NONLINEAR PRICING STRATEGIES AND MARKET CONCENTRATION IN THE AIRLINE INDUSTRY

A Dissertation

by

MANUEL A. HERNANDEZ GARCIA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2009

Major Subject: Economics

NONLINEAR PRICING STRATEGIES AND MARKET CONCENTRATION IN THE AIRLINE INDUSTRY

A Dissertation

by

MANUEL A. HERNANDEZ GARCIA

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Approved by:

Chair of Committee,	Steven N. Wiggins
Committee Members,	Li Gan
	James Griffin
	Steven L. Puller
Head of Department,	Larry Oliver

August 2009

Major Subject: Economics

ABSTRACT

Nonlinear Pricing Strategies and Market Concentration
in the Airline Industry. (August 2009)

Manuel A. Hernandez Garcia, B.A., Universidad del Pacifico, Peru
Chair of Advisory Committee: Dr. Steven N. Wiggins

This dissertation investigates the effect of market concentration on nonlinear pricing strategies in the airline industry. The study develops a theoretical nonlinear pricing model with both discrete product and consumer types to derive testable implications about the impact of market concentration on the structure of relative prices within a menu of prices. The analysis then uses a unique, airline ticket level data set to test the model predictions. The data set consists of a representative sample of airline tickets purchased between June and December 2004 from one major Computer Reservation System (CRS), for travel in the fourth quarter of the same year. The study restricts attention to 246 domestic routes in the United States, resulting in 878,169 tickets. This unique data set allows us to examine the effect of market structure conditions on relative prices within a menu of fare types with restrictive ticket characteristics. The analysis also contributes to the understanding of how the level of competition in a market affects the dispersion of airline prices.

The results indicate that market concentration differentially impacts high versus low priced fares, as predicted by the theoretical model. More specifically, there is a decrease in the ratio of high- to low-quality fares as markets become more concentrated, after controlling for numerous factors that may affect prices through costs and market characteristics. The ratio of medium- to low-quality fares, however, increases with less competition. From a welfare perspective, it is interesting to observe that not all travelers are affected in the same way by a decrease in the level of competition.

Business travelers, who purchase high priced fares, end up paying relatively lower prices in more concentrated markets while leisure travelers pay more.

To my father

ACKNOWLEDGMENTS

I am deeply grateful to my advisor, Steven N. Wiggins, for his guidance throughout the course of this research and for sharing with me a lot of his expertise and research insight. I also want to extend my gratitude to my committee members, Li Gan, James Griffin and Steven L. Puller, and each of my professors at Texas A&M University, especially Qi Li. I thankfully acknowledge financial support from the Fulbright Commission and the Department of Economics at Texas A&M University.

Thanks to my friends and colleagues in College Station, particularly Danilo Trupkin and Raul Ibarra for their companionship.

I also thank my family for their unconditional support throughout my life. Thanks to my mother Gladys, my father Alejandro, my aunt Antuca, and my brothers Pepe and Miguel. Thanks to my daughter Pierina for her patience and love. And I cannot finish without saying how grateful I am to my wife Silvia for her encouragement and for always being there when I needed her most.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TABLE Page

CHAPTER I

INTRODUCTION

A. Motivation and Objectives

This dissertation examines the impact of market concentration on nonlinear pricing strategies in the airline industry. In a context where firms offer a menu of prices, market structure conditions are likely to affect both the level of prices and the structure of relative prices within the price schedule. This study uses a unique, airline ticket level data set to investigate this issue by examining the effect of concentration on relative prices within a menu of fare types with restrictive ticket characteristics.

The analysis also contributes to the understanding of how market concentration affects the dispersion of airline prices. Borenstein and Rose (1994) show that airlines offer highly dispersed prices, in particular, that the expected absolute difference in prices between two passengers on the same airline and route is 36 percent of the average price. They also find that price dispersion decreases with market concentration. The authors argue that the dispersion observed in airline prices may arise either from variation in costs or from discriminatory pricing. This dissertation focuses on nonlinear pricing, a particular form of price discrimination that has received little attention in the airline literature probably due to data limitations. The study analyzes the relationship between concentration and the structure of relative prices within a fare menu while controlling for numerous factors that may affect prices through costs and market characteristics.

To the best of my knowledge, this is the first study in the airline industry to examine the impact of market concentration on relative prices within a menu of fare

The journal model is *The Review of Economics and Statistics.*

types and ticket restrictions. Borenstein (1989) finds that low-end fares increase with market concentration while high-end fares decrease, but the analysis does not explicitly account for ticket-specific factors such as ticket characteristics (restrictions) and time of purchase. Stavins (2001) uses marginal implicit prices of ticket restrictions as a proxy for price discrimination and concludes that price discrimination decreases with concentration. The study, however, only focuses on two ticket restrictions and on a limited number of routes. This dissertation is more in line with Busse and Rysman (2005) who examine the relationship between competition and price-size schedules offered for display advertising in Yellow Pages directories.

Since the pioneer work of Mussa and Rosen (1978) and Maskin and Riley (1984) on monopolistic nonlinear pricing, there has been a growing theoretical literature extending the analysis to competitive environments. Stole (2007) provides an extensive survey of models on nonlinear pricing and imperfect competition. These models assume that firms compete via a collection of quality-price pairs. Consumers self-select choosing both the firm and a particular quality-price pair.

A caveat of the models with continuous product and consumer types is that they fail to provide clear predictions regarding the relationship between nonlinear pricing strategies and market concentration. Busse and Rysman (2002) correctly point out that two of the most recent theoretical contributions, Stole (1995) and Rochet and Stole (2002), make differing predictions about the effect of competition on prices within a price schedule.

In contrast, models with both discrete product and consumer types provide a better framework to explicitly examine the effect of competition on relative prices. Two-type models, as in Villas-Boas and Schmidt-Mohr (1999) and Liu and Serfes (2006), allow us to derive testable predictions about the impact of market concentration on relative prices of high- and low-quality products. This study develops a similar discrete-type model to derive and test implications for airline pricing.

The airline industry provides an ideal framework for studying the relationship between nonlinear pricing strategies and market structure. Airlines charge different fares to different customers by grouping wide-ranging fares with restrictive ticket characteristics so that travelers self-select and purchase these different tickets.[1] In addition these menus of fare types and ticket restrictions are similar across routes, even when routes have different levels of competition. Some routes are mainly served by one carrier while others are served by many. Yet the basic fare structure is highly similar. This feature allows us to compare the pricing of a standard set of ticket options across different competitive settings.

The study is made possible because the unique data set enables us to separate tickets into broad quality groups. Specifically, fares are grouped into four quality categories according to cabin class, refundability, and travel and stay restrictions. The lowest quality group is then set as the base group to examine if there are any systematic variations in the relative prices of the different fare types across markets with different levels of concentration. The analysis includes several controls at the ticket, flight and market level that may affect airline fares.

The results indicate that market concentration differentially impacts high versus low priced fares, as predicted by the theoretical model. More specifically, there is a decrease in the ratio of high fares to low fares as concentration increases. The ratio of medium fares to low fares, however, increases with less competition. Overall, the observed relative pricing pattern is consistent with the negative relationship between market concentration and price dispersion found in Borenstein and Rose (1994). This

[1]On this matter, Puller, Sengupta, and Wiggins (2007) find evidence that theories in which ticket characteristics segment customers and facilitate price discrimination may play a major role in airline pricing. Sengupta and Wiggins (2006) also reveal that ticket characteristics explain much of the variation in airline fares.

dissertation contributes to this analysis by describing the effect of concentration on the structure of relative prices within a fare menu.

From a welfare perspective, the results suggest that not all travelers are affected in the same way by a decrease in the level of competition. Business travelers, who purchase high priced tickets and are generally more brand-loyal, end up paying relatively lower fares in less competitive markets while leisure travelers pay more.

B. Scope

The body of this dissertation contains five chapters. Chapter II provides a brief overview of the literature on nonlinear pricing and imperfect competition. The chapter also develops a discrete-type model with testable implications. The baseline model is a two-type model with two firms offering two products, differentiated by quality, and two consumer types. The model is also extended in two directions.

Chapter III describes the data set on airline ticket transactions as well as the various market level data used in the analysis. An explanation of how wide-ranging fares with restrictive characteristics are separated into broad quality groups is also provided. This grouping of airline fares is essential to test the predictions of the theoretical model in the next chapter. The chapter ends with a preliminary analysis of the data.

Chapter IV discusses the empirical strategy, the model specification and the estimation results. More specifically, the chapter addresses the importance of carrying out a regression analysis to control for several cost and market-specific factors that may affect airline prices, and examine the effect of market concentration on relative prices within a menu of fare types and ticket restrictions. Two log-linear fare equations are estimated, a no-interaction model and an interaction model. In the no-interaction model, the relative premia of the different ticket group fares are assumed to not vary with market structure while in the interaction model the relative premia are allowed to vary with market structure. Further, separate estimations by main carrier are performed to examine whether these carriers follow a similar nonlinear pricing strategy when they face less competition. Finally, an alternative semiparametric model is estimated to check the robustness of the results. Chapter V presents the conclusions of the dissertation.

CHAPTER II

THEORETICAL FRAMEWORK

This chapter provides a brief overview of the models on nonlinear pricing and imperfect competition. Next, a model with both discrete product and consumer types is developed to derive testable implications about the impact of market concentration on relative prices within a menu of quality-price pairs. The baseline model is a two-type model with two firms offering two products, differentiated by quality, and two consumer types. The model is then extended in two directions.

A. Models on Nonlinear Pricing and Imperfect Competition

The growing literature on nonlinear pricing provides an excellent framework for analyzing price discrimination strategies in varied settings. Since the seminal work of Mussa and Rosen (1978) and Maskin and Riley (1984) on nonlinear pricing under monopoly, there has been an increasing number of studies that extend the analysis to settings where several firms compete (e.g. Stole, 1995; Villas-Boas and Schmidt-Mohr, 1999; Armstrong and Vickers, 2001; Rochet and Stole, 2002; Johnson and Myatt, 2003; Liu and Serfes, 2006; and Yang and Ye, 2008). This work has also found increasing empirical applications, for example, Miravete and Röller (2004), Seim and Viard (2004) and Miravete (2009) in mobile phones, Busse and Rysman (2005) in Yellow Pages advertising, and McManus (2007) in specialty coffee.

The models on nonlinear pricing and imperfect competition typically consider two dimensions of consumer heterogeneity, one vertical and one horizontal. The vertical dimension captures different marginal preferences for quality while the horizontal dimension captures the intensity of brand preferences.[1] Firms do not observe consumer preferences and compete by offering a menu of quality-price (quantity-price) pairs. Based on their preferences, individuals choose both the firm and a particular quality-price pair. These quality-based models of price discrimination rely on self-selection constraints where consumers choose the combination that better matches their preferences.[2]

One source of controversy of the general models with continuous product and consumer types is the effect of market structure on prices within a price schedule. Most of these models focus on the variety of products offered and the efficiency consequences of competition, but yield differing predictions regarding the impact of competition on prices. As pointed by Busse and Rysman (2002), two of the most recent theoretical contributions in nonlinear pricing, Stole (1995) and Rochet and Stole (2002), make opposite predictions about how competition affects the structure of relative prices within a price schedule.

In the model of Stole (1995), competition reduces prices at the bottom of the price schedule proportionally more than at the top since consumers with a higher marginal valuation for quality are more brand-loyal, and the price reductions necessary to attract them to their less preferred brand are too high. Conversely, in the model of Rochet and Stole (2002), competition reduces prices at the top of the price schedule proportionally more than at the bottom since consumers with a higher marginal valuation for quality enjoy more information rents or net surplus and are best able to

[1]To overcome technical difficulties, most models focus on one dimension (vertical or horizontal), perform numerical simulations in case there is not a closed-form solution, or impose further restrictions on preferences to avoid multidimensional settings (Stole, 2007).

[2]Firms maximize profits subject to incentive compatibility and participation constraints.

seek out substitutes.[3] More recently, Yang and Ye (2008) extend Rochet and Stole's (2002) model by relaxing the assumption of full-market coverage, but do not provide predictions about the effect of competition on relative prices.[4]

Models with both discrete product and consumer types provide a better framework to explicitly examine the impact of competition on relative prices. As in Villas-Boas and Schmidt-Mohr (1999) and Liu and Serfes (2006), this study develops a two-type model with two firms offering two products, differentiated by quality, and two consumer types. This model yields closed-form solutions and enable us to perform comparative static analysis, while maintaining a fixed number of product types. The model is also extended in two directions, as discussed later.

B. A Testable Model

The model builds on the models developed by Villas-Boas and Schmidt-Mohr (1999) and Liu and Serfes (2006).[5] Different assumptions are made that allow us to solve the model as a two-stage non-cooperative game and look for a subgame-perfect symmetric equilibrium, as in Piga and Poyago-Theotoky (2005).

Consider two firms located at the end points of a unit-length interval. Firm 1 is located at zero and Firm 2 is located at one. The firms each offer two products

[3]Stole (1995) develops a model of horizontal preference uncertainty with a positive correlation between the intensity of brand preferences and the marginal valuation for quality. Rochet and Stole (2002), in turn, develop a model of horizontal and vertical preference uncertainty where both dimensions are uncorrelated.

[4]These authors show that competition has a larger negative effect on prices in the higher end of the quality range. However, more competition also increases the coverage of individuals with a lower marginal valuation for quality, which end up paying lower prices for products in the lower end of the quality range.

[5]Villas-Boas and Schmidt-Mohr (1999) analyze the effect of horizontal differentiation (intensity of competition) on loan-granting practices while Liu and Serfes (2006) evaluate the relationship between the degree of competition and the Gini coefficient in the airline industry.

differentiated by quality, a low-quality product q_L at price p_L and a high-quality product q_H at price p_H. Both firms have the same technology and costs. To produce a unit of quality q a firm incurs in cost cq $(c \geq 0)$. There are also fixed costs of producing good of quality q equal to $q^2/2$.[6]

Consumer preferences differ regarding both quality and location. These preferences are unobservable and noncontractable. An individual who purchases product (q, p) from Firm 1 enjoys utility $U(\theta, q, p, d) = v + \theta q - p - td^2$, where $v > 0$ is the reservation utility obtained from making a purchase, θ is the marginal preference for quality, t are per-unit transportation costs, and d is the distance to Firm 1 (horizontal location).[7] The marginal preference for quality or vertical type θ and the horizontal location d are independent. Conversely, an individual who purchases product (q, p) from Firm 2, enjoys utility $U(\theta, q, p, d) = v + \theta q - p - t(1-d)^2$. These utility functions imply that firms are only able to sort consumers with respect to their marginal preference for quality.[8]

In the airline context, the quality or vertical dimension captures different marginal preferences over ticket characteristics (restrictions) while the location or horizontal dimension captures different preferences over carriers (or departure times). The marginal disutility of flying in a particular airline or departure time, which is not the consumer's preferred one, is then increasing in the difference (distance) between the two.

Assume two consumer types in the vertical dimension, a fraction λ with a low

[6]The quadratic functional form assumed is not crucial. A convex cost function is sufficient to solve the model.

[7]The assumption that transportation costs are quadratic in distance is standard for these models. In this study, the model yields similar predictions under both linear and quadratic transportation costs.

[8]Refer to Appendix A for further details about the model.

marginal preference for quality denoted by θ_L (hereafter low-type consumers), and a fraction $1-\lambda$ of individuals with a high marginal preference for quality denoted by θ_H (hereafter high-type consumers), where $\theta_H > \theta_L$. Low-type consumers could be regarded as leisure travelers while high-type consumers as business travelers. Each consumer type is uniformly distributed over the unit-length interval with a unit mass. Further assume that the reservation utility v is sufficiently high so that the whole market is covered.[9]

Firm i's, $i = 1, 2$, decision problem consists of offering quality-price pairs (q_{iL}, p_{iL}) and (q_{iH}, p_{iH}) that maximize profits subject to incentive-compatibility (IC) and participation constraints, given the other firm's quality-price pairs. Formally,

$$\underset{p_{iL},p_{iH},q_{iL},q_{iH}}{\text{Max}} \; \pi_i = \lambda[(p_{iL} - cq_{iL})x_{iL}] - \frac{q_{iL}^2}{2} + (1-\lambda)[(p_{iH} - cq_{iH})x_{iH}] - \frac{q_{iH}^2}{2}$$

s.t.

$$\theta_H q_{iH} - p_{iH} \geq \theta_H q_{iL} - p_{iL}, \tag{IC$_\text{H}$}$$

$$\theta_L q_{iL} - p_{iL} \geq \theta_L q_{iH} - p_{iH}, \tag{IC$_\text{L}$}$$

$$q_{iL}, q_{iH}, p_{iL}, p_{iH} > 0,$$

where x_{iL} and x_{iH} are the demands for Firm i's low- and high-quality products, respectively. The IC constraints, (IC$_\text{H}$) and (IC$_\text{L}$), imply that truth telling is a dominant strategy for all customers. It can be shown that Firm 1's demand functions are given by,

$$x_{1L} = d_L = \frac{t + \theta_L(q_{1L} - q_{2L}) - (p_{1L} - p_{2L})}{2t}, \tag{2.1}$$

[9]This is equivalent to the full-scale competition case in Villas-Boas and Schmidt-Mohr (1999).

$$x_{1H} = d_H = \frac{t + \theta_H(q_{1H} - q_{2H}) - (p_{1H} - p_{2H})}{2t}. \tag{2.2}$$

The participation constraint regarding competition for customers with the other firm is already embedded in the demand functions. The second participation constraint is the standard individual-rationality (IR) constraint, which is assumed slack for all consumers due to the full-market coverage assumption.

It is further assumed that the difference in quality between the high- and low-type product is a fixed proportion. Let $q_{iH} = \delta q_{iL}$, $i = 1, 2$, where $\delta > 1$. This assumption allows us to solve the model as a two-stage non-cooperative game and derive a subgame-perfect symmetric equilibrium where (IC_H) binds and (IC_L) does not.[10] In the first stage firms set quality while in the second stage they compete in prices. The details of the derivations are presented in Appendix A.

Following Villas-Boas and Schmidt-Mohr (1999) and Yang and Ye (2008), the degree of horizontal differentiation, captured by the per-unit transportation cost t, serves as an index for the level of competition among firms. A decrease in t is equivalent to an increase in the intensity of competition. In the extreme case of t=0, the horizontal dimension becomes irrelevant and the model reduces to a perfectly competitive market.[11] In the airline context, a lower t implies that travelers will view alternative carriers (flights) as closer substitutes. More competitive routes usually exhibit a higher flight density than less competitive ones, and competing firms schedule flights at closer departure times between one another. In the sample of routes used later in the analysis, the average difference in departure times between flights

[10]This further assumption is plausible in the airline industry since the quality ratio between high- and low-type fares could well be fixed across routes.

[11]Yang and Ye (2008) indicate that an increase in the number of firms (brands) in a circular brand-preference dimension is equivalent to a decrease in t with only two firms.

among highly concentrated routes more than doubles the average difference among less concentrated routes.

Figure 1 shows the impact of competition, measured through t, on the optimal price ratio p_H^*/p_L^*. Relative prices increase with competition (lower t) or, conversely, decrease with concentration (higher t). More specifically, the prices of both the low- and high-quality product decrease with more competition, but the price of the former decreases proportionally more than the price of the latter. It follows that firms compete more fiercely for low-type consumers when they face more competition.[12]

This baseline model is also extended in two directions:[13]

Extension 1: Each firm offers three product qualities (high, medium and low) to three consumer types (high, medium and low marginal preference for quality). Each consumer type is uniformly distributed over the unit-length interval. Per-unit transportation costs remain equal to t. The idea is to examine the impact of competition on relative prices within a wider range of product qualities, considering that airline tickets are later grouped into several quality categories.

Extension 2: Each firm offers two product qualities to two consumers types, as in the baseline model, but per-unit transportation costs differ across individuals. Following Liu and Serfes (2006), let $t_H > t_L$. High-type consumers are less likely to switch firms than low-type consumers or it is more costly for them to move away from their preferred carrier or departure time (Stole, 1995).

Figure 2 presents the effect of concentration on relative prices under the first

[12]The decrease in absolute prices with a lower t is consistent with the lower market power enjoyed by firms. The purchase of the high-quality product, in turn, must leave a higher net surplus to high-type consumers because they can also purchase the low-quality product. With increased competition, firms worry less about providing additional informational rents to high-type consumers because they already enjoy a higher net surplus with a lower t.

[13]For more details refer to Appendix A.

model extension with three product qualities and three consumer types. The price ratio of both the high- and medium- to low-quality product decreases with market concentration. The price ratio of the high- to low-quality product, however, decreases proportionally more than the price ratio of the medium- to low-quality product with an increase in t. Firms compete more fiercely for low-type consumers and, to a lower extent, for medium-type consumers when they face more competition.[14]

Figure 3 shows how the optimal price ratio will vary with concentration under the second model extension with two product qualities and two consumer types but $t_H > t_L$. In this case, variations in the level of competition are measured through changes in t_L and t_H. An increase in t_L is equivalent to a decrease in the level of competition for low-type consumers while an increase in t_H indicates a decrease in the level of competition for high-type consumers. Relative prices decrease with market concentration, but this inverse relationship is more pronounced with changes in the level of competition for low-type consumers, which are also more likely to switch firms.[15]

To summarize, the following testable implications can be derived. First, the price ratio of high- to low-quality products decreases with market concentration. The inverse relationship between relative prices and concentration is more pronounced when low-type individuals are less reluctant to switch firms. This seems reasonable in the airline industry, provided that low-type travelers are generally less brand-loyal

[14]Firms need to worry less about medium- than low-type consumers with increased competition because the former will enjoy of higher information rents with a lower t. High-type consumers will enjoy of even higher information rents with increased competition.

[15]Although not reported, absolute prices decrease with either a decrease in t_L or t_H. This is explained by the incentive compatibility constraints that restrict consumers to select the product type designed for them. A decrease in t_L, for example, decreases both p_L and p_H (in a lower extent), to prevent high-type consumers from buying the low-quality product.

and more price sensitive than high-type travelers. Second, the price ratio of medium- to low-quality products decreases with less competition, but to a lower extent than the price ratio of high- to low-quality products.[16]

The following chapters describe the data used in the analysis and empirically examine the relationship between market concentration and relative prices in the context of a menu of airline fares. The goal is to test the model predictions derived in this chapter and analyze whether market structure conditions affect a carrier's nonlinear pricing strategy.

[16] Note that these predictions imply a negative correlation between price dispersion and market concentration, predicted in other related models under a different theoretical framework, e.g. Borenstein (1985), Holmes (1989) and Gale (1993). Borenstein (1985) and Holmes (1989) work under a monopolistic competition setup where firms primarily sort customers based on the strength of their brand preferences. It is shown that firms will compete more fiercely for customers who are less brand loyal (probably low-type individuals in the present model) when they face more competition. Gale (1993) develops a two-period airline model with price discrimination. Tickets are initially homogenous and become horizontally differentiated just prior to flight departure. The author shows that firms will compete more fiercely for consumers who are less time-sensitive (probably low-type individuals in the present model) with increased competition.

CHAPTER III

DATA

The main data source of this study is a census of airline ticket transactions from a major Computer Reservation System (CRS). The data set consists of tickets purchased between June and December 2004 for travel in the fourth quarter of the same year. It includes tickets purchased directly from airlines, including their websites, and through travel agents and several online travel sites. Overall, the data represents around thirty percent of all domestic ticket transactions in the U.S. For each ticket sold or itinerary, there is information on the fare paid, origin and destination, segments (coupons) involved in the itinerary, carrier and flight number, cabin and booking class, and dates of purchase, departure and return.

Following Borenstein (1989) and Borenstein and Rose (1994), a route is defined as an airport-pair, regardless of direction, and itineraries other than one-way and roundtrips are not considered. The analysis is restricted to nonstop itineraries. Tickets that involve travel with different airlines (interline tickets) are also excluded. Prices are measured as roundtrip fares, so in the case of one-way tickets the fare is doubled. To avoid holiday peaks, transactions involving travel on Thanksgiving, Christmas and New Years are dropped.[1] The data set includes tickets for flights operated by AirTran, Alaska, American, America West, Continental, Delta, Frontier, Hawaiian, Midwest, Northwest, Spirit, Sun Country, ATA, United and US Airways.[2]

---

[1]The analysis excludes travel on the Wednesday prior to Thanksgiving until the following Sunday, as well as travel beginning on December 22nd through the end of year.

[2]The data set includes tickets from all carriers, except Southwest whom transported at least five percent of all domestic travelers during the fourth quarter of 2004. Southwest tickets are excluded because there is only limited information for these tickets.

Due to confidentiality reasons, the major CRS vendor did not provide information on ticket restrictions. Consequently, the transaction data set was merged to historical data from a travel agent's CRS containing a large subset of ticket fares offered for travel in the last quarter of 2004.[3] For each fare listed on this second data set, there is information on origin and destination, carrier, booking class, departure date from origin, advance purchase requirements, refundability, travel restrictions, and maximum or minimum stay restrictions. The matching procedure, described in Puller, Sengupta, and Wiggins (2007), matches an itinerary from the transaction data set to a fare from the travel agent's data set based on route, carrier and prices. The matching process ensured that fares matched within two percent and that the itinerary matched advance purchase requirements and travel and stay restrictions.

The analysis restricts attention to matched itineraries where there are at least one thousand observations per route and one hundred observations per carrier-route. This restriction results in 878,169 tickets on 246 routes or 460 carrier-routes. The list of routes is reported in Table 1.

Figure 4 presents kernel densities comparing the fares of the matched transactions and the more complete, original data. The matching procedure appears to match at a somewhat lower rate at the lower end of the fare distribution, but generally the matched tickets are representative.

The matched data set permits us to group tickets into broad quality groups. Specifically, tickets are grouped into four quality categories. Group F fares include first class tickets. Group 1 fares correspond to refundable business, full coach and coach tickets. Group 2 fares include nonrefundable tickets without travel or stay restrictions while Group 3 fares include nonrefundable tickets with travel and/or stay

[3]The travel agent's data set is incomplete because some of the posted fares are usually deleted after a certain period of time, although not in a systematic way.

restrictions.

Quality generally decreases as one moves from Group F through Group 3. Group F is first class, refundable and unrestricted, Group 1 is refundable typically without restrictions, Group 2 is nonrefundable but without restrictions, while Group 3 is nonrefundable and carries significant travel and/or stay restrictions. Table 2 shows the variation in mean fares by group for various carriers, which tend to confirm the asserted price/quality differences.[4] Specifically the data was calculated as deviations from the mean fare at the carrier route level. These deviations were then averaged across routes for individual carriers.

Overall, there is a strong correlation between the grouping of tickets and prices. Figure 5 shows that the average fare per mile among tickets in Group F through Group 3 is 96, 57, 26 and 17 cents, respectively. The positive correlation between the broad quality categories and prices is recurrent across itineraries involving different travel distances. This price/quality differences perfectly fit in the theoretical setup where carriers are assumed to offer different quality-price combinations for consumers to self-select.[5]

In addition to the transaction data, various market level data from other sources is also used. These include route level carrier market share and market structure measures, as well as other market level variables widely used in the literature. Table 3 details the sources of information consulted to construct these variables. Other market level variables include hubs, slot-controlled airports, presence of Southwest

[4]The carriers include American, United, Delta, Continental, US Airways and Northwest. Each of these carriers transported at least five percent of all domestic travelers during the last quarter of 2004.

[5]This four-type fare structure together with dummy variables for time of purchase and one-way travel and carrier fixed effects, explain on average 73 percent of the fare variation in each of the routes analyzed. Details are available upon request.

and other low cost carriers, distance, total number of flights, per capita income, tourism index and temperature difference. Appendix B provides a full description of all the variables used in the analysis.

In the case of the market structure measures, there is a continuous variable, the Herfindahl-Hirschman Index or HHI. As an alternative measure, three categorical variables are considered: monopoly, duopoly and competitive, which where developed by Borenstein and Rose (1994). A route is considered a monopoly if a single carrier transports more than 90 percent of nonstop passengers. A non-monopoly route is considered a duopoly if two carriers cumulatively transport more than 90 percent of nonstop passengers. All other routes are considered competitive.[6]

Table 4 presents descriptive statistics of the final data set. Roundtrip fares range from 62 dollars for a trip Las Vegas (LAS) – Los Angeles (LAX) in American to 4,806 dollars for a trip San Francisco (SFO) – New York-Kennedy (JFK) in United. The average fare paid is 457 dollars or 31.3 cents per mile. The fraction of tickets in Group F through 3 is 5, 20, 28 and 47 percent, respectively. Roughly 61 percent of the tickets are bought less than two weeks prior to departure, and 25 percent are purchased in the last 3 days. Additionally, more than 80 percent of the itineraries involve travel to/from a hub of the operating carrier, 74 percent of the itineraries are for roundtrip travel, and 65 percent of the tickets involve travel during peak times.[7]

The distribution of tickets by market structure, reported in Table 5, indicates that 40 percent of the itineraries in the sample correspond to competitive routes, 48

[6]This study uses the number of nonstop passengers on a route to calculate the market structure measures, instead of the number of flights used by Borenstein and Rose (1994). Previous studies have found that using either the number of passengers or the number of flights as a basis for market concentration calculations yields similar results (Stavins, 2001).

[7]Peak time is defined as Monday through Friday between 7–10am and 3–7pm.

percent to duopoly routes, and 12 percent to monopoly routes. In terms of routes, 18 percent of them are monopolies, 48 percent are duopolies and the remaining 34 percent are competitive markets.[8] A similar distribution of tickets and routes by market structure is observed across different flying distances. On average, there is a reasonable number of tickets per route across markets with different levels of concentration and travel distance.

A. Preliminary Analysis

Figure 6 provides a preliminary look at the ratio of various ticket group fares and Group 3, the lowest price tickets, under different market concentration levels. The figure shows that the average fare per mile of Group F (First Class) decreases relative to Group 3 as markets become more concentrated. On competitive routes the ratio of Group F to Group 3 fares is approximately 5.9 while on monopolistic routes the ratio is less than 4.6. In contrast, the ratio of Group 1 to Group 3 fares increases as we move to less competitive markets, from 2.7 in competitive markets to 3.7 in monopoly markets, while Group 2 relative fares do not seem to vary with market structure conditions (the ratio fluctuates around 1.5). This relative pricing pattern, moreover, holds under alternative market structure definitions (see Figure 7).[9]

[8]In Borenstein and Rose (1994), 12 percent of the 521 routes analyzed are monopolies, 41 percent are duopolies, and 46 percent are competitive markets. The period of analysis is the second quarter of 1986.

[9]The alternative definitions include the HHI and Verlinda's (2005) market structure categories. In the case of the HHI, routes are divided into three groups: HHI less than or equal to 0.5, HHI between 0.5 and 0.8, and HHI greater than 0.8. In the case of the market structure categories, a route is considered a monopoly if a carrier transports at least 50 percent of nonstop passengers and the share of the second major carrier is less than one ninth of the share of the first carrier. A non-monopoly route is considered a duopoly if two carriers cumulatively transport at least 50 percent of nonstop passengers and the share of the third major carrier is less than one ninth of the share of the second carrier. All other routes are considered competitive.

The decrease in the ratio of high- to low-type fares as markets become more concentrated, specifically the ratio of Group F to Group 3 fares, matches the predictions of the theoretical model. In the model, as we move to less competitive markets, the lower price ratio results from the fact that low-type fares increase proportionally more than high-type fares. The relative increase of Group 1 fares (i.e. medium-type fares), however, does not match the model predictions.[10] Overall, the observed relative pricing pattern is in line with Borenstein and Rose (1994) which find a negative effect of market concentration on price dispersion.[11]

Another preliminary look at the data can be obtained by examining carrier pricing on monopoly versus competitive routes matched by distance. For example, Figures 8 and 9 show United Airlines' (UA) average relative prices, by fare type and day of purchase, for two of the main short-distance and long-distance routes in the sample.[12] Among the short-distance routes, Washington-Dulles (IAD) – Boston (BOS) is a competitive market and San Francisco (SFO) – San Diego (SAN) a monopoly market. Among the long-distance routes, San Francisco (SFO) – New York-Kennedy (JFK) is a competitive route and San Francisco (SFO) – Washington-Dulles (IAD) a monopoly route. The ratio of Group F to Group 3 fares is typically lower in the selected monopoly routes than in the competitive ones, independent of the time of purchase. Moreover, Group F relative fares appear to overlap with Group 1 relative fares in monopoly markets while in competitive markets they are different.

[10] A possible explanation for this result is discussed later.

[11] Borenstein and Rose (1994) do not include first class tickets. It is interesting to still observe a negative correlation between market concentration and price dispersion when including a broader range of ticket types.

[12] Day of purchase is the number of days prior to departure that the ticket was purchased. As discussed later, fares may vary as the purchase date approaches the departure date due to variations in capacity utilization.

CHAPTER IV

EMPIRICAL ESTIMATION

This chapter discusses the empirical strategy, the model specification and the estimation results. The chapter first addresses the importance of carrying out a regression analysis to control for several cost and market-specific factors, and examine whether carriers modify their nonlinear pricing strategy when they face less competition. Next, the two log-linear fare equations estimated are described, a no-interaction model and an interaction model. The chapter then presents the estimation results, including separate estimations by main carrier. The estimation results of an alternative semi-parametric model are discussed at the end.

A. Empirical Strategy

As noted, the theoretical model predicts that the ratio of high- to low-quality fares will decrease as a market becomes more concentrated. The model also predicts that the ratio of medium- to low-quality fares will decrease with less competition, but to a lower extent than the ratio of high- to low-quality fares. Considering that nonlinear prices enable firms to price discriminate, the ultimate goal of this dissertation is to examine whether market structure conditions affect a carrier's price discrimination strategy. This involves isolating the effect of competitive interactions on relative prices from cost and other market-specific effects.

More specifically, Clerides (2004) argues that any price variation that cannot be explained by cost differences is usually regarded as price discrimination. The present study adopts this reasoning. To conclude then that nonlinear prices are discriminatory and that carriers modify their price discrimination strategy when they face less competition, it is necessary to account for costs.[1] Ideally, this requires comparing the price-cost ratio of the different ticket groups and Group 3 across routes with different levels of competition. Marginal costs, however, are not directly observed.

An option is to assume that the marginal cost ratio of various ticket group fares and Group 3 do not change with market structure, as in Busse and Rysman (2005). But the marginal cost of an airline ticket (seat) is the sum of the marginal cost of the service, incurred only on sold tickets, plus the shadow cost of capacity, incurred whether or not the ticket is sold (Dana, 1998). The former is, for example, the cost of fuel and meals while the latter results from variations in capacity utilization over time and/or changes in the perceived probability that demand will exceed capacity. The cost ratio of the different ticket groups might be neutral to market structure if only the marginal cost of the service is considered, but it is not necessarily neutral if the shadow cost of capacity is included.[2] The shadow cost of capacity of a ticket depends on several factors at the ticket, flight and route level.

Another element to consider is that routes not only differ in the level of competition, but they may also differ in other market characteristics, like relative demands for different fare types. The difference in relative demands could affect the nonlinear pricing strategy followed by carriers, regardless of the level of competition on the route. In Figure 8, for example, there might be a higher fraction of business travelers

[1] In the theoretical model firms are assumed to face a constant marginal cost, so it is not necessary to worry about any cost effects.

[2] For example, assume that there is excess demand for high-quality tickets during peak periods. Further assume that competitive routes exhibit a higher flight density during peak periods than monopoly routes. The shadow cost of capacity of high- to low-quality fares is then expected to change as we move to more competitive markets. The direction of the change, however, is uncertain. As pointed by Borenstein and Rose (1994), an increase in the number of flights is likely to lower the shadow cost of capacity for flights facing excess demand but may raise the demand uncertainty for any given flight.

and a higher demand for high-quality fares, relative to low-quality fares, on the route Washington-Dulles (IAD) – Boston (BOS) versus the route San Francisco (SFO) – San Diego (SAN). The difference in relative prices between these routes could be partly explained by differences in the relative demand for different fare types.

It is necessary then to isolate the effect of competitive interactions on relative prices from cost and other market factors that may explain airline fares. A regression analysis allows us to do so by controlling for several factors at the ticket, flight and market level. The idea is to account for possible differences in costs, particularly shadow costs, across fares as well as for differences in market characteristics, like relative demands for different fare types, across routes.

B. Model Specification

The model to be estimated allows us to examine the quality premium of the different ticket group fares over Group 3, the lowest price tickets, and whether these premia vary with market concentration. It also allows us to control for factors that may affect prices through costs or through market characteristics. In particular, fares are modeled as a function of group dummies for fare type, market concentration, carrier market share on the route and a set of controls at the ticket, flight and market level. The key variables are the group dummies which capture the quality premia of the different ticket group fares over Group 3.

Two log-linear fare equations are estimated. In the first equation the quality premia are assumed to not vary with market concentration. In the second equation the quality premia are allowed to vary with market concentration, so the group dummies are interacted with the market concentration measures. The first equation is referred to as the no interaction model and the second equation as the interaction model.

The log-linear fare equation of the no interaction model is given by,

$$\begin{aligned}\ln p_{ijkt} &= \beta_0 + \sum_{f=F}^{2} \beta_{f1} q_{f_i} + \beta_2 mktstructure_k + \beta_3 mktshare_{jk} \\ &+ X_{ijkt}\lambda + \alpha_{1j} + \kappa_{1k} + \varepsilon_{ijkt}\end{aligned} \tag{4.1}$$

where p_{ijkt} is the fare per mile of ticket (itinerary) i charged by carrier j on route k at time t, q_{f_i} is a dummy variable for Group f fare, $f = F, .., 2$, $mktstructure_k$ is the route market structure (measured through the HHI or categorical variables for monopoly and duopoly), $mktshare_{jk}$ is the carrier market share on the route, and X_{ijkt} is a vector of ticket, flight and route controls. The error term is assumed to have a carrier effect α_{1j}, a route effect κ_{1k} common to all carriers on a route, and a white noise error ε_{ijkt} specific to each observation.

The log-linear fare equation of the interaction model is given by,

$$\begin{aligned}\ln p_{ijkt} = \quad & \delta_0 + \sum_{f=F}^{2} \delta_{f1} q_{f_i} + \delta_2 mktstructure_k + \sum_{f=F}^{2} \delta_{f3}(q_{f_i} \times mktstructure_k) \\ & + \delta_4 mktshare_{jk} + X_{ijkt}\gamma + \alpha_{2j} + \kappa_{2k} + \upsilon_{ijkt}.\end{aligned} \tag{4.2}$$

The parameters of interest are β_{f1} in equation (3) and δ_{f1} and δ_{f3} in equation (4), where $f = F, .., 2$. The magnitude of the coefficients β_{f1} and δ_{f1} approximates the quality premium of Group F through Group 2 fares over Group 3. The sign of δ_{f3} indicates how these premia vary with market concentration.

The vector of controls X_{ijkt} is intended to account for cost and market-specific factors, other than market structure and carrier market share, that may explain airline pricing. The ticket-specific controls include dummy variables for number of days in advance the ticket was purchased (0–3 days, 4–6 days, 7–13 days, and 14–21 days) and one-way tickets. The shadow cost of a fare, for example, may vary as the purchase date nears departure due to variations in capacity utilization.

In addition to ticket characteristics it is also important to control for flight characteristics. More specifically, the theories developed by Dana (1998, 1999a, 1999b) and Gale and Holmes (1993) indicate that prices may vary with load factor.[3] Variations in the load factor of a flight may reflect both changes in capacity utilization and in the perceived probability that demand will exceed capacity. Accordingly, two peaking variables are included: the average load factor at purchase of the itinerary's flight segments and whether the itinerary involves departure and/or return during periods of peak travel.

The analysis also includes market-specific controls widely used in the literature.[4] These market variables include a hub dummy if the carrier has a hub at the airport of origin or destination, a dummy variable to indicate if either of the endpoint airports is a slot-controlled airport, and a Southwest dummy and low cost dummy indicating the presence of Southwest and other low cost carriers on the route.[5] Slot-controlled airports are supposed to raise the costs of serving a market, while the presence of Southwest or other major low cost carriers on a route may result in significant price reductions.

Other market-specific variables include distance, frequency of flights on the route, average per capita income at the endpoint cities, a tourism index, and the absolute temperature difference between the origin and destination.[6] The latter two variables

[3]These theories argue that airline pricing can be explained in a context of costly capacity, perishable goods and demand uncertainty.

[4]See Borenstein (1989), Brueckner, Dyer, and Spiller (1992), Borenstein and Rose (1994), Stavins (2001) and Lee and Luengo-Prado (2005).

[5]Slot-controlled airports include Washington-National (DCA), New York-Kennedy (JFK) and New York-La Guardia (LGA). A five percent market share threshold is used to account for the presence of Southwest or other low-cost carriers on a route, as in Lee and Luengo-Prado (2005).

[6]The tourism index is the fraction of accommodation to personal income at the destination city.

are intended to control for tourist effects and, potentially, for differences in the relative demand for different fare types. The tourism index is a proxy of the proportion of leisure travelers to each destination (Borenstein, 1989; Borenstein and Rose, 1994). A larger absolute temperature difference between the origin and destination might also indicate a higher proportion of leisure travelers on the route (Brueckner, Dyer, and Spiller, 1992; Stavins, 2001).

In sum, the set of variables at the ticket, flight and market level allows us to control more accurately for costs and market factors that may explain airline pricing. The idea is to isolate the effect of market concentration on the quality premium of the different ticket group fares. Any variation of these premia will suggest that carriers modify their price discrimination strategy when they face less competition.

C. Estimation Results

1. Least-Squares Estimations

The fare equations specified in (3) and (4) are estimated by both ordinary (OLS) and two-stage least squares (2SLS). Carrier effects are treated as fixed and route effects as random.[7] The 2SLS approach is required to address the potential endogeneity of the carrier market share and route HHI. The analysis uses the same instruments as Borenstein (1989) and Borenstein and Rose (1994). A carrier's market share is endogenous because it is a function of the price it charges and is instrumented using the carrier enplanement share at the two endpoint airports. To the extent that market share is endogenous, the route HHI is also endogenous since the square of market share is one component of the HHI. The HHI is instrumented with the square of the fitted

[7]Route effects are treated as random in order to include route-specific variables, like market structure measures, in the estimations.

value of market share (from its first regression) plus the rescaled sum of the square of all other carriers' shares on the route.[8]

Table 6 presents the results of estimating fare equation (3), the no interaction model.[9] These regressions examine the quality premium of Group F through Group 2 fares, over Group 3, using several ticket-, flight- and market-specific controls. In Model 1 market concentration is measured using the HHI while in Model 2 three categorical variables are used: monopoly, duopoly and competitive, where the latter category is left out.

The estimation results confirm the asserted price/quality differences of the different ticket group fares, after controlling for cost and market-specific factors. The quality premium over Group 3 fares declines progressively as we move from Group F through Group 2. In the first model, where the HHI is used as the measure of market concentration, the 2SLS results indicate that Group F through Group 2 fares per mile are, on average, 168, 67 and 31 percent higher than Group 3 fares, respectively. In the second model, where categorical variables are used to measure market concentration, the corresponding premia are 169, 65 and 31 percent.

The coefficients of the control variables generally have the expected signs and are statistically significant in both models. For clarity of exposition, the estimation results of the second model are described next. The results show that both the time of purchase and one-way tickets have an important effect on ticket prices. Tickets bought closer to departure time are typically more expensive than those bought several days in advance. More specifically, travelers who purchase a ticket 0–6 days in advance

[8]Refer to Appendix B for further discussion on these instruments. The total number of flights on a route is also instrumented using the average population at the two endpoint cities.

[9]For ease of presentation, estimates of the carrier fixed effects are omitted. The standard errors reported are robust, clustered on the origin city.

end up paying between 13 and 16 percent more per mile than those who purchase a ticket over 21 days in advance. One-way tickets are 16 percent more expensive than half the price of roundtrip fares.

The results also indicate that the flight or peaking variables are statistically significant, but their economic magnitudes are small. A one standard deviation increase in the average load factor at the time of ticket purchase (0.29) only increases fares per mile by four percent. Tickets that involve travel during peak times of day are approximately three percent more expensive than those during off-peak times.

Most of the coefficients of the market variables are consistent with the literature. The results show that fares per mile on routes where the operating carrier has a hub at either or both endpoint airports are 45 percent higher than fares on routes not involving a carrier's hub. The presence of a slot-controlled airport increases average fares by about 19 percent. In routes where low-cost carriers, other than Southwest, are present fares per mile are 11 percent lower than in other routes, while in routes where Southwest is present fares are 38 percent lower. Distance between endpoints and flight frequency on the route decrease the average fare per mile while a higher per capita income at the endpoint cities increases fares. The results also reveal that the average fare per mile decreases with market concentration, as found in previous studies of airline pricing.[10] The carrier market share on the route, however, does not result significant.

Regarding the tourist effect variables, which are a proxy of the proportion of leisure travelers on a route, only the tourism index is statistically significant but economically small. A one standard deviation increase in the tourism index (0.03) results in a four percent decrease in the average fare per mile.

[10]See Borenstein (1989) and Stavins (2001).

Turning to whether the quality premium of the different ticket group fares (over Group 3) vary with market concentration, Table 7 presents the estimation results for equation (4), the interaction model.[11] As noted, in addition to the variables used in equation (3), this model includes the interactions of the group dummies with the market concentration measures. In Model 1 the group dummies are interacted with the HHI while in Model 2 they are interacted with categorical variables for monopoly and duopoly. Note that the estimated coefficients of the control variables in both models are very similar to those in Table 6.

The 2SLS results using the HHI as the measure of concentration (Model 1) show a statistically significant but moderate decrease in the premium of Group F over Group 3 fares as markets become more concentrated. The results also show an increase in the premium of Group 1 over Group 3 fares as markets become less competitive while the relative premium of Group 2 fares does not seem to vary with market concentration. In the upper section of Table 8 the quality premium of the different fare groups, over Group 3, are reported at various percentile levels of HHI. The estimated Group F relative premium decreases from 174 percent at the 10th percentile of HHI (0.34) to 158 percent at the 90th percentile of HHI (0.89). The estimated Group 1 relative premium increases from 50 to 88 percent at the corresponding percentile levels of HHI.

The estimation results using categorical variables as measures of market concentration (Model 2) also indicate a decrease in the relative premium of Group F fares as markets become less competitive. From the lower section of Table 8, the Group F relative premium decreases by 42 percentage points as we move from competitive to monopoly markets (from 171 to 129 percent). The relative premium of Group 1 fares

[11]The estimates of the carrier fixed effects are also omitted and the standard errors reported are robust, clustered on the origin city.

exhibits, in turn, an increase of 47 percentage points from competitive to monopoly markets (from 54 to 101 percent) while the relative premium of Group 2 fares appears to not vary with market structure conditions. The variations in the relative premia with market concentration are very similar to the observed variation in relative prices in the preliminary analysis (see Figure 6).

To summarize, the regression analysis reported in Tables 6–8 provides two important results. First, controlling for cost and market-specific factors, the quality premium over Group 3 fares declines progressively as we move from Group F (First Class) through Group 2. This result confirms the asserted price/quality differences of the ticket groups. Second, the quality premium of high- to low-type fares decreases as markets become more concentrated, specifically the relative premium of Group F fares which also matches the predictions of the theoretical model. The relative premium of Group 1 fares or medium-type fares, however, increases as markets become less competitive. Overall, the results suggest that carriers modify their price discrimination strategy when they face less competition, at least some of them as discussed later.

A possible explanation for the relative increase of medium-type fares as markets become more concentrated, which the theoretical model fails to predict, is that carriers might be following a complementary strategy when they face less competition. More specifically, the relative increase of medium priced fares together with the relative decrease of high priced fares suggest that carriers could be inducing travelers to purchase tickets of higher quality. Although not reported, certain carriers show a higher fraction of high-quality tickets sold in monopoly routes, relative to competitive routes, together with a lower fraction of medium-quality tickets sold. The analysis of this complementary strategy is beyond the scope of the present study.[12]

2. Estimations by Carrier

Separate estimations for each major carrier were also performed to examine whether the changes in the quality premia of the different ticket group fares with market concentration, are recurrent across carriers. The major carriers include American, United, Delta, Continental, US Airways and Northwest.[13] The 2SLS results of estimating equation (4), the interaction model, for each of these carriers are shown in Table 9. As noted, in Model 1 market concentration is measured using the HHI while in Model 2 categorical variables are used.

The estimation results, particularly under the second model specification, indicate that carriers behave differently when they face less competition. Delta, United and American, in a minor extent, show a decrease in the premium of Group F fares, relative to Group 3, as markets become more concentrated. In the case of Delta, the premium of Group F tickets decreases from 173 percent in competitive markets to 111 percent in monopoly markets. In the case of United, the corresponding premium decreases from 182 to 123 percent while in the case of American the premium decreases from 144 to 120 percent.

Of these three carriers, only American shows at the same time a statistically and economically significant increase in the relative premium of Group 1 fares as markets become less competitive. The premium increases from 30 percent in competitive

[12]Theoretically, the analysis of this complementary strategy requires to modify the current setup where consumers are assumed to buy the product type designed for them. Empirically, the analysis implies a joint estimation of price and quantity shares of the different fare groups.

[13]Each of these carriers transported at least five percent of all domestic travelers during the fourth quarter of 2004.

markets to 110 percent in monopoly markets. In contrast, United and Delta exhibit a moderate increase in the relative premium of Group 2 fares.

Regarding the other airlines, both US Airways and Northwest show an important increase in the relative premium of Group 1 fares from competitive to monopoly markets, but the relative premium of Group F fares does not decrease with market concentration. The premium of Group 1 fares increases from 40 to 106 percent in the case of US Airways and from 58 to 106 percent in the case of Northwest. Continental, in turn, does not seem to vary the relative premia of the different ticket group fares with market structure.

D. Alternative Estimation

In this section, an alternative partially linear smooth coefficient regression is performed to check the robustness of the results. This semiparametric estimation method allows us to model the quality premium of Group F through Group 2 fares, over Group 3, as a function of HHI without imposing any functional form on the relationship between these premia and market concentration. The estimation procedure also allows us to include a set of control variables.

The following log fare equation is estimated,

$$\ln p_{ijkt} = g_0(HHI_k) + \sum_{f=F}^{2} g_{f1}(HHI_k)q_{f_i} + X_{ijkt}\phi + \alpha_j + \kappa_k + \nu_{ijkt} \tag{4.3}$$

where p_{ijkt} is the fare per mile of ticket (itinerary) i charged by carrier j on route k at time t, $g_0(\cdot)$ and $g_{f1}(\cdot)$, $f = F, .., 2$, are unspecified smooth functions of HHI, and X_{ijkt} is a subvector of the controls used to estimate the no interaction model in equation (3) and the interaction model in equation (4). More specifically, the controls include all the ticket and flight controls used previously plus a dummy variable for the presence of a hub on the route. The other market controls are not included due to multicollinearity issues in the estimation process.[14]

The estimation is performed over a one percent random sample of the data set, approximately 8,740 observations, due to the computational burden of the methodology. The random sample maintains the proportion of tickets by route, carrier and fare type. The bandwidth of HHI was first estimated via least-squares cross validation using a second-order Gaussian kernel function.[15]

Figure 10 shows how the quality premia of the different ticket group fares, over Group 3, vary with the level of HHI. Consistent with the previous results, the Group F premium declines in highly concentrated markets (i.e. monopoly markets). The premium is close to 180 percent until a HHI of 0.7 and then decreases up to 130 percent at a HHI close to one. The premium of Group 1 fares shows, in turn, a non-monotonic increase with market concentration. The premium is between 80 and 90 percent at HHI levels below 0.6 and between 125 and 130 percent at HHI levels above 0.8. The premium of Group 2 fares does not seem to vary with the level of competition in the market. In sum, the pattern observed is similar to the one obtained under the least-squares approach, particularly the relative decrease of the Group F premium and the relative increase of the Group 1 premium in highly concentrated markets.

[14]Both the carrier and route effects are treated as random in this case.

[15]The estimation of the bandwidth of HHI also accounts for distance, per capita income and the tourism index. These market-specific variables are then smoothed out to derive the unspecified smooth functions, $g_0(\cdot)$ and $g_{f1}(\cdot)$, where $f = F, .., 2$. For further details on the estimation method refer to Li and Racine (2007).

CHAPTER V

CONCLUSIONS

This dissertation has provided new insights about the impact of market concentration on nonlinear pricing strategies in the airline industry. The analysis develops a nonlinear pricing model with both discrete product and consumer types to derive testable implications about the impact of concentration on relative prices within a menu of quality-price pairs. These predictions are then tested using a unique, ticket level data set that allows us to separate wide-ranging fares with restrictive ticket characteristics into different quality groups.

The estimation results show that market concentration differentially impacts high versus low priced fares, as predicted by the theoretical model. Controlling for numerous factors that may affect prices through costs and market characteristics, high-quality fares (First Class tickets) decrease relative to low-quality fares as markets become less competitive. The ratio of medium- to low-quality fares, however, increases with more concentration. Separate regressions for each main carrier also suggest that carriers do not all behave similarly when they face less competition.

Overall, the study contributes to the understanding of the effect of market structure conditions on the dispersion of airline prices. The observed relative pricing pattern within a menu of fare types and ticket restrictions also confirms the negative relationship between market concentration and price dispersion found in Borenstein and Rose (1994).

From a welfare perspective, it is interesting to observe that not all travelers are affected in the same way with a decrease in the level of competition. Business travelers, who purchase high priced fares, end up paying relatively lower prices in less competitive markets while leisure travelers pay more. Conversely, leisure travelers end up paying relatively lower prices with more competition. This result seems reasonable in a context where individuals with a low marginal preference for quality, e.g. leisure travelers, are generally less brand-loyal.

REFERENCES

Armstrong, Mark, and John Vickers, "Competitive Price Discrimination," *RAND Journal of Economics* 32:4 (2001), 579–605.

Borenstein, Severin, "Price Discrimination in Free-Entry Markets," *RAND Journal of Economics* 16:3 (1985), 380–397.

——— "Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry," *RAND Journal of Economics* 20:3 (1989), 344–365.

Borenstein, Severin, and Nancy L. Rose, "Competition and Price Dispersion in the U.S. Airline Industry," *Journal of Political Economy* 102:4 (1994), 653–683.

Brueckner, Jan K., Nichola J. Dyer, and Pablo T. Spiller, "Fare Determination in Airline Hub-and-Spoke Networks," *RAND Journal of Economics* 23:3 (1992), 309–333.

Busse, Meghan, and Marc Rysman, "Competition and Price Discrimination in Yellow Pages Advertising," Working paper Boston University (2002).

——— "Competition and Price Discrimination in Yellow Pages Advertising," *RAND Journal of Economics* 36:2 (2005), 378–390.

Clerides, Sofronis K., "Price Discrimination with Differentiated Products: Definition and Identification," *Economic Inquiry* 42:3 (2004), 402–412.

Dana, James D., "Advance-Purchase Discounts and Price Discrimination in Competitive Markets," *Journal of Political Economy* 106:2 (1998), 395–422.

——— "Using Yield Management to Shift Demand When Peak Time Is Unkown," *RAND Journal of Economics* 30:3 (1999a), 456–474.

——— "Equilibrium Price Dispersion Under Demand Uncertainty: The Roles of Costly Capacity and Market Structure," *RAND Journal of Economics* 30:4 (1999b), 632–660.

Gale, Ian L., "Price Dispersion in a Market with Advance-Purchases," *Review of Industrial Organization* 8:4 (1993), 451–464.

Gale, Ian L., and Thomas J. Holmes, "Advance-Purchase Discounts and Monopoly Allocation of Capacity," *American Economic Review* 83:1 (1993), 135–146.

Holmes, Thomas J., "The Effects of Third-Degree Price Discrimination in Oligopoly," *American Economic Review* 79:1 (1989), 244–250.

Johnson, Justin P., and David P. Myatt, "Multiproduct Quality Competition: Fighting Brands and Product Line Pruning," *American Economic Review* 93:3 (2003), 748–774.

Kleibergen, Frank, and Richard Paap, "Generalized Reduced Rank Tests Using the Singular Value Decomposition," *Journal of Econometrics* 133:1 (2006), 97–126.

Lee, Darin, and Jose Luengo-Prado, "The Impact of Passenger Mix on Reported 'Hub Premiums' in the U.S. Airline Industry," *Southern Economic Journal* 72:2 (2005), 372–394.

Li, Qi, and Jeffrey S. Racine, *Nonparametric Economics: Theory and Practice* (Princeton, New Jersey: Princeton University Press, 2007).

Liu, Qihong, and Konstantinos Serfes, "Second-Degree Price Discrimination and Price Dispersion: The Case of the U.S. Airline Industry," Working paper University of Oklahoma (2006).

Maskin, Eric, and John Riley, "Monopoly with Incomplete Information," *RAND Journal of Economics* 15:2 (1984), 171–196.

McManus, Brian, "Nonlinear Pricing in an Oligopoly Market: The Case of Specialty Coffee," *RAND Journal of Economics* 38:2 (2007), 512–532.

Miravete, Eugenio J., "Competing with Menus of Tariff Options," *Journal of the European Economic Association* 7:1 (2009), 188–205.

Miravete, Eugenio J., and Lars-Hendrik Röller, "Estimating Price-Cost Markups Under Nonlinear Pricing Competition," *Journal of the European Economic Association* 2:2-3 (2004), 526–535.

Mussa, Michael, and Sherwin Rosen, "Monopoly and Product Quality," *Journal of Economic Theory* 18:2 (1978), 301–317.

Piga, Claudio, and Joanna Poyago-Theotoky, "Endogenous R&D Spillovers and Locational Choice," *Regional Science and Urban Economics* 35:2 (2005), 127–139.

Puller, Steven L., Anirban Sengupta, and Steven N. Wiggins, "Measuring Evidence of Peak-Load Pricing and Consumer Heterogeneities in Airline Pricing," Working paper Texas A&M University (2007).

Rochet, Jean-Charles, and Lars A. Stole, "Nonlinear Pricing with Random Participation," *Review of Economic Studies* 69:1 (2002), 277–311.

Seim, Katja, and V. Brian Viard, "The Effect of Entry and Market Structure on Cellular Pricing Tactics," NET Institute Working Paper No. 03–13 (2004).

Sengupta, Anirban, and Steven N. Wiggins, "Airline Pricing, Price Dispersion, and Ticket Characteristics on and off the Internet," Working paper Texas A&M University (2006).

Stavins, Joanna, “Price Discrimination in the Airline Market: The Effect of Market Concentration,” *Review of Economics and Statistics* 83:1 (2001), 200–202.

Stole, Lars A., “Nonlinear Pricing and Oligopoly,” *Journal of Economics and Management Strategy* 4:4 (1995), 529–562.

——— “Price Discrimination and Imperfect Competition,” in Mark Armstrong and Robert Porter (Eds.), *Handbook of Industrial Organization* Vol. III (Amsterdam: North Holland, 2007).

Verlinda, Jeremy A., “The Effect of Market Structure on the Empirical Distribution of Airline Fares,” Working paper Economic Analysis Group, U.S. Department of Justice (2005).

Villas-Boas, J. Miguel, and Udo Schmidt-Mohr, “Oligopoly with Asymmetric Information: Differentiation in Credit Markets,” *RAND Journal of Economics* 30:3 (1999), 375–396.

Yang, Huanxing, and Lixin Ye, “Nonlinear Pricing, Market Coverage, and Competition,” *Theoretical Economics* 3:1 (2008), 123–153.

APPENDIX A

MODEL DETAILS

About the Sorting Condition

From the utility function, the marginal rate of substitution (MRS) between contract parameters p and q is given by,

$$MRS_{pq} = -\frac{\partial U/\partial p}{\partial U/\partial q} = \frac{1}{\theta} \approx \frac{\Delta q}{\Delta p}. \tag{A.1}$$

Then,

$$\frac{\partial MRS_{pq}}{\partial \theta} = -\frac{1}{\theta^2} < 0, \tag{A.2}$$

$$\frac{\partial MRS_{pq}}{\partial d} = 0. \tag{A.3}$$

From equation (A.2), consumers with a low marginal preference for quality (hereafter low-type consumers) require a higher increase in quality (q) than consumers with a high marginal preference for quality (hereafter high-type consumers) to accept a unit increase in price (p). In contrast, equation (A.3) indicates that the marginal rate of substitution between the contract parameters is independent of the consumer's location (d). Consequently, firms are able to sort consumers with respect to their marginal valuation for quality, but not by their horizontal location. The sorting condition does not hold with respect to a consumer's location.

About the Incentive-Compatibility and Participation Constraints

Since both firms face a symmetric situation, Firm 1's decision problem is discussed next without loss of generality. In the baseline model, this firm will select quality-price pairs $\{q_1(\theta), p_1(\theta)\}_{\theta \in \{\theta_L, \theta_H\}}$ to maximize profits subject to incentive-compatibility (IC) and participation constraints, given the other firm's quality-price pairs.

The incentive-compatibility constraint is equivalent to the requirement that truth telling is a dominant strategy for all consumers in a direct revelation game. Let $U(\theta, q_1, p_1) = \theta q_1 - p_1$. Then, the IC constraint can be expressed as,

$$U_1(\theta) = U(\theta, q_1(\theta), p_1(\theta)) = \max_{\tilde{\theta}} U(\theta, q_1(\tilde{\theta}), p_1(\tilde{\theta})). \tag{A.4}$$

Regarding the participation constraints, one of them results from the competition for customers with the other firm. A consumer of type (θ, d) will prefer the incentive-compatible offer (q_1, p_1) from Firm 1 to the other firm's incentive-compatible offer (q_2, p_2) if and only if,

$$U_1(\theta) + v - td^2 \geq U_2(\theta) + v - t(1-d)^2 \tag{A.5}$$

where $U_2(\theta) = U(\theta, q_2(\theta), p_2(\theta))$. The other participation constraint is the standard individual-rationality (IR) constraint under monopolistic nonlinear pricing. This constraint implies that a consumer of type (θ, d) will prefer incentive-compatible offer (q_1, p_1) from Firm 1 to not buying if and only if,

$$U_1(\theta) + v - td^2 \geq 0. \tag{A.6}$$

Condition (A.6) is slack for all consumer types since it is assumed that the reservation utility of making a purchase v is sufficiently high that, in equilibrium, all individuals make a purchase. From condition (A.5), Firm 1's demand functions for the low- and high-quality products are respectively given by,

$$x_{1L} = d_L = \frac{t + \theta_L(q_{1L} - q_{2L}) - (p_{1L} - p_{2L})}{2t}, \tag{A.7}$$

$$x_{1H} = d_H = \frac{t + \theta_H(q_{1H} - q_{2H}) - (p_{1H} - p_{2H})}{2t}. \tag{A.8}$$

The demand functions for Firm 2's product types are then $1 - d_L$ and $1 - d_H$. It is further assumed that the quality difference between the high- and low-type product is a fixed proportion, such that $q_{iH} = \delta q_{iL}$, $i = 1, 2$, where $\delta > 1$. The model can then be solved as a two-stage non-cooperative game and a subgame-perfect symmetric equilibrium can be derived where the incentive-compatibility constraint for high-type consumers (IC_H) binds and the incentive-compatibility constraint for low-type consumers (IC_L) does not. In the first stage firms set quality and in the second stage they compete in prices.

In the case of the first model extension which also includes a medium-quality product and a medium-type consumer, Firm 1's demand function for this product type is given by,

$$x_{1M} = d_M = \frac{t + \theta_M(q_{1M} - q_{2M}) - (p_{1M} - p_{2M})}{2t} \tag{A.9}$$

where θ_M is the marginal preference for quality of medium-type consumers and q_{iM} and p_{iM}, $i = 1, 2$, are the quality and price, respectively, of the medium-type product. Obviously, $\theta_H > \theta_M > \theta_L$. The demand functions for the other two product types are similar to those specified in equations (A.7) and (A.8).

This model extension requires six incentive-compatibility conditions to ensure that consumers will choose the product type designed for them. It is assumed that in equilibrium high-type consumers will be indifferent between buying high- or medium-quality products, while medium-type consumers will be indifferent between buying medium- or low-quality products. Then, $p_{iH} = p_{iM} + \theta_H(q_{iH} - q_{iM})$ and $p_{iM} = p_{iL} + \theta_M(q_{iM} - q_{iL})$ for $i = 1, 2$. The model can be solved as a two-stage non-cooperative game by further assuming that the quality differences between the high- and low-type product and the medium- and low-type product are a fixed proportion. Specifically, $q_{iH} = \delta_1 q_{iL}$ and $q_{iM} = \delta_2 q_{iL}$, $i = 1, 2$, where $\delta_1 > \delta_2 > 1$.

In the case of the second model extension which includes two product qualities and two product types, but $t_H > t_L$, the demand functions for the low- and high-quality products are, respectively, given by,

$$x_{1L} = d_L = \frac{t_L + \theta_L(q_{1L} - q_{2L}) - (p_{1L} - p_{2L})}{2t_L}, \tag{A.10}$$

$$x_{1H} = d_H = \frac{t_H + \theta_H(q_{1H} - q_{2H}) - (p_{1H} - p_{2H})}{2t_H}. \tag{A.11}$$

As in the baseline model, $q_{iH} = \delta q_{iL}$, $i = 1, 2$, where $\delta > 1$. The model can also be solved as a two-stage non-cooperative game by assuming that the $(\mathrm{IC_H})$ constraint binds and the $(\mathrm{IC_L})$ constraint does not.

Subgame-perfect equilibrium[1]

The steps involved to derive a subgame-perfect symmetric equilibrium for the baseline model, where the $(\mathrm{IC_H})$ constraint binds and the $(\mathrm{IC_L})$ constraint does not, are described next.[2] From the $(\mathrm{IC_H})$ constraint binding, $p_{iH} = p_{iL} + \theta_H(q_{iH} - q_{iL})$, $i = 1, 2$, and given that $q_{iH} = \delta q_{iL}$, where $\delta > 1$, the maximization problem presented in Chapter II can be transformed into the following problem with decision variables p_{iL} and q_{iL},

$$\begin{aligned} \underset{p_{iL}, q_{iL}}{\mathrm{Max}}\ \pi_i = \quad & \lambda[(p_{iL} - cq_{iL})x_{iL}] - \frac{q_{iL}^2}{2} + (1 - \lambda)[(p_{iL} + \theta_H(\delta - 1)q_{iL} \\ & - c\delta q_{iL})x_{iH}] - \frac{\delta^2 q_{iL}^2}{2} \end{aligned}$$

---

[1]This section follows Piga and Poyago-Theotoky (2005). These authors look for a subgame-perfect equilibrium in a three-stage non-cooperative game where firms first choose location, then they decide the level of R&D to improve the quality of the product, and finally they compete in prices. In their model each firm only offers one product variety.

[2]Details of the derivation of a subgame-perfect symmetric equilibrium for the two model extensions are available upon request.

where $x_{1L} = d_L$ and $x_{1H} = d_H$, which are specified in equations (A.7) and (A.8) respectively, while $x_{2L} = 1 - d_L$ and $x_{2H} = 1 - d_H$.[3] To simplify the analysis, in what follows c is normalized to zero.

The price subgame is first examined which corresponds to the last stage of the game. From the first-order conditions, the following equilibrium prices are derived,

$$\begin{aligned} p_{iL} &= t + \left(\frac{1}{3}\lambda\theta_L + (1-\lambda)\theta_H - \frac{2}{3}\delta(1-\lambda)\theta_H\right) q_{iL} \\ &\quad - \frac{1}{3}(\lambda\theta_L + \delta(1-\lambda)\theta_H) q_{jL}. \end{aligned} \tag{A.12}$$

where $i, j = 1, 2$, $i \neq j$. The second-order condition, given by $\partial^2 \pi_i / \partial p_{iL}^2 = -1/t < 0$, is satisfied.

Next, these equilibrium prices p_{iL}, $i = 1, 2$, are substituted in the profit functions in order to move to the first stage of the game where firms set quality. After taking first-order conditions from the new expressions for profits, the following best-response functions are obtained,

$$q_{iL}(q_{jL}) = \frac{1}{2} \frac{A q_{jL} - 6(\delta(1-\lambda)\theta_H + \lambda\theta_L)t}{B - 9(\delta^2 + 1)t} \tag{A.13}$$

where $i, j = 1, 2$, $i \neq j$, $A = 9\lambda(1-\lambda)(\delta - 1)\theta_H^2 + 2(\lambda^2\theta_L^2 + \delta^2\theta_H^2) - \lambda(1-\lambda)(5\delta - 9)\theta_L\theta_H - 2\lambda(2-\lambda)\delta^2\theta_H^2$ and $B = \lambda^2\theta_L^2 + \delta^2\theta_H^2 + 9\lambda(1-\lambda)(\theta_H^2(\delta - 1) + \theta_L\theta_H) - 7\lambda(1-\lambda)\delta\theta_L\theta_H - \lambda(2-\lambda)\delta^2\theta_H^2$. The equilibrium qualities q_{iL}, $i = 1, 2$, are finally derived from the intersection of the best-response functions,

$$q_{iL} = \frac{(B - 9(\delta^2+1)t)^2(\delta(1-\lambda)\theta_H + \lambda\theta_L)(6t)\left(\frac{A}{B - 9(\delta^2+1)t} + 2\right)}{(A^2 - 4(B - 9(\delta^2+1)t)^2)(B - 9(\delta^2+1)t)}. \tag{A.14}$$

[3] It is also necessary to check at the proposed solution whether the low-type consumers strictly prefer the low-quality product since the analysis looks for an equilibrium where the (IC_L) constraint is slack. Similarly, the solution must be an interior solution where both firms are active.

Without loss of generality and for clarity of exposition, hereafter it is assumed that certain parameters take a specific value.[4] More specifically, it is assumed that 60% of the customers are low-type individuals, i.e. $\lambda = 0.6$, $\delta = 2$ and $\theta_L = 0.5$.

The associated second-order condition of the first stage of the game, where firms set quality, requires that $t > \frac{1}{45}(2.8\theta_H^2 - 0.6\theta_H + 0.09)$. This condition also implies that best-response functions specified in equation (A.13) are negative sloped. The stability condition requires, in turn, that $|dq_{iL}/dq_{jL}| < 1$, $i, j = 1, 2$, $i \neq j$, and is satisfied if $t > \frac{1}{90}(9.04\theta_H^2 - 1.32\theta_H + 0.36)$. Figure 11 presents both the second-order condition and the stability condition on the space (t, θ_H) for $\theta_H > 0.5$.[5] It follows that satisfying the stability condition is sufficient to guarantee the existence of an equilibrium at the first stage of the game and hence in the overall game.

The following can be concluded: if firms compete by setting the quality and price of the low-type product while the quality of the high-type product is given by $q_H = \delta q_L$, $\delta > 1$, then for a sufficiently high t there is a subgame-perfect equilibrium where the ($\mathrm{IC_H}$) constraint binds and the ($\mathrm{IC_L}$) constraint does not. The equilibrium involves full-market coverage and is symmetric.

The equilibrium low-type price and quality, under the previous assumptions, are given by,

$$p_L^* = t - \frac{(0.53\theta_H^2 + 0.2\theta_H)t}{25t + 0.3\theta_H - 0.6\theta_H^2}, \tag{A.15}$$

$$q_L^* = \frac{(1.33\theta_H + 0.5)t}{25t + 0.3\theta_H - 0.6\theta_H^2}, \tag{A.16}$$

[4] This procedure is standard in this class of models and allows us to later evaluate the impact of competition, measured through t, on relative prices.

[5] Note that, by definition, $\theta_H > \theta_L = 0.5$. This condition also ensures that low-type consumers strictly prefer the low-quality product, i.e. the ($\mathrm{IC_L}$) constraint is slack.

while the equilibrium high-type price and quality reduce to,

$$p_H^* = t + \frac{(0.79\theta_H^2 + 0.29\theta_H)t}{25t + 0.3\theta_H - 0.6\theta_H^2}, \tag{A.17}$$

$$q_H^* = \frac{(2.67\theta_H + 1)t}{25t + 0.3\theta_H - 0.6\theta_H^2}. \tag{A.18}$$

Figure 1 presents the impact of t, the index of competition intensity, on the optimal price ratio p_H^*/p_L^* for $\theta_H = 1$ and $t \geq 0.1$.[6] As can be seen, relative prices decrease with market concentration (higher t). The inverse relationship between relative prices and market concentration holds for any value of $\theta_H > 0.5$.

Figure 2 shows the impact of competition on relative prices when the model is extended to three product qualities (high, medium and low), three consumer types (high, medium and low marginal preference for quality) and $t \geq 0.1$. It is assumed that $\theta_L = 0.4$, $\theta_M = 0.6$, $\delta_1 = 4$, and $\delta_2 = 2$, and θ_H is set to one to derive the figure.[7] The price ratio of high to low-quality products decreases proportionally more than the price ratio of medium to low-quality products with a higher t.

Finally, Figure 3 shows the impact of competition on relative prices under the second model extension with different per-unit transportation costs across the two consumer types. Specifically, $0.1 \leq t_L \leq 0.25$ and $0.25 \leq t_H \leq 0.5$. In this case θ_H is also set to one to derive the figure.[8] There is a negative relationship between market concentration and relative prices, but this inverse relationship is more pronounced with changes in the level of competition for low-type consumers (t_L), which are more likely to switch firms.

---

[6]The stability condition requires that $t \geq 0.09$ for $\theta_H = 1$.

[7]The stability condition requires that $t \geq 0.05$ for $\theta_H = 1$.

[8]The other parameters take the same value as in the baseline model. For the stability condition to hold, both $t_L \geq 0.09$ and $t_H \geq 0.09$ for $\theta_H = 1$.

APPENDIX B

DESCRIPTION OF VARIABLES

Below is a full description of the variables used in the analysis:

Fare: Roundtrip fare paid. In case of one-way tickets, the fare paid is multiplied by two.

Fare per mile: Roundtrip fare (in cents) divided by two times nonstop origin to destination mileage.

Group F: Equal to one if any segment of the itinerary involves travel in first class. Otherwise, equal to zero. Group F is the highest quality group.

Group 1: Equal to one if ticket is refundable and all segments of the itinerary involve travel in business, full coach or coach class. Otherwise, equal to zero. A full coach fare has features that allow for upgrades and last seat availability.

Group 2: Equal to one if ticket is nonrefundable but does not carry any travel or stay restrictions. Otherwise, equal to zero. A travel restriction indicates that the ticket includes a travel day restriction, e.g. that the individual must travel during certain days of the week. A stay restriction indicates that the ticket includes a minimum and/or maximum stay requirement, e.g. that the individual must return after a certain number of days.

Group 3: Equal to one if ticket is nonrefundable with travel and/or stay restrictions. Otherwise, equal to zero. Group 3 is the lowest quality group.

Market share: Fraction of nonstop passengers transported by a carrier on a route during the fourth quarter of 2004.

Herfindahl-Hirschman Index (HHI): Sum of the square of market shares of each of the carriers operating on a route.

Monopoly: Equal to one in routes on which a single carrier transports more than 90 percent of nonstop passengers. Otherwise, equal to zero. This definition is in line with Borenstein and Rose (1994), but the number of nonstop passengers on a route are used instead of number of flights to calculate market shares.

Duopoly: Equal to one in non-monopoly routes on which two carriers cumulatively transport more than 90 percent of nonstop passengers. Otherwise, equal to zero.

Competitive: Equal to one in routes that are neither monopolies nor duopolies, otherwise zero.

Advance purchase: Categorical variables indicating whether the ticket was purchased 0–3 days prior to departure (*Adv0_3*), 4–6 days (*Adv4_6*), 7–13 days (*Adv7_13*), 14–21 days (*Adv14_21*) and over 21 days (*Adv22_over*).

One-way: Equal to one if ticket is one-way, otherwise zero.

Load factor at purchase: Average load factor of the itinerary's flight segments one day before the ticket was purchased. For example, consider a ticket bought on November 5, 2004 for travel on November 7, 2004 from New York-Kennedy (JFK) to Los Angeles (LAX) on American Flight 117, and travel back on November 9, 2004 on

American Flight 22. The load factor at purchase for this itinerary is the average of the estimated load factors for these two flights at November 4, 2004 (one day before the ticket was purchased). The load factor at each flight segment is derived following the methodology applied by Puller, Sengupta, and Wiggins (2007). Basically, from the data provided by the CRS vendor, the total number of tickets sold on each of the flights involved in an itinerary until the day before the individual transaction took place can be observed. These observed tickets can then be scaled up by the inverse of the CRS' total share of tickets sold at the carrier-route level, to obtain an estimate of the total sales for each flight. This scale factor is obtained by dividing the total number of nonstop itineraries sold through the CRS in the last quarter of 2004 at the carrier-route level, by the corresponding total number of tickets sold reported by the Bureau of Transportation Statistics (BTS). These scaled number of tickets sold are finally divided by the total number of seats available for each flight, obtained from the Official Airline Guide (OAG).

Peak time: Equal to one if the itinerary involves departure and/or return on weekdays between 7 and 10am or 3 and 7pm, otherwise zero.

Hub for carrier: Equal to one if either of the endpoint airports on a route is a primary or secondary hub for the operating carrier, otherwise zero.

Slot-controlled airport: Equal to one if the number of takeoffs and landings at either endpoint airport on a route is regulated, otherwise zero. The three slot-controlled airports during the period of analysis were Washington-National (DCA), New York-Kennedy (JFK), and New York-La Guardia (LGA).

Southwest on route: Equal to one if Southwest has five percent or more of the market share on the route, otherwise zero. The five percent threshold follows Lee and Luengo-Prado (2005).

Low cost carrier on route: Equal to one if low-cost carriers, other than Southwest, collectively have five percent or more of the market share on the route, otherwise zero. The low-cost carriers include Frontier, AirTran, Spirit, ATA, Sun Country, JetBlue, Allegiant, Primaris and Independence.

Distance: Nonstop mileage between the two endpoint airports on a route.

Total flights: Total number of direct flights between the two endpoint airports on a route.

Per-capita income: Average 2004 per capita personal income at the two endpoint Metropolitan areas of a route.

Temperature difference: Absolute difference in average October temperatures between the origin and destination of a route.

Tourism index: 2004 accommodation earnings divided by personal income at the Metropolitan area of destination of the itinerary. The accommodation subsector (Code 721 in the North American Industry Classification System) includes traveler accommodation, recreational accommodation and rooming and boarding houses.

Main carriers: Categorical variables indicating whether the ticket involved traveling in one of the major carriers in the sample. These include American (AA), United (UA), Delta (DL), Continental (CO), US Airways (US) and Northwest (NW), all of whom transported at least five percent of all domestic travelers during the last quarter of 2004.

Instruments description

Geoshare: Instrument for market share. Following Borenstein (1989) and Borenstein and Rose (1994), it is defined as a carrier's geometric mean of enplanements at the endpoint airports of a route, divided by the sum of all carriers' geometric mean of enplanements at the endpoint airports. Formally,

$$Geoshare = \frac{\sqrt{ENP_{i1} \cdot ENP_{i2}}}{\sum_j \sqrt{ENP_{j1} \cdot ENP_{j2}}},$$

where j indexes all carriers, i is the observed carrier, and ENP_{j1} and ENP_{j2} are carrier j's average daily enplanements at the two endpoint airports during the fourth quarter of 2004. This instrument is valid under the assumption that a carrier's current price responds to actual competition but not to entry threats.

Xtherf: Instrument for HHI. Following Borenstein (1989) and Borenstein and Rose (1994), it is defined as the square of the fitted value of market share $\widehat{MktShare}$ (from its first-stage regression) plus the rescaled sum of the square of all other carriers' share on the route. Specifically,

$$Xtherf = \widehat{MktShare}^2 + \frac{HHI - MktShare^2}{(1 - MktShare)^2}(1 - \widehat{MktShare})^2.$$

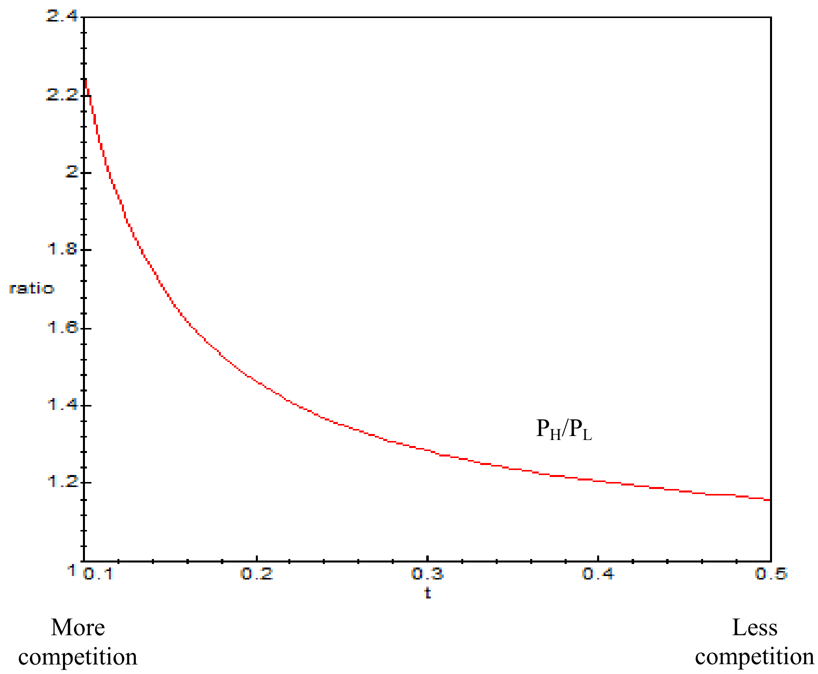
This instrument is valid under the assumption that the observed carrier's price does not affect the allocation of passengers it does not get.

Population: Instrument for the total number of flights on a route. It is defined as the average 2004 midyear population estimates (in thousands) at the two endpoint Metropolitan areas of a route.

APPENDIX C

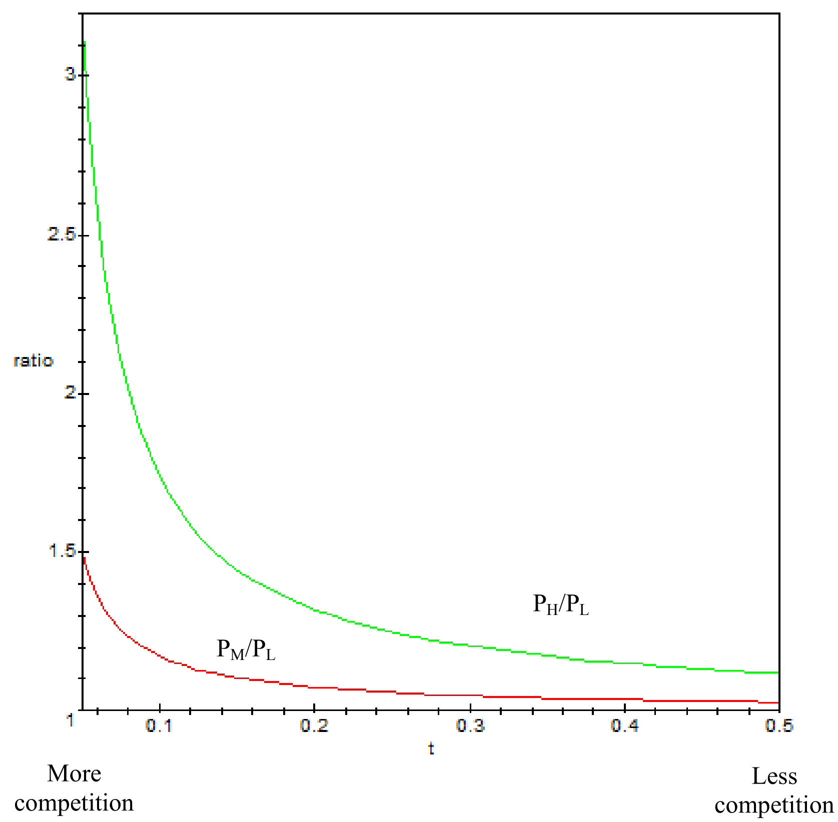
FIGURES AND TABLES

Figure 1.— Price Ratio and Intensity of Competition



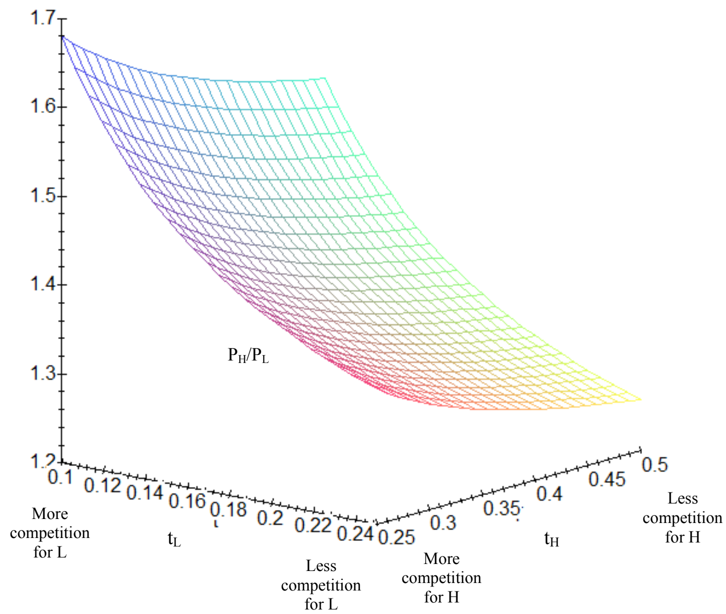
Note: $\theta_H = 1, \theta_L = 0.5$. This pattern holds for any value of $\theta_H > \theta_L$.

Figure 2.— Price Ratios and Intensity of Competition, 3 Types



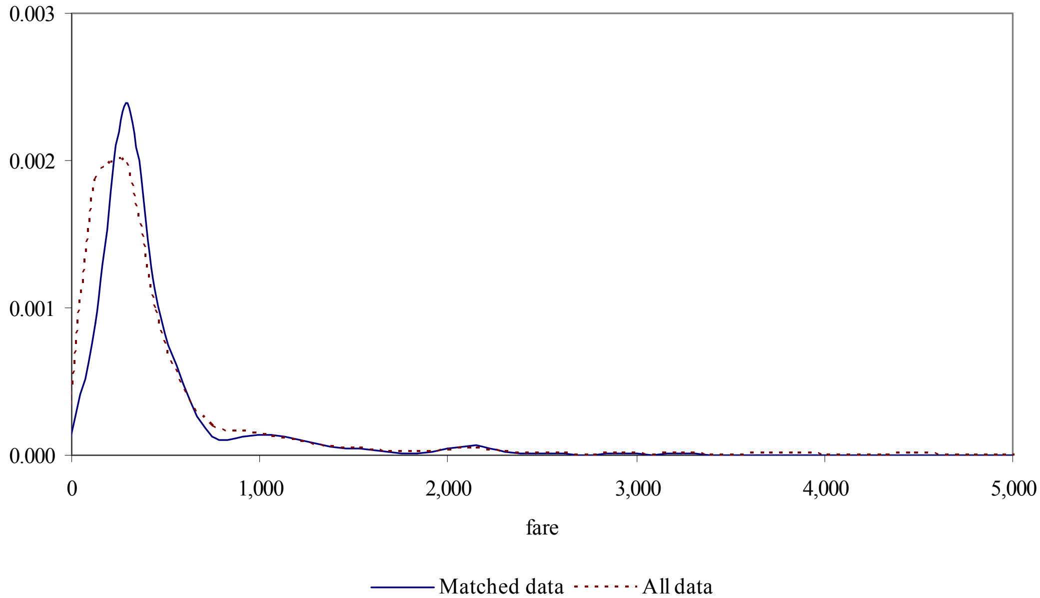
Note: $\theta_H = 1, \theta_M = 0.6, \theta_L = 0.4$. This pattern holds for any value of $\theta_H > \theta_M > \theta_L$.

Figure 3.— Price Ratio and Intensity of Competition, $t_H > t_L$



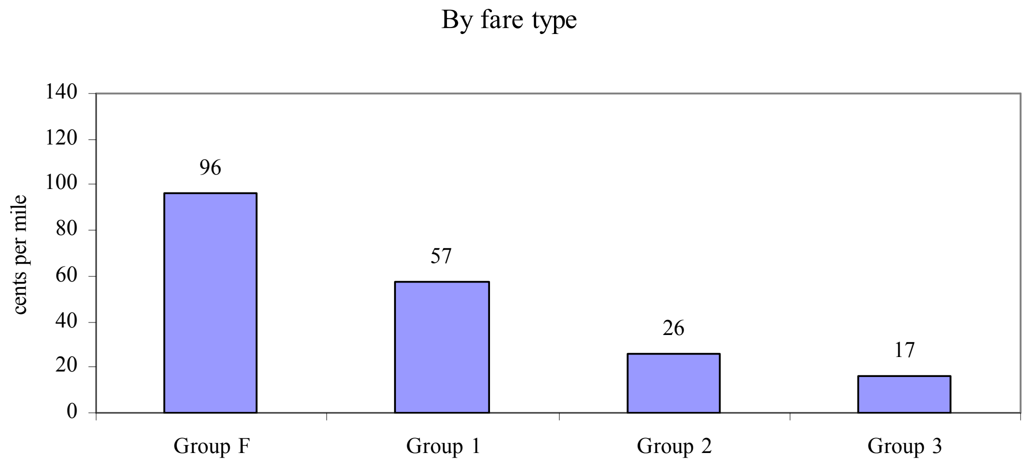
Note: $\theta_H = 1, \theta_L = 0.5$. This pattern holds for any value of $\theta_H > \theta_L$.

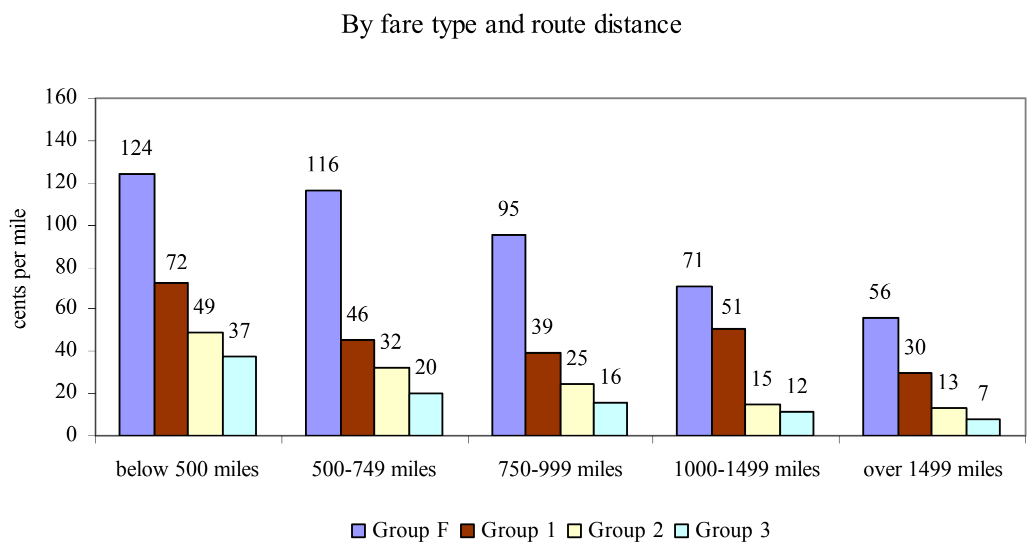
Figure 4.— Kernel Density Estimates of Matched vs. All Fares



Note: Bandwidths (h) computed using normal-reference "rule of thumb", i.e. $h_j = 1.06\sigma_j n^{-1/5}$, where σ_j is the standard deviation of fares and n_j the number of observations for $j = \{\text{matched data, unmatched data}\}$. The kernel type used is second-order Gaussian.

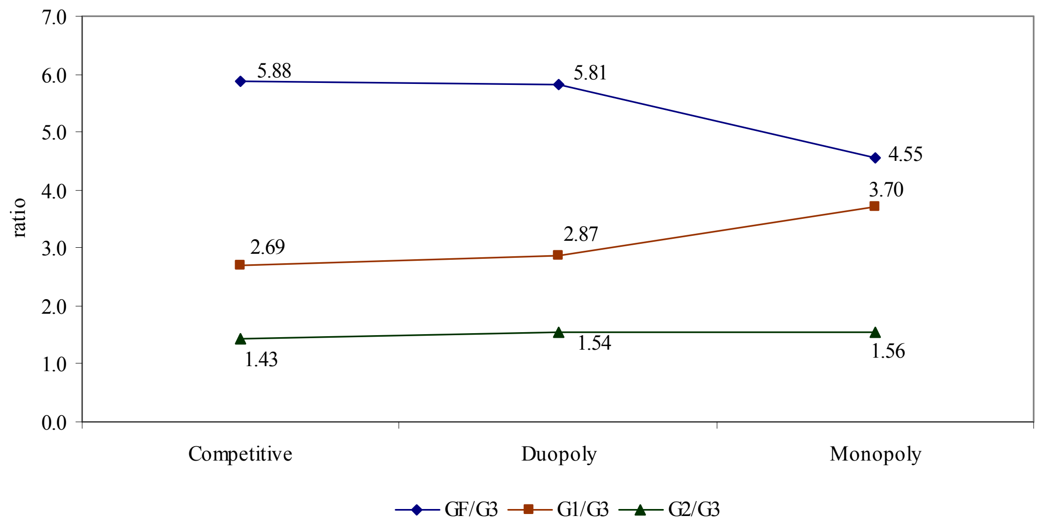
Figure 5.— Average Price per Mile





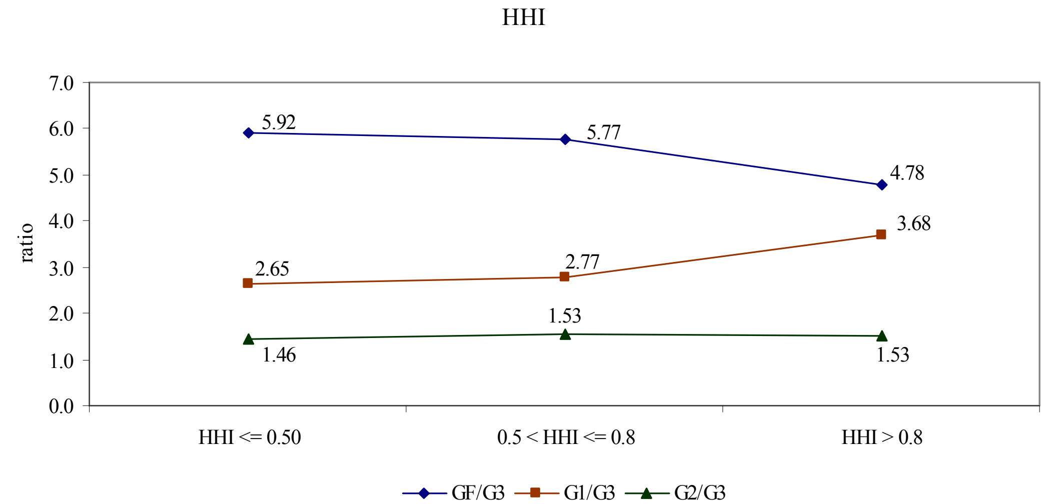
Note: Price per mile = roundtrip fare (in cents) / (2 x nonstop origin to destination mileage).

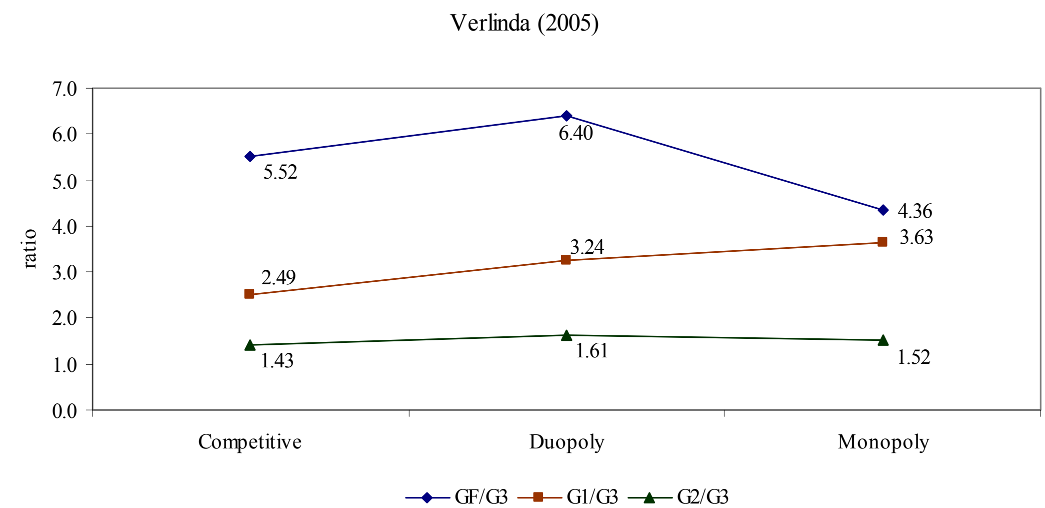
Figure 6.— Relative Prices by Fare Type and Market Structure



Note: Relative prices are a weighted average of the relative fares by flying distance for each market structure. Market structure categories defined according to Borenstein and Rose (1994).

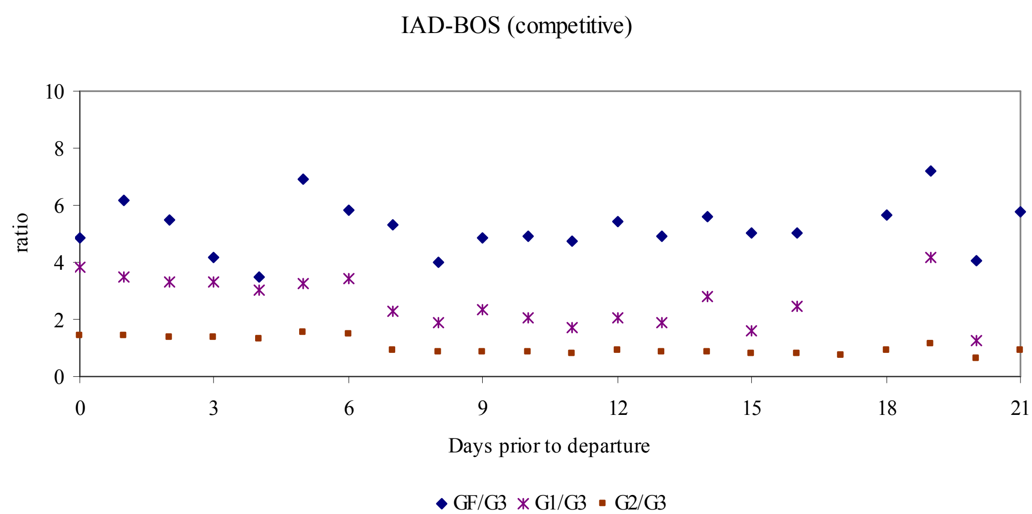
Figure 7.— Relative Prices by Fare Type and Alternative Market Structure Definitions

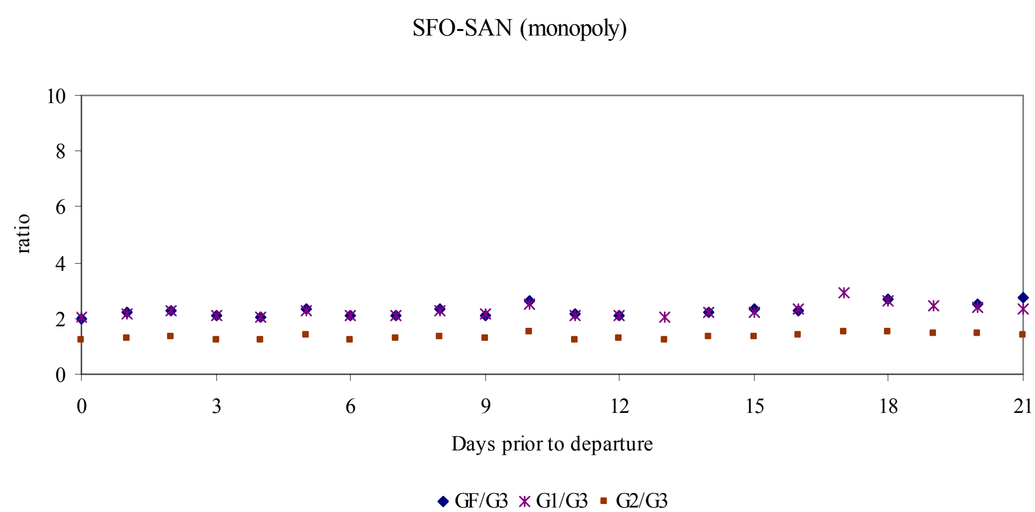




Note: Relative prices are a weighted average of the relative fares by flying distance under each market structure. In Verlinda (2005), a route is considered a monopoly if a carrier transports at least 50 percent of nonstop passengers and the share of the second major carrier is less than one ninth of the share of the first carrier. A non-monopoly route is considered a duopoly if two carriers cumulatively transport at least 50 percent of nonstop passengers and the share of the third major carrier is less than one ninth of the share of the second carrier. All other routes are considered competitive.

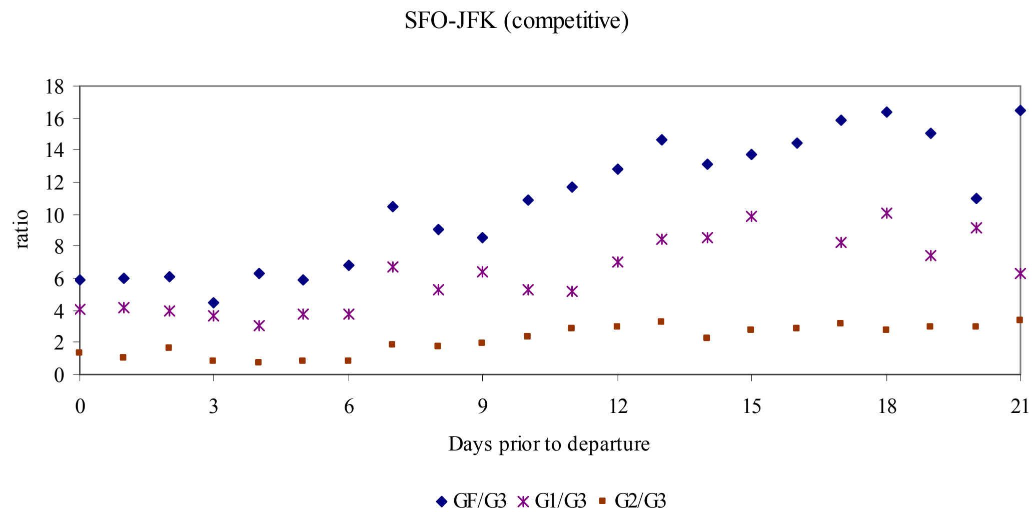
Figure 8.— UA Relative Prices by Fare Type and Day of Purchase, Short-Distance Routes

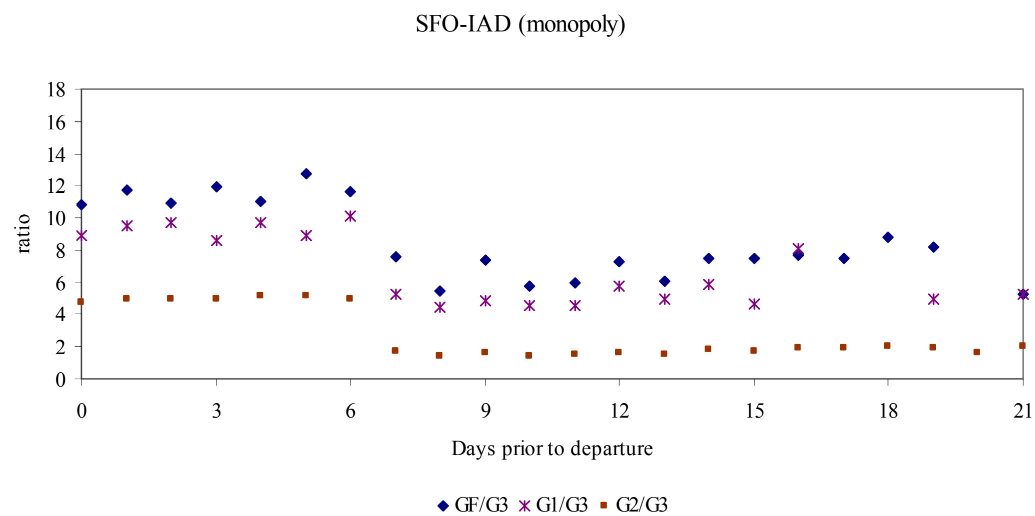




Note: Relative prices are the ratio of average fares per mile for a given day prior to departure.

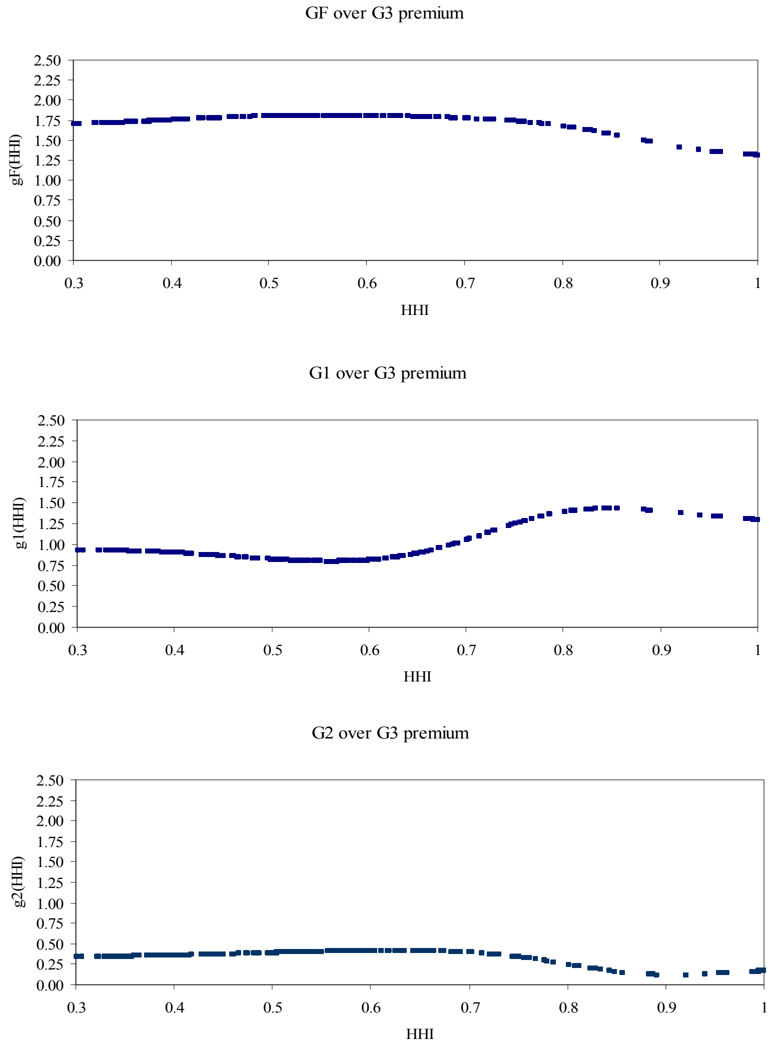
Figure 9.— UA Relative Prices by Fare Type and Day of Purchase, Long-Distance Routes





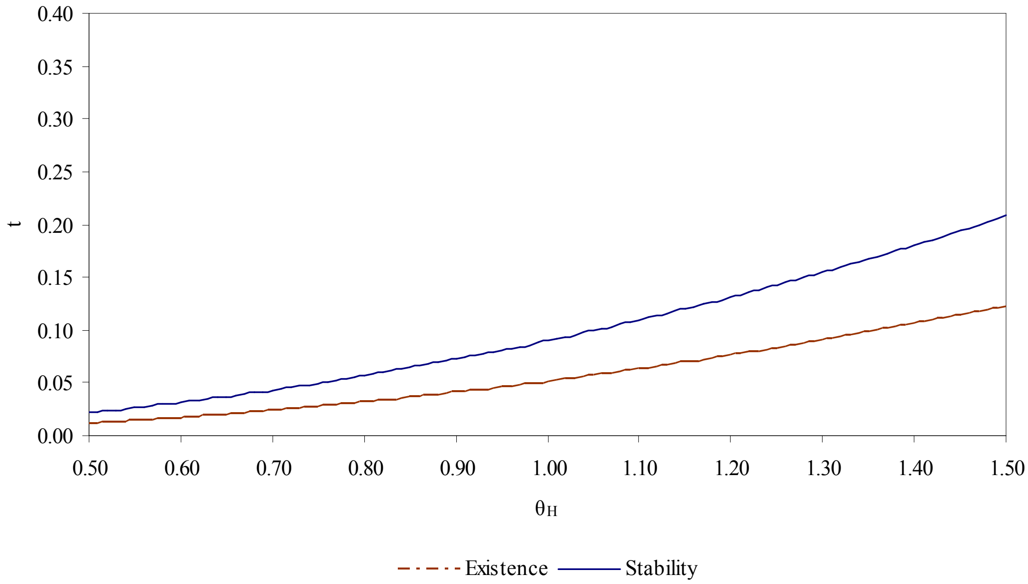
Note: Relative prices are the ratio of average fares per mile for a given day prior to departure.

Figure 10.— Quality Premia by Market Concentration, Smooth Coefficient Model



Note: Bandwidth of HHI estimated via least squares cross-validation, accounting also for distance, per capita income and tourism index at the route level. The kernel type used is second-order Gaussian. The unspecified smooth functions, $g_0(HHI)$ and $g_{f1}(HHI)$, $f = F, .., 2$, were derived by smoothing out the market-specific variables. Controls at the ticket and flight level include time of purchase, one-way travel, load factor at purchase and peak periods. The estimation also controls for the presence of a hub on the route.

Figure 11.— Conditions for Existence and Stability of Equilibrium



Note: $\theta_L = 0.5$.

Table 1.— Routes by Market Structure

Competitive							
	ATL-EWR	ATL-IAD	ATL-MEM	ATL-MIA	ATL-ORD	ATL-PHL	BOS-DCA
	BOS-FLL	BOS-LAX	BOS-LGA	CLE-LGA	CLE-ORD	CLT-ORD	CVG-ORD
	DEN-ATL	DEN-DFW	DEN-IAH	DEN-PDX	DEN-PHL	DEN-PHX	DEN-SLC
	DEN-STL	DFW-ATL	DFW-IAH	DFW-MSP	DFW-PHX	DTW-EWR	DTW-LAS
	DTW-ORD	FLL-LGA	FLL-PHL	IAD-BOS	JFK-LAS	JFK-SFO	LAS-ATL
	LAS-DEN	LAS-DFW	LAS-MSP	LAS-SEA	LAX-DEN	LAX-EWR	LAX-HNL
	LAX-JFK	LAX-LAS	LAX-PHL	LAX-SMF	LGA-MCO	MCO-BOS	MCO-LAX
	MCO-ORD	MSP-DEN	MSP-EWR	MSP-PHX	ORD-EWR	ORD-FLL	ORD-IAD
	ORD-IAH	ORD-LAS	ORD-MSP	ORD-MSY	ORD-PHL	ORD-PIT	PDX-LAS
	PDX-SFO	PDX-SJC	PHL-MCO	PHL-PHX	PHX-BUR	PHX-DTW	PHX-LAX
	PHX-ORD	PHX-PDX	RDU-LGA	RDU-ORD	SAN-JFK	SEA-DEN	SEA-JFK
	SEA-ORD	SEA-PHX	SJC-LAS	SJC-LAX	SLC-LAX	STL-ORD	TPA-ORD
Duopoly							
	ATL-BWI	ATL-DCA	ATL-FLL	ATL-IAH	ATL-LGA	ATL-MCO	ATL-MSY
	ATL-TPA	BDL-DCA	BOS-ATL	BOS-EWR	BOS-ORD	BOS-PHL	BOS-SFO
	BOS-TPA	BWI-BOS	BWI-DFW	BWI-LAX	BWI-ORD	DCA-ORD	DEN-BOS
	DEN-DCA	DEN-EWR	DEN-LGA	DEN-MCI	DEN-MCO	DEN-SJC	DFW-BOS
	DFW-DTW	DFW-IAD	DFW-LAX	DFW-MCI	DFW-MCO	DFW-SFO	DTW-ATL
	DTW-LGA	DTW-MCO	EWR-DCA	EWR-DFW	EWR-LAS	EWR-MDW	EWR-PHX
	FLL-DCA	FLL-DFW	FLL-EWR	FLL-JFK	FLL-LAX	HPN-ORD	IAD-DEN
	IAD-LAS	IND-DFW	JFK-MCO	LAS-BOS	LAS-BWI	LAS-SFO	LAX-DTW
	LAX-IAD	LAX-ORD	LAX-STL	LGA-DCA	LGA-DFW	LGA-ORD	LGA-TPA
	MCI-ORD	MCO-BDL	MCO-EWR	MCO-IAD	MCO-MSP	MDW-DEN	MDW-DFW
	MIA-EWR	MIA-ORD	MSP-MDW	MSP-MKE	OAK-LAX	OAK-PDX	OAK-SEA
	OMA-ORD	ORD-BDL	ORD-CMH	ORD-DEN	ORD-DFW	ORD-SAN	ORD-SNA
	PBI-BOS	PBI-LGA	PBI-PHL	PDX-LAX	PHL-DFW	PHL-LAS	PHL-SFO
	PHX-LAS	PHX-OAK	PHX-SJC	RDU-ATL	SAN-DEN	SAN-DFW	SAN-PHX
	SEA-DFW	SEA-LAX	SEA-SMF	SFO-ATL	SFO-DEN	SFO-EWR	SFO-LAX
	SFO-ORD	SFO-SEA	SFO-SNA	SJC-SAN	SJC-SEA	SLC-SEA	SLC-SNA
	SNA-DEN	SNA-LAS	SNA-OAK	SNA-SJC	STL-BWI	TPA-DFW	TPA-PHL
Monopoly							
	ATL-LAX	BOS-MIA	BOS-PIT	CLT-LGA	CVG-ATL	CVG-LGA	DCA-MCO
	DFW-DCA	DTW-BOS	EWR-CLE	EWR-IAH	EWR-PBI	IAH-BOS	IAH-LAS
	IAH-MCO	IAH-TPA	JFK-MIA	LAX-IAH	LAX-TPA	LGA-IAH	LGA-MIA
	LGA-MSP	LGA-PIT	MDW-LGA	MIA-LAX	MSP-DTW	MSP-LAX	MSY-IAH
	OAK-DEN	PDX-SAN	PIT-PHL	SAN-SEA	SAN-SFO	SEA-MSP	SEA-SNA
	SFO-IAD	SFO-MSP	SJC-AUS	SJC-DFW	SNA-DFW	STL-DFW	STL-LGA
	TPA-EWR						

Note: Market structure categories defined according to Borenstein and Rose (1994). Airport codes: ATL = Atlanta, AUS = Austin, BDL = Hartford, BOS = Boston, BUR = Burbank, BWI = Baltimore, CLE = Cleveland, CLT = Charlotte, CMH = Colombus, CVG = Cincinnati, DCA = Washington-National, DEN = Denver, DFW = Dallas-Ft. Worth, DTW = Detroit, EWR = Newark, FLL = Fort Lauderdale, HNL = Honolulu, HPN = NY-White Plains, IAD = Washington-Dulles, IAH = Houston, IND = Indianapolis, JFK = NY-Kennedy, LAS = Las Vegas, LAX = Los Angeles, LGA = NY-La Guardia, MCI = Kansas City, MCO = Orlando, MDW = Chicago-Midway, MEM = Memphis, MIA = Miami, MKE = Milwaukee, MSP = Minneapolis-St. Paul, MSY = New Orleans, OAK = Oakland, OMA = Omaha, ORD = Chicago-O Hare, PBI = West Palm Beach, PDX = Portland, PHL = Philadelphia, PHX - Phoenix, PIT = Pittsburgh, RDU = Raleigh-Durham, SAN = San Diego, SEA = Seattle, SFO = San Francisco, SJC = San Jose, SLC = Salt Lake City, SMF = Sacramento, SNA = Santa Ana, STL = St. Louis, TPA = Tampa.

Table 2.— Mean Deviations of Price per Mile by Fare Type and Carrier

	American	United	Delta	Continental	US Airways	Northwest
Group F	34.5	80.6	49.7	43.2	36.5	59.4
Group 1	12.0	21.7	17.4	15.3	6.7	18.3
Group 2	1.6	-8.8	-4.9	0.1	-7.8	-0.9
Group 3	-6.0	-15.4	-14.8	-9.3	-14.2	-10.5

Note: The mean deviations are a weighted average of the deviations from the mean price per mile by group and route for each carrier. Each of these carriers transported at least five percent of all domestic travelers during the fourth quarter of 2004.

Table 3.— Sources of Information for Market Controls

Source	Variables
T-100 Domestic Data (U.S. Carriers) http://www.bts.gov	Market share, HHI, market structure dummies, distance, Southwest and low cost carrier dummies, total flights, and geoshare
Bureau of Economic Analysis http://www.bea.gov	Per capita income, tourism index
U.S. Census Bureau http://www.census.gov	Population
National Climatic Data Center (NCDC) http://www.ncdc.noaa.gov/oa/ncdc.html U.S. Weather Information (for missing cities) http://www.countrystudies.us	Temperature difference
Wikipedia http://en.wikipedia.org	Hubs, low cost carriers (identification)
Stavins (2001)	Slot controlled airports

Table 4.— Summary Statistics for Variables in Analysis

	Mean	St. dev.	Min	Max
Fare (dollars)	457	464	62	4,806
Fare per mile (cents)	31.3	32.0	3.4	305.9
Dummies for fare type				
Group F	0.05	0.22	0.00	1.00
Group 1	0.20	0.40	0.00	1.00
Group 2	0.28	0.45	0.00	1.00
Group 3	0.47	0.50	0.00	1.00
Market structure variables				
Market share	0.57	0.26	0.00	1.00
HHI	0.56	0.20	0.19	1.00
Monopoly	0.12	0.33	0.00	1.00
Duopoly	0.48	0.50	0.00	1.00
Competitive	0.40	0.49	0.00	1.00
Ticket and flight controls				
Adv0_3	0.25	0.44	0.00	1.00
Adv4_6	0.14	0.35	0.00	1.00
Adv7_13	0.21	0.41	0.00	1.00
Adv14_21	0.16	0.36	0.00	1.00
Adv22_over	0.23	0.42	0.00	1.00
One-way	0.26	0.44	0.00	1.00
Load factor at purchase	0.44	0.29	0.00	1.37
Peak time	0.65	0.48	0.00	1.00
Market controls				
Hub for carrier	0.83	0.38	0.00	1.00
Slot-controlled airport	0.21	0.40	0.00	1.00
Southwest on route	0.09	0.28	0.00	1.00
Low cost carrier on route	0.34	0.47	0.00	1.00
Distance	1,020	654	185	2,704
Total flights on route	2,785	1,390	341	6,576
Per capita income (dollars)	38,693	3,461	31,811	48,150
Temperature difference	9.61	6.77	0.10	26.70
Tourism index	0.01	0.03	0.00	0.13
Main carriers				
AA	0.28	0.45	0.00	1.00
UA	0.20	0.40	0.00	1.00
DL	0.15	0.35	0.00	1.00
CO	0.11	0.31	0.00	1.00
US	0.08	0.27	0.00	1.00
NW	0.05	0.22	0.00	1.00
# observations				878,169

Note: For a detailed description of the variables refer to Appendix B.

Table 5.— Distribution of Tickets and Routes by Market Structure and Flying Distance

	Tickets		Routes		Tickets per route
	#	%	#	%	
By market structure					
Competitive	351,570	40.0	84	34.2	4,185
Duopoly	418,982	47.7	119	48.4	3,521
Monopoly	107,617	12.3	43	17.5	2,503
Total	*878,169*	*100.0*	*246*	*100.0*	*3,570*
By route distance					
1. Below 500 miles					
Competitive	76,735	41.6	21	38.9	3,654
Duopoly	91,242	49.5	26	48.1	3,509
Monopoly	16,454	8.9	7	13.0	2,351
Total	*184,431*	*100.0*	*54*	*100.0*	*3,415*
2. 500 - 749 miles					
Competitive	98,207	51.4	18	39.1	5,456
Duopoly	77,339	40.5	22	47.8	3,515
Monopoly	15,513	8.1	6	13.0	2,586
Total	*191,059*	*100.0*	*46*	*100.0*	*4,153*
3. 750 - 999 miles					
Competitive	44,955	26.8	13	28.3	3,458
Duopoly	102,981	61.3	25	54.3	4,119
Monopoly	19,954	11.9	8	17.4	2,494
Total	*167,890*	*100.0*	*46*	*100.0*	*3,650*
4. 1,000 - 1,499 miles					
Competitive	54,034	34.7	15	29.4	3,602
Duopoly	61,822	39.7	21	41.2	2,944
Monopoly	39,702	25.5	15	29.4	2,647
Total	*155,558*	*100.0*	*51*	*100.0*	*3,050*
5. Over 1,499 miles					
Competitive	77,639	43.3	17	34.7	4,567
Duopoly	85,598	47.8	25	51.0	3,424
Monopoly	15,994	8.9	7	14.3	2,285
Total	*179,231*	*100.0*	*49*	*100.0*	*3,658*

Note: Market structure categories defined according to Borenstein and Rose (1994).

Table 6.— Log of Fare per Mile Regressions, No-Interaction Models

	Model 1: HHI				Model 2: Structural Categories			
	OLS		2SLS		OLS		2SLS	
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Group F	1.595	0.037	1.683	0.036	1.601	0.037	1.688	0.039
Group 1	0.672	0.067	0.670	0.075	0.673	0.066	0.653	0.070
Group 2	0.314	0.024	0.309	0.022	0.316	0.025	0.313	0.022
Market share	0.123	0.081	-0.032	0.109	0.121	0.064	-0.308	0.184
HHI	0.159	0.092	-0.704	0.272				
Monopoly					0.145	0.052	-0.197	0.148
Duopoly					-0.006	0.025	-0.147	0.071
Adv0_3	0.147	0.030	0.167	0.028	0.142	0.028	0.157	0.026
Adv4_6	0.133	0.027	0.140	0.025	0.128	0.025	0.132	0.023
Adv7_13	0.124	0.022	0.122	0.019	0.119	0.021	0.116	0.018
Adv14_21	0.066	0.014	0.068	0.013	0.064	0.013	0.063	0.012
One-way	0.177	0.017	0.159	0.019	0.177	0.017	0.157	0.020
Load factor at purchase	0.118	0.025	0.126	0.021	0.121	0.024	0.152	0.020
Peak time	0.031	0.006	0.025	0.008	0.031	0.006	0.026	0.008
Hub for carrier	0.186	0.048	0.421	0.101	0.190	0.049	0.454	0.104
Slot-controlled airport	0.075	0.030	0.179	0.043	0.059	0.030	0.185	0.040
Southwest on route	-0.279	0.046	-0.402	0.074	-0.264	0.047	-0.382	0.064
Low cost carrier on route	-0.103	0.036	-0.100	0.039	-0.096	0.037	-0.108	0.041
Log distance	-0.739	0.022	-0.948	0.063	-0.744	0.021	-0.942	0.060
Log total flights on route	0.022	0.030	-0.611	0.170	0.028	0.031	-0.591	0.160
Log per capita income	0.438	0.158	0.700	0.237	0.543	0.153	0.734	0.223
Log temperature difference	0.013	0.018	0.009	0.017	0.017	0.018	0.008	0.018
Tourism index	-0.936	0.284	-1.406	0.511	-0.881	0.270	-1.410	0.528
Constant	2.719	1.762	6.642	3.068	1.628	1.680	5.973	2.826
Underidentification test:								
Kleibergen-Paap rk LM stat.				981.17				1023.65
Chi-sq(1) P-val				(0.00)				(0.00)
Weak identification test:								
Kleibergen-Paap rk Wald F stat.				547.92				955.04
# observations		878,169		878,169		878,169		878,169
R-squared		0.776		0.711		0.777		0.715

Note: Fare per mile = roundtrip fare (in cents) / (2 x nonstop origin to destination mileage). All regressions include carrier fixed effects. White robust standard errors reported, clustered on origin city. Market share and HHI instrumented using the same instruments as Borenstein (1989) and Borenstein and Rose (1994). Log of total flights instrumented with the log of population. The underidentification and weak identification tests follow Kleibergen and Paap (2006) and are heteroskedastic-robust.

Table 7.— Log of Fare per Mile Regressions, Interaction Models

	Model 1: HHI				Model 2: Structural Categories			
	OLS		2SLS		OLS		2SLS	
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Group F	1.791	0.067	1.843	0.078	1.621	0.034	1.714	0.031
Group 1	0.172	0.107	0.270	0.138	0.545	0.075	0.539	0.084
Group 2	0.356	0.052	0.254	0.062	0.300	0.022	0.283	0.022
Market share	0.141	0.081	0.013	0.104	0.146	0.059	-0.245	0.173
HHI	0.001	0.069	-0.875	0.257				
Monopoly					0.030	0.035	-0.316	0.146
Duopoly					-0.041	0.020	-0.186	0.075
Group F*HHI	-0.363	0.141	-0.302	0.170				
Group 1*HHI	0.854	0.155	0.683	0.199				
Group 2*HHI	-0.073	0.098	0.100	0.121				
Group F*Monopoly					-0.364	0.074	-0.425	0.073
Group F*Duopoly					-0.013	0.045	-0.022	0.054
Group 1*Monopoly					0.522	0.095	0.469	0.095
Group 1*Duopoly					0.086	0.073	0.073	0.084
Group 2*Monopoly					-0.044	0.068	0.005	0.065
Group 2*Duopoly					0.043	0.030	0.060	0.025
Adv0_3	0.144	0.028	0.166	0.027	0.145	0.028	0.161	0.026
Adv4_6	0.129	0.025	0.138	0.024	0.128	0.025	0.133	0.023
Adv7_13	0.117	0.021	0.117	0.019	0.116	0.020	0.114	0.017
Adv14_21	0.064	0.013	0.067	0.012	0.063	0.012	0.063	0.011
One-way	0.179	0.016	0.162	0.019	0.180	0.017	0.160	0.020
Load factor at purchase	0.121	0.025	0.126	0.021	0.117	0.024	0.147	0.020
Peak time	0.029	0.006	0.024	0.008	0.029	0.006	0.025	0.008
Hub for carrier	0.175	0.043	0.402	0.095	0.176	0.044	0.430	0.096
Slot-controlled airport	0.072	0.031	0.176	0.046	0.048	0.029	0.172	0.040
Southwest on route	-0.244	0.045	-0.375	0.074	-0.228	0.047	-0.347	0.063
Low cost carrier on route	-0.112	0.038	-0.105	0.039	-0.101	0.038	-0.112	0.043
Log distance	-0.739	0.020	-0.947	0.063	-0.748	0.019	-0.941	0.060
Log total flights on route	0.029	0.026	-0.600	0.170	0.035	0.029	-0.570	0.157
Log per capita income	0.439	0.148	0.693	0.231	0.619	0.138	0.799	0.216
Log temperature difference	0.009	0.018	0.005	0.016	0.014	0.017	0.004	0.017
Tourism index	-0.953	0.288	-1.403	0.503	-0.887	0.272	-1.396	0.502
Constant	2.714	1.626	6.678	3.083	0.828	1.493	5.145	2.725
Underidentification test:								
Kleibergen-Paap rk LM stat.				1094.25				1116.89
Chi-sq(1) P-val				(0.00)				(0.00)
Weak identification test:								
Kleibergen-Paap rk Wald F stat.				299.45				975.27
# observations		878,169		878,169		878,169		878,169
R-squared		0.783		0.719		0.785		0.726

Note: Fare per mile = roundtrip fare (in cents) / (2 x nonstop origin to destination mileage). All regressions include carrier fixed effects. White robust standard errors reported, clustered on origin city. Market share and HHI instrumented using the same instruments as Borenstein (1989) and Borenstein and Rose (1994). Log of total flights instrumented with the log of population. The underidentification and weak identification tests follow Kleibergen and Paap (2006) and are heteroskedastic-robust.

Table 8.— Quality Premia by Market Structure

	Model 1: HHI		
	$HHI_{0.1} = 0.34$	$HHI_{0.5} = 0.51$	$HHI_{0.9} = 0.89$
Relative to Group 3,			
Group F	174%	169%	158%
Group 1	50%	62%	88%
Group 2	29%	30%	34%
	Model 2: Structural Categories		
	Competitive	Duopoly	Monopoly
Relative to Group 3,			
Group F	171%	169%	129%
Group 1	54%	61%	101%
Group 2	28%	34%	29%

Note: Market structure categories defined according to Borenstein and Rose (1994).

Table 9.— Log of Fare per Mile Regressions by Carrier, 2SLS

	American				United			
	Model 1		Model 2		Model 1		Model 2	
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Group F	1.646	0.112	1.437	0.084	1.979	0.199	1.821	0.047
Group 1	-0.141	0.363	0.298	0.187	0.535	0.312	0.669	0.158
Group 2	0.194	0.117	0.242	0.040	0.032	0.073	0.190	0.035
Market share	0.161	0.185	0.379	0.210	-0.019	0.232	-0.358	0.255
HHI	-0.598	0.576			-0.337	0.250		
Monopoly			-0.458	0.236			0.192	0.144
Duopoly			-0.157	0.120			0.059	0.048
Group F*HHI	-0.525	0.170			-0.464	0.424		
Group 1*HHI	1.274	0.566			0.375	0.507		
Group 2*HHI	0.116	0.174			0.550	0.103		
Group F*Monopoly			-0.233	0.093			-0.588	0.201
Group F*Duopoly			-0.209	0.080			-0.094	0.085
Group 1*Monopoly			0.807	0.236			0.201	0.208
Group 1*Duopoly			0.319	0.241			0.125	0.159
Group 2*Monopoly			-0.019	0.081			0.377	0.082
Group 2*Duopoly			0.053	0.048			0.210	0.028
Adv0_3	0.258	0.020	0.262	0.018	0.094	0.043	0.096	0.043
Adv4_6	0.216	0.018	0.225	0.017	0.078	0.033	0.079	0.034
Adv7_13	0.163	0.019	0.172	0.019	0.064	0.024	0.062	0.024
Adv14_21	0.096	0.008	0.092	0.008	0.045	0.010	0.048	0.011
One-way	0.075	0.035	0.081	0.025	0.296	0.023	0.297	0.026
Load factor at purchase	0.232	0.026	0.224	0.022	0.144	0.035	0.140	0.033
Peak time	0.035	0.008	0.032	0.008	0.009	0.013	0.010	0.013
Hub for carrier	0.296	0.121	0.254	0.076	0.505	0.215	0.821	0.227
Slot-controlled airport	0.114	0.064	0.110	0.052	0.207	0.037	0.190	0.038
Southwest on route	-0.458	0.109	-0.443	0.085	-0.225	0.080	-0.288	0.086
Low cost carrier on route	-0.143	0.027	-0.156	0.035	0.026	0.047	0.104	0.068
Log distance	-0.844	0.105	-0.838	0.075	-0.825	0.059	-0.795	0.046
Log total flights on route	-0.307	0.302	-0.196	0.149	-0.343	0.118	-0.278	0.092
Log per capita income	1.009	0.327	1.152	0.343	0.848	0.223	0.739	0.195
Log temperature difference	-0.004	0.028	-0.004	0.028	0.010	0.016	-0.001	0.013
Tourism index	-1.461	0.507	-1.495	0.575	0.051	0.829	0.476	0.831
Constant	0.030	3.810	-2.674	3.341	1.602	2.035	1.697	1.669
Underidentification test:								
Kleibergen-Paap rk LM stat.		34.09		105.23		93.15		108.16
Chi-sq(1) P-val		(0.00)		(0.00)		(0.00)		(0.00)
Weak identification test:								
Kleibergen-Paap rk Wald F stat.		7.83		71.51		108.68		253.15
# observations		245,684		245,684		175,910		175,910
R-squared		0.667		0.684		0.753		0.760

Table 9.— Continued

	Delta				Continental			
	Model 1		Model 2		Model 1		Model 2	
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Group F	1.737	0.078	1.729	0.042	1.025	0.104	1.204	0.259
Group 1	0.866	0.214	0.853	0.139	1.111	0.258	1.228	0.524
Group 2	0.272	0.086	0.354	0.030	0.318	0.116	0.351	0.118
Market share	-0.533	0.234	-0.422	0.206	0.605	0.460	4.522	2.204
HHI	0.218	0.195			-1.768	0.530		
Monopoly			0.030	0.119			-1.468	1.272
Duopoly			-0.070	0.054			-0.279	0.787
Group F*HHI	-0.045	0.124			0.795	0.149		
Group 1*HHI	-0.107	0.266			0.233	0.368		
Group 2*HHI	0.237	0.128			0.086	0.162		
Group F*Monopoly			-0.619	0.049			0.075	0.342
Group F*Duopoly			0.034	0.037			0.104	0.264
Group 1*Monopoly			0.047	0.157			-0.420	0.772
Group 1*Duopoly			-0.173	0.169			-1.181	1.009
Group 2*Monopoly			0.146	0.075			0.492	0.320
Group 2*Duopoly			0.088	0.040			-0.290	0.109
Adv0_3	0.104	0.034	0.105	0.034	0.326	0.024	0.671	0.212
Adv4_6	0.083	0.042	0.081	0.042	0.320	0.021	0.610	0.188
Adv7_13	-0.013	0.021	-0.016	0.022	0.276	0.025	0.448	0.119
Adv14_21	-0.041	0.009	-0.040	0.011	0.155	0.017	0.269	0.099
One-way	0.180	0.031	0.170	0.033	0.057	0.020	0.160	0.045
Load factor at purchase	0.136	0.021	0.148	0.022	-0.023	0.057	-0.466	0.222
Peak time	0.012	0.008	0.012	0.009	0.021	0.011	0.047	0.028
Hub for carrier	0.286	0.081	0.312	0.091				
Slot-controlled airport	0.052	0.029	0.073	0.034	0.240	0.175	0.888	0.596
Southwest on route	-0.282	0.137	-0.312	0.138				
Low cost carrier on route	0.111	0.063	0.109	0.063	-0.146	0.067	0.112	0.227
Log distance	-0.993	0.049	-1.024	0.050	-0.645	0.131	-0.018	0.367
Log total flights on route	-0.299	0.109	-0.371	0.121	-0.525	0.208	1.601	1.363
Log per capita income	0.156	0.151	0.193	0.174	-0.673	0.391	0.332	0.622
Log temperature difference	-0.036	0.018	-0.036	0.019	-0.053	0.033	-0.222	0.111
Tourism index	-1.457	0.881	-1.369	1.080	-3.307	0.628	-4.786	3.036
Constant	9.801	1.404	10.245	1.892	18.821	5.980	-14.942	15.102
Underidentification test:								
Kleibergen-Paap rk LM stat.		708.24		627.86		48.61		4.10
Chi-sq(1) P-val		(0.00)		(0.00)		(0.00)		(0.04)
Weak identification test:								
Kleibergen-Paap rk Wald F stat.		126.62		266.18		4.26		2.01
# observations		128,985		128,985		94,393		94,393
R-squared		0.853		0.848		0.793		0.359

Table 9.— Continued

	US Airways				Northwest			
	Model 1		Model 2		Model 1		Model 2	
	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.	Coeff.	Std. err.
Group F	1.414	0.240	1.143	0.065	1.144	0.260	1.072	0.073
Group 1	-0.109	0.203	0.396	0.042	0.403	0.075	0.582	0.087
Group 2	0.152	0.164	0.157	0.028	0.399	0.149	0.112	0.071
Market share	-0.791	1.744	0.214	0.425	-0.126	0.749	-0.492	1.265
HHI	1.710	3.333			0.652	1.648		
Monopoly			-0.322	0.180			-0.036	0.094
Duopoly			-0.253	0.071			-0.278	0.265
Group F*HHI	-0.451	0.409			0.504	0.384		
Group 1*HHI	1.116	0.259			0.689	0.116		
Group 2*HHI	0.020	0.344			-0.511	0.206		
Group F*Monopoly			0.067	0.083			0.376	0.213
Group F*Duopoly			0.028	0.093			0.622	0.120
Group 1*Monopoly			0.667	0.068			0.476	0.092
Group 1*Duopoly			0.094	0.047			0.308	0.198
Group 2*Monopoly			-0.111	0.159			-0.306	0.095
Group 2*Duopoly			0.074	0.045			0.109	0.060
Adv0_3	-0.002	0.022	0.037	0.028	0.158	0.054	0.134	0.067
Adv4_6	0.018	0.026	0.045	0.030	0.132	0.047	0.118	0.052
Adv7_13	0.055	0.023	0.073	0.018	0.118	0.016	0.122	0.018
Adv14_21	0.030	0.026	0.054	0.009	0.090	0.016	0.098	0.013
One-way	0.113	0.020	0.130	0.015	0.113	0.021	0.111	0.018
Load factor at purchase	0.224	0.051	0.214	0.026	0.090	0.027	0.090	0.042
Peak time	0.052	0.024	0.051	0.021	0.070	0.015	0.068	0.009
Hub for carrier	0.021	0.453	0.286	0.213				
Slot-controlled airport	0.280	0.269	0.367	0.125	-0.314	0.085	-0.125	0.307
Southwest on route	0.329	0.523	0.074	0.163	-0.302	0.132	-0.509	0.151
Low cost carrier on route	-0.220	0.119	-0.120	0.069	-0.293	0.119	-0.323	0.056
Log distance	-0.595	0.251	-0.818	0.139	-0.831	0.260	-1.232	0.537
Log total flights on route	0.118	0.307	-0.208	0.156	0.288	0.826	-0.621	1.245
Log per capita income	0.098	1.471	0.531	1.707	3.074	0.293	2.422	1.010
Log temperature difference	-0.246	0.136	-0.176	0.097	0.180	0.025	0.261	0.091
Tourism index	-2.813	1.157	-0.525	0.946	0.249	1.054	-1.676	1.506
Constant	4.433	19.075	3.980	16.509	-26.758	10.075	-9.651	24.184
Underidentification test:								
Kleibergen-Paap rk LM stat.		0.72		20.46		2.37		0.86
Chi-sq(1) P-val		(0.39)		(0.00)		(0.12)		(0.35)
Weak identification test:								
Kleibergen-Paap rk Wald F stat.		0.12		10.30		0.45		0.49
# observations		71,056		71,056		46,604		46,604
R-squared		0.865		0.876		0.835		0.834

Note: Fare per mile = roundtrip fare (in cents) / (2 x nonstop origin to destination mileage). White robust standard errors reported, clustered on origin city. Market share and HHI instrumented using the same instruments as Borenstein (1989) and Borenstein and Rose (1994). Log of total flights instrumented with the log of population. The underidentification and weak identification tests follow Kleibergen and Paap (2006) and are heteroskedastic-robust.

VITA

Manuel A. Hernandez Garcia was born in Lima, Peru. He received his Bachelor of Arts degree in economics from Universidad del Pacifico, Peru, in December 1999. Prior to starting his graduate studies, he worked for more than five years in different research institutes in Peru. He entered the graduate program in economics at Texas A&M University in August 2004 and received his Doctor of Philosophy degree in August 2009. Under the supervision of Dr. Steven N. Wiggins, his research interests include industrial organization, labor economics and applied econometrics.

Dr. Hernandez Garcia may be reached at the Department of Economics, Texas A&M University, College Station, TX 77843-4228. His email address is mhg@tamu.edu.