest fare to additional passengers while trying to limit fare dilution from actual customers. These passenger stimulations are in fact an artificial way to increase the demand, but are in no way a solution to current unprofitability of US airlines.

## **Distribution**

As long as free, convenient information remains available on the internet, consumers will continue to research all possible options, keeping reference prices in mind and investigating

all low-fare alternatives.

### 5.3 Future Research

As the nature of this research is dependent on data and trends originating from a highly cyclical airline industry, it should be replicated periodically in order to observe future changes. Given the dynamic nature of the airline industry, the developments discussed in this thesis are by no means a prediction of future trends, and it is plausible that different changes in fares and passengers will result in very different conclusions for air travel demand.

One of the most noteworthy limitations of this study in terms of data is the lack of information on business and leisure passengers and associated fares. By including this data, one could state with greater credibility that business travel experienced a decline in demand, and fare distribution could be observed in greater detail. This augmentation of data would probably yield interesting results and should confirm the present trends.

There are several other sources of data that could prove useful to this research and conclusions. By adding the service level offered by airlines to the database, one could better determine consumer choice behavior and see if this has changed over time. To further explore all the effects, the corresponding load factors should be studied to relate the demand with the supply. Beyond that, regional economic factors such as income should be taken into consideration, especially to obtain better results for the regression models.





## Appendix A

# Snapshot of Data Set

	Year 2004	Year 2003	Year 2002	Year 2001	Year 2000									
10 New York/Newark NY	1,603	2,478.6	325,813.1	100.00	8.12	1,619	20040	+NY	+SU	+NY	+SU	1 Total	New York/Newark NY	San Juan PR
10 American Airlines	1,603	1,253.9	163,750.7	50.59	8.13	1,606	20040	+NY	+SU	+NY	+SU	2 AA	New York/Newark NY	San Juan PR
10 Jet Blue	1,603	567.5	73,094.3	22.90	8.07	1,596	20040	+NY	+SU	+NY	+SU	2 B6	New York/Newark NY	San Juan PR
10 Continental Airlines	1,603	427.4	60,204.2	17.24	8.72	1,616	20040	+NY	+SU	+NY	+SU	2 CO	New York/Newark NY	San Juan PR
10 Delta Air Lines	1,603	168.2	20,379.1	6.78	7.02	1,726	20040	+NY	+SU	+NY	+SU	2 DL	New York/Newark NY	San Juan PR
10 Other Locals	1,603	57.7	7,358.1	2.32	7.00	1,824	20040	+NY	+SU	+NY	+SU	3 Other	New York/Newark NY	San Juan PR
10 Off-line Connects	1,603	4.0	1,026.8	0.17	0.00	1,619	20040	+NY	+SU	+NY	+SU	4 Offline	New York/Newark NY	San Juan PR
16 New York/Newark NY	1,603	1,908.0	314,821.1	100.00	10.10	1,634	20020	+NY	+SU	+NY	+SU	1 Total	New York/Newark NY	San Juan PR
16 American Airlines	1,603	1,128.3	189,125.2	59.13	10.42	1,609	20020	+NY	+SU	+NY	+SU	2 AA	New York/Newark NY	San Juan PR
16 Continental Airlines	1,603	365.0	62,081.6	19.13	10.51	1,619	20020	+NY	+SU	+NY	+SU	2 CO	New York/Newark NY	San Juan PR
16 Jet Blue	1,603	208.2	32,244.4	10.91	9.70	1,596	20020	+NY	+SU	+NY	+SU	2 B6	New York/Newark NY	San Juan PR
16 Other Locals	1,603	204.5	30,825.7	10.72	8.20	1,839	20020	+NY	+SU	+NY	+SU	3 Other	New York/Newark NY	San Juan PR
16 Off-line Connects	1,603	2.1	544.3	0.11	0.00	1,634	20020	+NY	+SU	+NY	+SU	4 Offline	New York/Newark NY	San Juan PR
13 New York/Newark NY	1,603	2,154.8	351,105.6	100.00	10.04	1,623	20000	+NY	+SU	+NY	+SU	1 Total	New York/Newark NY	San Juan PR
13 American Airlines	1,603	1,027.8	169,258.7	47.69	10.21	1,613	20000	+NY	+SU	+NY	+SU	2 AA	New York/Newark NY	San Juan PR
13 Trans World Airlines	1,603	594.2	92,918.0	27.58	9.75	1,604	20000	+NY	+SU	+NY	+SU	2 TW	New York/Newark NY	San Juan PR
13 Continental Airlines	1,603	357.5	62,292.8	16.59	10.83	1,609	20000	+NY	+SU	+NY	+SU	2 CO	New York/Newark NY	San Juan PR
13 Other Locals	1,603	171.6	25,458.5	7.96	8.35	1,776	20000	+NY	+SU	+NY	+SU	3 Other	New York/Newark NY	San Juan PR
13 Off-line Connects	1,603	3.8	1,177.6	0.18	0.00	1,623	20000	+NY	+SU	+NY	+SU	4 Offline	New York/Newark NY	San Juan PR

Market Rank: 10, 16, 13

Year: 2004, 2002, 2000

Market: New York-San Juan

Figure A-1: Snapshot of Data Set, detail of New York-San Juan Market

## Appendix B

# Correlation Matrix of Variables



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