

Empirical Essays in Industrial Organization: Application in Airline and Automobile Industries

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(ABSTRACT)

This dissertation consists of three essays in empirical industrial organization with applications in U.S. airline and automobile industries. Chapter 1 motivates the aim of this dissertation with a brief summary of the main goals and findings of the subsequent chapters.

The main focus of this dissertation is to highlight the changing environments in the U.S. airline and automobile industries in recent years and investigate their implications for the nature of industry competitiveness. Following the recession of 2000 and post 9/11 events, the U.S. airline industry has undergone major restructuring which has defined the way airlines compete today. Chapter 2 of this dissertation explores the impact of the presence of Low Cost Carriers (LCCs) on consumer welfare in this newly restructured market environment. Previous studies on LCC competition have not addressed the welfare issue and have only been limited to impact of LCC entry on average airfare. Departing from previous literature, this question is posed using a discrete choice model of demand for differentiated products. In chapter 3 we use a structural oligopoly model for differentiated products similar to chapter 2 to unveil the nature of conduct that exists in markets with endpoints which qualify as hubs of legacy carriers. In contrast to previous literature on airline hub market conduct, this chapter investigates the nature of conduct that exists in markets defined exclusively by network carrier hubs as a whole group incorporating product differentiation in the model framework. Finally chapter 4 uses the same methodological framework outlined in chapter 3 to explore the importance of frequent incidence of manufacturer incentives in shaping market conduct in the automobile industry. Unlike past literature on automobile market conduct, this is achieved using proprietary dealer level average transaction price data obtained from

J.D. Power and Associates (JDPA) with a focus on the Big Three automakers. Specifically we use the widely successful Employee Discount Pricing (EDP) promotional program of 2005, the first of its kind, as a backdrop to identify changes in the nature of short run conduct among the Big Three that might be signalled by such promotional programs.

Dedication

This dissertation is dedicated to my parents whose unconditional love and support has been critical to the completion of this work. They never doubted my potential and gave me the much needed encouragement when I needed it the most. Their commitment, endurance and sacrifice throughout this journey is unforgettable.

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CHAPTER 1

Introductory Remarks

The field of industrial organization (IO) has mainly been involved in analyzing behavior of firms and the underlying market structure. Since most real world markets have tended to be imperfectly competitive, empirical methods within the discipline have advanced drastically in the last few decades. Integration of game theory in the study of oligopolistic markets, increasing availability of industry or firm level data, improvement of computing power and progress of econometric techniques helped shape the empirical methods.¹ As a consequence, contemporary empirical IO has undergone a paradigm shift from the structure-conduct-performance approach to structural models developed under the New Empirical Industrial Organization (NEIO) framework, a term coined by Bresnahan (1989), to analyze industry structure. This approach has involved estimation of a system of demand and supply relations assuming that the observed prices and output are the equilibrium outcome of such an interaction. This dissertation adds to the growing literature on estimation of structural models of oligopoly with differentiated products in analyzing some recent trends in the U.S. airline and automobile industries.

Both airline and automobile industries are integral parts of the U.S. economy. An economic impact study conducted by the Air Transport Association reports that in 2006 alone, U.S.

¹Einav and Levin (2010) present a detailed account of these developments.

commercial aviation contributed to 5.2% of GDP and was responsible for generating 10.9 million jobs.² This includes both the direct impact on airline employment, company profitability and net worth as well as the indirect effects on aircraft manufacturing industry, airports, tourism industry and any other economic activity dependent on airtravel services (Belobaba et al. (2009)). On the other hand, the U.S. automobile industry has been the largest of its kind in the world. McAlinden et al. (2003) finds that in 2002 U.S. motor vehicle output was responsible for 3.3% of GDP while in 2004 automotive manufacturing represented 7.7% of the country's total manufacturing employment (Cooney and Yacobucci (2005)). According to McAlinden et al. (2003), including both direct and indirect effects, the automotive industry was responsible for 6.6 million jobs nationwide in 1998.

Historically, both the airline and automobile industries have shared some common features of an oligopolistic market structure. Both industries are characterized by high degrees of product differentiation and strategic interdependence among firms. Consequently these features have raised issues of market power and inhibition of competition. At the same time some similarities in the inherent structure of these industries have intertwined their fate over the years. The capital intensive nature of these industries and their vulnerability to demand fluctuations have resulted earnings in both these industries to be highly volatile to external shocks. This has further been exacerbated by increasing labor related expenses. Such conditions coupled with dynamically changing consumer preferences have allowed some niche players to gain strong foothold in these markets and thus redefine the competitive landscape of both these industries. This dissertation investigates the implications of the recent changes in the competitive circumstances in the airline and automobile industries on their underlying market structure.

Chapters 2 and 3 are devoted to analysis concerning the airline industry. Both these chapters highlight the importance of the low cost carriers (LCCs) in the evolution of competitiveness

²Air Transport Association

<http://www.airlines.org/Economics/AviationEconomy/Pages/EconomicImpact.aspx>

in the airline industry in recent years. Specifically, chapter 2 estimates the impact of the presence of LCCs on consumer welfare. Previous empirical work has largely focussed on cross sectional fare regressions to calculate the differences in airfares resulting from LCC entry across routes at different periods of time. None of these studies have explicitly estimated the consequence of LCC presence on consumer welfare. A study by Morrison (2001) has gone as far as calculating fare savings achieved by passengers due to LCC entry in a selected sample of routes. Furthermore all these studies have relied on reduced form price regressions and thus have refrained from the NEIO tradition.

Chapter 2 of this dissertation builds upon the NEIO framework to estimate an equilibrium model of demand and supply for the welfare calculation exercise. According to Akerberg et al. (2007), demand systems are most crucial to studies concerning pricing decisions and consumer welfare since they determine the incentives faced by producers. Earlier models of demand posed serious estimation challenges when products are categorized by unique characteristics. For many industries in that case presence of product differentiation will result in a large number of substitute products. Thus specifying a demand system on a J products space will require J^2 parameters to be estimated which will result in serious econometric issues given the available data. This problem was circumvented by characteristics-based demand models pioneered by Lancaster (1971) and McFadden (1973, 1981) and later extended by Berry (1994) and Berry, Levinsohn and Pakes (1995). This approach is based on derivation of demand models by aggregating individual choices in a utility maximizing framework. Since utility is based on consumer preferences of different product specific characteristics, different assumptions on consumer preferences can further put more structure on such demand specification and also mitigate the “too many parameters” problem. The discrete choice framework, adopted in this dissertation, falls within the class of characteristics-based demand models where each consumer is assumed to choose at most one of the available alternatives on each purchase occasion.

In chapter 2, we employ the discrete choice methodology to estimate consumer preferences

which explicitly depend on the characteristics of the products. Based on such estimates and corresponding supply side specification, we simulate a counterfactual equilibrium with no LCCs to estimate the compensating variation in order to measure the welfare effect. The welfare change is further decomposed into a variety effect resulting from a change in consumer surplus due to a change in the product choice set and a price effect capturing the benefits due to reduced competition upon LCC exit. Results indicate an average of 25.08% of the consumer surplus can be attributed to LCC presence with the variety effect dominating the price effect of such welfare gain.

The third chapter of the dissertation uses a structural oligopoly model for differentiated products similar to chapter 2. The main objective of this chapter is to estimate the actual nature of conduct that exists in markets with endpoints which qualify as hubs of legacy carriers. Previous studies of market conduct have typically assumed quantity setting duopolies treating airline products as homogeneous. On the other hand none of these studies have investigated the nature of market conduct that exists in markets defined exclusively by hubs as a whole group. This consideration in chapter 3 is based on the possibility of strategic interdependence among hub carriers arising from multimarket contact already documented in the literature. Explicit estimation and identification of conduct parameters can be problematic in the absence of real industry marginal cost data. We follow the methodology outlined in Sudhir (2001) to specify a parametric function of marginal cost to estimate the firm's pricing equation in order to uncover the conduct parameters. Specifically, in the spirit of Sudhir (2001) our model uses the weighted profit approach where models of collusion and competition are nested in a general framework and the conduct parameter can capture different modes of market conduct relative to the Bertrand benchmark. Our results imply that the nature of competition is more aggressive relative to Bertrand behavior in hub-to-hub markets. We also use our supply side framework to identify different conduct parameters for markets with and without LCC presence and shed some light on the issue of perfect contestability, a much debated issue in airline markets.

The sample period of our study in both chapters 2 and 3 is first quarter of 2004 which allows us to capture some of the recent changes taking place in the airline industry. Following the recession of 2000 and post 9/11 events, the network carriers have struggled to remain profitable while the LCCs have emerged as a stronger group in the marketplace. In the wake of these events the airline industry has undergone major restructuring with reduced demand for airtravel and increased price sensitivity of passengers including business travellers. The legacy carriers have taken this opportunity to restructure and redefine their business model with an attempt to reduce costs by downsizing, cutting operating costs and improve overall productivity. Our results do indicate that these factors have directly contributed to the way airlines compete today.

Finally in chapter 4, we use the same methodological framework outlined in chapter 3 to analyze competition in the U.S. automobile market between third quarter of 2004 to second quarter of 2007 with a specific focus on the Big Three automakers. In contrast to previous work on competition in the automobile industry, we use quarterly proprietary dealer level average transaction price data obtained from J.D. Power and Associates (JDPA) to incorporate information on manufacturer incentives in both consumer and firm objective functions. Specifically we use the widely successful Employee Discount Pricing (EDP) promotional program of 2005, the first of its kind, as a backdrop to identify changes in the nature of short run conduct among the Big Three that might be signalled by such promotional programs. Our results imply that the overall nature of competitiveness in the U.S. automobile industry is consistent with a static model of Bertrand behavior without any changes in conduct among the Big Three during the EDP promotion period. Our results corroborate the problems of inventory backlog faced by the Big Three in recent years due to formidable challenges faced from the foreign transplants. This indicates that the EDP program has been more of a novel marketing intent on part of the Big Three to clear up such backlogs.

CHAPTER 2

Presence of Low Cost Carriers in the U.S. Airline Industry - Disentangling the Effects on Consumer Welfare

2.1 Introduction

The U.S. airline industry in the 1990's has experienced an unprecedented growth of low cost carriers (hereafter, LCCs¹). Evidence suggests LCC presence in 2,304 out of top 5,000 city pair markets as of 2003. This accounts for exposure to 85% of all air travellers.² The LCCs have caught attention of many industry analysts and academicians because on one hand they have offered low fares (resulting from their low cost structure of service delivery) and on the other they have lowered fares charged by existing network carriers due to intense competition. Traditionally LCCs have been defined as a new breed of air carriers offering mostly low-cost, no-frills, point-to-point service by targeting dense short and medium haul markets. LCCs have been viewed as an alternative for price sensitive leisure travellers due to their low fare structure. Following the recession of 2000 and terrorist attacks of 9/11, the network carriers have struggled to remain profitable while the LCCs have emerged as a stronger group in the marketplace. In the wake of these events the airline industry has undergone major restructuring with reduced demand for airtravel and increased price sensitivity of passengers

¹Identification of LCC is based on Ito and Lee (2003^a) and Ito and Lee (2003^b)

²U.S. General Accounting Office (2006)

including business travellers. The network carriers have been forced to lower their fares in all classes of service since LCCs have become a viable option for business travellers as well.³ LCCs have taken advantage of the situation by expanding their network and also entered into long haul U.S. transcontinental markets by developing mini hubs in certain cities. Some of the network carriers have entered and emerged from bankruptcy with a leaner cost structure by focussing on ‘down-sizing by cutting operating costs and improving productivity as part of their restructuring efforts’.⁴

At this juncture with the restructuring of the airline industry, this paper attempts to estimate the benefits to consumers resulting from the presence of LCC’s in network carrier markets. While the literature has documented fare savings that consumers have achieved with LCC entry over the years, most of these studies have been dated to the years before the recent restructuring of the airline industry. As discussed earlier there have been subsequent increases in consumers’ price sensitivity in recent years. Further all earlier studies have used cross sectional fare equations to calculate differences in airfares between routes with and without LCC entry at different periods of time without explicitly modeling demand for airtravel products. Airline services have long been viewed as differentiated products (Berry (1990)). Demand models estimating consumer preferences for airtravel products have accounted for non-price product attributes such as stop v/s nonstop flights, number of connections, airline’s presence in endpoint airports, flight frequency etc. which significantly affect consumers’ choice of airlines and related itineraries. Building on the discrete choice empirical literature in the airline industry, we model airtravel demand as a differentiated product accounting for different aspects of service delivery and price. Moreover we also use the median airfare from the fare distribution instead of the mean airfare to account for some aspect of price discrimination practiced by airlines. With the demand estimates we calculate consumer welfare by simulating a counterfactual scenario that would have existed in the absence of LCCs. Thus

³U.S. General Accounting Office (2004^a).

⁴MIT Global Airline Industry Program

http://web.mit.edu/airlines/analysis/analysis_airline_industry.html

instead of comparing differences in average airfares across different time periods and across different routes with and without LCC presence, we look at the welfare aspect by simulating the equilibrium price that the newly restructured network carriers would have charged in the absence of LCCs. The time span of this study is during the period when network carriers have undergone restructuring in terms of their operating costs and productivity. Part of this has been driven by strive for survival during difficult economic times due to exogenous events while part of this has been in quest for getting better equipped to meet challenges due to competitive pressure from LCCs (Tsoukalas, Belobaba and Swelbar (2008)). Finally we decompose the total change in consumer surplus into two parts (i) *the variety effect* i.e. part of consumer benefits that accrues in terms of fare and service attributes of LCCs vis-a-vis network carriers and (ii) *the price effect* i.e. consumer benefits that results from lower fares charged by network carriers as compared to what they would have charged in the absence of LCCs.⁵

Our results indicate that the presence of LCCs is responsible for an average of 25.08% of consumer surplus during the first quarter of 2004 in our sample markets. 21.61% of the total consumer surplus can be attributed to the new product variety offered by LCCs while the remaining 3.47% is due to the competitive effect of LCC presence. In the counterfactual scenario we find that the scope of price increase by network carriers is limited by an average of 2.52% across the sample markets. Some of the recent structural changes in the industry resulting in increased price sensitivity of consumers and improved efficiency of network carriers are expected to contribute to such a finding.

The rest of the paper is organized as follows. In Section 2 we present a brief description of how network carriers and LCCs have evolved over the years and how the competition between them is reshaping the landscape of the airline industry. In Section 3 we outline the structural model of airline demand and the associated welfare calculation techniques. Section 4 depicts the specification of the empirical model of demand estimation. We discuss

⁵We follow the terminology of Hausman and Leonard (2002).

the data in Section 5 while results are presented in Section 6. Finally Section 7 concludes the paper.

2.2 Evolution of Network Carriers and LCCs over the years

Since the deregulation of the airline industry in 1978, the successful emergence of the LCCs have been one of the most significant structural developments of the U.S. airline industry in recent years. Low-fare carriers started offering service even before deregulation as early as 1971 with the advent of Southwest Airlines. Although by early 1990's Southwest established itself as the only successful LCC, its footsteps have been followed by other carriers in this breed such as Jet Blue, Frontier, AirTran to name a few. The LCCs have distinguished themselves from established network carriers by offering tickets at lower prices with the tag of 'no frills' service, characterised by reduced in flight service, no seat reservation and limited frequent-flyer benefits. Unlike the network carriers the LCCs have typically offered single cabin service, with no premium classes with their aim of capturing price sensitive leisure travelers. However in recent years some newly developed LCCs like JetBlue have provided amenities like all-leather seating and in-flight entertainment thus expanding the scope of product offerings of traditional LCCs.

LCCs have also been distinguished from network carriers with respect to their network characteristics of service delivery. While network carriers have provided services on a hub-and-spoke network thus largely relying on connecting passengers, LCC have developed mainly point-to-point service delivery with more direct flights in short and medium haul routes and simpler connections in long haul routes. A hub is an airport where an airline concentrates most of its operations by offering direct flights to different spoke cities (Aguirregabiria and Ho (2009)). This enables anyone to go from anywhere to everywhere due to the connectivity of

the hub and spoke network. Passengers originating or departing at hub airports of a certain airline benefit from the airline's scale of operation at such airports, some of these being better landing and check-in facilities, easier access to gates and higher frequency of flights. Alternatively, LCCs function on a point-to-point network thus not relying on connecting passengers but connections as a natural byproduct of such a network system. As Ito and Lee (2003^a) and Levine (2002-2003) point out that some LCCs like AirTran, Frontier, America West have operated hub and spoke network with significant volume of connecting passengers as they have expanded their coverage from only short and medium haul markets to long haul markets as well. Levine (2002-2003) also illustrates Southwest's recent strategies to move from purely point-to-point operations to 'quasi-hub' operations as it has mixed nonstop, onestop and connecting itineraries to provide different alternatives to passengers.

After the deregulation of the airline industry, airlines realized that they can benefit from the liberalized market and increase their profitability by segregating the customer base according to their willingness to pay and thus offer them different fares for the same itinerary based on different ticket restrictions. These restrictions appeared in form of in-flight amenities, ticket refundability options, advanced booking and minimum stay requirements. This enabled airlines to identify between high and low willingness to pay passengers and thus charge fares accordingly. Such differential pricing was common for both network carriers and LCCs although the latter offered much simplified fare structures with less ticket restrictions and less in-flight amenities. Tretheway (2004) points out that the widespread appearance of LCCs in the 1990's started to pose a serious threat to the effectiveness of the complex fare structure of the network carriers.

The effect of LCC entry on average airfare has been well documented in the literature. Morrison (1997) reports that routes served by only Southwest Airlines have seen average real fares falling by about 50% in 1996 as compared to the regulatory era. The unprecedented success of Southwest in lowering fares on routes served by network carriers have been sometimes cited as the 'Southwest Effect' (U.S. Department of Transportation (1993)). Dresner, Lin

and Windle (1996) considered the impact of LCCs on average yield (fare per passenger mile) for the top 200 city pairs for the period of third quarter of 1991 to second quarter of 1994. They found average yield to decline by 53% when only Southwest served a route while the effect was reduced to 38% when routes with all low cost carriers were considered. Richards (1996) documents how actual presence of Southwest on a route can have a dampening effect on average yields. Morrison (2001) estimated fare equations for routes served by Southwest in 1998 and found that fares were 46% lower than routes it didn't serve. He further estimated savings of about \$3.4 billion enjoyed by travellers due to travel by Southwest. It has also been seen that Southwest results in significant decrease of airfares and consequently results in savings due to its adjacent and potential competitive effects on other routes as well. Studies like Dresner, Lin and Windle (1996) and Morrison (2001) further find that fares on competitive routes will fall as well due to spillover effect from Southwest competition. Goolsbee and Syverson (2008) report that major incumbent airlines have responded by dropping fares significantly even in the event of threat of entry by a major LCC like Southwest when Southwest establishes its presence in both the endpoint airports of a route served by a major airlines but does not actually start flying on the route. As Southwest has been the role model for LCCs, most studies have focussed on the effect of entry of Southwest on average airfares. Dresner and Windle (1999) demonstrated fare reduction by Delta on its routes due to entry by ValuJet (renamed Airtran), thus establishing the fact that effect of reduced fares on consumers due to LCC entry is not limited to Southwest only. Ito and Lee (2003^b) consider effect of LCC entry on 370 hub markets of network carriers between 1991 and 2002. They find network carriers to reduce fares by 15% on an average due to entry by LCCs.

In spite of the dampening effect on network carrier airfares due to LCC entry, the network carriers still managed to attract the high-yield convenience oriented business travellers using their differential price system till the late 1990's. Although the fares charged to price insensitive passengers were kept competitive, the fares charged to the business travelers rose to

spectacular heights in 1999-2001 period (Levine (2002-2003)). With the burst of the dotcom bubble in 2000 and following the events of 9/11, overall air travel demand fell and many business travellers started shopping for cheaper alternatives. Belobaba et al. (2009) point out that the rapid growth of internet distribution channels also made consumers more aware of alternative fare and airline options. LCCs captured the market for this new pool of price sensitive business customers with their simplified fare structure and low fare levels. In addition to reduction of fares across all fare levels, this forced the network carriers to simplify their fare structures by incorporating fewer fare levels, reduced restrictions and less price dispersion between highest and lowest fares. The major advantage of LCCs over the network carriers has been lower cost of service delivery and higher levels of productivity. Belobaba et al. (2009) documents that since 2001 the network carriers have faced severe financial trouble which led them to restructure in order to reduce unit cost and achieve improved labor and aircraft productivity. Their study in fact demonstrates a trend towards productivity and cost convergence between network carriers and LCCs. In this paper we attempt to estimate consumer benefits from LCC presence in network carrier markets in the newly evolving phase of the airline industry.

2.3 Demand specification and consumer welfare

Consumer demand for airtravel is modeled following the structural specification as outlined in Berry (1994). We estimate the effect of LCC presence on consumer welfare by calculating the welfare loss that would result from their removal or exit from the markets.

2.3.1 Demand

Following Berry (1992), Berry, Carnall and Spiller (1996) (hereafter, BCS) and Aguirregabiria and Ho (2009), a market is defined as a directional city-pair consisting of an origin

city and a destination city. According to this definition, a round-trip from Houston to Chicago is in a different market when compared to a round-trip from Chicago to Houston. This allows for the possibility of the characteristics of the origin and destination cities to affect demand (BCS). Unlike some other studies like Borenstein (1989), markets defined by city-pairs account for the fact that some cities have multiple airports (for example DCA and IAD in Washington DC) and thus allow for the possibility of substitutability of airports within the same city by both consumers and airlines (Aguirregabiria and Ho (2009)).

Within each market we define a product as a round-trip between the origin and the destination cities involving a unique combination of a ticketing carrier and flight itinerary. A ticketing carrier is the airline who markets the product while an operating carrier is the one in which the passenger actually travels. A flight itinerary is a specific sequence of airports including the origin, connecting and destination airports in a passenger's roundtrip travel.

Following Aguirregabiria and Ho (2009) and Ciliberto and Williams (2007) we model demand for airtravel as a discrete choice among differentiated products where consumer i 's $\in \{1, \dots, I_t\}$ utility from product $j \in \{1, \dots, J_t\}$ in market $t \in \{1, \dots, T\}$ is given by

$$u_{ijt} = x_{jt}\beta - \alpha p_{jt} + \xi_{jt} + v_{ijt} \tag{2.1}$$

where x_{jt} is a vector of observed product characteristics (e.g. number of stops in the itinerary, the airline's scale of operation in the origin airport etc.), p_{jt} is the ticket price and ξ_{jt} represents product characteristics unobserved by the researcher.

The first three terms on R.H.S. in equation 2.1 taken together i.e. $x_{jt}\beta - \alpha p_{jt} + \xi_{jt} \equiv \delta_{jt}$ measures the mean valuation of product j , common to all consumers within market t while the additive error term v_{ijt} captures the deviation of individual buyer preferences around this mean. The distribution assumption on v_{ijt} determines the substitution patterns among products. To avoid unrealistic substitution patterns among products, we use the nested logit formulation where we group products within a market introducing correlation in utility

between products with similar characteristics belonging to the same group (BCS). In our case this amounts to partitioning alternatives within each market into two groups namely the inside group containing people who choose to fly and the outside group containing people who decide not to fly.⁶ The outside option allows for the possibility of aggregate demand for airtravel to decrease following an increase in the prices of all airline products. Thus the error term v_{ijt} in equation 2.1 is decomposed into an i.i.d. shock ϵ_{ijt} and a group specific component ς_{ig} which is common to all products in group g in market t . Therefore a consumer solves

$$\max_{j \in \{0, 1, \dots, J_t\}} u_{ijt} = \delta_{jt} + \varsigma_{igt} + (1 - \sigma)\epsilon_{ijt} \quad (2.2)$$

where $j = 0$ is the outside option belonging to the outside group. The additive error term $\varsigma_{igt} + (1 - \sigma)\epsilon_{ijt} \equiv v_{ijt}$ has a distribution function that depends on a parameter σ which is to be estimated, with $0 \leq \sigma < 1$. The term ς_{igt} captures preferences for goods belonging to the same nest g and thus does not vary across products within group g while $(1 - \sigma)\epsilon_{ijt}$ represents the idiosyncratic tastes for product j . The correlation in unobserved utility among products in group g is captured by the parameter σ . If $\sigma=1$ then the preferences for products within the same group are perfectly correlated while if $\sigma=0$ then there is no correlation of preferences between the products in the group and the model reduces to a standard logit.

Following Berry (1994), if both ϵ_{ijt} and $\varsigma_{ig} + (1 - \sigma)\epsilon_{ijt}$ follow a type I extreme value distribution then the within group market share of product j i.e. share of the product j out of total number of tickets sold in group g is given by

$$\bar{s}_{j|g}(\delta, \sigma) = \frac{e^{\delta_j/(1-\sigma)}}{D_g} \quad (2.3)$$

where $D_g = \sum_{j \in \mathcal{J}_g} e^{\delta_j/(1-\sigma)}$, while the probability of choosing a group g in a market i.e. group

⁶The outside group can also include people who might want to travel between the origin and destination cities by alternative modes of transportation e.g. driving a car.

share is given by

$$\bar{s}_g(\delta, \sigma) = \frac{D_g^{(1-\sigma)}}{\sum_g D_g^{(1-\sigma)}} \quad (2.4)$$

This gives the market share of a product j in market t as

$$s_{jt}(\delta, \sigma) = \bar{s}_{j|g}(\delta, \sigma) \bar{s}_g(\delta, \sigma) = \frac{e^{\delta_j/(1-\sigma)}}{D_g^\sigma \sum_g D_g^{(1-\sigma)}} \quad (2.5)$$

It should be noted that this $s_{jt}(\delta, \sigma)$ is the market share of product j as predicted by the model and is not the observed market share in the data. We need to take the predicted market shares to the data where we observe the actual product shares to enable estimation of the parameters of the model.

2.3.2 Welfare effects

The change in total consumer welfare can be calculated for a nested logit model following Trajtenberg (1989) and Small and Rosen (1981) as a compensating variation (CV) measure. CV for an individual consumer i in market t is given as the difference in consumer's expenditure with and without LCCs, holding utility constant at a level when LCCs are present. Thus

$$CV_{it} = \frac{1}{\alpha} \ln \left[\sum_g \left[\sum_{j \in \mathcal{J}_g^{WithLCC}} \exp \left(\frac{\delta_j (p^{WithLCC})}{1 - \sigma} \right) \right]^{(1-\sigma)} \right] - \frac{1}{\alpha} \ln \left[\sum_g \left[\sum_{j \in \mathcal{J}_g^{NoLCC}} \exp \left(\frac{\delta_j (p^{NoLCC})}{1 - \sigma} \right) \right]^{(1-\sigma)} \right] \quad (2.6)$$

where g denotes the groups or nests, α is the coefficient on price, δ_j the mean utility level, $p^{WithLCC}$ and p^{NoLCC} are respectively the equilibrium prices in the presence and absence of

LCCs and σ measures the correlation of consumer tastes across products. We decompose the total compensating variation of equation 2.6 into two effects⁷ - (1) the *variety effect* and (2) the *price effect* following

$$CV_i = \underbrace{W^{WithLCC}(p^{WithLCC}) - W^{NoLCC}(p^{WithLCC})}_{\text{variety effect}} + \underbrace{W^{NoLCC}(p^{WithLCC}) - W^{NoLCC}(p^{NoLCC})}_{\text{price effect}} \quad (2.7)$$

$$\text{where } W(p_r) = \frac{1}{\alpha} \ln \left[\sum_g \left[\sum_{j \in \mathcal{J}_g} \exp \left(\frac{\delta_j(p_r)}{1 - \sigma} \right) \right]^{(1-\sigma)} \right]$$

The first term i.e. the *variety effect* captures the change in consumer welfare due to the availability of the new products offered by LCCs, holding the prices of the existing airline products offered by the network carriers at the post LCC period i.e. $p^{WithLCC}$. The *price effect* is evaluated by setting LCC demand to zero in order to capture only the price changes of products of network carriers due to competition from LCCs. For the counterfactual scenario we estimate the equilibrium with the LCC products and then simulate the prices p^{NoLCC} of network carriers in the absence of LCCs. Computation of the counterfactual equilibrium prices requires us to specify the supply side of the model which we discuss next.⁸

Each airline $f \in \{1, \dots, F\}$ is assumed to produce some subset \mathcal{J}_{ft} of the total set of products \mathcal{J}_t in market t . Also assume J is the total number of products for all firms and all markets and firm f produces some subset \mathcal{R}_f of J products taken all markets together. Assuming price setting behavior, each airline f solves

$$\max_{p_{j \in \mathcal{R}_f}} \pi_f = \sum_{t=1}^T \sum_{j \in \mathcal{J}_{ft}} (p_{jt} - c_{jt}) M_t s_{jt}(\mathbf{p}_t) - C_f \quad (2.8)$$

⁷The decomposition of the total conjectural variation adopted here is similar to Di Giacomo (2008) and Fershtman and Gandal (1998).

⁸For the supply side, I follow the exposition as in Nevo (2001) and BCS.

where c_{jt} is the constant marginal cost of production of product j in market t , C_f is the fixed cost of production and \mathbf{p}_t is the vector of prices of all products in market t . M_t is the size of market t so that $M_t s_{jt}(\mathbf{p}_t)$ is the quantity of product j in market t .⁹ Assuming a pure strategy Bertrand Nash equilibrium exists in prices, the first order condition for profit maximization for product j of firm f yields

$$\frac{\partial \pi_f}{\partial p_{jt}} = s_{jt}(\mathbf{p}_t) + \sum_{k \in \mathcal{J}_{ft}} (p_{kt} - c_{kt}) \frac{\partial s_{kt}(\mathbf{p}_t)}{\partial p_{jt}} = 0 \quad (2.9)$$

The J first order conditions can be summarized as follows

$$\mathbf{p} - \mathbf{c} = \mathbf{\Delta}(\mathbf{p})^{-1} \mathbf{s}(\mathbf{p}) \quad (2.10)$$

where \mathbf{p} , \mathbf{c} and \mathbf{s} are vectors of prices, marginal costs and market shares of the J products respectively and $\mathbf{\Delta}$ is a $J \times J$ matrix with jk^{th} element equal to $-\partial s_{kt}(\mathbf{p}_t)/\partial p_{jt}$ if products j and k belong to the same airline and the same market t and zero otherwise.

To calculate the counterfactual prices we follow the techniques outlined in merger simulation exercise in Nevo (2000). First we estimate the demand side using the full sample i.e. inclusive of the LCCs. Using the estimates of the demand side we recover the marginal costs of network carriers from equation 2.10 i.e.

$$\mathbf{c} = \mathbf{p}^{\text{WithLCC}} - \mathbf{\Delta}(\mathbf{p}^{\text{WithLCC}})^{-1} \mathbf{s}(\mathbf{p}^{\text{WithLCC}}) \quad (2.11)$$

where \mathbf{c} represents the marginal cost series for network carriers, $\mathbf{p}^{\text{WithLCC}}$ is the price in the presence of LCCs and $\mathbf{p}^{\text{WithLCC}}$, $\mathbf{\Delta}$ and \mathbf{s} are for set of products belonging to only network carriers. Thus using the demand side estimates and the recovered marginal costs \mathbf{c} , we solve for the new equilibrium prices for the network carriers as would have existed in the absence

⁹Demand for a product in market t only depends on prices in market t and not on prices in other markets. This is a reasonable assumption in the airline case that potential travellers in a city pair market are not affected by price changes in other city pair markets and hence across-market cross elasticities are zero. This is the assumption maintained in the literature as well on the supply side.

of LCCs.

$$\mathbf{p}^{\text{NoLCC}} = \mathbf{c} + \mathbf{\Delta}(\mathbf{p}^{\text{NoLCC}})^{-1}\mathbf{s}(\mathbf{p}^{\text{NoLCC}}) \quad (2.12)$$

where \mathbf{c} , $\mathbf{p}^{\text{NoLCC}}$, $\mathbf{\Delta}$ and \mathbf{s} are for set of products belonging to network carriers. One might argue that this marginal cost might not reflect the true marginal cost of the network carriers in the absence of LCCs if network carriers have become more efficient in their service delivery in the presence of LCCs. On the other hand based on our discussion regarding the restructuring of the airline industry we have noted that part of the efficiency achieved by network carriers is due to LCC competition while part of it is due to survive during bad economic times by mitigating some of the inherent efficiencies with their traditional business models. Since we cannot identify such marginal cost differences in the counterfactual exercise, the equilibrium price $\mathbf{p}^{\text{NoLCC}}$ that will exist in the absence of LCCs should be taken as a lower bound of the actual resulting price.

2.4 Demand estimation and identification

Normalizing the mean utility of the outside good to zero we invert the market shares following Berry (1994) to get

$$\ln(s_{jt}) - \ln(s_{0t}) = x_{jt}\beta - \alpha p_{jt} + \sigma \ln(\bar{s}_{j/gt}) + \xi_{jt} \quad (2.13)$$

where s_{0t} is the share of the outside good in market t . The observable exogenous product characteristics contained in x_{jt} that are assumed to affect demand for airtravel relative to the outside good are *Stops*, *AirlinePresenceOrigin*, *AirlinePresenceDest*, *Departures* and *Slots*. *Stops* is the number of times the passenger has to change planes in the entire roundtrip itinerary. *AirlinePresenceOrigin* and *AirlinePresenceDest* are variables capturing the extent of the airline's presence in origin and destination airports respectively which are measured by the number of cities connected by the airline from an endpoint airport using direct

flights. These variables capture the ‘hubness’¹⁰ of the airline at the endpoint airports of the market and thus capture airport facilities and different loyalty programs associated with the airline. *Departures* is the total number of departures performed by the airline from the origin airport during the quarter and is intended to capture the frequency of flights outbound. In constructing this variable we consider the total number of departures for the first outbound segment of the itinerary during the quarter. This variable can somewhat capture the frequency of flights at the originating airport for the itinerary and reflect the convenience of the consumer to find a desired schedule of flights accordingly.¹¹ *Slots* is a dummy variable if the airline passes through a slot controlled airport. FAA imposed slot controls in Washington National (DCA), Chicago O’Hare (ORD), and New York’s La Guardia (LGA) and Kennedy (JFK) airports in order to reduce traffic by limiting number of takeoffs and landings per hour. These airports might result in delay problems due to congestion and thus might be avoided by passengers. *Price* is the fare paid by each passenger for the product. For *Price* we consider the median fare from the distribution of fares weighted by the number of passengers paying each fare. This takes into account the fact that the airline is unlikely to put equal weightage on all fares made available to consumers.

The linear equation 2.13 can be estimated with our market level data. In order to control for the unobserved product characteristics ξ_{jt} , we introduce product fixed effects in the form of airline dummies ξ_j capturing product characteristics that do not vary across markets within an airline. The product characteristics captured by ξ_j may include, among others, quality of in-flight service offered by each airline. Thus the unobserved product characteristics can be written as

$$\xi_{jt} = \xi_j + \Delta\xi_{jt} \quad (2.14)$$

where $\Delta\xi_{jt}$ represents the remaining unobserved product valuations that vary across products

¹⁰This term is due to Borenstein (1992).

¹¹Number of departures are collected from Department of Transportation T100 Segment data which reports departures for every nonstop origin-destination segments flown by the operating carrier. The departures for codeshare regional carriers are aggregated with their respective alliance ticketing carriers.

and markets. Both ξ_j and $\Delta\xi_{jt}$ to some extent can help to account for unobservable factors like ticket restrictions and service quality. To control for the fact that appeal of the outside option can be different for different markets originating from the same city, we use controls for vacation oriented markets. *Vacation* is a dummy variable which takes a value of 1 for tourist oriented destinations.¹²

In equation 2.13, *Price* and within group shares will be endogenous and thus the error term $\Delta\xi_{jt}$ will be correlated with prices and within group shares. This is because, although unobserved to the econometrician, both airlines and passengers are believed to be aware of any relevant demand factor while making decisions. In that case ordinary least squares will produce biased estimates. In order to identify our model in presence of endogeneity we adopt the instrumental variable technique following Berry, Levinsohn and Pakes (1995), Brenkers and Verboven (2005), Nevo (2000), Gayle (2006) and Brown and Gayle (2010). These instrumental variables should be correlated with the endogenous variables but uncorrelated with the unobserved error to enable consistent estimation. Formally one needs to find the vector of instruments Z for which $E[\Delta\xi_{jt}|Z] = 0$ holds. One obvious candidate for instruments are variables that affect cost but not demand. In these lines we consider the distance covered by the airline in the entire roundtrip travel which will affect the marginal cost of the product. Our second set of instruments exploits the extent of competitiveness in the market environment. Because of strategic interdependence among firms, it is expected that price and within group share of a firm will depend on the extent of competition with competitors' products and closeness of competitors' products in the product space. Based on this argument the firm will price more competitively the large the number of competitor products in the market. Accordingly we consider the following instruments to measure competitiveness in the market - total number of products offered by the competitors to transport a passenger in the roundtrip market, total number of competitor products in the market with equivalent number of intermediate stops and the total number of firms present in the market. Finally

¹²New Orleans, Las Vegas, Florida and California are considered as tourist oriented destinations.

each airline is assumed to jointly maximize profits for all its products and thus price of a product will be correlated with the number of products offered by the firm in a market. We construct route level instruments for each product namely the total number of products and number of products with equivalent number of stops offered by the firm in the market. We also expect *Departures* to be endogenous. We instrument *Departures* by the number of distinct itineraries of the firm that includes the first outbound segment for which we calculate *Departures*. Finally all the exogenous variables that appear in the share equation 2.13 also qualify as a set of valid instruments since they are correlated with themselves but orthogonal to the error term $\Delta\xi_{jt}$.

2.5 Data

The main source of our data is the Airline Origin and Destination Survey (DB1B) which is a 10% sample of airline tickets from reporting carriers published by the Bureau of Transportation Statistics (BTS). The data is available at a quarterly frequency and provides information on flight itinerary, ticketing and operating carrier for each segment in the itinerary, itinerary fare, number of passengers travelling on that itinerary at a given fare and distance travelled on each segment. This paper uses DB1B data from first quarter of 2004. For the first quarter of 2004 DB1B reports 2.3 million tickets with 6.6 million segment records. Following the literature we apply several filters to construct our working sample. We also use T100 Segment data to construct *AirlinePresenceOrigin*, *AirlinePresenceDest* and *Departures* variables.

2.5.1 Construction of sample

As mentioned before, a market is defined as a directional city pair. This raises the possibility of thousands of markets that need to be considered. Following Berry (1990), BCS, Berry and Jia (2008), Aguirregabiria and Ho (2009) and other empirical studies on airlines, we

select markets constituting of city or MSA pairs based on population. For the purpose of this paper we restrict ourselves to those U.S. cities or city groups¹³ which lie in MSAs with a population of at least 800,000 which form the origins and destinations of the markets considered in this paper.¹⁴ Since we are interested in competition between network carriers and LCCs we restrict the dataset to only include markets where both LCCs and network carriers operate. Following BCS, we assume the potential size of a market equal to the geometric mean of the population of the origin and destination cities.

DB1B reports information regarding the ticketing and operating carriers for each segment of an itinerary. There can be instances where the ticketing and operating carriers differ. Such an arrangement is called a codeshare where a ticketing carrier markets seats on a partner operating carrier's flight for some or all parts of the itinerary. Such codeshare can exist in the form of a major operating carrier offering service to another major ticketing carrier¹⁵ or a regional operating carrier flying on behalf of a major ticketing carrier.¹⁶ In the latter case the regional carrier can be a wholly owned subsidiary of the major (for example, American Eagle owned by American Airlines) or the regional carrier can subcontract with the major carrier and fly on the major's behalf (for example, Mesaba offering service to Northwest Airlines). Since in all these forms of codeshare arrangements the ticketing carrier is solely responsible for setting the final price of the roundtrip ticket, our analysis considers the ticketing carrier as the firm responsible for offering the product in question.¹⁷ Further we drop itineraries where the marketing carrier differs across different segments of the itinerary since such cases are extremely rare in practice.¹⁸ A list of network carriers and LCCs considered in this paper are presented in Table 2.1.

¹³In some cases an airport serves to more than one city in the same metropolitan area. We rely on Department of Transportation's T100 Segment data to get a list of all airports and the respective cities or city groups that they serve.

¹⁴City population figures are obtained from Population Estimates for Incorporated Places and Minor Civil Divisions published by the U.S. Census Bureau.

¹⁵Gayle (2006) and Ito and Lee (2005).

¹⁶Forbes and Lederman (2009).

¹⁷Similar carrier assignments are adopted in Berry and Jia (2008) and Ciliberto and Williams (2007).

¹⁸Armantier and Richard (2005).

Table 2.1: List of carriers in the sample by type

Network Carriers	
Carrier Name	Carrier Code
American	AA
Alaska	AS
Continental	CO
Delta	DL
Northwest	NW
United	UA
US Airways	US
Midwest	YX
LCCs	
Carrier Name	Carrier Code
JetBlue	B6
Frontier	F9
AirTran	FL
Allegiant	G4
America West	HP
Spirit	NK
Sun Country	SY
ATA	TZ
Southwest	WN

In selecting tickets we drop observations where the operating or the ticketing carrier is a foreign airline. Following BCS, Berry and Jia (2008), Aguirregabiria and Ho (2009) we consider only round-trip itineraries. Further we consider tickets with up to a maximum of five coupons.¹⁹ This helps us to eliminate some ‘circular’ (e.g. BOS-LAX-SFO-SFO-BOS) itineraries and helps in identification of correct round-trip itineraries. We also drop round-trip tickets with fare credibility questions by Department of Transportation and those below \$50 and higher than \$5,000.²⁰ In order to make the estimation and counterfactual simulation

¹⁹A coupon is similar to a boarding pass which identifies the point where a passenger changes an airplane.

²⁰We follow Baik, Trani, Hinze, Swingle, Ashiabor and Sheshadri (2008) to filter out extremely high and low fares.

manageable we aggregate the dataset at the level of unique ticketing carrier and itinerary. Thus total quantity corresponds to total number of passengers in DB1B who purchased a specific itinerary from a specific ticketing carrier. It should be noted that we do not use fare class information as reported by DOT in ticket classification. Also we do not classify tickets as being restricted or unrestricted. Both fare class and ticket restriction information published by DOT is not recommended by Bureau of Transportation Statistics for analysis purpose. As an example, for the first quarter of 2004 (our sample period) all Southwest tickets in DB1B data are coded as first class tickets whereas Southwest do not offer any first class service. In order to avoid any erroneous conclusions we fail to include fare class and ticket restriction information in our analysis. Rather we use the median fare instead of an average fare from the fare distribution to utilize some information regarding the distribution of prices available from the DB1B database.

Our final dataset contains a total of 59,557 products, 1978 directional markets, 17 airlines and 59 airports each appearing in the 52 origin and destination cities.

2.5.2 Summary of Data

Our dataset contains 49528 products offered by network carriers while the remaining 10029 being offered by LCCs. Table 2.2 shows the summary of the entire sample.

Table 2.3 is of particular interest which presents some of the summary statistics separately for network carriers and LCCs. First we notice that the sample average of the median fare charged by network carriers is higher than the LCCs. Also the deviation between fare levels is higher for network carriers. This captures the different levels of services and ticket restrictions placed by network carriers on different products in different markets. We also find that network carriers typically offer tickets with more average number of intermediate stops than LCCs. Still the considerable number of stop flights in case of LCCs depicts the fact that on one hand they mix network types, while on the other hand, as they keep

Table 2.2: Summary Statistics for the dataset

Variable	Mean	Std.Dev.	Min	Max
Price (\$100)	3.80	2.56	0.50	45.18
Stops	1.87	0.62	0	3
AirlinePresenceOrigin (100 cities)	0.25	0.31	0	1.44
AirlinePresenceDest (100 cities)	0.27	0.33	0	1.44
Departure (00s)	4.85	3.25	0	26.22
Slots (0/1)	0.33	0.47	0	1
Vacation (0/1)	0.37	0.48	0	1
$\ln(s_j) - \ln(s_0)$	-12.37	1.65	-15.55	-4.36
$\ln(s_{j/g})$	-5.42	1.99	-10.14	-0.001
No. of Observations: 59557				

growing and expanding their coverage, connecting itineraries will be a byproduct of such an expansion.

The presence of an airline in the endpoint airports of a market is much higher for the network carriers than the LCCs. This brings out the fact that network carriers base their operations majorly on hub and spoke networks. Some LCCs like America West maintains hubs at Phoenix and Las Vegas while some LCCs like Southwest has recently mixed its network patterns by developing ‘quasi-hubs’. But still these hubsizes are much smaller compared to the traditional hubs of network carriers. In fact network carriers enjoy dominant positions in some of these hubs which are sometimes referred to as ‘fortress hubs’ e.g. Delta in Atlanta, Northwest in Detroit. Table B.1.1 in the appendix presents the largest hub airports for each of the 17 airlines in the sample. It is evident that most of the major network carriers like American, Continental, Delta, Northwest, United and US Airways have significantly dominated hub airports compared to the LCCs. Among the LCCs only America West, Southwest and Airtran have some of the largest hub or ‘quasi-hub’ presence but nowhere comparable to the major network carriers. Table 2.3 also shows that LCCs typically tend to avoid congested slot controlled airports.²¹ This enables LCCs to operate efficiently on quick

²¹Southwest in its 2004 Annual Report states “...we prefer to avoid congested hub airports if there are

Table 2.3: Summary Statistics for the dataset by type of carriers

Network Carriers				
Variable	Mean	Std.Dev.	Min	Max
Price (\$100)	3.93	2.74	0.50	45.18
Stops	1.90	0.59	0	3
AirlinePresenceOrigin (100 cities)	0.27	0.33	0	1.44
AirlinePresenceDest (100 cities)	0.29	0.35	0	1.44
Departure (00s)	5.02	3.24	0	26.22
Slots (0/1)	0.38	0.49	0	1
Vacation (0/1)	0.37	0.48	0	1
No. of Observations: 49528				
LCCs				
Variable	Mean	Std.Dev.	Min	Max
Price (\$100)	3.19	1.11	0.50	12.38
Stops	1.72	0.72	0	3
AirlinePresenceOrigin (100 cities)	0.15	0.15	0.01	0.74
AirlinePresenceDest (100 cities)	0.16	0.16	0.01	0.74
Departure (00s)	4.02	3.12	0	24.34
Slots (0/1)	0.08	0.27	0	1
Vacation (0/1)	0.40	0.49	0	1
No. of Observations: 10029				

turns by avoiding delays and also reduces their cost of slot related fees. Finally it can be seen that LCCs fly to more vacation or tourist oriented destinations than network carriers. This is no wonder since serving leisure travellers has been the modus operandi of LCCs especially Southwest Airlines.

better alternatives.”

2.6 Results

2.6.1 Demand estimates

The demand estimation results are presented in Table 2.4. Both OLS and 2SLS results are reported. The negative coefficient on *Price* implies that higher prices result in disutility of the consumer. The significantly smaller value of the *Price* coefficient in the OLS specification as compared to the 2SLS shows the endogeneity of prices in the OLS regression.

Table 2.4: Demand Parameter Estimates from Nested Logit

Variable	OLS		2SLS	
	Est.	S.E.	Est.	S.E.
Price	- 0.058	0.001	- 0.356	0.010
$\ln(s_{j/g})$	0.635	0.002	0.401	0.005
Stops	- 0.535	0.006	- 0.600	0.012
AirlinePresenceOrigin	0.301	0.013	0.532	0.029
AirlinePresenceDest	0.350	0.012	0.362	0.020
Departure	0.030	0.001	0.073	0.003
Slots	- 0.058	0.009	- 0.335	0.013
Vacation	0.652	0.008	0.436	0.011
Constant	- 7.930	0.066	- 8.003	0.093
R-squared:	0.742		0.511	
Observations:	59557			

Notes: All estimations include airline dummy variables although the coefficient estimates of the dummy variables are not reported for brevity. All estimates are significant at 1% level.

The coefficient of $\ln(\bar{s}_{j/gt})$ is significant and lies between 0 and 1. This implies that consumer preferences who wish to fly are correlated and thus is consistent with utility maximization. Consumer's utility is expected to decrease the more the number of stops in the itinerary. The negative coefficient on *Stops* confirms this. The positive coefficients on *AirlinePresenceOrigin* and *AirlinePresenceDest* show the fact that consumers do prefer to fly with airlines who have larger scales of operation in the endpoint airports thus valuing airport facilities attached

with the airline. This also captures the attractiveness of loyalty programs like frequent flyer benefits that consumers take into account when choosing a particular airline from an airport. We also see that a higher frequency of flights, captured by the *Departures* variable, makes the service associated with an airline more attractive. The negative coefficient on *Slots* means that consumers avoid congested airports. Finally the *Vacation* dummy shows that vacation oriented destinations attract more passengers and thus helps to fit the model better in presence of high traffic volume in these tourist places which cannot be captured with observed product characteristics. The significance of the non-price characteristics in the demand model suggests the importance of these characteristics in shaping passengers' choice of airlines products associated with these services. In fact we can derive the measures of willingness to pay for different product characteristics, in dollar amounts, by dividing the coefficient of the product characteristic by the price coefficient α . For example, expanding the airport presence of an airline in the origin airport (destination airport) by connecting to hundred cities would increase consumers' willingness to pay by \$1.49 (\$1.02).

The price elasticities implied by our nested logit specification are consistent with some of the existing empirical literature which have used more flexible demand specification incorporating heterogeneity in consumer preferences for product characteristics and price. Our model yields a median elasticity of 1.78 which is very close to the aggregate elasticity of 1.66 obtained by Berry and Jia (2008) for the airline industry in 2006.

2.6.2 Effect on equilibrium prices in absence of LCCs

As discussed in section 3.2, we simulate the counterfactual equilibrium prices for the products of network carriers in the absence of LCCs once we have the demand estimates in hand and we have recovered the marginal cost of the network carriers using the markup equation. For the nested logit model the markup equation 2.12 has a closed form as follows which we use to simulate the counterfactual prices. The derivation is shown in the appendix. The pricing

equation for product j belonging to firm f can be written as

$$p_j = c_j + \frac{1 - \sigma}{\alpha \left[1 - \sigma \sum_{k \in \mathcal{J}_{fg}} \bar{s}_{k|g} - (1 - \sigma) \sum_{k \in \mathcal{J}_{fg}} s_k \right]} \quad (2.15)$$

where $\bar{s}_{k|g} = \frac{e^{\delta_k/(1-\sigma)}}{D_g}$ and $s_k = \frac{e^{\delta_k/(1-\sigma)}}{[D_g^\sigma + D_g]}$, assuming that the mean utility of the outside good is equal to zero.

Since the shares in the markup term in equation 2.15 are themselves functions of the vector of counterfactual prices, the counterfactual prices are derived using non-linear system solving routine. We find that the network carriers will increase the median prices of their products by an estimated average of 2.52% with a standard deviation of 5.09. We find a modest increase in average price of the network carrier products in the absence of LCCs.²² This is not surprising given the time period of our analysis when consumers' price sensitivity had increased substantially following internal changes such as increased price transparency due to prevalence of internet booking channels and external events such as the economic downturn and 9/11 events. Also recent studies have documented the overall efficiency gains achieved by network carriers as a result of their restructuring efforts (Tsoukalas, Belobaba and Swelbar (2008)).

We find that the predicted price increase varies widely across products and across markets. The reason for such large variation of prices is due to the fact that we consider our analysis at the product level which include specific travel itineraries with distinct product features. Thus in order to gain some insight into the predicted price increase, we regress the predicted percentage price increase on product and market specific characteristics. The results of the regression are reported in Table B.1.2 in the appendix. The variable *Stops* has a negative sign implying that products with more number of stops will experience smaller predicted price increase. This follows from the fact that passengers dislike products with more number

²²Berry and Jia (2008) also find demand to be significantly more price sensitive in 2006 as compared to 1999.

of stops and hence firms will not find it profitable to increase prices significantly on such products. On the other hand we find that products associated with larger presence of the airline offering the product at the end point airports will fetch higher prices in the counterfactual scenario. This finding supports the fact that such products are desired by passengers because of their association with loyalty programs. Products with longer itinerary distance will have a negative impact on the predicted price increase since long distance flights are not favored by passengers (BCS(1996)). Itineraries with higher frequency of flights, captured by the *Departures* variable are desired by passengers and will see a higher price increase in the counterfactual scenario. The variable *Total Network Firms* represents the total number of network firms present in the market associated with the product. A larger number of network carriers in the market will imply greater competition even in the absence of LCCs and thus will restrict the counterfactual prices to increase substantially. On the other hand *Total LCC Firms* is the total number of LCCs present in the market which would imply greater competition. In the absence of these LCCs, network carriers will have a scope to increase prices by a greater magnitude. Finally *HHI* represents the Herfindahl-Hirschman Index which captures the level of concentration in the markets in the presence of LCCs. Products associated with more concentrated markets would experience a higher price increase following an intensification of the concentration level after LCCs exit.

2.6.3 Effect on consumer welfare in absence of LCCs

With the counterfactual equilibrium prices we can calculate the welfare change for each consumer in a market if LCCs exit. Normalizing the mean utility of the outside good to zero and given the fact that our nested logit specification has only two nests i.e. flying and the outside good, the welfare term in section 3.2 simplifies to

$$W(p_r) = \frac{1}{\alpha} \ln \left[1 + \left(\sum_{j \in \mathcal{J}_g} \exp \left(\frac{\delta_j(p_r)}{1 - \sigma} \right) \right)^{(1-\sigma)} \right] \quad (2.16)$$

Consumers in our nested logit specification are identical up to the unobservable logit error, v_{ijt} , which is assumed to be i.i.d. across individuals, markets and choices. As a result, each consumer has a probability of buying a particular good in a given market. Knowing this probability of purchase for each good, we can assign an amount of money that these consumers would be willing to give up to buy the goods at the new equilibrium prices. Since we assume consumers to have identical mean utilities we can derive the compensating variation measure for an average passenger in each market. Upon exit of LCCs in the counterfactual scenario, our findings of change in consumer surplus averaged across all markets in the sample are presented in Table 2.5.²³ It should be noted that in our counterfactual exercise we simulate the new market equilibrium holding the product offerings and product characteristic choices of the network carriers constant at the post LCC period. This might not necessarily be the case since network carriers might adjust their product characteristics and product offerings in the absence of LCCs. Such endogenous product related choices by the network carriers are beyond the scope of this current paper.

We find that consumers will experience a loss of total consumer surplus by 25.08% in the absence of LCCs. We further decompose this change in consumer welfare into the variety effect and the price effect. Most of the welfare loss (about 86%) to consumers in the absence of LCCs originates from reduced product variety implying that the biggest beneficiaries of LCC presence are those who are flying with LCCs.

Table 2.5: Consumers' Welfare Change upon LCC Exit (Average across sample markets)

Total Change in Consumer Surplus	Variety Effect	Price Effect
-25.08%	-21.61%	-3.47%

Although LCCs have been considered to provide lower quality products as opposed to the network carriers, still their low fare structure appears to be the major driving force for the welfare improvement in their presence due to the variety effect. Since our calculations are

²³Consumer surplus in the post LCC period serves as the benchmark in the counterfactual results reported here.

based on the median price from the fare distribution we would expect higher welfare estimates if we work with mean fares. This is because there is more price dispersion on the upper tail of the price distribution and more so for the network carriers.²⁴ The magnitude of the price effect is significantly smaller than the variety effect. This indicates higher price sensitivity of consumers during the sample period and the efficiency gains achieved by network carriers due to their restructuring efforts.

2.7 Conclusion

The main aim of this paper has been to estimate consumer demand for airtravel and use these demand estimates to compute changes in consumer welfare due to presence of LCCs in the market of network carriers. We have achieved this by performing a counterfactual experiment by simulating the new market equilibrium that would have prevailed if LCCs exit. Further we have also disaggregated the benefits from lower price charged by LCCs on passengers facing a choice between different airtravel products and also on the existing competitiveness in the airline market. Our results indicate that bulk of the benefits to consumers is due to the new variety of products offered by LCCs. The counterfactual price increase by network carriers in the absence of LCCs is found to be somewhat modest. Our findings reconfirm some of the recent trends in the airline industry when air travel demand has become more price sensitive and network carriers have attempted to restructure their business model in order to achieve higher productivity and thus become more efficient.

One of the major caveats of our study is that it is static in nature. In our counterfactual exercise we do not account for any adjustment in product characteristics and product offerings by network carriers that might occur following the exit of LCCs. Our study also does not account for efficiency gain of network carriers due to presence of LCCs which is

²⁴The average fares weighted by passengers are approximately \$410 and \$332 for network carriers and LCCs respectively.

being passed on to consumers. This will capture further improvements in consumer welfare due to such efficiency effects of LCC competition. Another interesting aspect would be to endogenize the change in the fare distribution in the counterfactual exercise. Also due to data limitations we do not explicitly account for product attributes such as classes of service (business, economy) and fare restrictions (advance purchase, refundability etc.). With availability of such detailed information consumer welfare studies can be fine tuned in the future. Lastly, an interesting extension of this study can be to model heterogeneity of passengers using a more flexible demand model in the spirit of BCS (1996), Berry and Jia (2008) and thus analyze how the presence of LCCs have differently affected the welfare of business and leisure travellers.

CHAPTER 3

Conduct in the U.S. Airline Industry: An Analysis of Hub-to-Hub Markets

3.1 Introduction

Since the deregulation of the U.S. airline industry in 1978, the market structure of the industry has immensely transformed and evolved over time. In this respect two most researched areas in the literature have been the formation of extensive hub and spoke networks by the legacy carriers following deregulation and the surge of entry by low cost carriers in the 1990's. The transformation of the market structure has brought with it a change in the competitive circumstances in the industry as well.

The proponents of deregulation, based on contestable market theory, predicted that the industry would converge to a competitive equilibrium following the years of deregulation. While deregulation resulted in real fares to decrease over the years, it did not result in the full blown competitive marketplace as envisioned by its creators. Development of extensive hub-and-spoke networks, introduction of customer loyalty programs such as frequent flyer programs, and development of computer reservation system (CRS) raised barriers to entry and thus limited competition. Dominance of legacy carriers in some of these hub airports resulted in higher market concentration and higher fares and thus the implications

of deregulation on market competitiveness were brought into question from time to time. Deregulation also resulted in entry of a new breed of carriers known as the low cost carriers (hereafter, LCCs) offering mostly low-cost, no-frills, point-to-point service. LCCs have attracted a lot of attention from both industry analysts and academics because of their importance in depressing existing airfares and thus disciplining the industry. LCCs have offered mostly point-to-point direct flights in dense short and medium haul markets. But over the years they have expanded their coverage to long-haul markets and also penetrated in some of the concentrated dominated network hub markets. Following the recession of 2000 and post 9/11 events, the network carriers have struggled to remain profitable while the LCCs have emerged as a stronger group in the marketplace. Borenstein (2005) and Borenstein and Rose (2007) find that hub premia enjoyed by legacy carriers have been declining in recent years. According to Borenstein (2005), the gap in average airfares across hub and nonhub airports has largely diminished by 2004.

The objective of this paper is to estimate a structural model of competitive behavior in the U.S. airline industry involving markets with endpoints which qualify as hubs of network carriers. Studies related to pricing in the airline industry and its implications for competition have been carried out, among others, by Morrison and Winston (1990, 1995, 2000), U.S. General Accounting Office (1991), Borenstein (1992). Relation between hub dominance and market power have been particularly addressed by Levine (1987), Borenstein (1989), Evans and Kessides (1993), U.S. Department of Transportation (2001^a) and Lee and Luengo-Prado (2005), to name a few. But only a handful of studies have explicitly estimated the nature of conduct that exists in airline markets in general and more specifically those involving hubs of legacy carriers. Brander and Zhang (1990) and Oum et. al (1993) estimate conjectural variation parameters for American and United Airlines using a sample of Chicago based duopoly routes during the 1980's, where Chicago is a major hub for both the airlines. In the same vein, Fischer and Kamerschen (2003) employ a conjectural variations framework to estimate conduct parameters and price-cost margins in selected airport-pair markets originating from

Atlanta between 1991 and 1996. The authors' choice of Atlanta based markets is justified by Delta having a dominant hub position in Atlanta. The most common competitive scenario considered in these studies is a symmetric duopoly. All these studies infer that airline competition can be explained, on average, by a traditional Cournot model.

Our present study adds to the empirical analysis of such market conduct in the U.S. airline industry in several ways. First of all, these existing studies have assumed airline products as homogeneous and thus ignored the presence of the widely accepted notion of product differentiation in the industry. Airline services have long been viewed as differentiated products (Berry (1990)). Demand models estimating consumer preferences for airtravel products have accounted for product attributes such as stop v/s nonstop flights, number of connections, airline's presence in endpoint airports etc. which significantly affect consumers' choice of airlines and related itineraries. Building on the discrete choice empirical literature in the airline industry,¹ we consider an oligopolistic framework in which airlines, offering differentiated products and facing asymmetric costs, maximize profit by setting prices. Product differentiation is also an important determinant of market power in that airlines develop a wide range of products to create their market niches. Market structure is identified by the conduct parameters, which capture the interaction of price setting behaviors among airlines. Instances of either fierce price wars (Busse 2002) or price coordination (Borenstein 2004) common in the airline industry also justify a price setting oligopoly framework rather than quantity setting behavior.²

In contrast to dupoly markets out of a single hub considered in the previous literature, we consider hub-to-hub markets where both market endpoints constitute a hub city of some network carrier. Borenstein (1989, 1992), among others, have already documented how hub airports provide hub carriers with a strategic advantage over their nonhub competitors by allowing them to capture essential airport facilities. But none of the previous studies have

¹See Berry, Carnall and Spiller (1996) (hereafter, BCS), Gayle (2006), Ciliberto and Williams (2007), Aguirregabiria and Ho (2009), Berry and Jia (2008) and Brown and Gayle (2010).

²Bilotkach (2005) also discusses why a price setting oligopoly might be appropriate for the airline industry.

looked into the nature of conduct in markets defined exclusively by hubs as a whole group. Our motivation in favor of such market selection is reinforced by the fact that the strategic effect of a hub airport on an airline's pricing decision can be strengthened by realization of reciprocal territorial interests that are created by the overlap of such hub markets. Gimeno (1999) observes that when airlines meet each other in their respective hub markets, they develop mutually recognized "spheres of influence" centered on their hub airports. Thus an airline refrains from initiating aggressive pricing actions in a competitor's hub market fearing similar retaliation of the competitor in their own hub markets. Although in this paper we do not explicitly model pricing decision linkages across markets, our market selection at least implicitly allows for the conduct parameter to capture any tacit-collusion enhancing effects that might be present due to such multimarket price coordination among airlines.

Finally the sample period of our study is first quarter of 2004 when the U.S. airline industry has undergone a paradigm shift following the recession of 2000 and terrorist attacks of 9/11. Increased fare transparency through the internet, enhanced price sensitivity of business passengers, heightened airport security processing time are some of the factors which are reshaping the landscape of today's airline industry. These factors have directly affected the way airlines compete today. On one hand LCCs have evolved as a viable travel option for all kinds of travellers including business travellers while legacy carriers have undergone major restructuring of their business model to become more efficient in order to survive in the dynamically changing marketplace. In this regard, our study will explore the strategic importance of network carrier hubs on airline market conduct simultaneously recognizing the overgrowing role played by LCCs in disciplining markets through intense competition. Our model set up will allow us to jointly estimate two conduct parameters in hub-to-hub markets - one in markets where LCCs directly compete head-to-head with legacy carriers and the other for markets which LCCs do not serve but has presence in the hub airports or adjacent airports comprising the market endpoints. Thus this paper also sheds some light on the role of actual vs. potential competitive effect of LCCs on market conduct, a topic which

has been the cornerstone of previous studies like Dresner, Lin and Windle (1996), Morrison (2001) and Goolsbee and Syverson (2008).

The rest of the paper is organized as follows. In the next section we present a brief anecdote of the growth of hub-and-spoke networks following the deregulation of the airline industry and how hubs have played a crucial role in shaping the strategic behavior of legacy carriers. In Section 3 we discuss the expansion of LCCs and associated changes in the industry competitiveness in recent years. In Section 4 we outline the structural model of airline demand, supply and finally incorporate competitive interactions to enable estimation of conduct parameters. In Section 5 we overview the data and depict the estimation procedure with a focus on identification issues. Results are presented in Section 6. Section 7 concludes the paper.

3.2 Deregulation and Development of Hub-and-Spoke Networks

On October 24, 1978, the U.S. airline industry was deregulated to enhance competition among air carriers and to open the industry to new entrant competition. The main principle supporting the deregulation was contestability theory which argued that an airline can enter a new market quickly with low sunk costs and thus potential competition would be sufficient to discipline firms which will force them to keep prices at competitive levels. In the words of Alfred Kahn, Chairman of the Civil Aeronautics Board (CAB):

“A realistic threat of entry (by new and existing carriers) on the initiative of management alone is the essential element of competition. Without it, market regulation is ineffective. It is only this threat that makes it possible to leave to management a wider measure of discretion over pricing: The threat of entry will

hold excessive price increase in check.”³

Following deregulation, many airlines quickly responded to the new opportunities thus resulting in proliferation of new entrants and rapid expansion of some of the incumbents. One of the most significant but unanticipated result of deregulation came in the form of legacy carriers' network transformation from simple point-to-point to complex hub-and-spoke system. Starting with its hub in Dallas/Fort Worth, American Airlines became the vanguard in adopting a hub-and-spoke type of network, a model that would fundamentally alter the economics of airline operations in the years to follow.

A hub is an airport where an airline concentrates most of its operations by connecting other cities in the network by non-stop flights through its hub. Hub-and-spoke networks have been recognized to generate both demand and cost side advantages (Berry (1990), BCS (1996), Caves et. al (1984), Ben-Yosef (2005)). On the demand side, by pooling passengers with different ultimate destinations a hub-and-spoke system naturally leads to load consolidation. Such load consolidation increases flight frequency allowing for more flight options for passengers flying to and from the hub airport. Further the enhanced connectivity resulting from such a network enables anyone to go from anywhere to everywhere. In order to support coordination of activities resulting from banks of incoming and outgoing flights several times a day in a hub airport, a hub airline typically gains exclusive access to essential airport facilities such as gates, ticket counters, baggage check-in rooms etc. which increases convenience of consumers traveling with the hub airline. The cost side advantages from operating a hub system stems from economies of density and scale enjoyed by the hub carrier with more densely traveled spokes having lower marginal costs. Since passengers with different ultimate destinations can be carried on a single aircraft flying to and out of a hub airport, this allows the hub airline to efficiently serve even small cities with low demand. Due to the network structure of a hub system, several new markets can be created by adding a new node while the cost of additional spokes gets averaged over many other spokes. Finally,

³As quoted in Ben-Yosef (2005).

load consolidation due to a hub-and-spoke system can enable the hub airline to serve the same number of markets with fewer flights due to cost efficiencies arising from the use of larger, cost-effective aircrafts flying to or out of a hub airport on densely traveled spokes.

In addition to demand and cost advantages, another important outcome of the adoption of a hub-and-spoke network stems from the strategic advantage that a hub airline enjoys from its large scale presence in the hub airport. Given the fact that most airports are logistically and economically constrained to support large scale operations of many carriers simultaneously, the hub airports have naturally become dominant areas for one or, occasionally two airlines (Evans and Kessides (1993)). This has resulted in significant market power for the hub airline allowing it to charge supracompetitive prices for flights to and from hub airports, known as the “hub premium”. Several studies like U.S. General Accounting Office (1991), U.S. Department of Transportation (2001^a) have consistently reported higher average fares at the hub airports as compared to the non-hub airports, with the latter referring to hubs as “pockets of pain”. Such hub dominance have further been reinforced by the hub airlines through sophisticated marketing practices to build consumer and travel agent loyalty (Borenstein (1989, 1991)). Pioneered by American Airlines in 1980 and subsequently adopted by others, frequent flyer programs (FFPs) and travel agent commission override programs (TACOs) have been the two most novel innovations following deregulation with an objective to build a loyal customer base. Although FFPs and TACOs are practices commonly used by all airlines, they create a strategic advantage for an airline with hub status in an airport. This is because travelers living around a hub airport can earn rewards faster and redeem them for future travel to more destinations by flying with the hub airline which flies significantly more cities from that airport than any other airline. TACOs create a similar stimulus for the travel agents since the commissions from booking with an airline are based on volume incentives which is positively affected by the large market share enjoyed by the dominant airline at its hub airport.⁴ Thus both exclusive access to essential airport facilities and marketing devices

⁴A survey conducted by the U.S. General Accounting Office (1990) reports about 50% of travel agents receiving TACOs.

have created significant barriers to entry thus insulating dominant carriers from competition in their respective hub airports.

Banerjee and Summers (1987) contended that switching costs arising from loyalty programs can in fact lower the cross-elasticity of demand between products of hub vis-à-vis non-hub carriers thus reducing the incentive of aggressive price cutting and facilitating market segmentation and tacit collusion. A related anticompetitive concern has been raised due to the nature of information dissemination through computer reservation systems (CRSs) used by airlines and travel agents. Borenstein (2004) documents the Airline Tariff Publishing Case (ATPCO) of 1992 when eight legacy carriers were accused of price coordination by announcing future fare changes using fare codes and footnote designators through CRSs. The U.S. Department of Justice (DOJ) also pointed out that such information sharing would have been most beneficial in routes where carriers had strong reciprocal relationships i.e. multiple carriers' overlapping markets characterized by presence of each others' hubs. The idea is based on the fact that since an airline has more to lose in its hub airport in the event of a price war, carriers will refrain from undercutting one another when they meet each other in their respective hub markets. Evans and Kessides (1994) also voice their concern regarding how hubs can become important vantage points for airlines giving rise to development of spheres of influence centered in hub airports, thus enhancing tacit collusion while such concern has been empirically corroborated by Gimeno (1999).

The contestability theory which fueled the deregulation of the airline industry lost much of its flair by the late 1980's. Although fares have declined following deregulation, the overwhelming success of hub-and-spoke networks has resulted in substantial increase in market concentration, particularly on hub routes from the late 1980's through the late 1990's (Borenstein and Rose (2007)). Studies like Morrison and Winston (1987), Borenstein (1991) have found the impact of potential competition to be limited especially in cases of airports dominated by one or two carriers. At the same time the development of hub-and-spoke systems has made location-specific fixed sunk costs extremely significant in the overall cost structure

and has created barriers to entry thus further lending skepticism to the contestability theory (Ben-Yosef (2005)). This has given rise to the widespread viewpoint that the airline industry is better explained by models of oligopolistic behavior rather than by contestability theory, with hubbing as a dominant strategy of rent seeking behavior (Oum et al. (1995)).

3.3 Expansion of LCCs and Changing Face of Industry Competition

LCCs started offering service even before deregulation with Southwest Airlines which flew only intrastate routes between Dallas and Houston in 1971 being the pioneer of the low cost business model . Although deregulation encouraged entry of many new LCCs such as People Express, PSA during the late 1970s and early 1980s, these new interstate entrants were short lived. By the late 1980s the industry experienced extensive consolidation and the LCC business model came to be synonymous mostly with only a single carrier, Southwest accounting for 7% of U.S. domestic passengers in 1990. Expansion by Southwest continued with a share of 9.6% of domestic traffic by the end of 1992.⁵ Beginning 1993, following the footsteps of Southwest, a new generation of well planned and well financed LCCs started setting up large scale operations, the most successful ones being Frontier, JetBlue, America West and ValueJet (renamed AirTran after 1998).

The LCC business model has been primarily based on efficiency and cost saving principles. In terms of network characteristics, LCCs have differentiated themselves from legacy carriers by offering mostly direct point-to-point flights leading to faster turn around times and thus efficient utilization of airline resources and personnel. Since load consolidation is not possible with a point-to-point network, LCCs have traditionally followed the strategy to serve mostly dense short and medium haul markets. In order to avoid expensive airport fees, LCCs have

⁵Ito and Lee (2003^a).

also typically chosen to fly from secondary airports of big cities e.g. Midway in Chicago instead of O'Hare International Airport. But over time LCCs have expanded and penetrated into markets of all distances coupled with their conspicuous presence in even some of the major network carrier hub airports e.g. AirTran in Hartsfield Jackson International Airport, Atlanta. Some LCCs like AirTran, Frontier, America West and Southwest have also moved from purely point-to-point to 'quasi-hub' operations, thus mixing nonstop, onestop and connecting itineraries to provide different alternatives to passengers.⁶

Several attempts have been made in the literature to assess the magnitude of the impact of LCC entry on average airfares with a focus on Southwest Airlines. The unprecedented success of Southwest in disciplining airline markets by reducing fares has often been cited as the 'Southwest Effect' (U.S. Department of Transportation (1993)). Dresner and Windle (1999) provide evidence that such competitive effect can be extended to LCCs other than Southwest. They demonstrate fare reduction by Delta on its routes terminating and flowing through its established hub airport in Atlanta due to entry by ValuJet (renamed Airtran). Some studies have also made an attempt to specifically investigate the role that LCCs might play to dampen the high fares eminent in hub airports. Along these lines a study by Morrison (1998) finds that average fares at 11 concentrated hub airports in 1996 are 21% higher than average fares at 64 of the other largest U.S. airports, but 7% lower when the comparison group excludes airports served by Southwest. Such evidence has been further corroborated by the U.S. Department of Transportation (2001) which reports that in 1999, passengers in dominated hub markets were paying on an average 41% higher than those in similar markets with LCC competition. According to this study, contrary to popular research on hub premium, it is the lack of effective LCC competition (not only limited to Southwest) rather than rationales of passenger mix, operational cost and quality of service that explains the higher average fare in hub markets. Ito and Lee (2003^b) consider effect of LCC entry on 370 hub markets of network carriers between 1991 and 2002. They find network carriers to

⁶Levine (2002-2003), Ito and Lee (2003^a).

reduce fares by 15% on average due to entry by LCCs.

One strand of literature has further studied LCC impact on airfares by measuring the effect of potential competition from LCCs, as distinct from its actual presence in a market. Using data for top 1000 routes during second quarter of 1995, Richards (1996) finds that the mere presence of Southwest at one of the endpoints of a route has a dampening effect on yields. Similar results are reported by Goolsbee and Syverson (2008) who examine the response of incumbents on fares in routes not served by Southwest but threatened by probability of a future entry when Southwest establishes its presence in both endpoint airports of the route. Between 1993 and 2004 the authors find that incumbents have lowered fares substantially around events when Southwest began or even announced to serve the second endpoint of a route. Morrison (2001) has expanded the scope of such studies by further considering the price effect of LCCs that spills over in competing markets through presence of a LCC in a nearby adjacent airport. Specifically they consider three variants of competition that can emerge from presence of Southwest in an airport - first when Southwest competes head on with a carrier in the route itself; second when Southwest serves a route adjacent to the route in question which are viewed as substitutes by some passengers; and third when Southwest doesn't serve a route but by its presence at the endpoint airports threatens to enter the route in the future. They find that almost half of the fare savings that have accrued to passengers comes from adjacent and potential competitive effects of Southwest presence. An earlier study by Dresner, Lin and Windle (1996) reports similar results from adjacent competition. In fact such overwhelming impact of LCCs on overall competition has spurred interest in the contestable market debate once again in the U.S. airline industry (Ito and Lee (2003^a)).

In spite of the competitive challenges brought about by the advent and expansion of LCCs, many studies report that network carriers have overall been fairly accommodating in response to entry by LCCs into their routes (Ito and Lee (2003^b); U.S. Department of Transportation (1996)).⁷ The feasibility of such coexistence of two distinct business models has been made

⁷The price cutting response of incumbent legacy carriers prior to and following LCC entry has raised

possible by different factors. The low fares offered by LCCs have attracted an influx of new passengers and this increased load factor has indirectly benefited the legacy carriers as well. While the LCCs traditionally appealed mostly to price sensitive leisure travelers, the network carriers managed to earn their share of profits by charging the high-yield convenience oriented business travellers fares close to their maximum willingness to pay using highly sophisticated differential pricing system. Extensive loyalty programs such as FFPs and TACOs lended additional support to sustain such strategy of the legacy carriers. Legacy carrier profits reached its peak during the mid to late 1990s aided by a strong economy which boosted business travel demand brought about by the so called dot-com boom of the 1990s. The U.S. airline industry as a whole reported record operating profits of nearly \$45.4 billion during the latter half of 1990s.⁸ The fate of the industry was about to change, albeit unexpectedly, in the next decade.

Following the burst of the dotcom bubble in 2000, the economy entered into a phase of recession by 2001. The economic downturn depressed overall travel demand and soaring unemployment resulted in legacy carriers losing some of their best customers i.e. business passengers. The terrorist attacks of 9/11 further exacerbated the impact of the economic recession. Increased security requirements and resulting travel delays especially in congested hub airports dampened business air travel demand. Travel inconvenience along with business travel budget cutbacks led business travelers to look for alternatives to paying premium air fares, such as teleconferencing or other modes of economical travel options. In order to cut losses, the network carriers were forced to reduce capacity. On the contrary, the LCCs responded to the new market opportunities and expanded as they became a viable travel option for the price sensitive business travelers.⁹ By 2002, LCCs successfully infiltrated

some concern of unfair predatory conduct. Between March 1993 and May 1999, DOT received 18 complaints from new entrant LCCs alleging to be victims of exclusionary conduct by the legacy incumbents in their hubs (Transportation Research Board Report (1999)). Based on the credibility and severity of these complaints the DOT examined a total of 12 cases. Although the DOT acknowledged that the incumbent airlines had both the opportunity and the motive to engage in unfair conduct, the result of the review was inconclusive.

⁸Oster and Strong (2006).

⁹U.S. General Accounting Office (2004^b).

almost every major hub city and collectively accounted for nearly 25% of all U.S. domestic origin and destination passengers.¹⁰ In an attempt to cut costs, most major airlines began to shift ticket distribution channels from traditional travel agents to their own websites or internet based travel agents (Belobaba et al. (2009)).¹¹ The complete fare transparency brought about by the online booking channels and the appeal of the simplified fare structure offered by LCCs limited the ability of legacy carriers to charge supra-competitive fares. In addition to reduction of fares across all fare levels, the network carriers were forced to simplify their fare structures by incorporating fewer fare levels, reduced restrictions and less price dispersion between highest and lowest fares. Borenstein (2005) finds that overall airfares, adjusted for inflation, decreased by more than 20% between 1995 and 2004, with hub premiums accounting for a 12% decline in the 10 most expensive airports in the nation. Considering the 50 busiest airports, he further reports that the standard deviation of the fare premium across airports has fallen from 23% to 12% during these years, thus indicating a converging trend of fares towards the national average.

Following the industry crisis, legacy carriers, on the brighter side, have taken the opportunity to restructure and redefine their business model in an attempt to overcome their difficulties and emerge as a stronger and more competitive group in the marketplace. By 2003 virtually every major network carrier entered into Chapter 11 bankruptcy protection or was on the verge of bankruptcy. The legacy carriers took serious attempts to reduce costs by downsizing, cutting operating costs and improve overall productivity. Attempts have also been made to dehub the least efficient hub networks and changing high frequency connecting banks of flights to rolling banks,¹² thus lowering congestion and delay costs in hubs and increase aircraft utilization rates (Belobaba et al. (2009)). As the legacy carriers emerge with a slimmer cost structure and higher productivity in the new decade, this holds important

¹⁰Ito and Lee (2003^b).

¹¹Traditional TACOs were discontinued in 2001-2002 as airlines started paying fixed per ticket booking fees to the travel service agents (Bilotkach and Pejcinovska (2009)).

¹²American Airlines debanked its hub in Dallas/Ft. Worth between 2001 and 2003, by evenly spreading high-frequency flight schedules throughout the day. U.S. Airways dismantled its hub status altogether in Pittsburg later during 2004.

implications for hub-to-hub market conduct in the presence of both actual and potential competition from the LCCs.

3.4 The Model

We first discuss the structural specification of the demand model for airline products. Then we lay out the supply side and subsequently specify the marginal cost of production. Finally we augment the supply side in order to incorporate competitive interactions among airlines in equilibrium.

3.4.1 Demand Specification

A market is defined as a directional city-pair consisting of an origin city and a destination city. This allows the characteristics of origin and destination cities to affect demand. Further the market definition based on city pairs instead of airport pairs turns out to be an important aspect for this current study. This is because sometimes some LCCs typically avoid the congested hub airports and choose smaller secondary airports to serve markets based on these important hub cities e.g. instead of Dallas/Fort Worth International Airport (DFW) which is a hub airport for American Airlines, Southwest chooses the much smaller airport Dallas Love Field (DAL) to fly markets comprising of Dallas/Ft. Worth as an endpoint city. On the demand side this allows for substitution of airports and airlines by passengers while on the supply side this enables an airline to potentially compete with a major hub airline without even physically serving the hub airport itself. Within each market a product is defined as a round-trip between the origin and the destination cities involving a unique combination of a ticketing carrier and flight itinerary. An itinerary consists of an origin, destination and intermediate airports that the passenger travels through. An example of three products in the Chicago-Washington D.C. market are (i) a non-stop

ticket with itinerary ORD-DCA:DCA-ORD marketed by American Airlines, (ii) a two-stop itinerary MDW-CVG-DCA:DCA-CVG-MDW marketed by Delta Airlines and (iii) a non-stop itinerary ORD-IAD:IAD-ORD marketed by United Airlines.¹³

In the spirit of BCS (1996), Berry and Jia (2008) and Brown and Gayle (2010), we model airtravel demand using a discrete choice framework. In particular, we assume that a potential passenger n in market t chooses between $J_t + 1$ alternatives where $j = 0$ is the outside good representing the passenger's option of not buying any of the J_t products. The outside option also represents alternative modes of transportation that the consumer might choose to travel between the origin and destination. Then the products in each market can be broadly partitioned into two mutually exclusive and exhaustive groups, $g \in \{0, 1\}$, where the outside option is the only member of group 0. Following this specification, consumer n 's indirect utility from product j in market t can be represented as

$$u_{njt} = \delta_{jt} + \varsigma_{ngt} + (1 - \sigma)\epsilon_{njt} \quad (3.1)$$

where δ_{jt} is the mean valuation of product j across passengers in market t . The term ς_{ngt} captures the random component of utility that is common to all products in group g while ϵ_{njt} is a consumer and product specific idiosyncratic error term, the sum of which thus represents the deviation of an individual passenger's utility around the mean product valuation. The parameter σ lies between 0 and 1 and captures the correlation in consumers' utility among products belonging to the same group. Higher values of σ imply that the consumer views products in different nests, here flying or not flying, as poor substitutes. The mean utility δ_{jt} from product j is expressed as a function of price and non-price characteristics of the product as follows

$$\delta_{jt} = x_{jt}\beta - \alpha p_{jt} + \xi_j + \Delta\xi_{jt} \quad (3.2)$$

¹³It should be noted that we do not further differentiate products of identical itinerary-airline combination but having different prices to avoid estimation problems that will arise with extremely small product market shares.

where x_{jt} is a vector of observed product characteristics (number of stops in the itinerary, the airline's scale of operation in the origin and destination airports), β is a vector of marginal utilities of the different characteristics included in x_{jt} , p_{jt} is the ticket price and α measures marginal disutility of price. ξ_j are airline fixed effects controlling for carrier specific product characteristics which are common across markets while $\Delta\xi_{jt}$ accounts for any remaining product characteristics which are unobserved by the researcher and takes on a value that sets observed market shares equal to those predicted by the model. This differentiated product assumption is vital since the goal of the model is to analyze competition between carriers in hub-to-hub markets. Berry (1990) and BCS (1996) show that passengers value the size of a hub carrier's network and this superior product quality explains much of the hub premium, the premium a carrier is able to charge on itineraries originating or terminating at its hub airport.

Assuming both ϵ_{njt} and $\varsigma_{ng} + (1 - \sigma)\epsilon_{njt}$ are type I extreme value random variables, the respective product market shares can be transformed following Berry (1994) to yield the following linear estimation equation

$$\ln(s_{jt}) - \ln(s_{0t}) = x_{jt}\beta - \alpha p_{jt} + \sigma \ln(\bar{s}_{j/gt}) + \xi_j + \Delta\xi_{jt} \quad (3.3)$$

where s_{jt} represents product j 's market share, s_{0t} , the share of the outside good, and $\bar{s}_{j/gt}$ the group share of product j . The demand for product j in market t is given by

$$q_{jt}(\mathbf{x}_t, \mathbf{p}_t, \Delta\xi_t; \theta_d) = M_t s_{jt}(\mathbf{x}_t, \mathbf{p}_t, \Delta\xi_t; \theta_d) \quad (3.4)$$

where \mathbf{x}_t and \mathbf{p}_t are respectively the vectors of observed non-price product characteristics and price, $\Delta\xi_t$ is a vector of unobserved product characteristics, M_t the market size and $\theta_d = (\beta, \alpha, \sigma)$ is the vector of demand parameters to be estimated.

3.4.2 Supply and Marginal Cost Specification

There are F multiproduct firms in T markets. In each market t a firm f sells a subset J_{ft} of the total set of J_t products sold in market t . Assuming price-setting behavior, the variable profit of firm f in a market is given by¹⁴

$$\pi_f = \sum_{i \in J_f \cap V_g} (p_i - c_i) Ms_i(\mathbf{x}, \mathbf{p}, \Delta\xi; \theta_d) \quad (3.5)$$

where c_i is the marginal cost of product i , which is assumed to be constant with respect to the quantity sold and V_g is the set of products in nest g . We do not have data for marginal cost, so they need to be estimated in order to make identification of the conduct parameters possible. We specify marginal cost of product j using the following functional form¹⁵

$$c_j = W_j\gamma + \eta_j + \omega_j \quad (3.6)$$

where W_j is a vector of observed variables that shift cost (number of stops in the itinerary, itinerary distance and hub status of origin and destination airports), η_j are product fixed effects (airline dummies) capturing market invariant components of airline's products' marginal cost, ω_j is a random error term capturing unobserved (to the researcher) idiosyncratic factors affecting costs and γ is a vector of unknown cost parameters to be estimated.

3.4.3 Competitive Interactions

In the spirit of Sudhir (2001) and Verboven (1996), the degree of competition or market conduct is measured by the extent to which equilibrium prices deviate from Bertrand-Nash

¹⁴We drop the market subscript t in order to avoid notational clutter. But it is to be noted that all subsequent equations are to be treated as if they are indexed by t .

¹⁵I follow the linear marginal cost specification in the spirit of Aguirregabiria and Ho (2009) and Berry and Jia (2008).

prices. We implement this by augmenting the profit function in equation 3.5 as follows

$$\pi_f = \sum_{i \in \mathcal{J}_f \cap V_g} (p_i - c_i) M s_i + \phi_k \sum_{i \notin \mathcal{J}_f \cap V_g} (p_i - c_i) M s_i \quad (3.7)$$

where ϕ_k is the weight that an airline puts on its competitors' profits. A similar exposition is also presented in Bresnahan (1987). This specification has the convenient property of nesting both Bertrand and collusive outcomes as special cases when ϕ_k takes values of zero and one respectively. At the same time, $\phi_k > 0$ will imply more cooperative behavior relative to Bertrand as the firm puts positive weights on its competitors' profits whereas $\phi_k < 0$ will imply more aggressive behavior relative to Bertrand. Since we are interested in exploring conduct in the presence and absence of LCCs in the market, we allow the conduct parameter to capture different weights in these different scenarios by indexing it with k . Thus k refers to two market groups namely markets with LCCs and markets without LCCs.¹⁶ Assuming a pure strategy Nash equilibrium exists at strictly positive prices, we can express the first-order profit maximizing conditions as

$$\frac{\partial \pi_f}{\partial p_j} = s_j + \sum_{i \in \mathcal{J}_f \cap V_g} (p_i - c_i) \frac{\partial s_i}{\partial p_j} + \phi_k \sum_{i \notin \mathcal{J}_f \cap V_g} (p_i - c_i) \frac{\partial s_i}{\partial p_j} = 0, \forall j \in \mathcal{J}_f \cap V_g \quad (3.8)$$

If there are a total of J products taken all markets together, then we have J first order conditions which can be summarized in vector form as follows

$$\mathbf{p} = \mathbf{c} + \underbrace{\left[\mathbf{\Delta}(\mathbf{p}) * \left(\mathbf{\Theta}^{own} + \sum_k \mathbf{\Psi}_k^{comp} \right) \right]^{-1}}_{Markup} \mathbf{s}(\mathbf{p}) \quad (3.9)$$

where $\mathbf{\Delta}(\mathbf{p})$ is a $J \times J$ matrix of first-order derivatives of product market shares with respect to prices, $*$ implies Hadamard (element-by-element) product of two matrices, $\mathbf{\Theta}^{own}$ and $\mathbf{\Psi}_k^{comp}$

¹⁶It is further possible to allow for different firms placing different weights on other firms' profits, or different groups of firms engaging in different forms of conduct. We do not explore these situations and thus present an estimate of average market conduct.

are $J \times J$ ownership matrices defined as

$$\Theta^{own}(i, j) = \begin{cases} 1 & \text{if } i \text{ and } j \text{ belong to the same airline} \\ 0 & \text{otherwise} \end{cases}$$

and

$$\Psi_k^{comp}(i, j) = \begin{cases} \phi_k & \text{if } i \text{ and } j \text{ are distinct products offered by different} \\ & \text{airlines and belong to same market group } k \\ 0 & \text{otherwise} \end{cases}$$

It should be noted that existence and uniqueness of pricing equilibrium have been established for the logit model of demand for single product firms by Caplin and Nalebuff (1991). Mizuno (2003) extends these results to a wider class of models including the nested logit. On the other hand none of these studies prove the existence of an equilibrium in case of multiproduct firms. Recently Konovalov and Sandor (2010) consider the multiproduct setting and establish that first order conditions of profit maximization have a solution that is a unique Nash equilibrium of the game. But their result is limited to a simpler class of discrete choice models like the simple logit. Andersen and dePalma (1992) suggest that the existence results probably do extend to nested logit models of demand with multiproduct firms. We follow the approach taken in the literature (Goldberg, 1995; Verboven, 1996) in assuming that a pure strategy Nash equilibrium exists and proceed below to derive the pricing equation.

For the nested logit model, the supply side pricing equation has a closed form which can be brought into data for estimation.¹⁷ The pricing equation for product j belonging to firm f in a market is given by

¹⁷Verboven (1996) presents the pricing equation for a multi-level nested logit while an earlier version of Sudhir (2001) derives the closed form pricing equation for a simple logit. I extend the derivation to a one-level nested logit adopted in this paper. I would like to thank K. Sudhir for providing me an earlier version of his 2001 paper which helped me to derive the estimation equation.

$$p_j = c_j + \frac{1}{\alpha \left[\frac{1}{1-\sigma} - L_g \left(\sum_{i \in \mathcal{J}_f \cap V_g} q_i + \phi_k \left(1 - (1-\phi_k)(1-\sigma)L_g \sum_{i \in \mathcal{J}_f \cap V_g} q_i \right) Y_g \right) \right]} \quad (3.10)$$

where $L_g = \frac{1}{M} + \frac{\sigma}{(1-\sigma)Q_g}$ and $Y_g = \sum_{\substack{c \in \mathcal{F} \\ c \neq f}} \left(\frac{Q_c}{1 - (1-\phi_k)(1-\sigma)L_g Q_c} \right)$ such that Q_g and

Q_c are the sums of quantities of all products in nest g and products belonging to firm c in nest g respectively. The derivation of the pricing equation is shown in the appendix. Substituting equation 2.6 in equation 2.10 yields the following estimable equation

$$\omega_j = p_j - \frac{1}{\alpha \left[\frac{1}{1-\sigma} - L_g \left(\sum_{i \in \mathcal{J}_f \cap V_g} q_i + \phi_k \left(1 - (1-\phi_k)(1-\sigma)L_g \sum_{i \in \mathcal{J}_f \cap V_g} q_i \right) Y_g \right) \right]} - W_j \gamma - \eta_j \quad (3.11)$$

Specifically, $\theta_s = (\gamma, \phi_{LCCMkt}, \phi_{Non-LCCMkt})$ is the vector of parameters we estimate on the supply side where ϕ_{LCCMkt} and $\phi_{Non-LCCMkt}$ are the conduct parameters for markets with and without LCCs respectively.

3.5 Data and Estimation Procedure

3.5.1 Data

Data employed in this analysis is drawn from the DB1B market survey which is a quarterly 10% random sample of all itineraries published by the U.S. Department of Transportation. Three separate databases of DB1B namely DB1B-Coupon, DB1B-Market and DB1B-Ticket were used for this paper. DB1B-Coupon provides information at the coupon or boarding pass level, DB1B-Market reports one directional origin-destination itinerary specific data while DB1B-Ticket consists of summary information for the entire trip of the passenger. Altogether these datasets provide information, among other things, on operating and ticketing carriers,

origin and destination airports, sequence of intermediate airports, number of passengers transported, distance flown and fare paid. Data was collected for the first quarter of 2004 and the three databases were merged using the unique Itinerary ID common in all these datasets.

Since our paper is about competition in hub-to-hub markets, we confine the dataset to observations where origin and destination cities qualify as U.S. hub cities for the major network carriers.¹⁸ In case of stop flights, we consider only those itineraries which involve intermediate airports in the 48 U.S. contiguous states. We drop observations where either the operating or the ticketing carrier is a foreign airline. Following Berry and Jia (2008) and Gayle (2006), firm assignments are done according to the ticketing carrier. We use the fare screen in the DB1B data set to eliminate tickets with possible coding errors. We also drop itineraries with extremely high or low fares and those which cannot be correctly identified as round trips. We keep tickets with a maximum of five coupons. Finally we only consider tickets where the ticketing carrier is the same for the different segments of the itinerary. Our final set of ticketing carriers is presented in Table 3.1 where we group them according to their type i.e. legacy carrier or LCC. Table 3.2 provides a list of hubs of the legacy carriers. In the same table we also report the hub cities in which these hub airports are located and whose combinations make up the markets in our sample.¹⁹

After our initial filtering of the data, we still find similar airline-itinerary observations with

¹⁸For hubs in this paper, we use the U.S. Department of Transportation (2001^b) definition of commercial airline hub which is the integral part of the hub-and-spoke network developed following deregulation. This definition follows the same principle used by airlines to identify their hub airports. There is also a second definition of hub based on total passenger enplanements also known as air traffic hubs which are categorized into small, medium and large types. The latter is also sometimes referred to as physical hubs (Bhadra and Texter (2004)).

¹⁹In this paper we consider markets comprised of hubs of only airlines classified as major carriers by the U.S. Department of Transportation i.e. those with annual operating revenues of more than \$1 billion. Since Midwest Airlines does not fall under this category we do not explicitly consider hubs of Midwest, although we keep the carrier in our analysis. On the other hand, Alaska Airlines concentrates most of its business in Seattle, Portland, Los Angeles and Anchorage with 68% of its total in and outbound traffic being generated in Seattle (2004 Annual Report). Thus, inspite of being a major carrier, Alaska gets underrepresented in our sample which prevents us from using hubs of Alaska as part of our market consideration. For our paper we restrict ourselves to markets formed by hubs of the six largest major carriers following Lee and Luengo-Prado (2005).

Table 3.1: List of Legacy and Low Cost Carriers

Legacy Carriers	
Carrier Name	Carrier Code
American	AA
Alaska	AS
Continental	CO
Delta	DL
Northwest	NW
United	UA
US Airways	US
Midwest	YX
LCCs	
Carrier Name	Carrier Code
JetBlue	B6
Frontier	F9
Airtran	FL
America West	HP
Spirit	NK
Sun Country	SY
ATA	TZ
Southwest	WN

different fares. This reflects the commonly practiced yield management techniques by the airlines. Since we do not have information on such ticket specific restrictions and further to make estimation manageable, we collapse the data by aggregating passengers to the level of unique airline and itinerary combination. Thus our product is a unique combination of the origin airport, the intermediate connecting airports, the destination airport, the ticketing carrier and the passenger weighted average ticket *Price* for the airline-itinerary combination. Our final sample has 15,828 products offered across 372 directional hub-to-hub markets.

The variables which we construct to be included on the demand side in the vector of observed product characteristics are - *Stops* which is the total number of stops in the itinerary, and

Table 3.2: Hubs of Legacy Carriers (2004)

Airline	Hub City (State)	Hub Airport (Code)
AA	Dallas/Ft. Worth (TX)	Dallas/Ft. Worth Int'l (DFW)
	Chicago (IL)	O'Hare Int'l (ORD)
	Miami (FL)	Miami Int'l (MIA)
	St. Louis (MO)	Lambert-Louis Int'l (STL)
CO	New York/Newark (N.Y./N.J.)	Newark Liberty Int'l (EWR)
	Houston (TX)	George Bush Intercontinental (IAH)
	Cleveland (OH)	Cleveland-Hopkins Int'l (CLE)
DL	Atlanta (GA)	Hartsfield Jackson Int'l (ATL)
	Cincinnati (OH)	Cincinnati-N. Kentucky Int'l (CVG)
	Salt Lake City (UT)	Salt Lake City Int'l (SLC)
NW	Detroit (MI)	Detroit Metro (DTW)
	Minneapolis/St. Paul (MN)	Minneapolis/St.Paul Int'l (MSP)
	Memphis (TN)	Memphis Int'l (MEM)
UA	Chicago (IL)	O'Hare Int'l (ORD)
	Denver (CO)	Denver Int'l (DEN)
	San Francisco (CA)	San Francisco Int'l (SFO)
	Washington D.C. (DC)	Dulles Int'l (IAD)
	Los Angeles (CA)	Los Angeles Int'l (LAX)
US	Philadelphia (PA)	Philadelphia Int'l (PHL)
	Charlotte (NC)	Charlotte Douglas Int'l (CLT)
	Pittsburgh (PA)	Pittsburgh Int'l (PIT)

Source: Form 10-K and Annual Reports of the different airlines for 2004

AirlinePresenceOrigin and *AirlinePresenceDest*²⁰ based on the number of cities that a ticketing carriers connects to from the origin and destination airports respectively by non-stop

²⁰We use Department of Transportation's T100 Segment data to construct the variables *AirlinePresenceOrigin* and *AirlinePresenceDest*.

flights. Population figures from the U.S. Census Bureau is used to calculate the potential market size M which we assume to be the geometric mean of the population of the origin and destination cities that comprise the market. Variables which we include in the marginal cost specification other than *Stops* are - *ItinDistance* i.e. roundtrip distance traveled by the passenger and a *Hub* dummy capturing whether the origin or destination airport is a hub for the airline.

Summary statistics of our sample is presented in Table 3.3. We notice substantial heterogeneity in the airlines' scale of operation in origin and destination airports as well as in the hub variable thus showing the dominant positions held by some carriers in their hub airports. The firm market share also reveals some important information about the nature of hub-to-hub markets. The high standard deviation of this variable reveals the fact that some hub carriers manage to disproportionately attract more passengers departing from or arriving at their hub airports. In order to gain some insight regarding the exposure of hub network carriers to LCCs in their hub airports (or adjacent airports in case of multiairport cities), we take a look at Table B.2.1 in the appendix. It is evident from the table that LCCs have established their presence in all hub cities of network carriers with the exception of Cincinnati. This has been achieved through either directly offering service from the hub airport or in some cases adjacent airports in the same city. Table B.2.2 in the appendix further illustrates the extent of LCC penetration in hub-to-hub markets that originate from or terminate into different hub cities of network carriers. Both tables B.2.1 and B.2.2 clearly reveal the nature of actual and potential competition that network carriers face in their hub airports. Table B.2.3 presents the price per mile paid by travelers for flights at hub cities averaged across all hub-to-hub markets with the hub city as origin or destination of such markets. We further disaggregate these averages by the fares charged by the hub operator, non-hub legacy carriers and the LCCs respectively. The presence of a hub premium is clearly depicted by the higher than market average fare charged by the hub carrier in these cities. It is also notable that in majority of these cases the LCCs charge fares substantially lower

than the market averages in these cities.

Table 3.3: Summary Statistics

Variable	Mean	Std.Dev.	Min	Max
Price (\$100)	4.81	3.37	0.50	45.18
Stops	1.72	0.73	0	3
AirlinePresenceOrigin (100 cities)	0.44	0.41	0	1.44
AirlinePresenceDest (100 cities)	0.46	0.42	0	1.44
Vacation (0/1)	0.27	0.44	0	1
ItinDistance ('000 miles)	3.21	1.38	0.19	7.82
Hub (0/1)	0.59	0.49	0	1
Product market share (%)	$0.34e^{-2}$	0.02	$0.18e^{-4}$	0.53
Firm market share (%)	16.38	24.42	0.02	99.60
Market size (100K)	10.34	8.36	2.38	56.97
No. of Observations: 15,828				

3.5.2 Identification

On the demand side, equilibrium prices and market shares will depend on both observed and unobserved product characteristics. Thus although unobserved to the researcher, the contemporaneous demand shock $\Delta\xi_j$ will be observed by market participants. As a result price and within group market shares will be correlated with the error term and thus OLS estimates of both α and σ will be biased. To overcome this problem we use an instrumental variable technique to estimate the parameters of the model. The best candidates for instruments in the differentiated products case are the product characteristics themselves, which are usually treated to be exogenous, based on the assumption that in the short run they cannot be quickly adjusted by a firm. Our choice of the second set of instruments is based on the proposition by Berry, Levinsohn and Pakes (1995) (hereafter, BLP). They suggest functions of the exogenous characteristics of competitors can qualify as instruments since they affect the competitive environment in the market and thus pricing decision of the

firm while being uncorrelated with the carrier's demand shock. In this spirit we include the means and sums of rival carriers' origin and destination airport presences as well as number of competitors and total number of competitor products in the market with equivalent number of intermediate stops as instruments. Another identification strategy relies on variables that shift marginal cost but does not affect demand. Based on this argument itinerary distance qualifies as a valid candidate for the instrumental vector. Motivated by supply theory of multiproduct pricing, we include also total number of products with equivalent number of stops offered by the firm in the market as valid instruments. To enhance identification we also use dummies for vacation oriented destinations such as New Orleans, Las Vegas, Florida and California. Finally in addition to the exogenous product characteristics, all the exogenous variables appearing in the share equation are included in the instrument vector Z_d since they are correlated with themselves but uncorrelated with the error term $\Delta\xi_j$.

On the supply side in the pricing equation, the structural error term ω_j which captures the unobserved components of marginal cost is expected to be correlated with price. Moreover the markup term in the pricing equation is a function of shares which themselves are functions of prices. Hence the markup term is also likely to be endogenous. Our supply side instrument vector Z_s includes all the excluded instruments that we use on the demand side other than itinerary distance based on a similar logic. Additionally all exogeneous variables in the pricing equation also form a part of Z_s .

Based on equation 3.9, it can be seen that assessment of market power and hence choice of appropriate oligopoly pricing model fundamentally rests on the substitution patterns generated by the demand model under consideration. Our choice of a nested logit demand specification is supported by the fact that it generates flexible substitution patterns necessary for reliable estimation of the supply side. On the other hand, absence of publicly available marginal cost data imposes a further challenge in distinguishing between alternative models of oligopoly competition (Bresnahan (1982)). Specifically, an identification problem arises in discerning whether higher marginal costs or higher values of conduct parameter rationalize

higher observed prices. Based on the intuition of Bresnahan (1982), recent work by Berry and Haile (2010) show that changes in the “market environment” can be used to distinguish between competing models of oligopoly conduct based on changes in firms’ incentive to collude. We believe that our current distinction of hub-to-hub markets with and without LCCs provides such an opportunity to enable identification of conduct parameters on the supply side.

3.5.3 Estimation

Our estimation of both demand and supply side parameters rests on the critical assumption that the structural error terms are orthogonal to the vector of instruments i.e. $E[\Delta\xi_j|Z_d] = 0$ and $E[\omega_j|Z_s] = 0$. There is some efficiency gain if demand and supply are estimated jointly (BLP). But on the other hand a step-by-step estimation reduces the computational burden of the estimation. At the same time the demand side identification in such a procedure becomes independent of the specification of the supply side functional form. Lastly it also reduces the need for a vast set of instruments that is demanded in the joint estimation of the parameters of the system. This is because identification of the model parameters requires the rank of the instrumental variables matrix to be at least as large as the number of parameters to be estimated. Following Nevo (2001) and Goldberg and Verboven (2001), we first estimate the demand system and use the estimated demand parameters to construct the matrix $\mathbf{\Delta}(\mathbf{p})$ of own and cross price derivatives. Then we substitute this matrix into the pricing equation to estimate the supply side parameters subsequently.

Since the share equation is linear in parameters, the demand side is estimated using a two stage least squares (2SLS) procedure. On the other hand the supply parameters enter the pricing equation in a highly nonlinear fashion. As a result we use a nonlinear Generalized Method of Moments (GMM) procedure to estimate the pricing equation. We exploit the orthogonality condition of the error term ω_j to form moment conditions whereby the GMM

routine estimates the vector of parameters which sets the sample analogue of the covariance of the errors and the instruments as close as possible to zero. In particular, the GMM estimate is given by

$$\hat{\theta}_s = \underset{\theta_s}{\operatorname{argmin}} \omega(\theta_s)' Z_s \Omega^{-1} Z_s' \omega(\theta_s) \quad (3.12)$$

where Z_s is a $N \times L$ matrix of supply side instruments such that N is the sample size, L is the number of instruments and Ω^{-1} is a positive definite optimal weight matrix.

3.6 Results

3.6.1 Demand Estimates

Results from the demand estimation are shown in Table 3.4. The noticeable difference in the magnitude of OLS and 2SLS estimates of *Price* and $\ln(\bar{s}_{j/gt})$ illustrates the endogeneity of these variables. All coefficient estimates are statistically different from zero at 1% level of significance. As expected, *Price* has a negative impact on consumers' mean valuation of airline products. Estimate of σ lies between 0 and 1, implying that our model is consistent with the principles of random utility maximization. This indicates that airtravel products within a market are viewed as better substitutes than the outside option. The negative coefficient on *Stops* depicts the inherent inconvenience associated with itineraries with connecting flights. Both *AirlinePresenceOrigin* and *AirlinePresenceDest* affect consumers' utility positively thus indicating consumers' preference of flying with an airline having larger scales of operation at origin and destination airports. Such preference is likely to be based on convenient flight schedules, airport facilities and loyalty programs associated with the airline. Finally, the positive *Vacation* coefficient shows that tourist oriented cities attract more consumers.

Table 3.4: Demand Parameter Estimates

Variable	OLS		2SLS	
	Est.	S.E.	Est.	S.E.
Price	- 0.035	0.002	- 0.200	0.012
$\ln(s_j/g)$	0.774	0.003	0.614	0.007
Stops	- 0.245	0.009	- 0.354	0.015
AirlinePresenceOrigin	0.264	0.014	0.568	0.033
AirlinePresenceDest	0.098	0.014	0.168	0.023
Vacation	0.350	0.013	0.259	0.018
Constant	- 7.650	0.117	- 7.992	0.157
R-squared:	0.847		0.736	
Observations:	15,828			

Notes: All estimations include airline dummy variables although the coefficient estimates of the dummy variables are not reported for brevity. All estimates are significant at 1% level.

Our nested logit model yields a median elasticity of 1.91 which is slightly higher than found by earlier studies estimating random utility models of airline products like Berry and Jia (2008). Such a difference is likely to arise because Berry and Jia (2008) estimates a more flexible random coefficient model allowing for two types of passengers with different price sensitivities. On the other hand our current analysis is based on only a subset of markets namely hub-to-hub markets instead of a larger set of markets as considered in the other studies. However our elasticity value lies within the reasonable range of 0.181 to 2.01 as reported by a survey of airtravel demand elasticities conducted by Gillen et al. (2008).

3.6.2 Estimates of Marginal Cost and Conduct Parameters

We report our GMM estimates from the pricing equation in Table 3.5. All coefficients of our marginal cost specification have the expected signs and are significant at conventional levels of statistical significance. In fact the signs of our marginal cost parameters are in accord with earlier studies such as Berry and Jia (2008).

Table 3.5: GMM Estimates from Pricing Equation

Variable	Est.	S.E.
<i>Marginal Cost Shifters</i>		
Stops	0.367	0.041
ItinDistance	0.298	0.031
Hub	- 0.370 †	0.176
Constant	1.026	0.267
<i>Conduct Parameters</i>		
$\phi_{Non-LCCMkt}$	- 0.736	0.188
ϕ_{LCCMkt}	- 1.308	0.150
Observations: 15,828		

Notes: Estimation includes airline dummy variables. All estimates are significant at 1% level except † which indicates statistical significance at 5% level.

The positive coefficient on *Stops* implies that connecting flies are more expensive to operate than non-stop flights. Berry and Jia (2008) argues that there are two countervailing factors which affect the marginal cost of connecting flights. On one hand load consolidation by pooling passengers with different destinations through the connecting airport can lead to economies of density thus resulting in lower marginal costs. But on the other hand more connections imply more takeoffs and landings which can lead to higher costs due to increased fuel consumption. Our results indicate that the net effect of these two factors is positive which might be a consequence of higher fuel prices in recent years offsetting any efficiency gain from economies of traffic density resulting from connecting flights. The coefficient on the *Hub* dummy is negative indicating marginal cost is lower for airlines flying into and out of their hub airports. Thus inspite of presence of congestion and delays in hub airports, airlines seem to exploit economies of scale in these airports by flying larger fuel efficient aircrafts. Finally, as expected, longer routes have higher marginal costs.

Next we look at the estimated conduct parameters from the pricing equation which is the focus of our current paper. Both the competitive interaction parameters $\phi_{Non-LCCMkt}$ and

ϕ_{LCCMkt} are negative and statistically significant. This implies that competition is more aggressive than the Bertrand benchmark in hub-to-hub markets with and without LCC presence, with the degree of aggressiveness heightened in markets served by LCCs. Our results corroborate the critical role played by LCCs in disciplining airline markets in recent years, both in form of actual and potential competition. We further check whether the nature of such aggressive competition is uniform across all hub-to-hub markets i.e. formally we test whether $\phi_{Non-LCCMkt}$ is statistically equal to ϕ_{LCCMkt} .²¹ Our test results indicate that the two conduct parameters are not statistically equivalent to each other thus implying that extent of aggressive competition is softened in the absence of LCCs. This further lends support to the idea that potential competition by LCCs is not a substitute for actual competition.

3.7 Conclusion

This paper explicitly estimates conduct parameters in hub-to-hub airline markets i.e. markets characterized by presence of legacy carrier hub airports at both endpoints. In order to highlight the growing importance of LCCs in recent years, we further distinguish between conduct in markets with and without LCC service. In doing so this paper acknowledges the prevalence of product differentiation and price setting behavior in the airline industry by utilizing a structural econometric framework for differentiated products with competitive interactions. The empirical results indicate that the nature of competition is more aggressive relative to Bertrand behavior in hub-to-hub markets. The competitive intensity is also found to be higher in markets actually served by LCCs compared to those where LCCs are merely present in market endpoints and thus pose a threat of potential future entry. Given the sample period of our study, our results shed light on the strategic importance of hubs during

²¹We test the null hypothesis $H_0: \phi_{Non-LCCMkt} = \phi_{LCCMkt}$ against the alternative hypothesis $H_1: \phi_{Non-LCCMkt} > \phi_{LCCMkt}$. The z score calculated is found to be 2.527 which is higher than the critical z value at 1% level of significance, thus leading to the rejection of H_0 in favor of H_1 .

an era of changing landscape of airline competition and hold some important implications for the role of LCCs in disciplining the airline industry.

Deregulation of the airline industry has resulted in substantial consumer benefits but the extensive growth of legacy carrier hubs have raised the concern that industry competition is less than perfect. Development of fundamental industry practices such as complex pricing mechanisms, importance of CRS and loyalty inducing programs have been the backdrop of such anticompetitive concerns. Since 2000 legacy carriers have faced several challenges which have changed the way they operate. On one hand, internal changes such as unprecedented growth of LCCs and impact of technological change on price transparency and feasibility of alternatives to business travel while external events such as global recession and 9/11 terrorist attacks on the other, have increased overall price sensitivity of consumers. As legacy carriers have undertaken painstaking steps to become more efficient, our results indicate that the increased competitiveness in the industry may pave the path of convergence towards a long run competitive equilibrium. Although the results are comforting some caution is warranted. First, the airline industry is highly turbulent and cyclical in nature. Given the time period of our study, it can be argued that financially distressed firms discount future returns more heavily than short term returns and thus are likely to behave more aggressively. However some of the structural changes occurring in the industry seem to be permanent which will definitely inhibit the scope of carriers to engage in anticompetitive behavior in the upcoming future. Second, although LCCs have been suggested as an important driving force behind the enhanced competitiveness, our results implicate that LCC presence have not been fully successful in ensuring perfect contestability in the industry. Further as LCCs reach their expansion limits and start losing some of their cost advantage with aging fleet and personnel and escalating fuel prices, only time will tell whether LCCs can be considered as an antidote to legacy carrier market dominance. Finally, hubs not only equip carriers with strategic advantages but they also generate enormous benefits for the flying public. At the same time, operating the hub system might involve substantial costs which justify higher hub fares for

the hub airline needed to recoup such costs. Although our analysis do show persistence of higher hub fares charged by the hub airline, a formal investigation for such an observation is beyond the scope of our present paper. Future studies of hub premium should incorporate such cost side considerations in hub pricing models in order to shed some light on how hubs can continue to create value by operating efficiently at cost levels which justify the value premium.

This study can be extended in several ways. Firstly, we have computed average conduct parameters at the market level by assuming that the weights associated with profits of competitor firms are identical for all firms. Relaxing this assumption might unfold strategic carrier specific interactions and elucidate its implications for market conduct. Finally incorporating multifirm linkages such as code sharing agreements, multimarket contact in the conduct parameter can further unveil important strategic effects of competitive interactions.

CHAPTER 4

Conduct in the U.S. Automobile Industry: Evidence from the 2005 Employee Discount Promotions

4.1 Introduction

During the summer of 2005, the Big Three U.S. automakers namely General Motors (GM), Ford and Chrysler (formerly DaimlerChrysler AG) offered sales promotion that allowed every customer to purchase most of their vehicles at the discounted prices usually paid by these companies' employees. These employee discount pricing (EDP) promotions resulted in an unprecedented sales triumph for the Big Three with GM's June 2005 sales hitting a record high in the past 19 years. In the backdrop of these EDP promotional events, this paper explores the nature of market conduct that exists in the U.S. automobile industry with a specific focus on the Big Three. In contrast to previous literature on automobile competition, this paper also uses quarterly average dealer-level transaction price data to capture the short term nature of interfirm competitive interactions that might be embedded in such promotional programs.

The novelty of our study is two-fold. Earlier studies on conduct have typically used annual manufacturer's suggested retail price (MSRP) data to assess the nature of competition in the automobile industry. Given the recent surge of manufacturer financial incentives and

the changing structure of the automobile industry, accounting for such incentive programs is expected to hold important implications for market conduct. This is mainly because on one hand, the final price paid by the customer is frequently found to be significantly different than the MSRP (Crafton and Hoffer (1981)) and thus incorporating information on financial incentives will directly affect vehicle demand. On the other hand, manufacturer incentives will influence the net price they receive from the sale of their vehicles and thus directly affect manufacturer profits. In fact previous studies of automobile market conduct have voiced concerns regarding potential limitations of MSRP for such analysis.¹ The consideration of MSRP rather than transaction prices in these studies has been mainly driven by sparseness of publicly accessible data on price incentives. In this paper we use proprietary dealer level transaction price data² obtained from J.D. Power and Associates (JDPA).

A second aspect of our paper is the frequency of our data and thus its importance in revealing information regarding short term dynamics of firm conduct. Although MSRP's are usually quoted on a model year basis³, the incidence of pricing promotions vary frequently and thus significantly affect both vehicle demand and firms' profits within a certain year. Given the EDP promotions were the first of its kind to be offered in 2005, we also use the EDP promotional period to identify any change in conduct that might have occurred during these times between the Big Three who participated in the promotional event. In this respect our paper is in the spirit of Bresnahan (1987) who investigates whether a transitory change in industry conduct was responsible for the remarkable increase in auto sales in 1955 compared to adjacent years. Unlike Bresnahan (1987) our paper utilizes average quarterly transaction prices to model demand outlining a random utility framework with product differentiation. Bresnahan's supply side approach is to model conduct under two extreme behavioral hypotheses i.e Bertrand competition and collusion and test the goodness-of-fit against model-level price and quantity data from 1954-1956. Our supply side set up allows

¹See Sudhir (2001) and Boyle and Hogarty (1975).

²Financial support from the Department of Economics, Virginia Tech is gratefully acknowledged.

³A model year is the time period for which a specific vintage of a vehicle model is produced and sold. This is different from calendar year.

for a more flexible specification thus enabling the conduct parameter to take a wide range of values from aggressive pricing to perfect collusion.

Evidence of cooperative pricing among the Big Three has been documented by previous studies such as Boyle and Hogarty (1975) and Bresnahan (1987). While both these studies date back to the heydays of the Big Three, a recent study by Sudhir (2001) covering the 1981-1990 time period sketches a different picture of industry conduct. His empirical results, based on overall market conduct, indicates cooperative behavior only in the compact and midsize car segments. He justifies his findings on the basis of ability-motivation paradigm indicating importance of customer loyalty and market share volatility as major determinants of successful cooperation. In fact, anecdotal evidence does suggest a major transformation of the structure of the U.S. automobile industry over the years. Till 1979, the Big Three dominated the U.S. automobile industry accounting for nearly 80% of all consumer vehicles (Cooney and Yacobucci (2005)). The 1980's era marked the massive proliferation of imported cars from Japanese and European manufacturers, hitting a 40% mark of U.S. total car sales in the mid 80's. Although export limits negotiated between United States and Japan provided a temporary respite to the Big Three but since 2001 there has been a reversal to the trend. Cooney and Yacobucci (2005) point out that since 2000, the dominant market position of the Big Three has been seriously challenged by the foreign manufacturers, primarily from their production at transplant manufacturing operations in North America. Increasingly stringent fuel economy and emission standards and rising contributions to pension funds and retiree health care have only added to the worry of the Big Three. In the midst of these adversities, the Big Three have escalated the generosity of financial incentive programs to boost sales and defend market shares. The EDP promotions was a novel innovation in this regard.

In the next section we discuss the trends and evolution of the structure of the automobile industry since 1950's. In Section 3 we briefly describe the underlying nature of the EDP promotions. Section 4 presents a brief discussion on the nature of automobile pricing in order to elucidate the differences in prices paid by the consumer and that received by the

firm in the presence of price incentives and dealer intervention. In Section 5 we describe the data and set up the empirical model in Section 6. Section 7 outlines the estimation strategy and identification issues. We present our estimation results in Section 8. We finally conclude the paper in Section 9.

4.2 Trends and Competition in the U.S. automobile industry

In the post World War II period, the U.S. automobile industry emerged as a strong pillar behind the growth and prosperity of the U.S. economy (Cooney and Yacobucci (2005)). The wide range of vehicles produced by the Big Three to meet varied consumer tastes and the need for economies of scale for successful operation insulated the Big Three from major foreign competition. This led to high industry concentration, with Japanese and European imports claiming a small niche in the market place.

Previous studies have presented evidence to support the hypothesis that the Big Three had followed the strategy of cooperative pricing in order to maintain their dominant position. Incidents have also been reported suggesting retaliation by members of the Big Three to overcome any threats of breakdown of such an collusive arrangement. Boyle and Hogarty (1975) is one of the earlier studies to empirically corroborate such claims. Their findings establish the presence of implicit collusion among the Big Three between 1957-71. They also report a temporary collusion breakdown between 1958-59 following a price cut initiated by Chrysler. The authors claim that the Automotive Information Disclosure Act introduced in late 1958 ironically facilitated collusive agreements in the latter years by changing the pricing practices in the industry. Prior to the Act manufacturers were not compelled to publicly announce MSRP which enabled them to offer secret concessions to individual buyers. This made the detection of cheating difficult and threatened the stability of the cartel. The passage

of the Act enabled cartel members to promptly react to cheating activities by appropriate retaliation. One such incident reported was Chrysler's massive discounts on fleet sales in 1962 which was subsequently matched by GM and Ford to terminate such cheating activity. Along similar lines, Bresnahan (1987) also depicts the presence of tacit collusion among the Big Three in the 1950's with a brief breakdown in such coalition in 1955.

Although both the above studies refer to temporary breakdown of the collusive agreement among the Big Three during different times, they are particularly silent on the reason for such occurrences. To some extent, however, the concern of threat from foreign competition is echoed, although dismissed, in both the papers. However, as Cooney and Yacobucci (2005) correctly note that foreign imports had already started to make an impact in the U.S. market in the 1960's with sales of foreign cars accounting for a 26% market share in 1969. The 1980's period witnessed a surge of foreign imported cars with a striking 40% of total sales in mid '80s. Due to the oil crisis of 1979, gasoline prices increased radically which dramatically changed the U.S. consumers' relative demand for vehicles towards smaller fuel efficient cars, thus giving a competitive advantage to Japanese imports. To safeguard the Big Three from intense Japanese competition a negotiation between U.S. and Japanese governments established export limits on imported vehicles from Japan. An additional concern was also voiced by the Big Three regarding the appreciation of the U.S. dollar against the Japanese yen during the early half of 1980's. This issue was addressed when the dollar's exchange rate was reduced between 1985 and the mid 90's. In spite of all these remedies, it was clear that Japanese automakers had already begun to develop strong brand loyalty among U.S. customers. In fact Sudhir's (2001) study of the U.S. auto market spans over the 1981-90 time period and his empirical results reflect some of this increasing tension between the Big Three and the foreign manufacturers. Compelling with the evidence of Japanese success in the small car market, Sudhir (2001) finds aggressive pricing behavior in the minicompact and subcompact car segments.

Following export limitations in the 1980's Japanese producers adopted a new strategy start-

ing 1982 - building and operating manufacturing plants in North America (also called transplant facilities), thus further consolidating their competitive advantage in the U.S. marketplace. Since then the growth of foreign transplants have continued and resulted in an increase of their share in total U.S. vehicle production to more than 25% in 2004.⁴ In fact a careful look into the growth of real output in the automotile sector in recent years reflects the change in the relative positions of the Big Three and the foreign owned transplants. In the passenger car segment alone in 2003, 43% of all cars in the U.S. are reported to have been produced in foreign owned transplant facilities.⁵ Adding imports to the transplants, increases the share to a striking 55%. As a natural response to the growing threat by the foreign manufacturers, the Big Three have shifted their focus on manufacturing of light trucks by 2003. Although the Big Three jointly dominated the light truck segment, but the foreign manufacturers did not lag behind. In 2003, imports and transplants combined claimed a share of 25% of all U.S. light truck sales.

In an attempt to deal with shrinking market share since 2001, the Big Three have resorted to heavy use of price incentive programs. Although price incentives in the form of rebates and discounts have been common in the industry since 1950's, but these seem to have become more of a norm rather than an exception in recent years. The financial position of the Big Three have further been impaired by rising contributions to employee pension funds and retiree health care. As Cooney and Yacobucci (2005) point out, the prospects for the Big Three have looked rather gleam starting 2005 with both GM and Ford reporting reduced earnings in the first quarter. These events set the stage for the EDP promotions which we study in this paper.

⁴Cooney and Yacobucci (2005).

⁵For example Honda's plants in Ohio and Alabama, Toyota's plants in Kentucky.

4.3 The 2005 EDP Promotions

GM was the first among the Big Three to announce the EDP promotions in June 2005.⁶ Ford and Chrysler followed suite a month later with similar programs but with different names than that initiated by GM. Although GM's "Employee Discount for Everyone" was initially announced to last only for a month, GM extended the promotional period through August 1 and subsequently until September 30. Ford's "Ford Family Pricing" and Chrysler's "Employee Pricing Plus" rolled in the month of July. Although both Ford and Chrysler initially announced their programs to expire in August, but following GM both firms subsequently extended their programs till September. The discounts under these programs were offered on selected 2005 car and light truck models. Dealers selling vehicles under these promotional plans were not allowed to charge more than the prices announced under EDP promotions.⁷ Manufacturers compensated the dealers by the discount amount for accepting lower prices from customers.

The success of the EDP promotions was evident from the sales figures of the participating firms, with sales being most pronounced during the first month of the launch of the respective firm's discount programs. GM reported a 40% increase in its sales in June 2005 relative to the same month in 2004 while the comparable numbers for Chrysler and Ford were 30% and 35% respectively in July 2005.

4.4 A primer on automobile prices: A digression

The way market automobile prices are determined depends upon the complex interaction between auto manufacturers, dealers and buyers.⁸ Most car models are purchased at retail by the consumer from authorized car dealers who are franchised by respective manufacturers.

⁶Most of the factual information about the EDP promotions discussed in this section has been drawn from Busse, Simester and Zettelmeyer (2007).

⁷The EDP promotional prices were lower than the MSRPs.

⁸See Crafton and Hoffer (1981) and Goldberg (1996).

Dealers purchase cars from manufacturers at wholesale or invoice prices. Such invoice prices are independent of the dealer identity and number of units purchased since U.S. dealer franchise law mandates dealers and auto manufacturers to behave as independent firms. The Automotive Information Disclosure Act of 1958 requires new automobiles to carry a sticker displaying the MSRP. This price, also referred to as the list price, is just a suggested price and does not obligate the dealer to sell the vehicle at that price. The dealer is free to negotiate prices with individual customers. While dealer rebates will lower the negotiated price, on the other hand dealer installed accessories and other dealer costs will inflate the negotiated price. Both the MSRP and negotiated price takes into account transportation fee which is a part of the dealer's invoice. Since the dealer's advertising allowance adds to the cost of selling the vehicle, this gets indirectly reflected in the negotiated price. The dealer also charges for after-market options,⁹ taxes, title fees and other document preparation costs. Manufacturer rebates can primarily take two forms - direct manufacturer to customer rebates (i.e. either cash rebates or reduced rate financing options) and manufacturer to dealer rebates. The former rebate, usually advertised, is directly passed on to the customer in its entirety while the latter rebate might or might not be passed on to the customer.¹⁰

A customer can trade-in an old vehicle while buying a new one. Thus the negotiated price of the new vehicle will depend upon whether the dealer makes a profit or loss on the trade-in vehicle. If the dealer offers a trade-in amount more than the true value of the trade-in vehicle then the dealer will "bump up" the negotiated price to cover the trade-in overallowance. The opposite will happen when the dealer engages in a trade-in involving an underallowance.

Finally the dealer is expected to make a markup on every vehicle sold. The difference between the price paid by the customer net of dealer provided rebates and the invoice price will determine the dealer's markup. In cases where the manufacturer provides a rebate to the dealer the part of the rebate which is not passed onto the customer will get reflected in

⁹This includes options such as undercoating or waxing.

¹⁰Busse, Zettelmeyer and Silva-Risso (2004) present an excellent analysis on impact of manufacturer rebates on transaction prices in presence of informational assymetries.

the dealer's markup.

4.5 Data

In order to construct our sample with information on prices, sales and vehicle characteristics we combine data from two different sources. Since one of our primary concerns is to analyze the EDP promotional program, the sample period for our data ranges from third quarter of 2004 to second quarter of 2007.

The first dataset provides average dealer level transaction prices for different vehicle models (at the nameplate level) collected from a sample of vehicle dealerships. The data originates from a database called Power Information Network (PIN), generated by JDPA. PIN sample has a 70% coverage of contiguous United States within which it represents roughly one-third of the dealerships and 20% of all national retail transactions. The price data we obtained from JDPA is an extracted sample¹¹ from the PIN database averaged (weighted) at a quarterly level and is called Vehicle Price minus Customer Cash Rebate. In compiling this price data, JDPA attempts to precisely measure the true transaction price of the vehicle. Vehicle Price is the price that the customer pays at the time of sale contract and includes prices of both manufacturer and dealer installed accessories,¹² transportation fees but excludes taxes, title fees and other documentary preparation costs. JDPA notes that both dealer advertising allowance and net effect of manufacturer to dealer incentives indirectly get reflected in the Vehicle Price. As noted in the previous section that the contract price might get biased upwards or downwards depending on overallowance or underallowance in used vehicle trade-ins. To alleviate such possibilities, JDPA adjusts the trade-in allowance in the vehicle price. To derive the price data from Vehicle Price, JDPA finally subtracts any manufacturer to

¹¹Our dataset is a subsample from the PIN database and encompasses transactions involving some of the best selling models. Following Sudhir (2001), we do not consider models belonging to the luxury segment since this segment is expected to be thin with idiosyncratic demand.

¹²According to JDPA this only includes hard adds such as roof racks, tires etc. and not after market options such as fabric protectant, paint sealants etc.

customer cash rebate.

We merge the dataset on prices to information on U.S. sales and vehicle characteristics obtained from Ward’s Automotive Yearbook. Sales figures are available at monthly levels which are aggregated to quarterly frequency. Following Copeland, Dunn and Hall (2011), we link price for a specific model with characteristics of the base model under that model nameplate along with total sales for the nameplate. Vehicle attributes include: a measure of size given by the product of length and width; degree of power and acceleration given by horsepower (HP); and fuel efficiency given by miles per gallon. For fuel efficiency, data is available for both city and highway miles per gallon. We use the EPA weighted harmonic mean formulation to get an average measure of fuel efficiency: $MPG = \frac{1}{0.55/City\ MPG + 0.45/Highway\ MPG}$. Since fuel prices are expected to be an important determinant of vehicle choice on the demand side, we use a slight variant of the fuel efficiency variable by dividing dollar fuel price per gallon by MPG. We call this measure Dollar per Mile. Quarterly retail fuel prices are obtained from U.S. Department of Energy’s website. Finally all nominal variables are converted into 2004 third quarter constant prices using CPI data collected from the BLS website.

Table 4.1: Average Vehicle Attributes by Segment

Segment	Price	Size	HP	MPG	No. of Models	U.S. Sales
Small/Compact	17.31	118.60	144.32	28.83	34	19,744
Mid-size	22.92	132.30	188.38	24.54	42	20,531
Full-size	25.04	150.55	221.93	22.80	10	18,067
Crossover/SUV	24.05	138.01	211.70	20.42	47	19,129
Pickup	19.89	152.25	217.37	20.02	19	41,163
Minivan/Van	22.64	156.70	208.55	19.70	14	19,890
All Vehicles	21.86	136.52	193.01	23.22	27	22,088

Notes: Price is in 2004 third quarter ’000 constant dollars; size (length x width) is in ’00 sq. inches.

In Table 4.1 we present a summary snapshot of the dataset for the different segment classifications based on similarity of vehicle characteristics and marketing intent. Some general

features about the industry are apparent from the summary statistics. Small/compact, Mid-size and Crossover/SUVs are the three largest segments. The large number of models in the first two car segments are possibly because of the overwhelming role played by the Japanese manufacturers in these categories. The Big Three have recently shifted their focus to more SUV production to capture drivers with growing safety-related concerns. This changing consumer taste has also made some of the Japanese and European manufacturers making major inroads in this segment. The sheer size of the Crossover/SUVs class seems to capture this trend. As expected, the larger vehicles generate more horsepower and are usually less fuel efficient. In all, our final sample is a panel of 1976 observations consisting of vehicles belonging to 6 segments over a period of 12 quarters.

4.6 Empirical Framework

The empirical framework broadly consists of two components: specification of consumer demand and specification of firm supply incorporating the nature of competitive interactions. We describe each in the following subsections.

4.6.1 Demand Specification

Consider a market with N_t consumers in time t . Each consumer $i \in \{1, \dots, N_t\}$ makes the decision of purchasing one vehicle from the set of J_t alternatives or some outside good $j = 0$ in time t . Following McFadden (1973), the random utility obtained by consumer i from choosing product $j \in \{0, 1, \dots, J_t\}$ in period t is given by

$$u_{ijt} = x_{jt}\beta - \alpha p_{jt} + \xi_{jt} + \epsilon_{ijt} \quad (4.1)$$

where x_{jt} is a vector of observed product characteristics, p_{jt} is the price and ξ_{jt} represents product characteristics unobserved by the researcher such as style, image etc. The term

$x_{jt}\beta - \alpha p_{jt} + \xi_{jt} \equiv \delta_{jt}$ is the mean valuation of product j common to all consumers while ϵ_{ijt} represents the consumer specific deviation from the mean utility which is assumed to be distributed i.i.d. across consumers and alternatives. Further assuming that ϵ_{ijt} follows the type I extreme value distribution, demand takes the familiar multinomial logit specification¹³ where the market share of product j can be analytically expressed as

$$s_{jt}(\delta) = \frac{e^{\delta_{jt}}}{\sum_{j=0}^{J_t} e^{\delta_{jt}}} \quad (4.2)$$

Following Berry (1994), normalizing the mean utility from the outside good to zero and inverting the above share results in the following linear estimation equation

$$\ln(s_{jt}) - \ln(s_{0t}) = x_{jt}\beta - \alpha p_{jt} + \xi_{jt} \quad (4.3)$$

where s_{0t} is the share of the outside good in market t . On the demand side the variables that we include in the vector of observed product characteristics are *Size*, *HP* and *Dollar per Mile*. For the variable *Size* we use the geometric mean of vehicle length and width. For calculating the market share of a product, we divide the total sales of the product by the market size. In the spirit of Berry, Levinsohn and Pakes (1995) we use the total number of households representing the size of the market where each household is a potential buyer of a new vehicle. We calculate the approximate number of potential households each quarter by dividing the quarterly U.S. population figures (from U.S. Census Bureau website) by 4.

A natural question arises whether our transaction price data truly captures the actual price faced by the consumer choosing among the product alternatives. One objection might be that the price data from PIN corrects for trade-in allowances but does not explicitly include the

¹³Alternative demand model specification like nested logit was tried out. Defining the nests based on the vehicle segment classifications and assuming a uniform nesting parameter generated nesting parameter value almost close to 1. We investigated this issue further by allowing for nest specific correlation parameters. The nesting parameters for some segments turned out to be greater than 1 which violates the property of random utility maximization. This also implies that substitution across some segments is greater than substitution within the specific segments. Hence our choice of a multinomial logit seems to better fit the transaction price data we consider in this paper.

trade-in amount that the buyer received while purchasing a car. Goldberg (1996) estimated consumer demand for automobiles using data from Consumer Expenditure Survey which accounts for trade-in values by incorporating the wholesale blue book value of the used car in the second hand market. She reports that confining the data to only those households not involved in a trade-in did not alter her estimation results.

4.6.2 Marginal Cost Specification and Firm Behavior

We specify marginal cost of product j as a linear function of product characteristics as follows

$$c_j = W_j\gamma + \omega_j \quad (4.4)$$

where W_j is a vector of observed product characteristics that shift cost while ω_j captures the unobserved (to the researcher) idiosyncratic cost associated with product j . W_j includes *Size*, *HP* and *MPG*. We do not expect fuel cost to affect firms' cost of production and hence use *MPG* instead of *Dollar per Mile* as a measure of fuel efficiency for cars in the marginal cost equation.

In order to assess the nature of market conduct, we incorporate the conduct parameter capturing interfirm interactions into the firms' profit functions. Based on anecdotal evidence discussed earlier, we can expect only the Big Three to behave cooperatively while the other firms are assumed to compete *à la* Bertrand. Since we are also interested specifically in the EDP promotions, restricting the coalition set to the Big Three suffices that objective. Suppose \mathcal{C} is the set of firms that are in the cooperative set so that $\mathcal{C} = \{\text{GM, Chrysler, Ford}\}$. Thus the profit function of firm f is given by

$$\pi_f = \begin{cases} \sum_{i \in \mathcal{J}_f} (p_i - c_i) M s_i + \phi_k \sum_{i \notin \mathcal{J}_f \cap \mathcal{V}_C} (p_i - c_i) M s_i & \text{if } f \in \mathcal{C} \\ \sum_{i \in \mathcal{J}_f} (p_i - c_i) M s_i & \text{if } f \notin \mathcal{C} \end{cases} \quad (4.5)$$

where J_f is the set of products sold by firm f and V_C is the set of all products belonging to firms in the cooperative set. The term ϕ_k is the weighting factor associated with profits of other firms in the cooperative set and measures the degree of competitiveness relative to the Bertrand benchmark. Positive values of ϕ_k will imply more cooperative behavior while negative values imply aggressive behavior. It can be noted that when $\phi_k = 0$, the model reduces to Bertrand competition.

Based on recent results by Konovalov and Sandor (2010), a pure strategy Nash equilibrium exists at strictly positive prices for the multinomial logit. Hence we can derive the first order condition for profit maximization as follows

$$\frac{\partial \pi_f}{\partial p_j} = \begin{cases} s_j + \sum_{i \in J_f} (p_i - c_i) \frac{\partial s_i}{\partial p_j} + \phi_k \sum_{i \notin J_f \cap V_C} (p_i - c_i) \frac{\partial s_i}{\partial p_j} = 0 & \forall j \in J_f, \forall f \in \mathcal{C} \\ s_j + \sum_{i \in J_f} (p_i - c_i) \frac{\partial s_i}{\partial p_j} & \forall j \in J_f, \forall f \notin \mathcal{C} \end{cases} \quad (4.6)$$

For the multinomial logit, the first order conditions above can be solved to derive closed form pricing equation which we finally estimate on the supply side. Substituting the parametric form of the marginal cost specification given by equation 4.4 in the closed form pricing equations, we can express the estimable equations as follows

$$\omega_j = \begin{cases} p_j - \frac{1}{\alpha \left[1 - S_f - \phi_k (1 - (1 - \phi_k) S_f) \sum_{\substack{c \in \mathcal{C} \\ c \neq f}} \frac{S_c}{1 - (1 - \phi_k) S_c} \right]} - W_j \gamma & \forall j \in J_f, \forall f \in \mathcal{C} \\ p_j - \frac{1}{\alpha (1 - S_f)} - W_j \gamma & \forall j \in J_f, \forall f \notin \mathcal{C} \end{cases} \quad (4.7)$$

where S_r has the general form $S_r = \sum_{i \in J_r} s_i$. The pricing equation for the cooperative possibility has been derived in the appendix. We allow ϕ_k to vary between the EDP and the non-EDP promotional time periods to capture any change in the nature of conduct among

the Big Three around the EDP period.

It should be noted that on the supply side, wholesale rather than transaction prices would be a better candidate for the firm's profit maximizing problem. This is because transaction price data will have dealer markup information incorporated into it too.¹⁴ Given the paucity of public data on wholesale prices (Goldberg 1996) and explicit dealer markups, following Copeland, Dunn and Hall (2010) we integrate the dealership and the manufacturer into one decision maker thus making a unified pricing decision. Also since the EDP promotion did not directly lower the wholesale prices nor did it involve a direct manufacturer to customer rebate, only transaction prices will be able to capture such a manufacturer incentive.

4.7 Estimation Strategy and Identification

For estimation of the demand model, one of the main identification assumptions is that the exogenous product characteristics x_{jt} are uncorrelated with the error term ξ_{jt} . This is based on the idea that the product characteristics are predetermined and they cannot be quickly adjusted by the firm in the short run. On the other hand it is expected that the firm will take into account the unobserved product characteristics when setting product prices. Thus product prices will be endogenous and need to be instrumented. Our choice of optimal instruments is inspired by Berry, Levinsohn and Pakes (1995). Based on the idea of oligopolistic interdependence, they suggest using functions of own and competitor product characteristics as instruments. Bresnahan et. al (1997) further propose a refined set of these instruments based on the closeness of products in the characteristics space. So we calculate the functions of characteristics within vehicle groups or segments . Specifically we create the following (i) total number of other products a firm produces within a segment (ii) total number of competitor products within a segment (iii) sum of characteristics of other products

¹⁴See Bresnahan and Reiss (1985) for an exposition on the interdependence between the dealer and the manufacturer related to rent distribution in a successive monopoly framework.

of the same firm within a segment (iv) sum of characteristics of products of competing firms within a segment. We interact these with the respective segment dummies and use them as instruments.

A second set of instruments can be variables which shift cost but do not affect demand. Since *MPG* is the only characteristic that we use on the cost side which do not appear on the demand side, we use some functional form of these characteristics. Following Song (2010), we use supply side product characteristics interacted with the time dummy variables as instruments. This essentially captures the variability of production costs over time.

In the spirit of Brenkers and Verboven (2005) we also exploit the panel structure of the data to specify the error term ξ_{jt} as a two-way error components model such that $\xi_{jt} = \xi_j + \xi_t + v_{jt}$. The product fixed effects ξ_j ¹⁵ capture unobserved time invariant mean product valuations while the time fixed effects ξ_t capture preferences for vehicles relative to the outside good. The remaining error term v_{jt} captures mean product valuations which vary across products and time. We also use segment dummies as an additional control in the demand estimation. Finally, all exogenous variables in the estimation equation are also included in the instrument vector since they are perfectly correlated with themselves but uncorrelated with the error term. We employ a two stage least squares instrumental variable procedure to estimate the share equation.

On the supply side, we expect both price and markup in the pricing equation to be correlated with the error term ω_j . Based on our discussion above, the first set of instruments on the demand side are also valid for the supply side. We further use fuel price as an instrument on the supply side since fuel price was assumed to affect demand and not cost. Product fixed effects and segment dummies are also included on the supply side. Given the nature

¹⁵We use firm dummy variables to control for product fixed effects. It should be noted that there have been substantial changes in the nature of corporate ownerships of automobile companies globally in recent years. For example during the late 1980s and 1990s, GM has acquired Saab and Ford has acquired Volvo. For our analysis we follow Cooney and Yacobucci (2005) to assign products to respective firms based on corporate ownership. Accordingly our sample has the following 12 firms: GM, Chrysler, Ford, Honda, Hyundai, Isuzu, Mitsubishi, Nissan, Subaru, Suzuki, Toyota and VW.

Table 4.2: Summary Statistics for the dataset

Variable	Mean	Std.Dev.	Min	Max
Price (\$100)	21.86	5.83	11.00	43.41
Size	116.62	7.29	100.02	134.50
HP	193.01	50.68	103	390
Dollar per Mile	0.12	0.03	0.05	0.23
MPG	23.22	4.54	12.17	37.84
log(Production)	9.41	1.19	4.61	12.57
$\ln(s_j) - \ln(s_0)$	-8.64	1.19	-13.45	-5.48
No. of Observations: 1,976				

Notes: Price is in 2004 third quarter constant dollars; size is square root of (length x width) and is in inches.

of the industry, we expect production to exhibit economies of scale. Accordingly we add the variable $\log(\text{Production})$ in the marginal cost specification and proxy production with total domestic sales (Berry, Levinsohn and Pakes (1995)). In addition, the instrument vector includes all exogenous variables that appear in the pricing equation. Given the non linearity of our supply side estimation equation, we use the non linear GMM routine to estimate the pricing equation. Table 4.2 summarizes our dataset that we bring to the estimation routine.

4.8 Estimation Results

4.8.1 Demand Estimates

We present our demand estimation results in Table 4.3. All reported coefficient estimates are statistically different from zero at 1% level of significance. As expected, *Price* has a negative impact on consumers' mean valuation from purchase of a vehicle. The positive coefficient on *Size* implies that people on an average prefer more spacious and larger vehicles, *ceteris paribus*. Consumers also derive positive utility from vehicles with higher *HP*.

Table 4.3: Parameter Estimates for IV-Multinomial Logit

Variable	Est.	S.E.
Price (\$1,000)	- 0.137	0.017
Size	0.092	0.006
HP	- 0.006	0.002
Dollar per Mile	- 7.187	2.164
Constant	- 16.080	0.550
Observations: 1,976		

Notes: Estimation includes three sets of dummy variables: segment dummies (5), time dummies (11) and firm dummies (11). All above estimates are significant at 1% level.

Dollar per mile has a negative sign as expected indicating consumers' preference for more fuel efficient vehicles. Our product own price elasticities for the multinomial logit lie within the range of -1.00 and -10.13 reported by Goldberg who estimated a flexible multilevel nested logit model with transaction price data from Consumer Expenditure Survey(1995).

4.8.2 Supply Estimates

We report our GMM estimates from the pricing equation in Table 4.4. All our marginal cost estimates are significant at conventional levels of statistical significance and most of them have the expected signs. The positive coefficients on *Size* and *HP* depicts the fact that it is more expensive to produce larger vehicles and vehicles with more horsepower. The negative sign on *MPG* implies lower cost of production for more fuel efficient vehicles. At the first outlook this result might not seem intuitive. Berry, Levinsohn and Pakes (1995) report negative coefficients for both *MPG* and *Size* assuming constant returns to scale for the cost function. By adding $\log(\text{sales})$ to the cost function, they find both these variables to change signs. In fact, we estimated a specification without the $\log(\text{Production})$ variable in the marginal cost function which also resulted in negative coefficients for both *MPG* and *Size*. Introducing the possibility of scale economies in our model, only the *Size* variable is found to

Table 4.4: GMM Estimates from Pricing Equation

Variable	<i>Specification1</i>		<i>Specification2</i>	
	Est.	S.E.	Est.	S.E.
<i>Marginal Cost Shifters</i>				
Size	0.076 *	0.016	0.078 *	0.016
HP	0.082 *	0.003	0.082 *	0.003
MPG	- 0.081 *	0.029	- 0.080 *	0.030
log(Production)	- 1.006 *	0.063	-1.013 *	0.063
Constant	17.279 *	2.885	16.868 *	3.000
<i>Conduct Parameters</i>				
$\phi_{\text{Non-EDP}}$	3.676	4.615	3.156	5.166
ϕ_{EDP}	0.953	5.380		
ϕ_{EDP}^{2Q}			- 0.888	7.386
ϕ_{EDP}^{3Q}			1.204	5.400
Observations: 1,976				

Notes: Both specifications include two sets of dummy variables: segment dummies (5) and firm dummies (11). * indicates statistical significance at 1% level.

switch signs. We also notice that the coefficient on $\log(\text{Production})$ is significantly negative implying increasing returns to scale. But as Berry, Levinsohn and Pakes (1995) pointed out that sales is just a proxy for total production and thus might not be a true measure of foreign production. In fact most of the Japanese vehicles are the ones with higher *MPG* and inspite of the presence of their transplants in North America, it seems in our case that sales is not a perfect proxy for their true production to adequately capture the scale economies. Our results are in line with Sudhir (2001) who also reports negative coefficient for the *MPG* variable. He argues that heavier cars with more cylinders are those with usually lower *MPG*. So probably the correlation between *MPG* and weight of a car is picking up the fact that it costs more to produce heavier cars with larger number of cylinders.

Next we take a look at the estimated conduct parameters which are of primary interest given the objective of this paper. We estimate two variants of the pricing equation. The

first specification considers the second and third quarters of 2005 as the EDP promotion period. The estimates of the two conduct parameters $\phi_{\text{Non-EDP}}$ and ϕ_{EDP} imply a move from cooperative pricing to a more competitive conduct during the EDP promotion period. But none of these parameters are statistically significant at conventional levels which leads us to infer that the Big Three are pricing at the Bertrand level during both the regular and EDP promotion periods. We also consider a second specification to take a closer look at the EDP period. Based on the chronology of events, GM was the first among the Big Three to announce the EDP promotions during the second quarter of 2005 which was then matched by Chrysler and Ford in the following third quarter. In our second specification we estimate different conduct parameters for the two different quarters encompassing the entire EDP period. We see some interesting results now. The conduct parameter switches from positive to negative briefly during the second quarter of 2005. This implies a move from a cooperative pricing regime to an aggressive pricing period following GM's announcement of the EDP program and then again back to a cooperative regime with Chrysler and Ford joining in. But still our estimates of the three conduct parameters are not statistically significant. This indicates that the EDP promotion did not result in a change in competitive behavior among the Big Three. Thus based on our overall results, average conduct in the U.S. automobile industry can be summarized by myopic Bertrand pricing.¹⁶

Our results, however, do support the facts from anecdotal evidence of the industry in recent years, in general, and events taking place prior to the announcement of the EDP promotions, in particular. As Cooney and Yacobucci (2005) point out that since the economy recovered from the 2000-2001 recession, the automobile industry also recuperated but with the Big Three emerging as a weaker group compared to their Japanese counterparts. While the Big Three struggled to remain profitable in 2004, all the three leading Japanese transplant producers namely Honda, Toyota and Nissan operated profitably with the latter two reporting double

¹⁶It should be noted that our pricing equation involves estimation of 24 parameters while the second and third quarters of 2005 consist of 164 and 165 observations respectively. So we believe that degrees of freedom issue is not driving the insignificance of our conduct parameters result in the pricing equation estimation.

digit percentage increase in sales. Stuck with overbuilt inventory and production capacity during the first quarter of 2005, GM announced a \$1.1 billion loss and Ford also reported substantially reduced earnings. Excessive inventory levels and financial trouble set the stage for the EDP promotions. Corrado, Dunn and Otoo (2006) point out that direct manufacturer to customer cash incentives have become quite generous and widespread in recent years. So it is apparent that the EDP promotion was nothing but just another innovative way to lure new car buyers to the dealerships.¹⁷

4.9 Conclusion

This paper has explored the question whether the EDP promotions of 2005, the first of its kind, signalled a change in the nature of competitive behavior in the automobile industry among the Big Three automakers. In doing so, this paper has made use of dealer level average transaction price data to take into account manufacturer based pricing promotions that are prevalent in the industry. The question has been addressed by estimating a structural model of oligopolistic competition allowing for competitive interactions among the Big Three automakers.

Our results imply that the overall nature of competitiveness in the U.S. automobile industry is consistent with a static model of Bertrand behavior without any changes in conduct among the Big Three during the EDP promotion period. Our results corroborate the problems of inventory backlog faced by the Big Three in recent years due to formidable challenges faced from the foreign transplants. This indicates that the EDP program has been more of a novel marketing intent on part of the Big Three to clear up such backlogs.

The results of this paper may be improved in the future by estimating a demand model with more flexible patterns of substitution. On the supply side, we a priori impose Bertrand

¹⁷Interested readers are referred to a paper by Busse, Simester and Zettelmeyer (2007) who analyze the “price cue” mechanism behind the overwhelming success of the EDP promotions.

restriction on the firms other than Big Three to unveil the nature of conduct specific to the Big Three only. Also in modeling the interactive conduct among the Big Three we have assumed each firm to place equal weights on the other firms' profits. But relaxing these assumptions and modeling firm specific conduct will entail estimation challenges since it will not be possible in that case to derive a closed form supply side estimation equation. Nevertheless, exploring such avenues can reveal more information about the nature of firm specific strategic behavior rather than an average measure of conduct. Incorporating supply side dynamics such as inventory management in the spirit of Copeland et al. (2010) into models of conduct will further shed light on the complex interaction of inventories, incentive programs and interfirm strategic behavior.

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APPENDIX A

Derivations

A.1 Derivation of pricing equation for the nested logit model

For the nested logit model the following can be derived from the share expressions.

$$\frac{\partial s_j}{\partial p_j} = -\frac{\alpha}{1-\sigma} s_j [1 - \sigma \bar{s}_{j|g} - (1-\sigma) s_j] \quad (\text{A.1.1})$$

$$\frac{\partial s_j}{\partial p_k} = \alpha s_k \left[s_j + \frac{\sigma}{1-\sigma} \bar{s}_{j|g} \right] \quad (\text{A.1.2})$$

Substituting the above derivatives in equation 3.8, the first order condition for product j of firm f can be expressed as

$$s_j - (p_j - c_j) \alpha s_j \left[\frac{1}{1-\sigma} - \frac{\sigma}{1-\sigma} \bar{s}_{j|g} - s_j \right] = - \sum_{\substack{k \in \mathcal{J}_{fg} \\ k \neq j}} (p_k - c_k) \alpha s_j \left[\frac{\sigma}{1-\sigma} \bar{s}_{k|g} + s_k \right] \quad (\text{A.1.3})$$

Rearranging terms and multiplying by s_j we get

$$-1 + (p_j - c_j) \frac{\alpha}{1-\sigma} = \sum_{k \in \mathcal{J}_{fg}} (p_k - c_k) \alpha \left[\frac{\sigma}{1-\sigma} \bar{s}_{k|g} + s_k \right] \quad (\text{A.1.4})$$

Since the right-hand side is the same for any product sold by the same firm, this implies that

$$-1 + (p_j - c_j) \frac{\alpha}{1 - \sigma} = -1 + (p_k - c_k) \frac{\alpha}{1 - \sigma} \quad (\text{A.1.5})$$

holds for any product sold by the firm f , so that

$$p_j = c_j + \frac{1 - \sigma}{\alpha \left[1 - \sigma \sum_{k \in \mathcal{J}_{fg}} \bar{s}_{k|g} - (1 - \sigma) \sum_{k \in \mathcal{J}_{fg}} s_k \right]} \quad (\text{A.1.6})$$

A.2 Derivation of pricing equation for nested logit with competitive interactions

For the nested logit model the following can be derived from the share expressions.

$$\frac{\partial s_i}{\partial p_i} = -\frac{\alpha}{1 - \sigma} s_i \left[1 - \sigma \bar{s}_{i|g} - (1 - \sigma) s_i \right] \quad (\text{A.2.1})$$

$$\frac{\partial s_i}{\partial p_j} = \alpha s_i \left[s_j + \frac{\sigma}{1 - \sigma} \bar{s}_{j|g} \right] \quad (\text{A.2.2})$$

Substituting the above derivatives in equation 3.8 and rearranging terms, the first order condition for product j of firm f can be written as

$$\begin{aligned} s_j - \frac{\alpha}{1 - \sigma} (p_j - c_j) s_j + \alpha \sum_{i \in \mathcal{J}_f \cap V_g} (p_i - c_i) s_i \left[s_j + \frac{\sigma}{1 - \sigma} \bar{s}_{j|g} \right] \\ + \alpha \phi_k \sum_{i \notin \mathcal{J}_f \cap V_g} (p_i - c_i) s_i \left[s_j + \frac{\sigma}{1 - \sigma} \bar{s}_{j|g} \right] = 0 \end{aligned} \quad (\text{A.2.3})$$

Multiplying by $\frac{M}{q_j}$ and rearranging, we get

$$1 - \frac{\alpha}{1 - \sigma} (p_j - c_j) + \alpha (1 - \phi_k) L_g \sum_{i \in \mathcal{J}_f \cap V_g} (p_i - c_i) q_i + \alpha \phi_k L_g \sum_{i \in \mathcal{N} V_g} (p_i - c_i) q_i = 0 \quad (\text{A.2.4})$$

where $L_g = \frac{1}{M} + \frac{\sigma}{(1-\sigma)Q_g}$ with $Q_g = \sum_{i \in \mathcal{I} \cap V_g} q_i$

The above equation cannot be directly used in an estimation procedure since there are several error terms ω_i in the equation through the c_i 's. We need to substitute out the c_i 's in order to eliminate all these error terms so that we are left with only the error term for product j i.e. ω_j .

In a similar way following the above steps we can write the first order condition for a product l produced by a different firm r . Then equating the two conditions, we can relate the price-cost margins of products produced across firms as follows

$$p_l - c_l = (p_j - c_j) + (1 - \phi_k)(1 - \sigma)L_g \left[\sum_{i \in \mathcal{I}_r \cap V_g} (p_i - c_i)q_i - \sum_{i \in \mathcal{I}_f \cap V_g} (p_i - c_i)q_i \right], \quad (\text{A.2.5})$$

$$\forall j \in \mathcal{I}_f \cap V_g \text{ and } \forall l \in \mathcal{I}_r \cap V_g$$

Now since the third and fourth terms in all first order conditions (of the form of equation A.2.4) for the products produced by the same firm are identical, the optimal prices of two products produced by the same firm can be related as

$$p_i - c_i = p_j - c_j, \quad \forall i \in \mathcal{I}_f \cap V_g \quad (\text{A.2.6})$$

Using relation A.2.6, we can substitute the $(p_i - c_i)$ terms in equation A.2.5 and thus express it only in terms of c_j and c_l

$$p_l - c_l = (p_j - c_j) \left[\frac{1 - (1 - \phi_k)(1 - \sigma)L_g \sum_{i \in \mathcal{I}_f \cap V_g} q_i}{1 - (1 - \phi_k)(1 - \sigma)L_g \sum_{i \in \mathcal{I}_r \cap V_g} q_i} \right] \quad (\text{A.2.7})$$

Substituting A.2.6 and A.2.7 into A.2.4, we can thus express the first order condition for product j purely in terms of c_j as follows

$$p_j = c_j + \frac{1}{\alpha \left[\frac{1}{1-\sigma} - L_g \left(\sum_{i \in \mathcal{J}_f \cap V_g} q_i + \phi_k \left(1 - (1 - \phi_k)(1 - \sigma)L_g \sum_{i \in \mathcal{J}_f \cap V_g} q_i \right) Y_g \right) \right]} \quad (\text{A.2.8})$$

where $Y_g = \sum_{\substack{c \in \mathcal{F} \\ c \neq f}} \left(\frac{Q_c}{1 - (1 - \phi_k)(1 - \sigma)L_g Q_c} \right)$ with $Q_c = \sum_{i \in \mathcal{J}_c \cap V_g} q_i$.

A.3 Derivation of pricing equation for multinomial logit with group-specific competitive interactions

For the multinomial logit model we can derive the following share derivatives from the product share expressions

$$\frac{\partial s_i}{\partial p_i} = -\alpha(1 - s_i)s_i \quad (\text{A.3.1})$$

$$\frac{\partial s_i}{\partial p_j} = \alpha s_i s_j \quad (\text{A.3.2})$$

Substituting the above derivatives in equation 4.6 and rearranging terms, the first order condition for product j of firm $f \in \mathcal{C}$ can be written as

$$s_j - \alpha(p_j - c_j)s_j + \alpha \sum_{i \in \mathcal{J}_f} (p_i - c_i)s_i s_j + \alpha \phi_k \sum_{i \notin \mathcal{J}_f \cap V_c} (p_i - c_i)s_i s_j = 0 \quad (\text{A.3.3})$$

Dividing by s_j and rearranging terms, we get

$$1 - \alpha(p_j - c_j) + \alpha(1 - \phi_k) \sum_{i \in \mathcal{J}_f} (p_i - c_i)s_i + \alpha \phi_k \sum_{i \notin \mathcal{J}_f \cap V_c} (p_i - c_i)s_i = 0 \quad (\text{A.3.4})$$

The above equation cannot be directly used in an estimation procedure since there are several error terms ω_i in the equation through the marginal cost terms i.e. c_i 's. We need

to substitute out the c_i 's in order to eliminate all these error terms so that we are left with only the error term for product j i.e. ω_j .

In a similar way following the above steps we can write the first order condition for a product l produced by a different firm $r \in \mathcal{C}$. Then equating the two conditions, we can relate the price-cost margins of products produced across firms as follows

$$p_l - c_l = (p_j - c_j) + (1 - \phi_k) \left[\sum_{i \in \mathcal{J}_r} (p_i - c_i) s_i - \sum_{i \in \mathcal{J}_f} (p_i - c_i) s_i \right], \quad (\text{A.3.5})$$

$$\forall j \in \mathcal{J}_f, \forall l \in \mathcal{J}_r \text{ and } \forall f, r \in \mathcal{C}$$

Now since the third and fourth terms in all first order conditions (of the form of equation A.3.4) for the products produced by the same firm are identical, the optimal prices of two products produced by the same firm can be related as

$$p_i - c_i = p_j - c_j, \quad \forall i \in \mathcal{J}_f \quad (\text{A.3.6})$$

Using relation A.3.6, we can substitute the $(p_i - c_i)$ terms in equation A.3.5 and thus express it only in terms of c_j and c_l

$$p_l - c_l = (p_j - c_j) \left[\frac{1 - (1 - \phi_k) S_f}{1 - (1 - \phi_k) S_r} \right] \quad (\text{A.3.7})$$

where $S_f = \sum_{i \in \mathcal{J}_f} s_i$ and $S_r = \sum_{i \in \mathcal{J}_r} s_i$

Substituting A.3.6 and A.3.7 into A.3.4, we can thus express the first order condition for product j purely in terms of c_j as follows

$$p_j = c_j + \frac{1}{\alpha \left[1 - S_f - \phi_k (1 - (1 - \phi_k) S_f) \sum_{\substack{c \in \mathcal{C} \\ c \neq f}} \frac{S_c}{1 - (1 - \phi_k) S_c} \right]} \quad (\text{A.3.8})$$

APPENDIX B

Additional Tables

B.1 Additional Chapter 2 Tables

Table B.1.1: Largest Hub Airports by Carrier

Network Carriers				
Carrier Name	Carrier Code	Airport Code	Airport City	No. of nonstop cities connected (00s) from airport
American	AA	DFW	Dallas/Ft. Worth	1.05
Alaska	AS	SEA	Seattle	0.58
Continental	CO	IAH	Houston	0.80
Delta	DL	ATL	Atlanta	1.44
Northwest	NW	MSP	Minneapolis/Saint-Paul	1.40
United	UA	ORD	Chicago	1.12
US Airways	US	PIT	Pittsburg	1.03
Midwest	YX	MKE	Milwaukee	0.45
LCCs				
Carrier Name	Carrier Code	Airport Code	Airport City	No. of nonstop cities connected (00s) from airport
JetBlue	B6	JFK	NewYork/Newark	0.20
Frontier	F9	DEN	Denver	0.37
Airtran	FL	ATL	Atlanta	0.43
Allegiant	G4	LAS	Las Vegas	0.10
Americawest	HP	PHX	Phoenix	0.74
Spirit	NK	DTW	Detroit	0.11
Sun Country	SY	MSP	Minneapolis/Saint-Paul	0.22
ATA	TZ	MDW	Chicago	0.38
Southwest	WN	LAS	Las Vegas	0.47

Note: We include the regional carriers who have codeshare agreements with the major carriers in the above calculations.

Table B.1.2: Regression of Predicted Price Increase

Variable	Est.	S.E.
Stops	- 0.575	0.039
AirlinePresenceOrigin	0.792	0.070
AirlinePresenceDest	1.331	0.061
Itin Distance ('000 miles)	- 0.401	0.019
Departure	0.074	0.007
Total Network Firms	- 1.489	0.023
Total LCC Firms	0.760	0.021
HHI	3.497	0.143
Constant	8.847	0.392
R-squared: 0.20		
Observations: 49528		

Notes: Estimation includes airline dummy variables. All estimates are significant at 1% level.

B.2 Additional Chapter 3 Tables

Table B.2.1: LCC Presence in Hub Cities of Network Carriers (2004)

Hub City	Hub Airport	LCC in Hub Airport	Other Airport in City	LCC in Other Airport
Atlanta	ATL	F9, FL, HP	None	None
Charlotte	CLT	TZ	None	None
Chicago	ORD	HP, NK	MDW	F9, FL, TZ, WN
Cincinnati	CVG	None	None	None
Cleveland	CLE	HP, WN	None	None
Dallas/Ft. Worth	DFW	F9, FL, HP, SY, TZ	DAL	WN
Denver	DEN	B6, F9, FL, HP, NK, SY, TZ	None	None
Detroit	DTW	HP, NK, WN	None	None
Houston	IAH	F9, HP, WN	HOU	FL, WN
Los Angeles	LAX	F9, FL, HP, NK, SY, TZ, WN	None	None

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Table B.2.1 – continued from previous page

Hub City	Hub Airport	LCC in Hub Airport	Other Airport in City	LCC in Other Airport
Memphis	MEM	FL, HP	None	None
Miami	MIA	FL, HP, SY, TZ	None	None
Minneapolis/St. Paul	MSP	F9, FL, HP, SY, TZ	None	None
New York/Newark	EWR	FL, HP, TZ	JFK LGA	B6, HP, SY F9, FL, NK, TZ
Philadelphia	PHL	FL, HP, TZ	None	None
Pittsburg	PIT	FL, HP, TZ	None	None
Salt Lake City	SLC	B6, F9, HP, WN	None	None
San Francisco	SFO	F9, FL, HP, TZ	None	None
St. Louis	STL	F9, HP, WN	None	None
Washington D.C.	IAD	FL, HP	DCA	F9, FL, HP, TZ

Table B.2.2: Hub-to-Hub Market Coverage of LCCs from each Hub City (2004)

Hub City	% of O&D H-H markets served by LCCs	Number of LCCs in Hub City
Atlanta	73.68	3
Charlotte	31.58	1
Chicago	94.74	6
Cincinnati	0	0
Cleveland	36.84	2
Dallas/Ft. Worth	78.95	6
Denver	94.74	7
Detroit	42.11	3
Houston	89.47	4
Los Angeles	94.74	7
Memphis	68.42	2
Miami	73.68	4
Minneapolis/St. Paul	78.95	5
New York/Newark	63.16	7
Philadelphia	57.89	3
Pittsburg	55.26	3
Salt Lake City	84.21	4
San Francisco	92.11	4
St. Louis	47.37	3
Washington D.C.	57.89	4

O&D H-H markets represent all hub-to-hub markets formed with the hub city as either origin or destination of a roundtrip travel.

Source: Author's calculation from DB1B sample.

Table B.2.3: Hub City Average Fares for Hub-to-Hub Markets (2004)

Hub City	Market Average Price (Cents per mile)	Average Price (Cents per Mile) charged by		
		Hub Carrier	Other Network Carriers	LCCs
Atlanta	21.3	25.0	15.8	12.5
Charlotte	29.8	45.2	20.9	11.9
Chicago	22.1	22.8	22.5	13.5
Cincinnati	28.8	32.5	22.2	N/A
Cleveland	20.1	20.4	20.9	12.2
Dallas/Ft. Worth	22.4	26.5	19.8	17.1
Denver	15.0	19.0	12.1	9.8
Detroit	23.8	29.9	20.6	12.2
Houston	18.0	23.8	16.7	16.4
Los Angeles	11.5	13.6	10.8	9.8
Memphis	25.1	32.3	20.9	15.5
Miami	13.7	14.7	13.3	10.5
Minneapolis/St. Paul	24.5	33.0	19.1	12.4
New York/Newark	17.3	20.3	17.5	9.2
Philadelphia	22.5	31.6	18.9	9.4
Pittsburg	25.3	36.5	19.4	11.8
Salt Lake City	12.8	14.1	11.5	11.2
San Francisco	12.3	14.8	10.7	8.0
St. Louis	21.3	25.4	19.7	14.5
Washington D.C.	18.0	20.5	17.5	9.7

Average fares are computed for only hub-to-hub markets formed with the hub city as either origin or destination of a roundtrip travel. This is not representative of overall average fares in hub cities or hub airports serving as either origin or destination for all hub based markets.

Source: Author's calculation from DB1B sample.