Market Structure and Competition: An Empirical Analysis of the U.S. Airline Industry

by

Giovanni Alberto Tabacco

A Dissertation submitted in partial fulfilment of the requirements
for the degree of Doctor of Philosophy

University of East Anglia
School of Economics

July 2012

Word Count: 25.637

Abstract

This thesis studies degree of competitiveness in the airline industry inferred by investigation of market structure. Chapter 2 documents empirical evidence that endogenous sunk costs investments in advertising and in expanding route network play a crucial role in determining equilibrium market structure and, that the industry is a natural oligopoly. In chapter 3 we perform an empirical analysis of market structure beyond the bounds approach, to explain firm numbers and market share asymmetry for city pair markets. In addition, splitting firms into two types, leaders and non-leaders, it is proposed evidence that nature of competition depends on presence of leader airlines. In particular, there is evidence consistent with learning; that is, non-leaders infer profitability of routes from the number and identity of leaders. Chapter 4 proposes two econometric models of entry to analyze market sharing agreements.

Acknowledgements

During Graduate school many people have helped me. First of all, I owe gratitude to my advisors Steve Davies and Bruce Lyons for extensive guidance, countless discussions and lots of draft readings. In addition, I would like to thank Franco Mariuzzo for precious suggestions and patient explanations on issues related to Chapter 4 in this thesis. A big thank you also to Peter Moffatt for some vital help about Chapter 2.

I wish also to thank seminar participants at the School of Economics of UEA for valuable feedback. During travelling to conferences I have had the privilege not just to benefit from thoughtful comments and suggestions, but also, more importantly, to meet, even for only few days, gracious people like Ivan Barreda-Tarrazona, Roberta Longo, Laura Rondi, Neil Gandal, Regine Oexl, Andrea Conte, Bradley Ruffle, Letizia Giorgetti, Quazi Shahriar, Claudio Panico, Emanuele Tarantino, Theresa Veer, Martina Sartori, Federico Etro, Emanuele Forlani, Georgi Burlakov, Lapo Filistrucchi, David Henriques, Claudio Piga, Tom Barbiero, Marco Alderighi, Alberto Gaggero, Gianluigi Pelloni, Joanna Poyago-Theotoky, Miguel Flores.

Life along my studies here at UEA have been shone by friendship endured since my early masters' days: Rod, Mark, Olivier, Sabrina, Okan, Fabiola, Jesus, Chris, Luca, Peter, Key, Federica. Also, more recently, during my Ph.D., my journey has been made much more joyful and rich than it could have been thanks to both close friendships and more occasional relations and interactions; Stephen and Chiyuki, Fr. Mark, Tony, Marcelo, Marion, Fabio, Fan, Daniel, Carlo, Paul, Eowyn, Samsoh, Luis, Katerina, Hope, Alimi, Gabor, Hoy.

Finally, I thank my family for all the love, financial and moral support, encouragements and trust in me. I wish to dedicate this doctoral dissertation to my parents, in particular to the memory of my dear father, Alberto.

"*Special thanks to God for the gift of my life, for being beside to me, and to us all, in every moments also in the most difficult ones; and thanks for the joy and serenity of discovering, step by step, the ultimate goal of our life on earth: to discover God's love and forgiveness for each human being regardless of what we do.*"

CONTENTS

CHAPTER 1

INTRODUCTION AND DATASET

1.1 Introduction

The purpose of this Chapter is to introduce objectives and a brief outline of the three original chapters of the dissertation, as well as to introduce some key features and definitions of the assembled dataset which, will be useful to understand econometric analysis performed in subsequent chapters.

This dissertation is broadly motivated by how markets work and how firms behave, specifically in the U.S. airline industry. The underlying analytical theme of Chapters 2 and 3 is to infer from market concentration competitive process at work. Very intriguingly, from the observed market structure we can draw back to competitive forces which have generated the structure we actually observe. This theme is not just of academic interest, but it also brings prominent relevance for competition policy. Chapter 4 attempts to gain insights on entry decisions of major firms into airline city pairs. Specific research question refers to whether airlines deliberately prevent competition head-to-head within city pair markets. The nature of the addressed research questions suggests employing empirical methods.

To answer the questions posed, I construct a novel dataset involving a cross-section sample of 661 airline city pair markets, with information on several market characteristics for each route including market size and identities of airlines operating in each route market with individual market shares, used to compute various measures of concentration (Hirshman-Herfindahl index and firm-concentration ratios). Most of this IO literature on airlines generally neglects to endogenize market structure as well as to study its competitive forces (exceptions are Berry (1992) and Ciliberto and Tamer (2009)). Also, the literature largely ignores the implications that vertical product differentiation can have on market structure.

The main body of this dissertation consists of three empirical Chapters (2, 3 and 4) on market structure and competitive conduct in airline markets; each chapter uses a different empirical strategy. Chapter 2 makes use of the bounds methodology to empirically investigate the relationship between market size and market structure. The econometric analysis is based on the theoretical framework developed by Sutton (1991), Shaked and Sutton (1983) and complemented by more recent theory work, (Vasconcelos 2006). Fundamentally, the chapter proposes an empirical test on various predictions of the endogenous sunk costs model (ESC). The results point to evidence that equilibrium market structure is driven by endogenous sunk costs competition; in particular, it appears that airlines escalate investments in advertising as well as investments for expanding route structure. The number of routes serviced out of the end points of a given city pair can enhance market shares within the given route market. Chapter 3 deduces the nature of competition from empirically analysing firm numbers and market share asymmetry, as well as the competitive effects between different types of firms. Using our novel data set, we extend the literature on empirical market structure in various ways. First, we complement the bounds approach by investigating structure above the lower bound and then, unlike previous literature on empirical models of market structure and entry, we study determinants of firm size inequality. The literature on empirical market structure is also extended by analysing nature of competition between different types of firms (e.g. Shaumans and Verboven (2008)). Chapter 4 assesses collusion in terms of territory allocation. To this goal, we estimate two alternative econometric models of entry. Results do suggest some evidence consistent with the possibility of collusion on market (route) allocation.

The rest of the chapter is structured as follows. Section 2 presents some elements of the database. The appendix lists the cities involved in the route markets.

1.2 Dataset

Coverage of the Sample

The econometric analysis of the dissertation focuses on a newly assembled dataset about U.S. airline city pairs. Market shares and concentration data are for 2006 collected from the US Transportation Bureau (BTS); whilst, demographic variables (population) refer to year 2000 obtained from US census.

Belobaba (2010) reports that US airline industry profits in 2006-2007 are positive after five year period, 2001-2005, of losses accruing to forty billions US dollar; the years 2008-2009 brings further negative profits.

The dataset contains 661 city pair markets involving 58 cities, of which 25 are from the 50 largest U.S. cities; seventeen cities in the dataset are in the largest top twenty. In addition, our dataset covers 66% of the revenue passenger boardings for all US large hub airports. The goal in assembling this dataset has been to obtain a sample of city pair markets reasonably representative of the whole industry. To this end, we followed the following criteria: i) to include many major airports with substantial air transport traffic; ii) to include also several medium sized and small cities, in order to obtain a sample of route markets with wide variation in population size.

The focus is on domestic routes similarly to IO literature on the US airline industry.

Airports/Cities

The FAA (Federal Aviation Administration) defines large hub as "a commercial service airport that has at least one per cent of the passenger boardings". In this dissertation we adhere to such legal/institutional definition for identifying the large hub cities (containing at least one hub airport).

Table 1 provides distribution of cities' population in our dataset, whilst Table 2 gives the distribution of large hub cities' population. The concept of city adopted throughout this dissertation refers narrowly to the urban area rather than the Metropolitan Statistical Area (MSA).

Table 1 – Cities by population size

Population range	# Cities
0 - 100.000	16
100.001 - 500.000	23
500.001 - 1.000.000	10
> 1.000.000	9
Total	58

Table 2 – Cities containing large Hub airports by Population size

Population range	# Large Hub
100.001 - 500.000	3
500.001 - 1.000.000	5
> 1.000.000	8
Total	16

We define as tourist cities as those located in California and Florida plus two tourist snow and ski resorts, Aspen and Colorado Springs, which are both located in Colorado. A strategy for identifying tourist city pairs could be that of collecting data on number of hotels in each city and setting up an arbitrary threshold of them, in order to classify the routes as either tourist or not. In contrast, the criterion followed in this paper is simpler without the need of further data. Essentially, it rests on the observation that U.S.A. do not have art cities as often it occurs in Europe, but rather tourism is motivated mainly by reaching seaside resorts which are located prominently in California and Florida. In the empirical models it is introduced a dummy equal to 1 for all markets with at least one end point city located either in California or Florida, plus the other two locations, Aspen and Colorado Springs. The criterion of classifying as tourist airline markets those having at least one end point in either California or Florida is also used in Berry (1992).

Airlines

The dataset contains 58 airlines (by coincidence these are as many as the cities) of which 10 are low cost (AirTran, Allegiant Air, Frontier Airlines, Horizon Air, JetBlue, Midwest, Southwest, Spirit Air, Sun, USA3000). A distinction used in the analysis of Chapters 2, 3 and 4 of this dissertation is between leader airlines and non-leaders in base of number of routes serviced within our data set. Table 3 below illustrates how the seven leaders serviced a number of routes equal to 95% of the number of those routes operated by the other fifty-one airlines in the dataset. In addition, each leader services on average 91 city pairs, while each non-leader on average offers only 13 routes. Only one low cost airline is classified as leader, Southwest.

Table 3 – Number of Routes serviced by leaders and non-leaders

# Routes		
Non-Leaders		666
American	136	
Delta Airlines	113	
Southwest	107	
Continental	77	
US Airways	69	
United Airlines	68	
Northwest	65	
Leaders		635

A motivation for this distinction relies on following reasoning. Airlines servicing a wider route structure may obtain demand and cost advantages; as a result, vertical product differentiation may arise between those firms providing a large network of routes and those offering a handful of routes.

Routes

The 58 cities contained in our dataset produce a sample of 661 city pair markets with at least one airline possessing positive market shares. The dataset involves non-stop airline markets. This can create some limitations when dealing with the U.S. airline industry, as most airlines on this market operate hub-and-spoke networks. Consequently, entry and frequency decisions on spoke-hub markets are determined by the expected demand on spoke-hub-spoke markets. This limitation is mitigated by introducing dummies for large hubs; in fact, in Chapters 3 and 4 the empirical analysis of market structure and entry decisions is controlled for large hub airports.

Consistently with previous literature about the industrial organization in the airline industry, we define the relevant market at route level, and precisely the city pair markets are non-directional (e.g. Los Angeles – Miami is integrated with Miami – Los Angeles) since market shares are determined not directionally. We can mention several examples of contributions where economic investigation focuses on single routes each of them treated as a separate market[1]. In support of this, competition authorities normally pursue investigations considering the relevant market at route level. In addition, Brueckner, Lee and Singer (2010) develop a market definition methodology for the airline industry, concluding that the most appropriate market definition is at route level.

Concentration is measured by the Hirschman-Herfindahl index. For robustness purposes concentration ratios, C1, C2 and C4, are tried in formal analysis of subsequent chapters.

Appendix

List of Airlines

Delta Airlines, AirTran, Atlantic, Champion, Continent, US Airways, Shuttle, PSA, Pace, Miami Air, Mesa, Freedom, Continental, Spirit Airlines, Midwest, Air, Casino, Chautauqua,

[1]For example, Aguirregabiria and Chun-Yu Ho (2010), Berry (1992), Borenstein (1989), Brander and Zhang (1990), Evans, Froeb and Warden (1993), Evans and Kessides (1993) (where actually two different market definitions are used, at route and airport level), Marin (1995), Mazzeo (2003), Charles and Seabright (2001),Bamberger, Carlton and Neumann (2004), Neven, Lars-Hendrik Roller, and Zhentang Zhang (2006), Lederman (2007, 2008).

United Airlines, Sky king, Republic, American, America, Mesaba, Northwest, ATA, JetBlue, Commute Airlines, Express Jet, Piedmont, Southwest, Trans, North, Alaska, Boston, Frontier, SkyWest, Allegiant, USA Jet, Horizon Air, World, Pinnacle, Ryan, Colgan, Go Jet, USA3000, Executive, Gulfstream, Victory, Hawaiian, Net jets.

List of cities with the associated States

City	State
Aberdeen	Maryland
Albany	New York
Alexandria	Louisiana
Allentown	Pennsylvania
Asheville	North Carolina
Aspen	Colorado
Atlanta	Georgia
Augusta	Maine
Austin	Texas
Baton Rouge	Louisiana
Bismarck	North Dakota
Boise	Idaho
Boston	Massachusetts
Buffalo	New York
Charlotte	North Carolina
Chicago	Illinois
Cincinnati	Ohio
Colorado Springs	Colorado
Columbia	South Carolina
Columbus	Ohio
Dallas	Texas
Des Moines	Iowa
Detroit	Michigan
Florence	South Carolina
Fort Lauderdale	Florida
Green Bay	Wisconsin

Houston	Texas
Ithaca	New York
Jacksonville	Florida
Kansas City	Missouri
Little Rock	Arkansas
Long Beach	California
Los Angeles	California
Madison	Wisconsin
Memphis	Tennessee
Miami	Florida
New Orleans	Louisiana
New York	New York
Ontario	New York
Palm Springs	California
Philadelphia	Pennsylvania
Pierre	South Dakota
Port Angeles	Washington
Portland	Oregon
Providence	Rhode Island
Richmond	Virginia
Sacramento	California
San Antonio	Texas
San Diego	California
San Francisco	California
San Jose	California
Santa Barbara	California
Spokane	Washington
Tallahassee	Florida
Washington	District of Columbia
Waterloo	Iowa
West Palm Beach	Florida
Yuma	Arizona

CHAPTER 2

NON-FRAGMENTATION, MONOPOLY OUTCOMES AND NATURAL OLIGOPOLY: EVIDENCE FROM THE U.S. AIRLINE INDUSTRY

Abstract: *Most of the industrial organization literature on airlines has neglected competitive forces which have generated industrial market structure. In addition, the majority of competition models of this literature assume homogeneous products or at most symmetric product differentiation. This paper, in contrast to previous work, shows the underlying competitive process in the airline industry inferred by investigation of market structure, as well as how product differentiation drives concentration. The empirical analysis is grounded on Sutton (1983, 1991) and Vasconcelos (2006) endogenous sunk costs model, finding evidence consistent with the fact that, the structure of airline city pair markets is mainly driven by competition in quality through endogenous sunk costs – namely, route structure and advertising.*

2.1 Introduction

This paper has the purpose to uncover competitive mechanisms at work in the airline industry which can be revealed by investigating structure. We do this by testing the endogenous sunk costs model developed by Sutton (1991) and complemented by Vasconcelos (2006). Estimation of the lower bound and the upper bound to concentration is performed for a sample of airline city pair markets.

A main motivation of this paper comes from the observation of how little is known about competitive forces that have generated the current structure in the airline industry. Indeed, literature on the economics of competition in air transportation[2] takes industry structure as given neglecting the underlying causes of it. However, this is not to ignore the voluminous literature on empirical models of entry and market structure in various industries[3], including airlines, but the emphasis in our paper is to uncover robust competitive

[2] See for example Aguirregabiria and Chun-Yu Ho (2010), Borenstein (1989, 2005), Evans and Kessides (1993), Charles and Seabright (2001), Bamberger, Carlton and Neumann (2004), Neven, Lars-Hendrik Roller and Zhentang Zhang (2006), Lederman (2007, 2008).

[3] Berry (1992), Berry and Waldfogel (1999), Bresnahan and Reiss (1991), Ciliberto and Tamer (2009), Cohen and Mazzeo (2007), Mazzeo (2002), Seim (2006), Shaumans and Verboven (2008), Toivanen and Waterson (2005).

mechanisms that have shaped market structure. One main robust competitive mechanism is the well-known endogenous sunk costs escalation process which alters consumers' willingness to pay and its consequences on market structure. Another motivating reason relies on the fact that many models about the industrial organization of airline markets, if not most, consider competition with homogeneous goods[4], settings involving horizontal product differentiation, or at most symmetric product differentiation[5] (e.g. Berry 1992). Finally, the U.S. airline industry may represent an excellent natural experiment for studying competitive forces that have generated industrial structure because deregulation took place in the early 1978; consequently, any imprint on current structure should be caused by the competitive process at work.

The underlying hypothesis for the analysis that follows is that airlines engage in the competitive mechanism of endogenous sunk costs escalation. The interpreting view of this paper is that such investments are sunk and endogenous[6]. A potential source of endogenous sunk costs is advertising. In the literature the empirical cut-off point for advertising/sales ratio is 1% and was set up by Sutton (1991) for his empirical estimation of the lower bound to concentration for twenty industries in the food and drinks sector. This threshold distinguishes advertising intensive industries from those industries where advertising does not play a role. Although the figure for the U.S. airline industry is not acknowledged, Nielsen Media research (May 2007) provides an advertising/sales ratio for the UK airline industry equal to 8.37%. Even if an advertising/sales ratio was below the cut-off point this industry would not be easily defined of an exogenous sunk costs type because another source of endogenous sunk costs is present. The other source of endogenous sunk costs is route structure. Firms can increase demand by increasing number of routes out from end points constituting a city pair. This route network requires endogenous fixed sunk costs (e.g. personnel training programs, number of established check-in points, and number of slots acquired).

A crucial element for the validity of applying the Sutton's bound approach is that endogenous sunk costs are local markets' specific. In other words, the endogenous sunk costs for the airline industry should be relevant at route level. If the endogenous sunk costs pertain exclusively at national level we will not be able to distinguish between the endogenous sunk

---

[4] Lederman (2007, 2008) contributions represent rare examples of analysing product differentiation in the airline industry.

[5] However, Lederman (2007, 2008) in her empirical analyses of frequent flyer programs (FFPs) considers a framework of vertical product differentiation where value of redeemed awards to travellers may be substantially different among carriers.

[6] The term endogenous refers to the fact that advertising and route network are variables fully under firm's control hence constituting key competitive weapons.

costs model from the exogenous sunk costs model using estimation of lower and upper bound to concentration. One claim of this paper is that there are rather substantial endogenous sunk costs relevant at route market level. Regarding advertising, we can observe that airlines establish a mix of investments in which some are more oriented at 'brand', often in newspaper advertising, while other investments are route specific, as observable from companies' website. Low cost carriers tend to advertise more specific city pairs. We may assert that a good portion of advertising expenditure is held at route level. Regarding the other type of endogenous sunk costs, investments in establishing a set of destinations out from end points of a city pair, are relevant at route market level. Overall, we are confident in claiming that the endogeneity of sunk costs is relevant at city pair market level.

Furthermore, our paper provides the first empirical test of the *upper bound* theory (Vasconcelos 2006) which predicts that in endogenous sunk costs industries maximal level of concentration remains invariant at any levels of market size. Finally, we find evidence that dominant airlines are between one and three in any city pair regardless of market size. This evidence suggests that the industry is a natural oligopoly. To sum up, this paper offers three results: i) there is evidence of a lower bound to concentration substantially above zero hence evidence of non-fragmentation; ii) we have monopolies even in very large route markets, so we have a sharp upper bound to concentration invariant to market size; iii) the number of dominant firms is from one to three in each city pair market irrespective of market size. These results suggest evidence of endogenous sunk costs competition. The implication of this is that price and horizontal product differentiation are not the only means of competition in airline markets, but quality boosted by endogenous sunk costs play an important role.

The rest of the paper is organised as follows: Section 2 reviews the relevant literature; Section 3 introduces some issues about data; Section 4 carries the econometric analysis; Section 5 provides a discussion of results and section 6 concludes.

2.2 Relevant Literature

Sutton's Lower Bound

The starting point of Sutton's (1991) bound approach is to define two broad classes of industries: exogenous sunk costs and endogenous sunk costs industries; then the author develops a theoretical framework for each of the two types of industries in which to analyze the relationship between market size and concentration. Since the theory aims at cross-industry empirical analysis, Sutton controls for a measure of set up costs, amount of capital (fixed costs) required to enter and operate efficiently, at minimum average cost, in a given industry. These set-up costs may greatly differ across industries, and may be correlated with market size; as a result, to prevent bias in the role of market size for each industry, size is divided by the set-up costs. Exogenous sunk costs industries are those with homogeneous products or with horizontal product differentiation, therefore main competitive weapon is price. In contrast, endogenous sunk costs industries supply goods which are vertically differentiated; consequently, quality plays a crucial role. The key feature is that real (perceived) product quality is enhanced for means of fixed sunk costs investments, for example in R&D and advertising. These investments can increase consumers' willingness to pay. Precisely, Sutton's (1991) empirical analysis of twenty industries in the food and drink sector in six major economies is based on the distinction between advertising intensive and non-advertising intensive industries.

Sutton's main novelty is not to derive a unique prediction, but rather, to obtain a range of predictions which hold across a wide class of oligopoly models, abstracting from various factors (e.g. toughness of price competition, degree of horizontal product differentiation) which are difficult to proxy or measure empirically. Fundamentally, Sutton derives a *lower bound*, that is the minimal level of concentration admissible, below which nothing can happen in long-run equilibrium; whereas, on and above the lower bound any market structure is consistent with the theory. Sutton looks for only robust results applicable to a large domain of industries. Motivation for this approach is given by the fact that game theoretic oligopoly models provide conclusions which depend on model's specifications. For instance, the researcher can choose among various equally reasonable assumptions regarding nature of competition (e.g. Cournot or Bertrand); whether firms are single-product or multiproduct; whether entry occurs either simultaneously or sequentially. In addition, these specifications, equally reasonable *a priori* are hard to measure empirically; as a result, often these game theoretic models do not produce empirically testable results.

Different predictions about market structure are associated with each of these two groups of industries. The key findings of the exogenous sunk costs model (Sutton 1991, pp. 308) are: i) a negative relationship market size-concentration; ii) concentration converges to zero as market size becomes extremely large tending toward ∞ ; iii) tougher price competition causes a more concentrated structure at any given market size, all else equal. In other words, for any pair of industries/markets with comparable size but different degree of price competition, the theory predicts that the market with tighter price competition will show higher concentration. As size of the economy grows significantly, firms' entry occurs until the last firm covers fixed sunk costs without incurring in losses (free-entry equilibrium rule). More intense price competition causes profits per firm to fall. Consequently, the number of firms able to survive in the market decreases. Conversely, a situation of collusive behaviour may determine excessive entry of firms leading, thus, to low concentration.

For industries where products are vertically differentiated and thus, quality becomes important, Sutton develops the endogenous sunk costs model. Here, two relevant results are reached (Sutton 1991, pp. 308): i) the traditional negative relation market size-concentration is not monotonic; ii) non-fragmentation as size grows. The basic intuition is that extra competition emerging from a larger market size is channelled mainly into an escalation process of expenditure in endogenous sunk costs such as advertising; in addition, this property holds also in a context where both vertical and horizontal product differentiation are present (Shaked and Sutton, 1987). Advertising and R&D alter real and/or perceived product quality, so consumers' willingness to pay increases. As product quality is improved, consumers will tend to shift from the outside good to the quality one; consequently, quality enhancements enlarge demand (market size). An implication is that expansion of market size does not attract further entry, but instead induces incumbent firms to increase expenditure in endogenous sunk costs leading to an *escalation process* which determines endogenously economies of scale. At very high levels of investments in such competitive weapons, entry may be even blockaded.

The Vasconcelos' Upper Bound Theory

Vasconcelos (2006) offers tighter predictions of the relationships between market size and structure complementing Sutton's (1991, 1998) work. Main research question addressed is that of whether arbitrarily concentrated structures can be sustained in large exogenous and endogenous sunk costs industries, hence if an upper bound to industry concentration exists. In particular, industry monopolization may be attainable for means of mergers. Building on Sutton's theoretical framework, Vasconcelos adds a stage in which firms may form coalitions and, the equilibrium used is that of Nash stability concept. Regarding exogenous sunk costs industries, Vasconcelos shows that the incentive to form a monopoly coalition at the second stage of the game, given the number of firms entered in stage 1, depends on product substitutability. When products are imperfect substitutes a merger to monopoly cannot be an equilibrium outcome as market size increases. Suppose that N firms enter in stage 1, and at the second stage of the game if the firms entered agree to merge in one coalition each of them will get $= \frac{1}{N}$. As market size increases we will get more entry, hence higher N which implies a lower profit for each coalition member; additionally, a firm, with imperfect substitute products, has the incentive to free ride on the $N - 1$ firms obtaining a duopoly profit which will be higher than $\frac{1}{N}$ obtainable in case of joining the monopoly coalition. Therefore, the upper bound to concentration declines as market size increases and monopoly cannot occur.

For endogenous sunk costs industries Vasconcelos argues that the marginal cost of investing in quality is unaffected by number of coalitions, while the marginal revenue does depend on the number of coalitions. The author's analysis reveals that there are two effects at work on the marginal revenue of quality. One effect is the "appropriability effect" which Vasconcelos shows to be positive and decreasing in the number of coalitions; the revenue from one additional unit of investment in quality increases the fewer number of coalitions there are. A second effect is the "competition effect". This is represented by the incentives to increase quality, hence to innovate, fostered by competition which is increasing in the number of coalitions. At equilibrium, the appropriability effect dominates the competition effects, then profit from an additional unit of investment in quality declines as the number of coalitions increases; as a result, the equilibrium level of quality will decline.

The analysis at the second stage of the game, coalition formation stage, is restricted to parameters for the elasticity of investment, β, and product substitutability, σ, for which only either a monopoly coalition or a duopoly coalition is viable at equilibrium. It is shown that "when products are sufficiently substitutable a duopoly coalition structure cannot be a SPE" (Vasconcelos 2006, pp. 242) if the two coalitions are similar in number of firms. The larger the number of firms composing the smaller coalition the higher the firms' incentive to deviate from the duopoly coalition structure is; as a result, it will be more likely to have one coalition therefore, monopolizing the industry. The incentive to deviate from the duopoly coalition structure derives from the fact that the larger the number of firms forming the smaller coalition the smaller the individual firm's share of profits. The firms will earn higher profits by forming a monopoly coalition. As a result, in endogenous sunk costs industries the upper bound to concentration exists and is unaffected by market size. In addition, monopoly can be an equilibrium outcome.

At this point, we need to discuss the applicability of this model to the airline industry. Airlines compete not just on prices but also along various quality dimensions such as on-time flights, mishandled bags (e.g. Mazzeo 2003; Forbes (2008a), (2008b)). Bilotkach (2011) observes as frequency is another important aspect of air transport service quality which is intimately linked to output and, higher frequency lowers the total price of travel by reducing the schedule delay. To provide higher frequency, clearly implies supplying more seats hence more output, but also it increases consumer's utility. The view of this paper is that there are other two attributes, advertising and routes flown out of cities of a city pair market, which, as discussed in the introduction, require sunk outlays. The argument brought out in the Introduction about the sources of endogenous sunk costs in the airline industry warrants the applicability of applying the ESC model hence Vasconcelos' model to this market.

Empirical evidence

Our work extends the empirical literature about testing the endogenous sunk costs model within single industries. Berry and Waldfogel (2010) offer an empirical analysis on market structure and quality measures in the newspaper and restaurant industries, where processes of quality production are believed to differ. The newspaper industry is believed to be characterised by investments in endogenous sunk costs for quality improvements and shows non-fragmentation; whereas, the restaurant industry is featured by the fact that quality is enhanced mainly by increasing variable costs, thus leading to a fragmented structure. Dick (2007) studies the banking industry and Latcovich and Smith (2001) focuses on online book market; both finding support to the endogenous sunk costs model. Finally, Ellickson (2007) demonstrates that the industrial structure of the supermarket industry is explained by escalation of endogenous sunk costs in store size, as well as the industry is a natural oligopoly with a competitive fringe of lower quality stores.

In addition to the single industry literature in which this paper is best placed, over the last twenty years there has been an empirical cross-industry literature about the bound approach[7]. Also, we have had a number of case histories documenting the evolution of structure within the endogenous sunk costs model in specific industries[8]. In addition, following the pioneer work of Sutton (1998) in deriving a bound's approach to analyse cross-industry differences in firms' size distribution, we have various contributions in single industries applying this methodology[9].

[7] Giorgetti (2003); Lyons and Matraves (1996); Lyons, Matraves and Moffatt (2001); Robinson and Chiang (1996); Symeonidis (2000); Balasubramanian and Lieberman (2011).

[8] Bakker (2005) researches reasons of the decline of the European movie industries in the endogenous sunk costs escalation mechanism operated by the US industry; Bresnahan and Greenstein (1999) apply the endogenous sunk costs model to the computer industry; Matraves (1999, 2002) explores the global pharmaceutical industry and how European integration has affected market structure in the soft drinks industry respectively; Motta and Polo (1997) studies market structure of television industry.

[9] De Juan (2002, 2003) analyse the Spanish banking industry; Buzzacchi and Valletti (2006) apply the bound approach to firms' size distribution in the Italian motor insurance industry.

2.3 Data

The sample consists of 58 U.S. cities leading to a potential sample of $1653 = \left(\frac{58*57}{2}\right)$ origin-destination markets of which, 661 have at least one firm with a positive output. Consistently with previous literature, we define the relevant market at route level[10].

The Bureau of Transportation Statistics compute firm's market shares using "passenger miles", number of passengers multiplied by distance. Therefore, each firm's market share is given by the number of passengers travelled on its flights on a given route multiplied by the distance between origin and destination of that route. Also, firms with market shares equal to or lower than 0.01 are excluded in the computation of the concentration measure. Such exclusion is motivated by the fact that these values identify firms posing irrelevant competitive pressure to rivals and may even constitute coding errors.

Market size is measured following Berry (1992), that is, it is defined as the product of population of the two end point cities for each city pair. Alternative measures have been tried, including the sum of populations of the two endpoints, and the population of the less populated city of the city pair. However, the choice of the product is felt to be better because of the fact that transportation demand is related to the probability of each person dwelling in city 2 is willing to visit city 1 depends on the number of people that such individual knows in city 1. Summing over such probabilities for all individuals leads to the product of populations[11].

The set-up costs measure used by Sutton and subsequent authors had the role to provide a homogenization across different industries. Since our analysis involves a single industry, it is reasonable to assume that the costs necessary for obtaining a single plant of minimum efficient scale are homogeneous across all city pair markets. In the airline industry the set-up costs may be associated to being operative in an airport city from which an airline services various destinations at minimum efficient scale. It appears reasonable to assume that these costs are broadly homogeneous across route markets. As a result, the stochastic frontier models do not include a measure for set-up costs. If set-up costs were positively correlated to market size we would underestimate predicted minimal concentration level.

[10] See chapter 1, pp. 11-12 for reasons justifying our choice of the relevant market definition.
[11] Berry (1992, pp. 907 footnote 10).

2.4 Empirical Analysis

In this Section we document empirical evidence about three predictions of the endogenous sunk costs model (ESC). The first prediction is about non-fragmentation which, we obtain through estimation of the lower bound to concentration. A second one pertains to the upper bound to concentration which is invariant to market size, and monopoly can appear in equilibrium in large markets. Finally, using the full population of firms we provide evidence that the airline industry is a natural oligopoly: one to three firms have a dominant position in each market regardless of size. Now, a clarification is in order. Results on the lower bound to concentration using the Herfindahl index actually imply the natural oligopoly result. However, the econometric methods used are heavily parametric, therefore the results depends substantially on error distributional assumptions. The evidence proposed for the third prediction, not suffering from that shortcoming, further reinforces the lower bound estimation.

Estimating a bound to concentration cannot be addressed by using OLS because we need to estimate a bound function which envelops all observations and not an average relationship.

In this paper estimation of the lower and upper bounds are performed using stochastic frontier. This technique is robust to outliers and allows low concentration disequilibria. We estimate the following equation:

$$ln(HHI/(1-HHI))_i = \beta_0 + \beta_1/\ln(S)_i + \nu_i + \varepsilon_i \qquad (1)$$

The dependent variable is the natural logarithm of the logistic transformation of Herfindahl index, and $0 < HHI \leq 1$. β_0 and β_1 are coefficients to be estimated. The odds transformation ratio for the dependent variable[12] is employed for ensuring that predicted values of limiting level of concentration are between 0 and 1 as well as to prevent heteroscedasticity. The variable S denotes market size. The reciprocal of natural logarithm of size employed in (1) is based on Sutton (1991) and subsequent authors (e.g. Lyons and Matraves 1996, Ellickson 2007). This functional form allows asymptotic HHI as market size tends to infinity to depend solely on the intercept term.

In the present context, the simple framework consists of a two error structures: a two sided error term (ν_i) with a normal distribution for allowing low concentration disequilibria,

[12] We set HHI equal to 0.99 in monopoly routes (where the HHI assumes value equal to 1 for the estimation of the upper bound to concentration.

that is, observations are allowed to be below the lower bound, and a one sided error (ε_i) to reflect the theoretical relevance of the lower bound. There are no strong theoretical reasons for choosing one particular distribution for the one sided error; usually in the literature the truncated normal, half normal, standard exponential[13] estimators have been tried for estimating a lower bound, which all gave similar results in Lyons and Matraves (1996). $\nu \sim N(0, \sigma^2)$ is the i.i.d. two-sided error term normally distributed; whereas, for the one-sided error term we assume three different distributions: $\varepsilon \sim \text{Half} - \text{Normal}\ (\delta)$, $\varepsilon \sim \text{Truncated} - \text{Normal}\ (\varphi)$, $\varepsilon \sim \text{Exponential}(\lambda)$. Following Greene (fifth edition), the stochastic frontier model given by (1) states that a relationship between the concentration measure and market size is defined. For any given value of market size the observed value of concentration must be either equal to or greater than the lower bound function given by equation (1). The one-sided error terms ε_i must be either zero or positive (nothing can happen below the lower bound in the long-run). Whereas, the two-sided error terms ν_i can assume values of both sign and it serves to pick up disequilibria low concentration. Therefore since ν_i is a stochastic component which can take either positive or negative values makes the frontier stochastic. The error term ε_i is a random variable which measures the distance from the bound. Estimation of the upper bound to concentration follows the same logic.

Lower Bound to Concentration

The data set used in this paper has the quite peculiar feature of right censored observations which refer to monopolies. There are 340 limiting observations that need to be excluded for two reasons. First, the theory underlying the lower bound to concentration does not predict monopoly outcomes; as a result, a pattern of data involving monopolies simply does not fit the theory. One theoretical explanation of monopoly outcomes, hence of the relationship between market size and maximal level of concentration is provided by the upper bound theory (Vasconcelos 2006). Second, the exclusion is necessary in order to draw the graph of the stochastic fitted lower bound[14] requiring the majority of observations located above it. The distributions for the one sided error available for stochastic frontier models impose restrictions such that the estimated lower bound is dragged upward; for instance, the half normal distribution requires that much of the observation mass is close to the mode. The truncated normal and exponential distributions are similar to the half normal causing the

[13] It is worth noting that there are no theoretical reasons justifying either these three distributions or any others.

[14] The three distributions used allow observations to be near the bound; therefore, since just over half of observations assume maximal value the distributions used tend, thus, to shift very much upward the lower bound.

same problem. This exclusion may arise concern of sample selection bias. However, excluding the upper bound should not bear any impact on the minimal level of concentration, as the stochastic frontier models just shift down the intercepts and have almost no impact on the slope parameter.

Results for the lower bound estimation are shown below in Tables 1, 2 and 3. The three models produce similar results as they differ solely on their assumption on disturbance terms. The fitted lower bound is presented in Figure 1. The coefficient of market size is statistically significant at 10% level and points to a weak negative relation with structure. Robinson and Chiang (1996, p. 392) observe that the negative impact of market size on concentration in an endogenous sunk costs industry is evidence of the fact that markets have started with a relatively small number of firms; consequently, as market size increases concentration falls approaching the bound limit from below. For each of the three employed distributions the asymptotic HHI[15] as market size tends to infinity is well above zero. This non-fragmentation result appears to rule out the exogenous sunk costs model while pointing to the endogenous sunk costs competitive mechanism.

Table 1 – Lower Bound

Normal/Half normal	
HHI	Coef.
$\boldsymbol{\beta_0}$	-2.104**
	(0.678)
$\boldsymbol{\beta_1}$	32.728*
	(17.798)
$HHI^{\infty} = 0.11$	
(0.081)	
Sample: 321	

*Significance at 10%; **Significance at 5%.
Standard errors in parenthesis.

[15] $HHI^{\infty} = \frac{e^{\beta_0}}{1+e^{\beta_0}}$

Table 2 – Lower Bound

Normal/Truncated normal	
HHI	Coef.
β_0	-1.810**
	(0.646)
β_1	30.219*
	(16.897)
$HHI^{\infty} = 0.14$	
(0.102)	
Sample: 321	

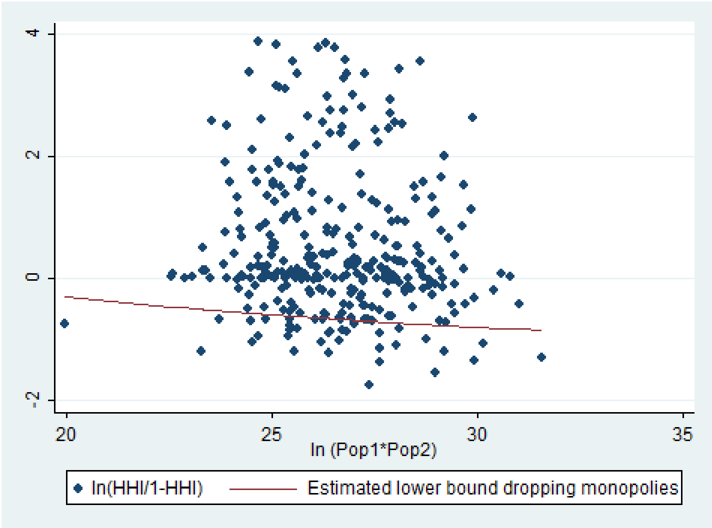
*Significance at 10%; **Significance at 5%.
Standard errors in parenthesis.

Table 3 – Lower Bound

Normal/Exponential	
HHI	Coef.
β_0	-1.748**
	(0.636)
β_1	29.676*
	(16.723)
$HHI^{\infty} = 0.15$	
(0.080)	
Sample: 321	

*Significance at 10%; **Significance at 5%.
Standard error in parenthesis.

Figure 1 – Lower Bound



We also perform lower bound regressions using alternative measures of market structure[16] which produce a similar lower bound for C2, while for C1 and C4we obtain evidence of a null relationship between size and structure; that is, coefficient of market size is never significant.

These findings showing that sign and significance of the slope are not stable for all the market structure measures employed are suggestive that the data pattern appears consistent with endogenous sunk costs competitive mechanism.

Upper Bound to Concentration

Vasconcelos' model (2006) provides two empirically testable predictions for endogenous sunk costs industries:

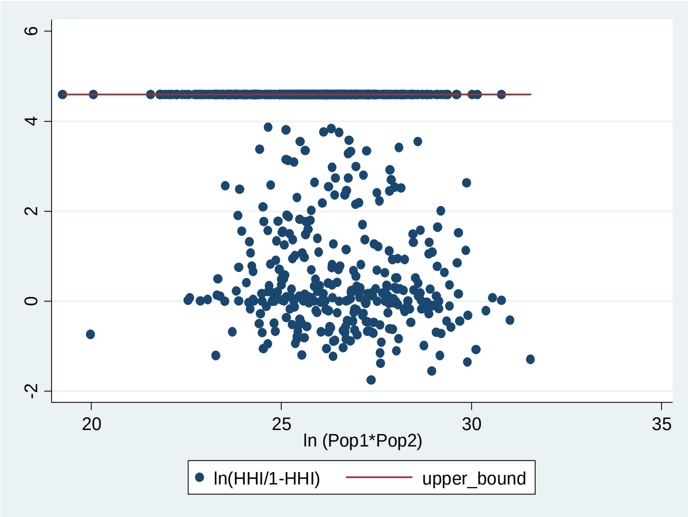
1) There is a high maximum level of concentration (upper bound) even in large markets which does not depend on size;
2) Monopoly can occur in equilibrium regardless of market size.

Empirical evidence lends support on predictions 1) and 2). Figure 2 shows that the maximal level of concentration, given by the estimated upper bound, does not decline as size increases, and monopoly can emerge in equilibrium. The upper bound to concentration is given by an asymptotic Herfindahl level, $HHI^{\infty} = 0.99$ using the model normal/half normal. In fact, in our data set we have 51% of our sample markets which are monopoly[17] lying indeed on our estimated upper bound. However, the result can depend on the choice of which value to set

[16] Concentration ratios C1, C2 and C4.
[17] As monopolies are considered markets with a dominant airline with at least 99% of market shares.

for monopolies (whether the value 0.9 or 0.99, 0.999, 0.9999, etc.). We re-estimate the upper bound setting the value *HHI* = 0.9 for monopoly markets, and we obtain a negative slope for the normal/half normal model while independence between market size and market structure for normal/truncated normal and normal/exponential models. This empirical evidence, therefore, supports Vasconcelos (2006) predictions about endogenous sunk costs industries.

Figure 2 – Upper Bound



A model of Bertrand competition with homogeneous products and fixed costs of entry would produce monopoly equilibrium outcomes. As a result, the upper bound to concentration could be explained alternatively by such model of Bertrand competition for homogenous products, where vertical product differentiation plays no role. The Nash equilibrium in the entry stage would be to enter if and only if no other rival has entered. Indeed, if more than one firm enters, then the usual Bertrand argument will lead to losses equal to the fixed cost of entry. The anticipation of this will suffice to get market structure equilibrium with only one firm charging the monopoly price. However, the result found earlier of a positive and substantially high lower bound to concentration as market size increases suggests vertical product differentiation. As a result, the maximal level of concentration coinciding with monopoly equilibria regardless of market size appears to be consistent with the empirical prediction of the upper bound theory.

Natural Oligopoly

Now our objective is to provide evidence that structure of this industry is best explained by the natural oligopoly theory developed by Shaked and Sutton (1983).The Shaked and

Sutton's early paper develops a necessary and sufficient condition for the *finiteness property*. The finiteness property states that there exists, for an interval of qualities $[\underline{u}, \overline{u}]$, a Nash equilibrium constituted by an upper bound to the number of single product firms with positive market shares charging price above marginal cost. Price competition drives down prices such that even the poorest consumer will not buy low quality products. The condition necessary and sufficient for existence of the finiteness property relies on the fact that there need to be no consumer indifferent between alternative products; consequently, all consumers agree in ranking the qualities in exactly the same order.

The finiteness property is more likely to be present in those vertically product differentiated industries where quality is enhanced through fixed costs; whereas, variable costs remain constant or increase very modestly or even decrease as quality rises.

Table 4 provides information on number of structures, in terms of firm numbers, the dataset contains. We note that the majority, 93%, of markets have at most four firms.

Table 4 – Number of airlines across routes

Relevant N	**#Markets**	**Percent**	**Cum.**
1	340	51.44	51.44
2	159	24.05	75.49
3	82	12.41	87.9
4	37	5.6	93.49
5	20	3.03	96.52
6	15	2.27	98.79
7	3	0.45	99.24
8	3	0.45	99.7
9	2	0.3	100
Total	**661**	**100**	

Table 5 provides some further descriptive facts on structure. We can note various facts i) that a large majority (84% with a share of at least 90% for the two biggest) of airline markets are dominated by at most two firms; ii) for markets with at least two firms the first largest firm is on average almost three times bigger than the second largest; iii) the Herfindahl-Hirshman index is on average extremely high; and iv) market share asymmetry for markets with at least two firms, measured by coefficient of variation (CV), is not high on average.

Table 5 – Market Shares and Concentration

Market shares (s1=first largest, s2= second largest)	# Markets	Mean	Std. Dev.	Min	Max
s1	321	0.673	0.213	0.207	1
s2	321	0.238	0.153	0	0.499
s1+s2	661	0.956	0.097	0.385	1
s1+s2≥ 0.9	557	0.993	0.017	0.901	1
s1+s2≥ 0.7	635	0.971	0.065	0.701	1
HHI	661	0.792	0.249	0.147	1
CV	321	0.672	0.370	0.001	1.928
N	661	1.974	1.387	1	9

Given the market structure of our sample, firm numbers and market share asymmetry can be shown by a simple geometric device, the oligopoly triangle (Davies, Olczak and Coles (2011)). It provides a clear representation of structural features of markets in terms of concentration and asymmetries. Figure 3 depicts the oligopoly triangle with S2 (second largest airline) on the horizontal axis and S1 (largest airline) on the vertical axis. The concentration in the triangle is given by the sum of top two firms in each market (S1+S2). Moving toward North-West we find high concentration and extremely pronounced asymmetries up to the North-west vertex of the triangle which identifies monopoly; whilst, moving from the North-West vertex toward South-East along the edge we have markets less asymmetric up to the South-East vertex which represents symmetric duopoly. Also, starting from monopoly and moving down toward South we find markets with lower concentration and greater symmetry up to the south vertex representing a perfectly symmetric triopoly. The vast majority of airline markets of our sample are fitted into the small triangle delimited by the above described vertices. In addition, most of those markets inside the small triangle show very high concentration and strong market share asymmetry. Relatively few markets lie outside our small triangle, showing smaller concentration and smaller size asymmetry moving down toward south nearer to the forty-five degree line. These city pair markets appear to have a fairly sizeable fringe. In addition, all markets with three or fewer airlines must be inside the small triangle, but the reverse is not necessarily true. In other words, some markets with more than three firms may lie inside the small triangle[18].

[18] Davies, Olczak and Coles (2011) develop and characterize fully the oligopoly triangle and its properties.

Figure 3 – Oligopoly Triangle

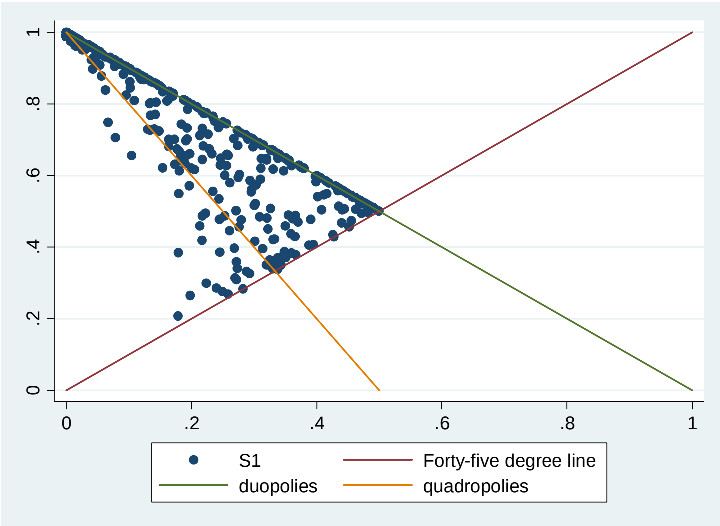


Figure 4 – Duopoly Triangle

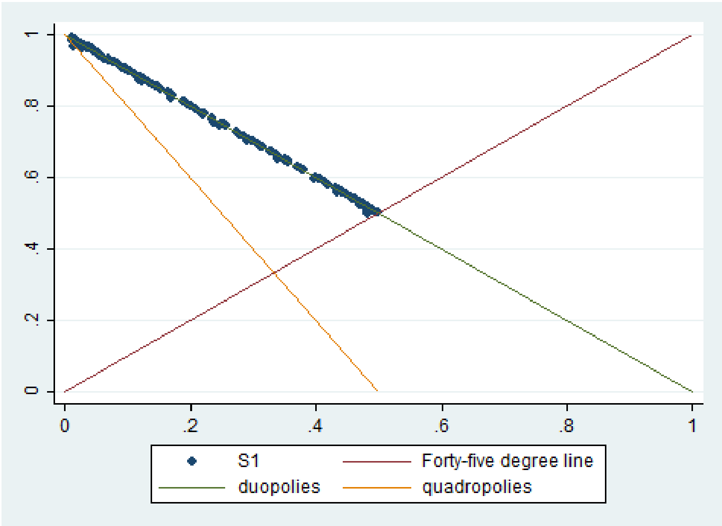


Figure 5 – Triopoly Triangle

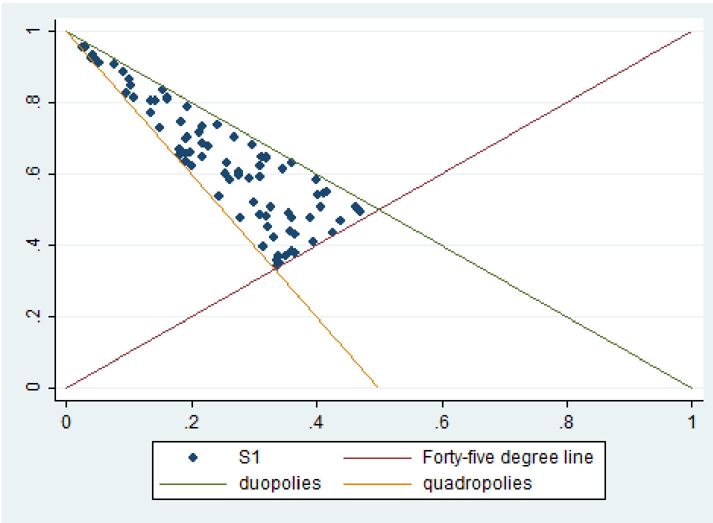
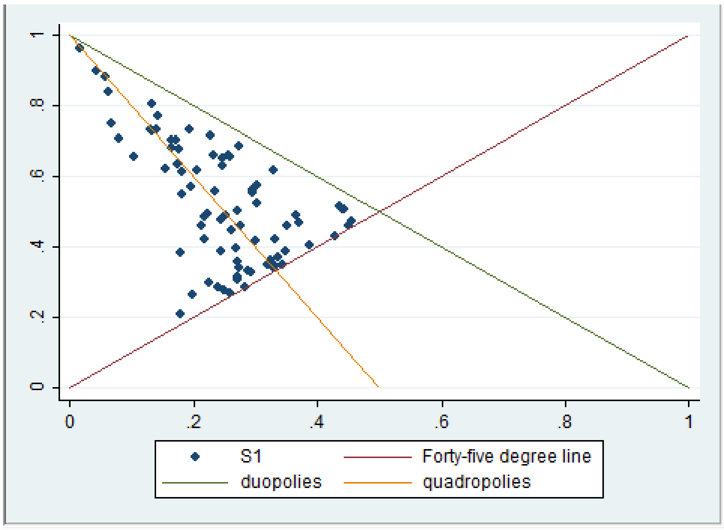


Figure 6 – Oligopoly Triangle for more than 3 firms



Figures 4-6[19] depict the triangle for different market structures. First, we note that among the 159 duopolies we find, at one extreme, those with one dominant firm accounting for the majority of shares; while at the other extreme, we observe those duopolies that are, more or less, symmetric; in between, our sample includes genuine, but still, rather asymmetric duopolies. The triopoly triangle, along as a limited number of symmetric triopolies, shows many markets with considerable market share asymmetries. Also, there are triopolies dominated by one very big firm. Finally, figure 6 proposes the triangle for the 80 oligopolies with more than three firms. All markets inside the triangle are dominated by at most two firms; thus, having small third and following firms. In contrast, below the triangle we envisage around 30 markets with more than two leading airlines; these are mainly triopolies and few quadropolies.

[19] In Figures 3-6 the diamond in the legend actually correspond to a point (S1, S2).

We can derive the following stylized facts:

FACT 1: from Table 4 we learn that just above half of our observations consist of monopoly routes.

FACT 2: from the oligopoly triangles we infer considerable market share asymmetries.

FACT 3: Table 4 also suggests that duopolies account for nearly one-quarter, and triopolies represent a further 12% of the sample (eighty-two markets).

FACT 4: Table 4 finally says that markets with more than four firms represent a rather negligible portion of our sample, approximately 6%.

FACT 5: of the 159 duopolies, 88 have the largest firm[20] with over three-quarter of market shares, that is, $s1 > 0.75$; then 33 are characterized by $0.6 < s1 < 0.75$; whilst, for the remaining 38 duopolies we have $s1 \leq 0.6$, constituting fairly symmetric duopolies.

FACT 6: 80% of the triopolies (66 markets) have a quite tiny third firm with a market shares up to 20%; for the remaining triopolies, 16 city pairs, the third airline has market shares sandwiched between 32% and 20%.

FACT 7: from Tables 6 below, we infer that among the 80 markets with four or more firms solely two (those highlighted in bold) have the first two largest firms possessing a combined share lower than 50%.

These facts lead to one analytical result: inspecting Table 6 below, given Figures 3-6 above, using Facts 5-7, and given Figures 1-2 we deduce that the number of dominant airlines, those taking up the majority of market shares, is between 1 and 3 irrespective of market size. This indeed suggests that the industry is a natural oligopoly.

[20] We denote with s_i the market shares of firm i-th.

Table 6 – C2 across oligopoly routes

Oligopolies	C2 range
Quadropolies	0.67-0.98
5 Firm markets	0.53-0.94
6 Firm markets	0.52-0.87
7 Firm markets	**0.46**-0.67
8 Firm markets	0.53-0.82
9 Firm markets	**0.39**-0.78

2.5 Discussion

Results of this paper paint a picture about the underlying competitive process at work in the airline industry. These results also help to identify those competition models that are and those which are not appropriate as candidate explanations of market structure and firms' conduct about the airline industry.

Models of competition with homogenous products and exogenous fixed sunk costs (Sutton 1991) are excluded in explaining the industrial organization of the airline industry, since fragmentation must occur. A fragmentation result is predicted also for horizontally differentiated industries with single-product firms and simultaneous entry (Shaked and Sutton 1990), contrasting therefore our finding. Models with either competition on a line, Hotelling (1929), D'Aspremont, Gabszewicz and Thisse (1979), or on a circle, Salop (1979) are not appropriate for two reasons: i) the airline industry is multi-product and more importantly ii) because a larger market size leaves room for a greater number of firms to enter in the market, and therefore concentration would be low, which here clearly it is not.

The finding of a lower bound to concentration not converging to zero when market size grows is inconsistent even with competition models of vertical differentiated products where quality investments are sustained by an escalation of variable costs, which gives rise to an increase of marginal costs. That context is identified, for example, by the restaurant industry. Indeed, Berry and Waldfogel (2010) finds that this industry fragments as market size grows and restaurant firms provide distinct products in terms of quality. Clearly, serving better food (so higher quality) implies investments in variable costs.

The empirical findings of non-fragmentation and existence of an upper bound to concentration invariant to market size are suggestive of evidence that structure and behaviour of our industry is best explained by a model of endogenous sunk costs (Sutton 1991; Vasconcelos 2006), and by the early vertical product differentiation literature (Gabszewicz and Thisse 1979, 1980; Shaked and Sutton 1982, 1983). This strand of vertical differentiation literature is characterized by the idea that quality is improved through fixed sunk outlays, and variable costs either remain constant or increase modestly (‘*the increase of unit variable cost is strictly less than the marginal valuation of the richest consumer’*, Shaked and Sutton 1987, p. 136). High concentration is also proved in a theoretical framework combining vertical and horizontal product differentiation (Shaked and Sutton 1987), which is consistent with our results of concentrated equilibria.

In addition to the endogenous sunk costs model, the finding of maximal level of concentration constant at any size is supported by a class of models encompassing horizontal product differentiation: i) theoretical models of multiproduct firms entering sequentially, therefore filling all profitable niches by product proliferation (Schmalensee 1978); ii) of monopolist’s location choice (Bonanno 1987); iii) explanations of local monopolies (Prescott and Visscher 1977, Eaton and Lipsey 1979 and Reynolds 1987).

One of endogenous sunk costs sources in our industry, route structure, may be interpreted as investments in extra capacity with the goal to deter entry. In fact, airlines increasing the number of routes serviced from endpoints of a city pair are potentially prepared to supply bigger output (more routes may imply more flights hence more passenger miles travelled). Therefore, our results of high concentration are also consistent with the class of models involving capacity investment decisions to deter entry (Spence 1977, 1979; Dixit 1979, 1980; Bulow, Geanakopolos and Klemperer 1985).

Along as the results of non-fragmentation and monopoly at any size, we find evidence of a further prediction of the endogenous sunk costs model: natural oligopoly. Indeed, we find that dominant firms range between one and three in each market, regardless of market size. This result further suggests evidence consistent with vertical product differentiation where quality is improved with escalation of sunk costs: advertising and route structure. The findings of non-fragmentation and natural oligopoly are obtained also by Ellickson (2007) for the U.S. supermarket industry.

2.6 Conclusion

In this paper we present empirical evidence of the size-structure relationship using the Sutton's framework (1983, 1991) and the complementary theory by Vasconcelos (2006). Three main results of the ESC model are reached: i) non-fragmentation - evidence of a lower bound to concentration with asymptotic concentration level well away from zero; ii) evidence of an upper bound to concentration regardless of size, hence arbitrarily high concentration including monopoly can be sustained as equilibrium even in large city pair markets; iii)using the full set of firms we find that irrespective of market size the number of dominant firms ranges between one and three, suggesting that the structure of the airline industry mirrors a natural oligopoly. Overall, the results of this paper suggests that models of airline competition entailing homogeneous products and assumptions of horizontal product differentiation are not the best or at least the most complete representation of this industry.

CHAPTER 3

FIRM NUMBERS, MARKET SHARE ASYMMETRY AND COMPETITION BETWEEN DIFFERENT TYPES OF FIRMS

***Abstract**: This paper deduces the nature of competition from empirically analysing firm numbers and market share asymmetry, as well as the competitive effects between different types of firms. Using a novel data set for a large cross-section sample of city pair markets, we extend the literature on market structure in various ways. First, we complement the bounds approach by investigating structure above the lower bound, and then unlike previous literature on empirical models of market structure and entry we study determinants of size inequalities, which can reveal about the competitive process as much as it is concealed when looking just at number of firms and firm's entry decision. The literature on empirical market structure is also extended by analysing nature of competition between different types of firms.*

3.1 Introduction

The study of industrial market structure has always been one of major topics of interest among industrial organization economists since Bain (1956). In fact, it is well known that by studying market structure we can draw inferences about the underlying competitive process about a specific industry. This is not just of academic interest, but it also bears substantial relevance for antitrust policy.

The objective of this paper is twofold. First, we study the determinants of firm numbers and market share asymmetry in the U.S. airline industry for a cross section sample of 661 city pair markets. The reason for analysing separately number of firms and market shares asymmetries relies on the issue that, studying market share asymmetries of individual firms may uncover information on the underlying competitive process which may remain concealed when looking just at firm numbers. Our second objective is to analyse competitive effects of two types of airlines in terms of their route structure, leaders and non-leaders.

In the previous Chapter we applied the bounds approach to market structure, providing evidence on various predictions of the ESC model. In this paper we continue the theme of studying concentration, again with the aim to deduce information on the competitive mechanisms at work; but, this time, we use an approach in the spirit of Bresnahan and Reiss's (1991) work. The methodology of this Chapter complements the analysis performed in

Chapter 2 by analysing concentration above the lower bound and below the upper bound. A main difference between this Chapter and the previous one, is that here we use econometric techniques which provide a fit to the scatter of data points, hence an average relationship between the variables of interest rather than estimating frontiers. Under an economic point of view, the analysis performed below enriches the bounds approach for means of describing how different market characteristics affect firm numbers and market share asymmetry and, more importantly, investigating competitive effects between different types of firms. Furthermore, while in the bounds approach symmetric firms equilibria are involved, in this chapter we attempt to explain firms' market share asymmetries.

We attempt to explain the number of firms in each city pair by ordered probit models, using a vector of covariates representing market characteristics. We find strong evidence of a positive relationship between market size and firm numbers, as well as of more fragmentation in large hub city pairs; in contrast, route markets with a longer distance between end points show substantial evidence of fewer firms.

We then proceed to analyse market shares asymmetries of individual firms across our sample of markets. We find evidence that market size is irrelevant; whilst, in large hub routes airlines have greater firm size inequality. In city pairs with longer distance there is strong evidence of less pronounced firms' market share asymmetry. In addition, routes with identities of leaders show evidence of more pronounced asymmetry in market shares.

Finally, we perform an empirical analysis of competitive interactions between two groups of airlines we identify in the dataset, leaders and non-leaders. Surprisingly, we find strong evidence that both number and identities of leading airlines affect positively the number of non-leaders in each route market. The empirical evidence appears to point to learning; non-leaders infer profitability of routes by the presence of leaders.

The remaining of the paper is organized as follows. Section 2 reviews related literature. Section 3 introduces some features of data. Section 4 provides formal empirical analysis of firm numbers and market share asymmetry. Section 5 studies empirically the nature of competition between leader airlines and non-leaders. Section 6 discusses main results. Finally Section 7 concludes.

3.2 Related Literature

This paper investigates the nature of competitive process inferred by analysing market structure in the U.S. airline industry. In the previous chapter we applied the endogenous sunk costs model (ESC).A well acknowledged limitation of the bounds approach is that all what the econometric evidence is about is solely an estimation of the *lower bound* and of the *upper bound* to all possible market structures admissible. Indeed, the theory is consistent with multiple equilibria. Our paper complements the literature by investigating market structure between the two bounds to concentration.

A parallel strand of literature to which this paper is related, refers to empirical models of market structure based on specific oligopoly theories tailored to the industry study in hand. Recent applications involve the video rental industry (Seim 2006), health care professions in Belgium (Shaumans and Verboven 2008), supermarkets (Cleeren, Verboven, Dekimpe, and Gielens 2010) and the UK burger industry (Toivanen and Waterson 2005)[21]. However just as the literature on the bounds approach, this empirical literature about entry and market structure explains the number of firms or firm's individual entry decisions, neglecting to account for firm size inequalities. Our paper attempts to fill this gap in uncovering information on the competitive process concealed when investigating firm numbers solely. Under this latter aspect, our paper is modestly related to the time-series literature on size distribution[22] which, part of it, is centred on the Gibrat's Law[23] (Gibrat 1931) by which firm growth rate follows a random walk; that is, firm growth rate is independent of its initial size and their size distribution conforms to skewed Yule distribution.

[21] Bresnahan and Reiss (1991), using ordered probit models, construct the novel concept of *entry thresholds* which relates the equilibrium number of firms to market size (measured by population); the estimated entry thresholds tell how much population is needed to support a given number of firms. Bresnahan and Reiss estimate also the *entry threshold ratios* which are ratios of per-firm market sizes; if this ratio is above one it means that entry increases competition. They find that the level of competition changes quickly as the number of firms increases, as well as most of competitive effect of entry is exhausted with the second or third entrant. Moreover, the literature has focused more explicitly on entry by solving the difficult problem of firm heterogeneity (Berry 1992 who used a simulated method of moments estimator proposed by McFadden (1989) and Pakes and Pollard (1989)). Other contributions extend the Bresnahan and Reiss's (1991) framework in allowing different types of firms (e.g. Mazzeo (2002) endogenizes product choice decisions for motels of high and low quality in Western U.S.). In addition, Berry and Waldfogel (1999) estimate the social inefficiency caused by free entry in radio broadcasting.

[22] See the large literature of stochastic models of firm's growth; examples are Hart and Prais (1956), Simon and Bonini (1958), Ijiri and Simon (1964, 1977), Jovanovic (1982), Davies and Lyons (1982), Davies and Geroski (1997), Sutton (1998).

[23] For surveys and discussions of the Gibrat's Law, see, for example, Curry and George (1983), Hall (1987), Davies (1988), Geroski and Machin (1992).

3.3 Data[24]

The variables used in the empirical analysis are:

- *Coefficient of variation of market shares, CV*. This represents the ratio of the standard deviation to the mean. In addition, for each city pair the Herfindahl and *CV* are linked by the following formula[25]:

$$CV = \sqrt{N \cdot HHI - 1}$$

  N stands for the number of firms operating in a given route.
- *Market size*. As in the previous chapter, market size is defined as the product of population of the two end point cities for each city pair. It is expressed in thousands of billions.
- *Distance*. This picks up costs and gives number of kilometres between end points of each city pair. It is expressed in thousands of kms.
- *Tourist dummy*. A dummy equal to 1 for all markets with at least one end point city located either in California or Florida, plus other two locations, Aspen and Colorado Springs.
- *Two hubs*. This is a dummy for routes having large hubs at both endpoints.
- *One hub*. A dummy for city pair markets containing one endpoint as large hub is introduced in the empirical models.
- *One dummy for each of the seven leader airlines*. These are American, Delta Airlines, Southwest, Continental, US Airways, United Airlines and Northwest. These leading airlines are identified as those who service the greater number of routes.
- *Number of leaders*. This identifies how many of the seven leaders operate in each city pair market.
- *Number of non-leaders*: Number of non-leading airlines in each route.

3.4 Firm Numbers and Market Share Asymmetry: Empirical Results

In this Section, we provide an econometric analysis of concentration in attempting to explain the variation of firm numbers and market shares asymmetries across our sample of city pair

[24] For more details upon the data set and the measurement of variables, we refer the reader to chapter 0.

[25] Following De (2010), we can derive the formula for *CV* directly from the Herfindahl-Hirshman index, $HHI = \frac{1}{N} + N * \sigma^2$. Now $N * \sigma^2$ can be written as $\frac{\sigma^2}{N/N^2} \Rightarrow \frac{\sigma^2}{\left(\frac{1}{N^2}\right) * N}$; replacing $\frac{1}{N^2}$ by μ^2 we obtain $\frac{\sigma^2}{\mu^2 * N}$, so, $HHI = \frac{1}{N} + \frac{\sigma^2}{\mu^2 * N} \Rightarrow HHI = \frac{1}{N} + CV^2 * \frac{1}{N} \Rightarrow HHI = \frac{CV^2+1}{N} \Rightarrow CV = \sqrt{N * HHI - 1}$.

markets located above the lower bound and below the upper bound estimated in the previous chapter.

Firm Numbers

To explain the first component of concentration, number of firms, we set out a very simple two-stage game, where in the first stage firms “enter” or “stay out” while in the second the entered firms play some competition game that determines post-entry profits. The number of firms present in a market is assumed to be an indicator of underlying market profitability. We specify a reduced form latent profit function for the total number of firms in market m:

$$\pi_m = X_m\beta + \varepsilon_m \qquad (1)$$

Where X is a vector of market characteristics, β is a vector of parameters to be estimated, and $\varepsilon \sim \Phi(0,1)$ is the stochastic component of profits i.i.d. as standard normal. A main assumption we make is that all firms within a route market do not have unobserved heterogeneity; in other words, the stochastic component of profits in each market is common to all firms. In addition, in our analysis we do not include firms’ characteristics, therefore, implying also no observed firm heterogeneity[26].

This simple theoretic structure leads to the use of ordered probit models where the “observable” dependent variable is the number of airlines observed in each city pair market.

Results about the number of firms regressed against a vector of market characteristics are shown in Table 1. There is evidence that market size’s coefficient is significant at one per cent level and positive, therefore bigger markets, on average, have more firms; distance brings evidence of being strongly significant and negative in sign; tourist is not significant, while large hub routes show strong evidence of a greater number of firms.

[26] In the next section we analyse competitive effects of different types of firms.

Table 1 – Determinants of firm numbers

N	Coef.
Market Size	0.038***
	(0.013)
Distance	-0.451***
	(0.052)
Tourist	-0.017
	(0.100)
Two-hubs	1.131***
	(0.145)
One-hub	0.434***
	(0.109)
Observations: 661	
Pseudo $R^2 = 0.086$	
Log likelihood = -823.83183	

***Significance at 1%.

Fewer firms in city pairs of greater length may be explained by the fact that, to operate in a longer route requires higher costs (e.g. fuel).

Regarding the three dummies, *Tourist*, *Two hub* and *One hub*, more than one effect can be at work. First, there can be a size effect; tourist and large hub markets may have size which could not be represented by just the product of populations of end point cities, therefore these dummies control for possible bias of our market size measure. In addition, in these markets the nature of competition may differ. In particular, tourist markets may be characterized by tougher price competition since demand can be much more elastic, making price undercutting more profitable. These two effects determine coefficient's sign in opposite directions. A positive coefficient would signal evidence that the size effect prevails on that of more intense price competition; whereas, a negative sign would suggest evidence that the competitive effect dominates the size effect. In large hub markets the nature of competition may lead a priori to either fiercer or softer competition. Previous literature tend to suggest that competition may well be limited in hub city pairs (Borenstein and Rose 2008 provides a good review); however, there may be the case that dominant firms running the hub need to compete fiercely in order to maintain and consolidate their leadership (e.g. Etro 2006). Consequently, the expected coefficient' sign for large hub markets is indeterminate.

Our reduced form econometric model for explaining firm numbers cannot disentangle whether the positive coefficients for large hubs are caused solely by size effects, or also a different nature of the competitive process is at work; in contrast, the model for market share asymmetry, presented below, does.

Market Share Asymmetry

The considerable asymmetry within oligopolies found in Chapter 2 deserves formal analysis. Our dependent variable is the coefficient of variation of market shares, taking into account the full set of firms in our dataset.

Clearly, monopoly city pairs produce a coefficient of variation equal to zero. Given the large fraction of monopolies in our sample (just over 50%), the distribution of our dependent variable appears to be censored; as a result, it calls for the need to apply Tobit estimation. However, the Tobit method is not valid under assumptions of non-normality; producing, in fact, not consistent estimates when distribution of data for the dependent variable is not normal. The Shapiro-Wilk test for normality (Shapiro and Wilk 1965) suggests rejecting the null hypothesis of normal distribution; consequently, we cannot apply Tobit technique.

An econometric estimator which is consistent and asymptotic normal is the censored least absolute deviations estimator (CLAD) (Powell 1984). Essentially, the method generalizes the quantile regression (least absolute deviations, LAD) for censored data. In addition, CLAD proves robust to heteroscedasticity; indeed, the standard errors are estimated by bootstrap techniques.

Results are reported in Table 2. Route markets with longer distance appear to be more symmetric with significance at 1% level; whereas, the large hub dummies have evidence of positive coefficients, thus of larger market share asymmetries. Market size and the tourist dummy bring evidence of bearing no effect.

The distance variable proxies costs, essentially due to fuel, which are the same for all airlines within a market, it attenuates firm size inequality; as a consequence, routes with longer distance indicates an equal increase of costs for all the firms, then bringing down market share asymmetry.

City pairs with greater traffic flow, large hub routes identified by the two dummies two-hub and one-hub, show evidence of more pronounced market share asymmetry. Intuition and theoretical literature suggest that higher firm size inequality may signal tougher product-market competition. For leading firms running the hub our estimates suggest findings consistent with theories of aggressive leadership (Etro 2006). In addition, suppose a vertical differentiated products oligopoly in the sense of Shaked and Sutton (1982). If firms compete a' la Bertrand, the higher quality firm will get most of the market; whereas, in case of Cournot competition, the higher quality firm will obtain bigger market shares but not as much as in the Bertrand case. Supposing collusive conduct, we do not know exactly but generally the firms might split the market fifty/fifty. Moreover, the theoretical literature on collusion (e.g. Tirole 1988) and, empirical evidence on cartels seem to point out that coordinated strategies are harder to sustain when firms are less symmetric in terms of market shares (e.g. Davies, Olczak and Coles 2011).

The set of dummies for identities of leaders have all statistically significant coefficients except that of Southwest, and positive in sign. Therefore, we have evidence of greater market share asymmetry when one leader is present. The strongest effect on size inequalities appear to be that of US Airways, which has the biggest coefficient. Following the argument, as set above, of interpreting bigger size inequalities as signal of more intense product market competition, we can infer that each leader, surprisingly except the low-cost airline Southwest, contributes to intensify product market competition.

Our proposed interpretation of results may be challenged by the following counter argument. A positive coefficient for the leading airlines may reveal a first mover, reputation or brand loyalty leader role. However, leader firms need to gain some sort of competitive advantages in order to be first movers, or to build a reputation for instance for means of supplying better quality (e.g. on-time flights, wide route structure) or charging lower fares, or developing brand loyalty. These arguments are then assimilated to tougher product market competition; leading firms in order to consolidate and improve their leadership role as first movers, or for brand loyalty or reputational reasons, need to compete fiercely and this is consistent with the strategy of top dog (Etro 2006).

Table 2 – Determinants of market share asymmetry

Coefficient of Variation	**Coef.**
Constant	-0.176
	(0.149)
Market Size	0.013
	(0.019)
Distance	-0.198***
	(0.054)
Tourist	-0.024
	(0.094)
Two-hubs	0.428***
	(0.140)
One-hub	0.329***
	(0.131)
American	0.234***
	(0.088)
Delta Airlines	0.377***
	(0.106)
Southwest	0.117
	(0.093)
Continental	0.442***
	(0.104)
US Airways	0.552***
	(0.107)
United Airlines	0.321***
	(0.122)
Northwest	0.412***
	(0.121)

Initial sample: 661

Final sample: 340

Pseudo R^2 = 0.1663

***Significance at 1%; robust standard errors in parenthesis.

3.5 Competitive Effects between Leaders and non-Leader airlines

This Section asks the question: what is the competitive effect, hence nature of competition, between leaders and non-leader airlines? We assume that firms enter sequentially, where the most profitable move first. We argue that the leaders, having a wide route structure, are more profitable[27] hence enter first. We employ ordered probit models using as dependent variables the number of non-leading airlines observed in city pair markets; among the covariates we include the number of the leaders. We also control for a vector of market characteristics, the same used in the previous section.

Table 3 below shows results about the impact of number of leading airlines on non-leaders. The analysis is restricted to those city pair markets with at least one leader because of our interest in assessing non-leaders market structure when at least one leader is already in the market. Market size and large one-hub bring evidence of being not significant. Distance appears to have a highly significant negative relationship with number of non-leaders. There is evidence that in tourist and in large two-hub markets the number of non-leaders is greater. Our variable of greatest interest here is the number of leaders. We note strong evidence that as the number of leaders increases so the number of non-leaders does.

[27] Borenstein and Rose (2008) reviews a literature which argues in part that running a hub and spoke network bears demand and costs advantages. See also Levine (1987).

Table 3 – (Ordered Probit) Effect of number of leaders

N of non-Leaders	Coef.
Market Size	0.002
	(0.015)
Distance	-0.238***
	(0.066)
Tourist	0.258**
	(0.124)
Two-hubs	0.320*
	(0.177)
One-hub	-0.059
	(0.137)
N of Leaders	0.246***
	(0.053)
Observations: 553	
Pseudo R^2 =0.0695	
Log likelihood = -427.64902	

*Significance at 10%**Significance at 5%; ***Significance at 1%.

The positive relationship we have found bears the question whether using identities of leaders confirms the results; in addition, we can explore whether specific leaders affect differently the number of non-leaders. In other words, the leaders may offer different quality among themselves, therefore there may be differences of vertical product differentiation among the group of leading airlines (e.g. some may engage in greater investments in advertising and for expanding route structure). Clearly, the analysis continues to be restricted to those city pairs with at least one leader.

Table 4 reports the impact of the identities of the leaders; it shows that only the airlines American, Delta and US Airways have evidence of statistically significant coefficients. The evidence of a positive coefficient suggests that the number of non-leaders is bigger in routes where these three leaders operate.

Table 4 – (Ordered Probit) Impact of identities of leaders

Number of non-leaders	Coef.
Market Size	0.003
	(0.015)
Distance	-0.332***
	(0.065)
Tourist	0.107
	(0.127)
Two-hubs	0.287
	(0.182)
One-hub	-0.046
	(0.137)
American	0.448***
	(0.130)
Delta Airlines	0.354**
	(0.145)
Southwest	0.162
	(0.144)
Continental	0.009
	(0.161)
US Airways	0.526***
	(0.161)
United Airlines	0.252
	(0.176)
Northwest	-0.084
	(0.190)
Observations: 553	
Pseudo R^2= 0.0738	
Log likelihood = -425.66592	

**Significance at 5%; ***Significance at 1%.

To explore leader heterogeneity, we compare results shown in Table 4 with a series of regressions reporting each leader in turn. Each dummy takes the value of one when the leader, say American, is present and of zero when one or more of the other six leaders are present. The logic is to ascertain if and at what extent the leading airlines differ among themselves in affecting the number of non-leaders. We report results of only those two regressions regarding American and US Airways that have statistically significant coefficients. Tables 5-6 provide results which broadly confirm those of Table 4. To conclude, the two leaders, American and US Airways, appear to have an additional effect on the number of non-leaders compared to the other leading airlines.

Table 5 – (Ordered Probit) Impact of American

Number of non-leaders	Coef.
Market Size	0.010
	(0.015)
Distance	-0.339***
	(0.064)
Tourist	0.179
	(0.122)
Two-hub	0.496**
	(0.171)
One-hub	0.022
	(0.135)
American	0.340***
	(0.124)
Observations: 553	
Pseudo $R^2 = 0.0543$	
Log likelihood = -434.63653	

**Significance at 5%; ***Significance at 1%.

Table 6 – (Ordered Probit) Impact of US Airways

Number of non-leaders	Coef.
Market Size	0.017
	(0.015)
Distance	-0.313***
	(0.063)
Tourist	0.194
	(0.123)
Two-hub	0.442**
	(0.174)
One-hub	-0.002
	(0.136)
US Airways	0.421***
	(0.155)
Observations: 553	
Pseudo R^2 = 0.0541	
Log likelihood = -434.72525	

**Significance at 5%; ***Significance at 1%.

The results documented in Tables 3-6 are, somewhat, not explainable by traditional theories of oligopoly competition. In fact, what we would expect is a negative effect of the number of leaders and their identities upon the number of non-leaders. This is because a firm choosing to enter in either a monopolistic market or into a duopolistic one will choose the former. In contrast, theories of learning (e.g. Baum, Li and Usher 2000; Caplin and Leahy 1998) provide a theoretical rationale for firms learning size and profitability of markets for means of observing rivals' decisions of entry and operation. In particular, Caplin and Leahy propose a formal model to capturing an information externality. This externality refers to the fact that firms assess demand and profitability of a market through waiting and observing for success (or failure) of rivals entering that market. Therefore, presence of the leaders in airline city pair markets may signal good profitability, thus, encouraging entry by small non-leader airlines.

Clearly, our analysis being in cross section does not really pick up dynamics, hence learning effects. However, the evidence seems consistent with the possibility of a learning process which would reflect the snapshot we observe. In addition, one may interpret the results as follow: some of the leaders create an environment in which fringe airlines thrive, while others do not. This interpretation would misunderstand the results. The main message is provided by estimates reported in Table 3, whereas number of leaders increases so the number of non-leaders (hence non-leaders' profits) does; whereas, in Tables 4-6 it is explored leader heterogeneity, that is, if some leaders are different in affecting non-leaders' profits (hence their number) and we obtain evidence that some leaders have an additional effect of non-leaders entry compared to other leaders, which is not to say that some leaders provide an environment in which non-leaders can prosper, while others do not.

Robustness checks. We re-estimate our ordered probit models inserting the market characteristic variables also in non-linear way (square and natural log) under the reasoning that possible nonlinearities may bias the coefficients of the market structure variables. In addition, we exclude the market characteristic with insignificant coefficients. Finally, we try different econometric techniques, OLS and Poisson model. The results of our market structure variables are nearly the same as those in the baseline specifications[28].

Alternative Hypotheses

The results of Section 5 seem consistent with evidence of learning. Airlines infer size and profitability of routes from presence of other carriers' type; in particular, American and US Airways appear to perpetrate an additional positive effect on the number of non-leaders. Now, we discuss potential alternative explanations to these findings, succeeding to rule out all of them.

A) Mature Industry

Our reading and interpretation of the results of this section may be subjected to criticism. Size and profitability of airline city pair markets should be well known as full deregulation took place in late seventies; therefore, the learning argument in our context may be flawed. However, the airline industry is subjected to extremely high demand volatility and

[28] The results of our robustness checks are reported in an appendix at the end of this chapter.

uncertainty (e.g. Borenstein and Rose 2008); consequently, this high degree of uncertainty may warrant learning behaviour even in this mature industry.

B) Crowd Externality

The same phenomenon may be explained by a theory of crowd externality, Rauch (1993). The author formalizes the idea that later entrants benefit from a crowd made by two or more incumbents; the intuition is that there may be positive spillovers among firms caused by economies of agglomeration. However, it is unlikely, in the airline industry, to get a story consistent with the crowd externality involving economies of agglomeration among airlines operating on a route. Actually, we may well obtain a negative crowd externality because of delays and congestion costs which can reduce demand.

C) Competition head-to-head

Consider that in Chapter 2 we provide evidence that airlines engage in endogenous sunk costs escalation in advertising and in expanding route structure. A direct implication of the endogenous sunk costs model is that firms compete head-to-head. This is because, any firm vis-à-vis rivals can carve out a fraction of consumers by increasing fixed sunk outlays. Consequently, our results of positive effects of the number of leaders on non-leaders may be explained by competition head-to-head. However, this interpretation is not valid for the non-leaders. Each airline of this group has a fairly tiny route structure; as a result, they do not seem to escalate investments in expanding network of routes from end points of the city pairs. Furthermore, advertising expenditure may be lower than that of leaders. The non-leaders, then, are not incentivized in competition head-to-head as implied by the ESC model. In contrast, given the evidence of data patterns it appears more plausible the interpretation that non-leaders infer market profitability by observing leaders' behaviour, as rationalized by the theories of learning.

D) Strategic Complementarities

Non-leader and leader airlines offer air transport service between end points of city pairs; such competitive environment is characterized by strategic substitutability. However, this type of service can involve strategic complementarity when some non-leaders are regional airlines operating routes on behalf or in partnership with some national leaders. This is, indeed, the case in our dataset; there are 16 non-leaders that are regional airlines with business links with some of the leaders.

In order to account for this strategic complement activity, in the econometric analysis of this section we have excluded the regional carriers with links with the leaders, re-computing the variable number of non-leaders. Consequently, all the results reported in Tables 3-6 are robust to the strategic complementarity effect.

3.6 Discussion

The result of greater size inequalities in large hub city pair markets merits further discussion and clarification. We have already noted earlier that the greater number of firms in large hub routes can be explained by larger market size, or by different competitive conduct, or by a combination of both. Clearly, market share asymmetries may be the result of several factors such as, capacity differences, cost heterogeneity, differences in quality (vertical product differentiation). Our econometric model for size inequalities cannot tell us how many and which of these factors have determined the asymmetry, since data on capacity, costs, or quality measures is hardly available. However, the results on firm size inequality seem to lend support to the hypothesis that product-market competition is tougher in large hub markets (more pronounced asymmetries when the focus on some dimensions of competition is tough). As a consequence, the evidence on asymmetry suggests that the nature of competition changes in large hub routes.

We have found in the previous section the empirical evidence that, markets with a bigger number of leaders show a positive relation with number of non-leaders. These patterns in the data suggest that markets with one firm type receive more entry from rival firm type. The proposed interpretation, as discussed in the previous section, is that of learning. Toivanen and Waterson (2005) provide empirical evidence of learning for the UK counter service burger industry.

3.7 Conclusion

In this paper we present empirical evidence on the determinants and competitive forces generating equilibrium market structure in the U.S. airline industry. The core of the analysis has been to model empirically firm number and market share asymmetry as well as investigating competitive effects between two firm types to deduce the nature of competition beyond the bounds approach applied in the previous chapter.

Main results refer to greater size inequalities for large hub routes as well as for identities of leaders, apart from Southwest, which appears consistent to tougher product market competition for these city pairs. We then empirically analyse competitive interactions between two types of airlines, leaders and non-leaders. The main finding is evidence consistent with learning; non-leaders tend to infer profitability of markets from leaders. In particular, the leaders American, perhaps Delta Airlines, and US Airways seem to have an additional effect in signalling market profitability to non-leader airlines.

The results of this paper paint a detailed portrait of the underlying competitive process at work. To understand, at least under some aspects, competition is of great importance for antitrust authorities, as well as for firms that need to comprehend the competitive environment in order to better interact strategically with rivals. In addition, we feel that our work contributes to the debate (Borenstein and Rose 2008) of how in the airline industry competition works, after more than three decades of deregulation.

Appendix

In Tables 7-8 below we run ordered probit models entering market characteristics in non-linear way.

Table 7

N of non-Leaders	**Coef.**
Market Size	0.030
	(0.043)
Distance	0.955*
	(0.518)
Market Size^2	-0.000
	(0.000)
Distance^2	-0.207**
	(0.089)
Ln Market Size	0.012
	(0.046)
Ln Distance	-0.542**
	(0.257)
Tourist	0.235*
	(0.126)
Two-hubs	0.254
	(0.187)
One-hub	-0.102
	(0.141)
N of Leaders	0.260***
	(0.054)

Observations: 553
Log Likelihood=-423.81996
Pseudo $R^2 = 0.0779$

*Significance at 10%**Significance at 5%; ***Significance at 1%.

Table 8

N of non-Leaders	**Coef.**
Market Size	0.039
	(0.044)
Distance	0.558
	(0.529)
Market Size^2	-0.001
	(0.001)
Distance^2	-0.149
	(0.090)
Ln Market Size	0.027
	(0.046)
Ln Distance	-0.441*
	(0.263)
Tourist	0.095
	(0.128)
Two-hubs	0.169
	(0.197)
One-hub	-0.105
	(0.142)
American	0.405***
	(0.132)
Delta	0.389***
	(0.147)
Southwest	0.133
	(0.146)
Continental	0.038
	(0.163)
US Airways	0.594***
	(0.164)
United Air	0.269
	(0.179)
Northwest	-0.064
	(0.191)
Observations: 553 Log Likelihood= -422.36773 Pseudo $R^2 = 0.0810$	

*Significance at 10%; ***Significance at 1%.

In Tables 9-10 we estimate ordered probit models dropping market characteristics with not significant coefficients.

Table 9

N of non-Leaders	Coef.
Distance	0.989*
	(0.513)
Distance^2	-0.212**
	(0.088)
Ln Distance	-0.551**
	(0.256)
Tourist	0.225*
	(0.125)
Two-hubs	0.382***
	(0.138)
N of Leaders	0.255***
	(0.052)
Observations: 553 Log Likelihood=-424.7712 Pseudo $R^2 = 0.076$	

*Significance at 10%; **Significance at 5%; ***Significance at 1%.

Table 10

N of non-Leaders	Coef.
Distance	0.604
	(0.516)
Distance^2	-0.147*
	(0.089)
Ln Distance	-0.447*
	(0.260)
American	0.478***
	(0.126)
Delta	0.432***
	(0.140)
Southwest	0.185
	(0.142)
Continental	0.056
	(0.159)
US Airways	0.640***
	(0.155)
United Air	0.318*
	(0.172)
Northwest	-0.020
	(0.185)

Observations: 553
Log Likelihood= -427.12532
Pseudo $R^2 = 0.0707$

*Significance at 10%; ***Significance at 1%.

In the following Tables we report results using OLS and Poisson models for the baseline specification.

Table 11 – OLS

N of non-Leaders	Coef.
Constant	0.234***
	(0.089)
Market Size	-0.002
	(0.009)
Distance	-0.108***
	(0.032)
Tourist	0.146**
	(0.065)
Two-hubs	0.175*
	(0.095)
One-hub	-0.054
	(0.070)
Number of Leaders	0.156***
	(0.029)

Observations: 553
$R^2 = 0.66277$

*Significance at 10%; ** Significance at 5%; ***Significance at 1%.

Table 12 – Poisson model

N of non-Leaders	Coef.
Constant	-1.179***
	(0.215)
Market Size	-0.007
	(0.014)
Distance	-0.314***
	(0.085)
Tourist	0.376**
	(0.152)
Two-hubs	0.395*
	(0.204)
One-hub	-0.115
	(0.175)
Number of Leaders	0.260***
	(0.055)

Observations: 553
Pseudo $R^2 = 0.0719$

*Significance at 10%; ** Significance at 5%; ***Significance at 1%.

CHAPTER 4

ENTRY AND TERRITORY ALLOCATIONIN THE U.S. AIRLINE INDUSTRY[29]

Abstract: *We assess collusion in terms of territory allocation among airlines. To this goal, first we develop a sequential entry model estimating firm-specific entry functions, for a cross-section sample of 661 airline city pair markets. Entry decisions depend upon market characteristics and market structure (rival's presence). Secondly, we construct another entry model using, in place of market structure dummies, variables measuring firm's own and rivals' number of routes flown out of end points constituting a city pair. Results suggest evidence consistent with the possibility of market collusion.*

4.1 Introduction

To study intensity of competition is a core theme among industrial organization economists. In addition to the usual challenges posed by understanding impact of factors such as demand and cost conditions, concentration, barriers to entry, on competition, we face considerable additional challenges when firm multi-market contact plays a role. The possibility that firms relax competition in each other territory in presence of important multi-market contact (MMC) has been recognised since a long ago, proved formally by Bernheim and Whinston's (1990) study.

The exogenous feature of firms competing in many local geographic markets, may lead to avoiding competition head-to-head; firms may reserve to themselves some territories (Scherer and Ross 1990). We can trace several antitrust cases involving this type of 'market' collusion in the US, under the Sherman Act for example, and with reference to the 1996 Telecommunications Act which recommends firms to enter into each other's territory. Also in Europe, the European Union competition office has faced cases on market collusion as the one involving Solvay and ICI in 1990, where the two firms proved to be guilty on market allocation[30]. In addition, the empirical literature on cartels brings forward the facts that, in some cases, cartelists make agreements on territory allocations (De 2010).

[29] This chapter has benefited greatly by the help of Franco Mariuzzo for means of several discussions, by generating the algorithm for implementing the sequential order of entry in our model 1, and by generating the variables contained in the vector *W* in model 2.
[30] Belleflamme and Bloch (2004) mention these antitrust cases.

Firm’s behaviour towards allocating geographic markets to themselves need not raise necessarily a case of collusion, but, it may just qualify as unilateral behaviour. Firms can have incentive to avoid competition head-to-head by entering in submarkets where some rival(s) is not present. Traditional microeconomic theory suggests that competition reduces profits; therefore, whenever a firm has to decide to enter either a monopoly market or one in which it faces competition, all else equal, it will choose to enter in the former. This incentive to avoid rival’s competition may also arise when firms have home markets. In these cases, it could be an optimal strategy to naturally stick on own home markets. Although unilateral effects do not break antitrust law, they may be harmful as much as coordinated strategies.

The empirical analysis of this paper has its rationale on the theoretical framework developed by Belleflamme and Bloch (2004). While Bernheim and Whinston (1990) take MMC as given and develop collusive pricing implications, Belleflamme and Block endogenize MMC. The authors study bilateral market sharing agreements in oligopoly and auction markets; that is, firms can establish bilateral agreements on not to compete in each other market. For example, suppose two firms, X and Y, and two markets, A and B. In addition, suppose that each firm has a home market; therefore, for instance, firm X has its home in market A and firm Y has its home in market B. Now, suppose that the two firms agree to stick on their home markets. As a result, firm X will stay in A without entering market B, while firm Y will remain in market B without entering market A. The model by Belleflamme and Bloch (2004) contemplates N firms each with a home market. Firm’s incentives at the base of deciding to establish bilateral market sharing agreements depend on characteristics of the two markets involved. More precisely, any firm engaging in a reciprocal market sharing agreement faces two conflicting incentives: 1) to increase profits by having one less competitor in its home market; 2) to give up to profits obtainable in foreign market.

Belleflamme and Bloch impose the following properties on firm profit functions: i) each firm profit decreases as number of firms increases; ii) each firm profit decline decreases as the number of firms increases. Consequently, firm profits are convex in the number of firms; iii) rate of decline of firm profit, that is percentage of profit reduction as a new firm enters the market, is decreasing in the number of firms. This property defines the profits as log-convex in the number of firms. The authors show that property i) is satisfied for Cournot oligopoly models with homogeneous products, increasing and convex costs, and inelastic slope of inverse demand function. Properties of convexity, ii) and iii), are satisfied for Cournot oligopoly models with homogeneous products, linear costs, inelastic slope of the inverse demand function, and increasing elasticity of the slope of inverse demand function.

For private value procurement auctions profits are shown to be both decreasing and log-convex in the number of firms. The property of log-convexity guarantees existence of stable collusive networks. A collusive network is the set of reciprocal market sharing agreements. Belleflamme and Bloch apply definitions of network theory to describe structure of stable collusive networks where firms and markets are identical. The concept of stability relies on i) once an agreement takes place both firms prefer to maintain it in place; ii) if two firms are unlinked (they do not establish an agreement) both cannot have an incentive to form an agreement. The authors show the following necessary and sufficient conditions to have stable collusive networks:

- The network can be decomposed into a set of isolated firms and components. The components have to be complete (all firms establish bilateral agreements among themselves) and of different firm numbers (different size), if components are of same size the log-convexity of profits in the number of firms will induce the two components to merge;
- A lower bound on the number of bilateral agreements for each components has to exist;
- If the number of market sharing agreements is equal to one then there must be at most one isolated firm.

A key vision in our paper follows the work by Belleflamme and Bloch (2004): multimarket contact is seen as endogenous; that is, it is the fruit of endogenous entry decisions through which, airlines decide in which city pair markets to compete along with rivals. We build two reduced-form econometric models of entry to find if there is evidence consistent with market sharing agreements. First, we implement a static sequential entry game where rivals' presence affects entry decisions along as market and firm characteristics. Estimates suggest that, mostly, market structure (past entry decisions) lowers firms' profits hence likelihood of entry. In addition, we build a second static entry model where, instead of using market structure variables (firm dummies), we include number of routes flown out of end points for each airline of each city pair as a proxy for rivals' presence. Results mostly confirm the pattern of the first model. Overall, there is evidence consistent with the possibility of market collusion[31].

The airline industry appears to be a natural setting for testing this theoretical model for two reasons. First, a feature of the assembled database is that airlines seem to compete in

[31]We refer to section four for details on our findings.

same city pairs relatively rarely. Secondly, the multi-product nature of the airline industry may provide a suitable environment to encourage strategic behaviour in terms of market contact and territory allocation.

The organization of the rest of the paper is as follows. Section 2 syntheses related literature. Section 3 presents the data. Section 4 provides the reduced form approach to entry. Section 5 concludes.

4.2 Related Literature

This paper is related to two strands of the literature. As we attempt to study if and at what extent firms choose to prevent competition head-to-head in local markets, our work is related to the literature concerned with the empirical measurement of the relationship between MMC and collusion. We analyze firm's choice of challenging rival competition in same local markets by estimating two discrete choice game theory models of entry; consequently, this paper extends the empirical static entry literature.

Relationship between MMC and Collusion

The first formal theory linking MMC to competition is developed by Bernheim and Whinston (1990). The theory predicts that MMC is irrelevant to collusive pricing when products are homogeneous, firms and markets are identical, and firms have constant returns to scale; whereas, when markets differ in terms of firm numbers and discount factor an increase of MMC can ease collusion. Similarly, when firms are heterogeneous in terms of costs, MMC can facilitate collusion. However, Bernheim and Whinston also show that sometimes MMC makes collusion harder; for example i) with identical firms and heterogeneous markets prices can fall in some markets because of MMC, while raising in other markets, ii) when markets are identical and firms have different costs, MMC can cause either higher or lower prices depending upon the discount factor.

Based on this theoretical framework, an empirical literature has flourished testing the main prediction which states a positive link between multimarket contact and prices. We can mention Piloff (1999) finding a positive empirical link between MMC and profitability in the banking industry; Jans and Rosenbaum (1997) provides empirical evidence in support of a positive relation between MMC and collusion for the cement industry; Busse (2000) in the cellular telephone industry finds not only that MMC allows harsher punishment, but also finds evidence that it helps coordination through price signalling; Fernandez and Marin (1998) find empirical evidence of a positive relation between MMC and price competition for the Spanish Hotel industry. Feinberg (1985) analyses the impact on price-cost margins in place of price for several industries. Parker and Roller (1997) study multimarket contact and collusion in the mobile telephone industry. This theme has been explored also in the airline industry (e.g. Ciliberto and Williams 2012; Evans and Kessides 1994; Singal 1996) confirming the prediction that contacts can cause higher prices. A smaller empirical literature has looked at the effects of MMC on non-price competition in the airline industry; Prince and Simon (2008) look at service quality in terms of flight-delays, and Bilotkach (2011) studies the impact on frequency. Both these papers provide evidence of higher delays and lower frequency, respectively, as MMC is enhanced.

The theory developed by Belleflamme and Block (2004) about territory allocation, has not received attention by academic empirical research. This theoretical approach suggests that in empirical studies multimarket contact should be seen as endogenous; in other words, firms, if colluding, select local markets in which to enter taking care of not entering into those markets where rivals are present, with which agreements have been taken place.

Empirical models of Entry and Market Structure

A strand of the literature to which this paper is related, refers to empirical models of entry and market structure. A seminal article in this area is that of Bresnahan and Reiss (1991), where a structural econometric model for homogenous goods and identical firms is constructed. Demand is assumed to be characterized by a representative consumer, and technology is featured by U-shaped average cost curves. The authors estimate a structural profit function of the following sort:

$$\Pi_m = S_m(\cdot) * V(\cdot)_m - F(\cdot)_m \qquad (1)$$

The left hand side represents the profits for the total number of firms in a given market m. The right hand side includes a market size function of population, multiplied by a variable profit per customer function, minus fixed costs. Bresnahan and Reiss assume that the unobserved component of profits is common to all the firms; this assumption allows them to estimate ordered probit models. Moreover, the authors set the coefficient of population in the function $S(\cdot)$ equal to one as $V(\cdot)$ contains a constant term, as well as allowing interpretation of the other variables included in the function as shifts in population equivalents. In the function $V(\cdot)$ demand and cost shifters are included along as positive intercepts capturing profits falling in the number of firms, while in the fixed costs function $F(\cdot)$ the price of land is included to identify fixed costs effects.

The authors develop the novel concept of *entry thresholds* which relates the equilibrium number of firms to market size (measured by population); the estimated entry thresholds tell how much population is needed to support a given number of firms in a market. Mathematically the entry threshold is given by the ratio of unobservable fixed costs to equilibrium variable profits per customer, and it gives the level of market size needed to support a single entrant. Bresnahan and Reiss estimate also the *entry threshold ratios* which are ratios of per-firm market sizes; if this ratio is above one it means that entry increases competition. As a result, these entry threshold ratios measure how the level of competition changes with the number of firms. They find that the level of competition changes quickly as the number of firms increases, as well as most of competitive effect of entry is exhausted with the second or third entrant.

Berry (1992) solves the difficult problem of firm heterogeneity for airline city pair markets using a simulated method of moments estimator proposed by McFadden (1989) and Pakes and Pollard (1989). Berry uses airport presence as observed firm heterogeneity in terms of fixed costs; airlines servicing a larger number of routes flown out of end points constituting a city pair or being present in at least one end point are assumed to have lower fixed costs. The specific research question addressed is to quantify firms profit advantages in operating a city pair from airport presence at the end points of the route. Additional articles studying entry in airline markets include Goolsbee, A., and Syverson, C., (2008), Bilotkach, Hueschelrath and Mueller (forthcoming), Boguslaski, Ito and Lee (2004), Dunn (2008), Oliveira (2008), and Reiss and Spiller (1989).

Mazzeo (2002) and Cohen and Mazzeo(2007) extend the Bresnahan and Reiss' methodology to motels in the Western U.S. and to the U.S. banking industry respectively. Mazzeo develops econometric models which make both endogenous product types and entry decisions to infer competitiveness from firm numbers for a cross-section sample of local markets. Mazzeo specifies a separate profit function for each firm type as follows:

$$\Pi_{Tm} = X_m\beta_T + g(\theta_T;\vec{N}) + \varepsilon_{Tm} \tag{2}$$

The right hand side of equation (2) encompasses three terms. The first term represents a vector of market characteristics reflecting demand and profitability of a given market$m$.The second term captures effects of competitors of each type$T$ ($\vec{N}$ is a vector of number of firms of each type); for instance, if in a local market we have a market structure configuration of two types $(2;2)$, a firm of a given type will face one competitor of own type and two competitors of other type. Mazzeo assumes that competitors are strategic substitutes hence profits decline in the number of firms, but profits decline less if competitors are of a different type. The third term is the unobserved portion of profits which varies depending on firm type, and follows either a bivariate standard normal distribution in the two-type case or a trivariate standard normal distribution in the three-type case. The dependent variable is then either an ordered pair for two product-type or an ordered triple for three different firm types.

Given multiplicity of equilibria that may arise easily in such context, the author responds by mapping equilibrium to the number of firms and assuming sequential entry. Also, moving from two to three types it requires using a ML simulator estimator. Results suggest that product differentiation gives higher profits because competition between different product types is less intense.

Competitive effects of different types are also analysed by Shaumans and Verboven (2008) for the health care professions in Belgium. They estimate bivariate (two types of firms, pharmacists and physicians) ordered probit models with and without entry restrictions (in the form of a ceiling for the number of firms of a given type that can enter) for a cross-section sample of local markets, and a model with both entry restrictions and strategic complementarity, by inclusion of dummies about other type's presence in addition to market structure dummies for own type competitors. The authors assume strategic complementarities between pharmacists and physicians hence profits of one type are increased by presence of other type. Results provide evidence that entry restrictions lead to fewer predicted number of firms of both types and higher profits, with consequence detrimental of consumers' welfare.

Traditional IO theories of entry predict that if a firm has to choose between entering a market in which faces competition and one monopoly market, under the assumptions that the two markets are identical, the firm will choose to enter the monopoly market. Whenever entry deterrence occurs, it will make such prediction even more likely. In particular, with sequential entry the first mover can prevent entry by product proliferation (e.g. Schmalensee 1978, Bonanno 1987, Hay 1976). In addition, in endogenous sunk costs industries where vertical product differentiation is prominent, the competitive mechanism of endogenous sunk costs escalation may block entry (Sutton 1991) and, through mergers, firms can succeed to monopolize an industry (Vasconcelos 2006)[32].Toivanen and Waterson (2005) ask the question whether when learning size and profitability of a market from watching behaviour hence success (failure) of incumbents may reverse the traditional prediction. The authors answer this question by constructing an empirical model of market structure based on a panel sample of entry data into local markets in the U.K. burger counter service industry. As we estimate a model of entry where firm entry decision depends on rival presence and we estimate firm-specific entry equations, the Toivanen and Waterson's (2005) article is the closest to our work.

Toivanen and Waterson argue that the industry is characterized mainly by two major players, McDonalds (McD) and Burger King (BK); as a consequence, the authors, unlike previous work, estimate firm-specific entry functions. They first develop a reduced form econometric model at the heart of which there is the following profit function to be estimated (Toivanen and Waterson (2005) pp. 688):

$$\Pi_{ijt} = X_{ijt}\beta_i + g\left(Own_{jt}, Rival_{jt}, \theta_i\right) + \nu_{ijt} \qquad (3)$$

The latent variable is the profit for firm $i (i \in \{McD, BK\})$ in market j in period t. This latent variable has the observable counterpart in whether firm i is in the market or not. More specifically, the entry decision for each firm in each period is phrased as follows, opening or not a new outlet in a given market. The right hand side of equation (3), like previous literature, contains a) a vector of market and firm specific factors related to market profitability; b) a function $g(\cdot)$ containing market structure dummies which represent past entry decisions; c) an i.i.d. error term with standard normal distribution, $\nu_{ijt} \sim \Phi(0,1)$. Toivanen and Waterson estimate equation (3) by Random-Effects Probit method. Interestingly, they find that market structure dummies have positive coefficients hence positive marginal effects. Own and rival outlet presence increases probability of opening a new outlet for both firms. The authors interpret and explain these results in the light of theories of learning (e.g. Baum, Li and Usher 2000; Caplin and Leahy 1998). Then they engage in an extensive range of robustness checks to possible correlations between market characteristics' covariates and unobservables, and to misspecification issues. The results are robust to all the checks they make. The second step in the analysis is to develop and

[32]See chapter 2 of this dissertation for details on models of endogenous market structure.

implement a structural econometric model of a static two-stage sequential entry game, where McDonalds is the leader and Burger King is the follower.

Other contributions include Seim (2006), who develops a very general empirical framework with incomplete information (she assumes that firms do not have full information on rival firms profitability) to analyze joint entry decisions and firm location choice applied to the video rental industry; Berry and Waldfogel (1999) study inefficient (excessive) entry in radio broadcasting; Scott Morton (1999; 2000) analyses entry in generic pharmaceutical markets as well as if pre-expiring brand advertising deters entry in the generic pharmaceutical industry.

4.3 Data

Relevant data for this paper is based upon a large cross-section sample of 661U.S. airline city pair markets for the year 2006.The variables used in the econometric model of entry and market structure are:

- *Market size*. As in previous chapters, market size is defined as the product of population of the two end point cities for each city pair and is expressed in thousands of billions.
- *Distance*. This measures the length in kilometres of the route and is expressed in thousands.
- *Tourist dummy*. A dummy equal to 1 for all markets with at least one end point city located either in California or Florida, plus other two locations, Aspen and Colorado Springs.
- *Two hubs*. This is a dummy for routes having large hubs at both endpoints.
- *One hub*. A dummy for city pair markets containing one endpoint as large hub is introduced in the empirical models.
- *Z*. This variable represents the number of routes flown out of origin/destination points constituting a city pair by each airline.
- *One dummy for each of the seven leader airlines*. These are American, Delta Airlines, Southwest, Continental, US Airways, United Airlines and Northwest. These leading airlines are identified as those who service the greater number of routes.

- *One dummy for the non-leader airlines*[33]. This is equal to one if one or more non-leaders are in the route
- *Nrt_1-nrt_8*. These eight variables measures the number of routs flown out of the end points for American, Delta Airlines, Southwest, Continental, US Airways, United Airlines, Northwest and non-leaders respectively.

Recall that according to the FAA, large hub airports are defined as those carrying at least one percent of the total annual passenger boardings. In Table 1 we present number of routes serviced by each airline; while in Table 2 we provide some information of the route market overlaps between the major carriers.

Table 1 – Number of Routes serviced by leaders

# Routes	
Leaders	
American	136
Delta Airlines	113
Southwest	107
Continental	77
US Airways	69
United Airlines	68
Northwest	65
Total	635

[33] As explained in the introductory chapter of this dissertation, the distinction between leaders and non-leader airlines is based on the number of routes each firm services across our dataset.

Table 2 – Measure of MMC

Firm-pairs	Observed Contacts
American - Delta	20
American - Southwest	18
American - Continental	15
American - US	12
American – United Airlines	18
American - Northwest	8
Delta - Southwest	5
Delta - Continental	30
Delta – US Airways	8
Delta - United	11
Delta - Northwest	4
Southwest - Continental	6
Southwest – US Airways	14
Southwest – United Airlines	10
Southwest - Northwest	2
Continental – US Airways	10
Continental – United Air.	6
Continental - Northwest	1
US Airways - United	8
US Airways - Northwest	2
United Airlines - Northwest	2

4.4 Two models of entry

Model 1. Our model borrows its structure from existing empirical literature on discrete choice game theory models of entry (e.g. Bresnahan and Reiss 1991; Berry 1992; Reiss 1996; Mazzeo 2002; Cohen and Mazzeo 2007; Toivanen and Waterson 2005).

We establish a very simple static two-stage model where in the first stage the entry decision for each firm takes place involving whether operating or not in a given market and, entry is assumed to happen sequentially. Also, when firms make their entry choice do not take into account the impact of this on later entrants' decisions; while in the second stage competition either in prices or quantities occurs. In this second stage the nature of competition is assumed to be common knowledge among all firms. The firms entry decisions are assumed to be indicators of market profitability and the coefficients can be interpreted as the derivatives of profits with respect to the variables at the right hand side. As discussed by Toivanen and Waterson (2000), if we estimate a simultaneous entry model consisting of a system of discrete choice equations where each equation has k's entry as an explanatory variable in the equation for i's entry will lead to (1) multiple equilibria. For instance, in case of monopoly equilibrium and with two potential entrants we get two Nash equilibria for which we do not know which firm enters and which does not; (2) endogeneity, as i's entry depends on k's entry and vice versa. To solve the problems (1) and (2) either we use the total number of firms as dependent variable or we estimate a sequential entry game. The latter solution is the choice we make in this paper. We impose an order of entry in terms of the routes flown out of end points constituting a city pair market. In the literature the order of entry is commonly assumed to be in base of profitability; also, the literature suggests that our firm characteristic (variable Z defined in the previous section) increases profits; for instance, it can be interpreted as a fixed costs term as Berry (1992) does, assuming that later entrants have higher fixed costs, then naturally, we impose an order of entry in base of our firm characteristics which implies assuming an order of entry in the light of profitability as it is standard in the literature. Common to the literature, a firm$i$ enters in market m if and only if expected gross profits, once fixed costs are taken into account, are non-negative:

$$E[\pi_{im}] - F_m \geq 0 \tag{4}$$

In our context, each firm decides to enter in a city pair market if:

$$E[\pi_{im}] = X_m\beta_i + \alpha_i Z_{im} + g(Rivals_{im}, \theta_i) \geq 0 \tag{5}$$

We estimate firm-specific probit equations using standard ML, applying the following reduced-form profit function as outcome of the competition stage:

$$\pi_{im} = X_m\beta_i + Z_{im}\alpha_i + g(Rivals_{im}, \theta_i) + \varepsilon_{im} \tag{6}$$

Subscript i denotes a firm ($i \epsilon \{American,\ Delta,\ Southwest,\ Continental,\ US\ Airways,\ United\ Air,\ Northwest,\}$), m a city pair market.

The vector X_m encompasses market specific variables related to market profitability and its attractiveness,β_i is a vector of market-specific parameters to be estimated. In the vector X_m we include, *Market size* (product of populations of both end points of a city pair), *Tourist* (dummy equal to 1 for route markets where at least one of the two end point cities are either in California or in Florida and for Aspen and Colorado Spring), *Distance* (measured in km between end point cities), *Two-hub* (dummy equal to 1 for city pairs where both end points qualify as large hubs), *One-hub* (dummy equal to 1 for route markets with one end point as large hub).

The variable Z_{im} is the number of routes serviced by airline i in market m. Berry (1992, pp. 890-891) reviews some of the early literature about effect of airport presence on route's profitability; some theories highlight that, to service routes flown out from the end points of a city pair can provide demand and costs advantages, whereas other contributions sustain the thesis that airport presence may provide strategic advantages in preventing entry. In particular, such firm characteristics introduced in our model could capture fixed costs and demand advantages; a wider route structure out of the city points of the pair may help gaining lower fixed costs and a larger fraction of consumers. Now it is worth noting the following point; one may object that this variable may be endogenous and, if so, correlated with the error terms. However, this may not be the case as in our context the relevant market is defined at route level. As a result, the number of routes flown out of the end points of a city pair can be an exogenous factor.

The function $g(\cdot)$is a function of rival presence in each city pair market (see Mazzeo 2002; Cohen and Mazzeo 2007; Toivanen and Waterson 2005); it contains dummies for rival firms.θ_i is a vector of firm-specific parameters to be estimated. Fundamentally, these market structure variables can represent past entry decisions.

The error term ε_{im}, which incorporates factors not observed by the econometrician, is assumed to be i.i.d. and is distributed as standard normal, $\Phi \sim (0, 1)$.

To sum up, the profit equation (6) contains demand and cost factors captured by the vector X, observed firm heterogeneity, captured by the variable Z, firm interactions, included in the function $g(\cdot)$, and the stochastic profit component, ε, modelled as standard normal.

Model 2. As alternative method and for robustness purposes, we estimate the same static entry game except for the fact that, in place of using firm dummies as explanatory variables we include the number of routes flown out of the end points constituting a route for each leader airline and for the variable non-leaders. We postulate that rivals' number of routes flown out of end points is a good proxy for rivals' profits. Since there are no firm dummies among the covariates there is no concern of simultaneity of entry decisions and multiplicity of equilibria, and therefore, there is no reason for implementing a sequential entry game. The equation being estimated is:

$$\pi_{im} = X_m\gamma_i + W_{im}\delta_i + \mu_{im} \quad (7)$$

Where the latent dependent variable is the profit of firm i; X is the vector of market characteristics, exactly as in model 1; W is a vector of firm characteristics which, include the number of routes flown out of the end points by the firm i(the variable Z in model 1) and number of routes flown out of end points by i's rivals (the eight variables *nrt_1-nrt_8*); γ_i is a vector of market specific parameters to be estimated; δ_i is a vector of firm specific parameters to be estimated; and μ_{im} is a i.i.d standard normal error term, $\Phi \sim (0,1)$.

For both models, we adopt a probit approach rather than using the total number of firms (e.g. ordered probit) because we are very much interested in the individual firms' entry decisions and on how firm identities affect entry.

Results. From variables contained in the vector $X_m$we expect the following. For *Market size* we clearly expect a positive coefficient, while for the variable *Distance* we expect a coefficient with negative sign, because this variable incorporates variable costs (e.g. fuel). We interpret the three dummies, *Tourist*, *Two-hub* and *One-hub*, exactly in the light of the reasoning proposed on pages 43-44 of this dissertation.

In Tables 3-4 we report probit results and marginal effects about individual entry decisions for the sequential entry game, Model 1. There is evidence that coefficient of *Market size* is always positive and significant at 5% level for American and Delta and at 10% for Continental, while statistically insignificant for the other airlines. The coefficient of *Distance* is statistically significant and negative for American, Southwest, Continental and non-leaders whilst is positive and significant for Delta; we cannot tell reasons for such non-consistency. Coefficient of *Tourist* has evidence of being significant and positive for American, Delta, Southwest and US Airways; therefore for these airlines in tourist markets the size effect offset the competition effect. There is evidence of a negative and significant coefficient for the airline Northwest, thus, for this firm in tourist routes the size effect is dominated by the competition effect. Regarding the variable two-hub, there is evidence of positive and significant coefficient for US Airways and Northwest and, negative and significant coefficient for Southwest. The variable one-hub appears negative and significant about American, Delta, Southwest, Continental and non-leaders.

The variable Z which, as noted earlier, captures firm's characteristics, shows a positive and highly significant coefficient for all the airlines. This evidence suggests that airport presence is an important factor in determining city pair profitability, and it is consistent with early literature (e.g. Berry 1992).

The most economically interesting are the market structure variables (firm dummies), and we focus the following discussion on marginal effects reported in table 4. Traditional entry models predict that a firm will enter a monopoly market instead of one in which faces competition, all else equal. Also, models of entry pre-emption would exacerbate such prediction. Consequently, coefficients of the market structure dummies that are statistically significant and negative can be interpreted in the light of the theories of entry and entry deterrence. Our results suggest evidence of a negative relationship between entry and rivals' presence in most cases. However, the presence of American increases the profits of Continental and United Airlines. This latter evidence is consistent with the possibility of complementarity and spillover effects.

Now, looking at firm-pairs and at their estimated entry functions we can draw on several cases. First, whenever (coefficients) marginal effects of rival presence are either not statistically significant or statistically significant but very small in magnitude, it suggests evidence that entrant's profits are not affected by rival's incumbency; this in turn suggests evidence consistent with the possibility of soft price competition[34] between the two firms under consideration (e.g. Southwest-American, Continental-US Airways, Southwest-Northwest, United Air-Northwest, Delta-Continental).Intuitively, profits can be higher if in the second stage of the game competition is soft. Second, in cases where for a given firm pair only one firm affects negatively the rival's profits, then this may probably provide evidence of vertical product differentiation (e.g. Northwest-American, Continental-Southwest, Delta-Southwest, United Air-US Airways); the firm that lowers the entrant's profits may be a tougher competitor. Marginal effects are reciprocally negative for American-non-Leaders, United Airlines-Delta Airlines and US Airways-Northwest. In addition, we note that the estimated entry function for Southwest reports 535 observations instead of the full sample of 661 markets; that is, 126 observations are dropped because of perfect collinearity as when United Airlines is present in a route Southwest is never there. These results where firms reciprocally lower profits can be consistent with the possibility of market collusion (mutual forbearance driven by territory allocation); however, we cannot rule out alternative explanations which are mainly referred to the conventional effect of competition on profits.

[34] We interpret 'soft' price competition in the sense of Sutton (1991); that is, at comparable level of market concentration price-cost margins are higher.

The estimation of Equation (7) produces results[35] reported in Table 5. We report only the marginal effects, because those are enough to understand entry competition. *Market size* appears positive and significant for American, Delta Airlines and Continental, whilst we have evidence of not significant marginal effects for the others airlines. We have evidence of negative and significant marginal effect for the variable *Distance* regarding American, Southwest, Continental, and non-leaders; in contrast, we have evidence of positive and significant marginal effect for Delta airlines. United Airlines and Northwest bring evidence of not significant marginal effects. There is evidence of significant and positive *Tourist*'s marginal effects for American, Delta Airlines, Southwest, US Airways, whereas a negative marginal effect for Northwest. The variable *Two-hub* brings evidence of being significant and negative for Southwest, Continental and non-leaders and not significant for the remaining airlines. For the variable *One-hub* we have evidence of significant and negative marginal effects for American, Delta Airlines, Southwest, Continental and non-leaders; whilst there is evidence of not significance for the other airlines.

Furthermore, we observe, consistent with Table 4, own route network out of end points increases profits of the city pair market. Looking at the estimated marginal effects of rivals' airport presence, it emerges evidence of negative impact on profits, in all except for three cases (American and US Airways for Continental's entry function, and Southwest for US Airways' entry function). Therefore, we have evidence that in most cases rival's airport presence lowers firm's profits. We interpret this as consistent with firms not deliberately increasing multimarket contact.

Overall, from the two models there is evidence consistent with the theory of market collusion developed by Belleflamme and Block (2004).

[35] We focus on marginal effects which, are indeed reported in table 4.

Table 3 – Model 1: Coefficients

VARIABLES	(1) American	(2) Delta	(3) Southwest	(4) Continental	(5) US	(6) United	(7) Northwest	(8) Non-leaders
Constant	-1.644***	-1.678***	-1.403***	-1.445***	-2.249***	-2.744***	-1.455***	-0.645**
	(0.317)	(0.204)	(0.205)	(0.240)	(0.240)	(0.327)	(0.251)	(0.253)
American		-0.343*	-0.196	0.695***	-0.329	0.516**	-0.352	-0.590***
		(0.191)	(0.211)	(0.288)	(0.241)	(0.227)	(0.280)	(0.171)
Delta	-0.448		-0.634	0.016	0.118	-1.037***	-0.510*	--0.341
	(0.383)		(0.453)	(0.196)	(0.268)	(0.282)	(0.308)	(0.277)
Southwest	0.015	-0.097		-0.180	0.064	-0.234	-0.386*	-0.348**
	(0.192)	(0.178)		(0.204)	(0.225)	(0.196)	(0.232)	(0.172)
Continental	-0.037	-0.033	-0.660		-0.112	0.300	-0.337	-0.628*
	(0.399)	(0.194)	(0.467)		(0.298)	(0.316)	(0.291)	(0.341)
US Airways	0.246	-0.631**	0.322	0.016		-0.184	-0.610**	-0.932***
	(0.273)	(0.308)	(0.274)	(0.246)		(0.259)	(0.256)	(0.217)
United Airlines	-0.855**	-0.409**		0.079	-0.628**		-0.045	-0.615**
	(0.380)	(0.204)		(0.271)	(0.268)		(0.256)	(0.267)
Northwest	-0.635	0.019	0.007	-1.006***	-0.651	-0.185		-0.549**
	(0.425)	(0.247)	(0.370)	(0.389)	(0.399)	(0.286)		(0.233)
Non-leaders	-0.440**	-0.226	-0.378*	-0.221	-0.059	-0.086	0.273	
	(0.187)	(0.177)	(0.206)	(0.306)	(0.249)	(0.206)	(0.284)	
Z	0.158***	0.079***	0.160***	0.137***	0.123***	0.173***	0.102***	0.092***
	(0.025)	(0.010)	(0.013)	(0.015)	(0.013)	(0.024)	(0.015)	(0.017)
Market size	0.054**	0.042**	-0.019	0.036*	-0.027	0.013	-0.079	-0.029
	(0.026)	(0.019)	(0.020)	(0.021)	(0.019)	(0.019)	(0.074)	(0.032)
Distance	-0.138*	0.155**	-0.221**	-0.597***	-0.056	0.143	0.125	-0.173***
	(0.082)	(0.070)	(0.091)	(0.118)	(0.099)	(0.093)	(0.097)	(0.065)
Tourist	0.475***	0.541***	0.337**	0.132	0.445**	0.301	-0.675***	0.125
	(0.184)	(0.172)	(0.172)	(0.205)	(0.222)	(0.214)	(0.221)	(0.135)
Two-hub	-0.256	0.038	-0.633**	-0.557	0.714**	0.298	0.618*	-0.388
	(0.280)	(0.249)	(0.315)	(0.371)	(0.317)	(0.301)	(0.323)	(0.265)
One-hub	-0.882***	-0.409*	-0.926***	-0.579**	-0.041	-0.264	0.002	-0.350**
	(0.236)	(0.209)	(0.232)	(0.246)	(0.266)	(0.256)	(0.221)	(0.147)
Pseudo R^2	0.50	0.42	0.41	0.50	0.49	0.45	0.52	0.26
Observations	661	661	535	661	661	661	661	661

Robust standard errors in parenthesis, ***p<0.01; **p<0.05; *p<0.1

Table 4 – Model 1: Marginal effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	American	Delta	SouthW	Cont.	US	United	NorthW	Non-leader
American		-0.055*	-0.027	0.041**	-0.02	0.024**	-0.021	-0.142***
		(0.032)	(0.028)	(0.019)	(0.015)	(0.011)	(0.02)	(0.035)
Delta	-0.07		-0.071*	0.001	0.007	-0.065***	-0.028	-0.085
	(0.051)		(0.036)	(0.012)	(0.017)	(0.021)	(0.018)	(0.062)
Southwest	0.003	-0.015		-0.01	0.004	-0.013	-0.02	-0.088**
	(0.035)	(0.027)		(0.012)	(0.014)	(0.011)	(0.013)	(0.039)
Continental	-0.007	-0.005	-0.071**		-0.006	0.018	-0.017	-0.138**
	(0.069)	(0.029)	(0.035)		(0.016)	(0.022)	(0.015)	(0.058)
US Airways	0.048	-0.076***	0.057	0.001		-0.01	-0.029**	-0.183***
	(0.058)	(0.027)	(0.054)	(0.015)		(0.013)	(0.013)	(0.03)
United Air.	-0.107***	-0.056**		0.005	-0.032***		-0.002	-0.133***
	(0.029)	(0.024)		(0.017)	(0.011)		(0.012)	(0.042)
Northwest	-0.084**	0.003	0.001	-0.040***	-0.029**	-0.01		-0.121***
	(0.036)	(0.039)	(0.056)	(0.012)	(0.013)	(0.014)		(0.04)
Non-leaders	-0.085**	-0.037	-0.054*	-0.014	-0.004	-0.005	0.012	
	(0.038)	(0.03)	(0.028)	(0.021)	(0.015)	(0.012)	(0.011)	
Z	0.028***	0.012***	0.024***	0.008***	0.007***	0.010***	0.005***	0.025***
	(0.006)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.005)
Market size	0.012**	0.006**	-0.003	0.002*	-0.0002	0.0007	-0.004	-0.007
	(0.005)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.004)	(0.008)
Distance	-0.025*	0.024**	-0.033**	-0.035***	-0.003	0.008	0.006	-0.047***
	(0.015)	(0.011)	(0.014)	(0.008)	(0.006)	(0.005)	(0.005)	(0.017)
Tourist	0.088**	0.088***	0.052**	0.008	0.029*	0.017	-0.033***	0.034
	(0.036)	(0.029)	(0.025)	(0.013)	(0.015)	(0.014)	(0.012)	(0.037)
Two-hub	-0.041	0.006	-0.071***	-0.024**	0.068	0.02	0.047	-0.094*
	(0.041)	(0.04)	(0.025)	(0.012)	(0.042)	(0.025)	(0.033)	(0.056)
One-Hub	-0.171***	-0.066*	-0.153***	-0.038**	-0.003	-0.015	0.000	-0.097**
	(0.053)	(0.036)	(0.039)	(0.018)	(0.016)	(0.016)	(0.011)	(0.042)
Pseudo R^2	0.50	0.42	0.41	0.50	0.49	0.45	0.52	0.26
Observations	661	661	535	661	661	661	661	661

Robust standard errors in parenthesis, ***p<0.01; **p<0.05; *p<0.1

Table 5 – Model 2: Marginal effects

VARIABLES	(1) American	(2) Delta	(3) SouthW	(4) Cont.	(5) US	(6) United	(7) NorthW	(8) Non-leader
nrt_1	0.059***	-0.002	-0.001	0.002***	0.000	0.000	0.000	-0.015***
	(0.007)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
nrt_2	0.005	0.017***	0.000	0.001	0.000	-0.001	0.000	-0.006*
	(0.004)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)
nrt_3	-0.007**	0.000	0.012***	0.000	0.002*	-0.001	-0.001	-0.011***
	(0.004)	(0.002)	(0.004)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)
nrt_4	-0.009**	0.000	-0.004**	0.010***	0.000	0.000	-0.001	-0.012***
	(0.005)	(0.002)	(0.002)	(0.003)	(0.001)	(0.002)	(0.001)	(0.005)
nrt_5	0.003	-0.000	0.001	0.002**	0.011***	-0.002	0.001	-0.015***
	(0.004)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)
nrt_6	-0.012**	0.001	-0.005***	0.001	0.000	0.014***	0.002	-0.009**
	(0.006)	(0.003)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.004)
nrt_7	-0.008*	-0.002	-0.001	0.001	-0.001	-0.001	0.011***	-0.014***
	(0.004)	(0.003)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.003)
nrt_8	-0.032***	-0.008**	-0.006***	0.002	-0.005***	-0.001	-0.001	0.043***
	(0.007)	(0.004)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.005)
Market size	0.018***	0.004	0.0005	0.002	-0.0008	0.001	-0.006	0.002
	(0.006)	(0.003)	(0.001)	(0.002)	(0.001)	(0.001)	(0.005)	(0.006)
Distance	-0.024	0.025**	-0.010**	-0.035***	-0.004	0.001*	0.007	-0.038**
	(0.018)	(0.012)	(0.009)	(0.009)	(0.006)	(0.006)	(0.007)	(0.018)
Tourist	0.036	0.088***	0.012	0.017	0.024	0.01	-0.047***	-0.011
	(0.044)	(0.032)	(0.01)	(0.015)	(0.015)	(0.016)	(0.016)	(0.041)
Two-hub	-0.056	0.037	-0.022**	-0.033***	0.002	0.019	-0.016	0.01
	(0.061)	(0.044)	(0.011)	(0.011)	(0.025)	(0.039)	(0.024)	(0.086)
One-hub	-0.127**	-0.097**	-0.040**	-0.079**	-0.034	-0.02	-0.053*	0.066
	(0.063)	(0.049)	(0.019)	(0.038)	(0.025)	(0.028)	(0.032)	(0.052)
Pseudo R^2	0.54	0.39	0.52	0.50	0.50	0.41	0.48	0.29
Observations	661	661	661	661	661	661	661	661

Robust standard errors in parenthesis, ***p<0.01; **p<0.05; *p<0.1

4.5 Conclusion

This paper has the objective to gain insights on entry in airline city pair markets. Specific questions explored are identities of entrants, how market structure in terms of identities of existing firms affects entry, impact of own and rival's airport presence on route profitability, whether there is evidence of market collusion. Similarly to Toivanen and Waterson (2005), we estimate firm-specific probit equations. We note that airlines, in various cases, differ in how they respond to market characteristics.

In addition to market characteristics as explanatory variables, our Model 1 of entry includes identities of existing firms. From these firm dummies we can explore generally as rival presence affects entry, and, in particular, we can investigate a form of collusive behaviour, territory allocation. In many cases, particularly for leader airlines, market structure reduces probability of entry in accordance with traditional theories of entry and entry deterrence. However, for some airlines it seems to be evidence of a positive relationship between entry and existing market structure. Whether this is caused by strategic complementarity, by learning or positive spillover effects, we cannot tell. Finally, interestingly, some firm-pairs show evidence consistent with the possibility of market collusion.

The second entry model we implement uses number of routes flown out of end points of each route in place of firm dummies. Firm's own airport presence is always positive and significant; this confirms previous literature in constituting an important factor of airline city pair's profitability. Also, we use a set of new variables capturing rivals' airport presence, studying its impact on entry hence route profitability. A fairly clear pattern emerges from the results, showing in most cases a negative relationship between rivals' airport presence and profits. This implies that where rival's entry is more likely in a given city pair, firm's profits are lower.

Overall, our results from the two models of entry do produce some evidence consistent with the possibility of the phenomenon studied theoretically by Belleflamme and Bloch (2004). However it is worth noting that the analysis proposed here does not rule out alternative explanations, as observed in the previous section.

CHAPTER 5

CONCLUSION

In this concluding chapter we sum up the results, their limitations, as well as considering some directions for future research.

5.1 Summary of results

In Chapter 2 we apply the bounds approach to concentration. We use stochastic frontier models to estimate the lower bound and the upper bound to concentration, producing the following results: i) evidence of a large and positive lower bound to concentration (non-fragmentation); ii) evidence of a maximal level of concentration corresponding to monopoly, which results to be invariant to market size; iii) using the full set of firms, we document evidence that the airline industry is a natural oligopoly where in each city pair market the number of dominant firms is between one and three, regardless of market size. These three results suggest evidence that equilibrium market structure is driven by endogenous sunk costs competition. Our interpretation is that airlines escalate investments in advertising as well as investments for expanding route structure. In fact, the number of routes serviced out of the end points of a given city pair can enhance market shares within the given route market. We argue that these sunk costs are endogenous crucially at route level.

In Chapter 3, we obtain the following findings: i) larger markets and large hub city pairs have evidence of greater number of firms, while longer routes have evidence of fewer airlines; ii) large hub markets and those with major airlines have evidence of more pronounced firm size inequality, consistent with tougher product market competition; iii) evidence of positive relationship between leader airlines and non-leaders which, appears to be consistent with learning: non-leader airlines deduce size and profitability of markets from observing behaviour of leaders. Moreover, we discuss alternative potential explanations which, we succeed to rule out.

In Chapter 4 we attempt to provide evidence if firms behave collusively in dividing markets with the goal to prevent competition head-to-head. Results suggest evidence consistent with the possibility of market collusion.

5.2 Limitations

The empirical analysis of market structure and competition of the airline industry provided in this dissertation has three kinds of limitations.

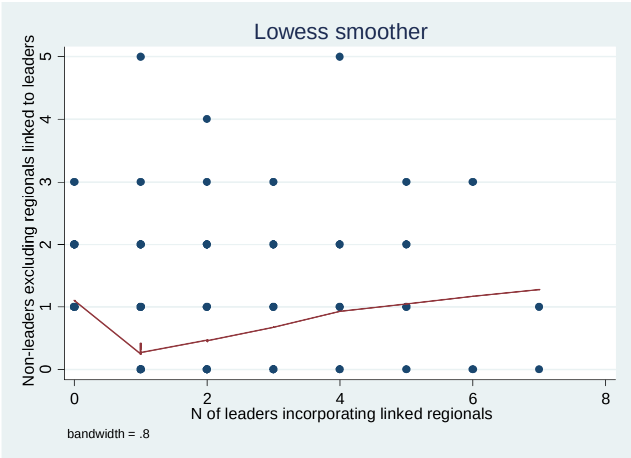
An Alternative Explanation

Econometric tests provided on the ESC model may be interpreted appealing to alternative mechanisms. In fact, forces and influences on market structure of this industry may be explained by entry deterrence strategies, though these include endogenous sunk costs escalation. A detailed industry history about the evolution of advertising expenditures and investments on expanding routes flown out of end points constituting a city pair will strongly reinforce the econometric evidence. However, there is anecdotal evidence that U.S. airlines have established and continuously expanded hub and spoke network since deregulation. This implies that firms have increased routes flown out of origin/destination of city pair markets.

A Contradictory Result

In Chapter 4 we found that profits of non-leader airlines decline when there is presence of the majors. These results of the nature of competition between the non-leaders and the leaders contradict evidence provided in Chapter 3 of a positive relation between the two groups of firms. An explanation for this discrepancy is as follows: in Figure 1 below we provide a fitted line of a non-parametric regression about the relationship between number of leaders and number of non-leaders. There is evidence that moving from markets with only non-leaders to those markets having at least one leader the number of non-leaders declines, while for markets with at least on leader the number of non-leaders increases as the number of leaders does. As in Chapter 3 we wanted to study the effect on non-leaders entry of presence of leaders, we obtain evidence of a positive relationship as suggested here by the Figure 1.

Figure 1 – Relationship between leaders and non-leaders



Further Evidence

The specific research question which was addressed in Chapter 4, was to test whether firms carve out route markets to prevent competition head-to-head. The two econometric entry models proposed although produce fairly clear results consistent with this collusive behaviour, there may be other forces causing these results. Consequently, the benefit of an industry history on the evolution of how major airlines have developed their route networks and if they have deliberately established little overlap on their territory coverage will be considerable.

5.3 Directions for Future Research

Given the limitations considered in the previous section, one natural direction of future research is to extend the work in Chapter 4 by developing an industry history to discern whether major airlines have developed over time their route structure in such a way to create little overlap; therefore preventing competition head-to-head. If so, it would complement and reinforce the econometric evidence we currently provide.

Another potential fruitful plan relates to perform an empirical analysis of market sharing agreements in others industries. In some real world market situations firms operating in multimarket industries may be able to coordinate entry in local markets, in such a way of determining local monopolies in which, thus, firms gain monopoly profits preventing competition head to head. The way through which firms may achieve this, is a sort of collusion strategy.

As mentioned in Chapter 4, there are several antitrust cases involving this type of ‘market’ collusion both in the US, under the Sherman Act for example, and in Europe. A further real world situation, which can provoke speculative thoughts, is provided by Sutton’s (1998) analysis of intensive R&D industries. For instance, the pharmaceutical industry at global level exhibits low concentration despite the fact that two sorts of endogenous sunk costs are prominent, advertising and R&D. In contrast, at more local level the industry shows high concentration within a given product market. This discrepancy in structure is explained by Sutton as a consequence of firms’ segmentation and specialisations (Sutton calls these as *‘technological trajectories’*), say, in some drug therapy. In other words, firms, given different technological characteristics, may tend to specialise in different *technological trajectories* giving, thus, scope to development of niche product markets, overall resulting in a fairly fragmented structure at global level but very concentrated at more local market level. This kind of behaviour may be the fruit of coordinated strategies.

The project would be based on a cross-industry analysis for a sample of EC prosecuted cartels studying which factors determine territory allocation as alternative to price fixing. The research would address the following questions; Are there any industry specific factors increasing the likelihood of this form of collusion? In homogeneous good industries agreements on markets can reduce probability of emergence of price wars in context of pronounced demand uncertainty, what about industries with differentiated products? Is this type of collusion as common in differentiated product industries as in homogeneous product industries?

References

Aguirregabiria, V., and Chun-Yu Ho, (2010) "A Dynamic Game of Airline Network Competition: Hub-and-Spoke Networks and Entry Deterrence", *International Journal of Industrial Organization*, 28, 377-382.

Bailey, E., and Panzar, J., (1981) "The Contestability of Airline Markets During the Transition to Deregulation", *Law and Contemporary Problems,* 49, 1425-1455.

Bain, J.S., (1956)*Barriers to New Competition: Their Character and Consequences in Manufacturing Industries*, Harvard University Press, Cambridge, MA.

Balasubramanian, N., and Lieberman, M.B., (2011) "Learning by Doing and Market Structure", *Journal of Industrial Economics*, 59, 177-198.

G. Bamberger, G., Carlton, D., and Neumann, L., (2004) "An Empirical Investigation of the Competitive Effects of Domestic Airline Alliances", *Journal of Law and Economics*, 47, 195-222.

Bakker, G., (2005) "The Decline and Fall of the European film Industry: Sunk Costs, Market Size and Market Structure, 1890-1927", *Economic History Review*, 58, 310-351.

Baum, J.A.C., Li, S.X., and Usher, J.M., (2000) "Making the Next Move: How Experimental and Vicarious Learning Shape the Locations of Chains' Acquisitions", *Administrative Science Quarterly*, 45, 766-801.

Belleflamme, P., and Bloch, F., (2004) "Market sharing agreements and collusive networks", *International Economic Review*, 45, 387-411.

Belobaba, P., (November 2010) "US Airline Competition and Consolidation 2010", *Global Airline Industry Program*, Massachusetts Institute of Technology.

Bernheim, D.B., and Whinston, M.D., (1990) "Multimarket contact and collusive behaviour", *RAND Journal of Economics*, 21, 1-26.

Berry, S., (1992) “Estimation of a model of entry in the Airline Industry”, *Econometrica*, 60, 889-917.

Berry, S., and Waldfogel, J., (1999) “Free Entry and Social Inefficiency in Radio Broadcasting”, *RAND Journal of Economics*, 30, 397-420.

Berry, S., and Waldfogel, J., (2010) “Product Quality and Market Size”, *Journal of Industrial Economics*, 58, 1-31.

Bilotkach, V., (2011) “Multimarket Contact and Intensity of Competition: Evidence from an Airline Merger”, *Review of Industrial Organization*, 38, 95-115.

Bilotkach, V., K. Hueschelrath, and K. Mueller (forthcoming) “The Construction of a Low Cost Airline Network: Facing Competition and Exploring New Markets”, *Managerial and Decision Economics*, in press.

Boguslaski, R., H. Ito, and D. Lee (2004) ”Entry Patterns in the Southwest Airlines Route System”, *Review of Industrial Organization*, 25, 317-350.

Bonanno, G., (1987) “Location Choice, Product Proliferation, and Entry Deterrence”, *Review of Economic Studies*, 54, 37-46.

Borenstein, S., (1989) “Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry”, *RAND Journal of Economics*, 20, 344-365.

Borenstein, S., (1991) “The Dominant-firm Advantage in Multi-product Industries: Evidence from the U.S. Airlines”, *Quarterly Journal of Economics*, 106, 1237-1266.

Borenstein, S., (2005) “US Domestic Airline Pricing, 1995-2004”, Competition Policy Center Working Paper CPC05-48, University of California, Berkeley.

Borenstein, S., and Rose, N.L., (2008) chapter 2, *How Airline Markets Work…or Do They? Regulatory Reform in the Airline Industry,* in *Economic Regulation and its Reform: What Have We Learned?* University of Chicago Press.

Brander, J., and Zhang, A., (1990) “Market Conduct in the Airline Industry: An Empirical Investigation”, *RAND Journal of Economics*, 21, 567-583.

Bresnahan, T.F., and Greenstein, S., (1999) “Technological competition and the structure of the computer industry”, *Journal of Industrial Economics*, 47, 1-40.

Bresnahan, T.F., and Reiss, P.C., (1991) “Entry and Competition in Concentrated Markets”, *Journal of Political Economy*, 99, 977-1009.

Brueckner, J.K., Lee, D., and Singer, E., (2010) “City-Pairs vs. Airport-Pairs: A Market-Definition Methodology for the Airline Industry”, working paper.

Bulow, J., Geanakopolos, J., Klemperer, P., (1985) “Holding Idle Capacity to Deter Entry”, *Economic Journal*, 95, 178-182.

Busse, M.R., (2000), “Multimarket contact and price coordination in the cellular telephone industry”, *Journal of Economics and Management Strategy*, 3, 287-320.

Buzzacchi, L., and Valletti, T., (2006), “Firm size distribution: Testing the ‘independent submarkets model’ in the Italian motor insurance industry”, *International Journal of Industrial Organization*, 24, 809-834.

Caplin, A., and Leahy, J., (1998) “Miracle on Sixth Avenue: Information Externality and Search”, *Economic Journal*, 108, 60-74.

Charles, Ng., and P. Seabright, P., (2001) “Competition, Privatisation and Productive Efficiency: Evidence from the Airline Industry”, *Economic Journal*, 111, 591-619.

Ciliberto, F., and Tamer, E., (2009) “Market Structure and Multiple Equilibria in the Airline Industry”, *Econometrica*, 77, 1791-1828.

Ciliberto, F., and Williams, J., (2012) “Does Multimarket contact Facilitate Tacit Collusion? Inference on Conduct Parameters in the Airline Industry”, working paper.

Cleeren, K., Verboven, F., Dekimpe, M.G., and Gielens, K., (2010) “Intra- and Inter- Format Competition among Discounters and Supermarkets”, *Marketing Science*, 29, 456-473.

Cohen, A.M. and Mazzeo M.J., (2007) “Market Structure and Competition among Retail Depository Institutions”, *Review of Economics and Statistics*, 89, 60-74.

Curry, B., and George, K., (1983) “Industrial Concentration: A Survey”, *Journal of Industrial Economics*, 31, 203-257.

D’Aspremont, C., Gabszewicz, J., and Thisse, J.F., (1979) “On Hotelling’s ‘Stability in Competition’”, *Econometrica*, 47, 1145-1150.

Davies, S.W., (1988) *Concentration*, in Davies, Lyons, Dixon and Geroski, *Economics of Industrial Organization*, London: Longmans.

Davies, S.W., and P.A., Geroski, (1997) “Changes in Concentration, Turbulence, and the Dynamics of Market Shares”, *Review of Economics and Statistics*, 79, 383-391.

Davies, S.W., and Lyons, B., (1982) “Seller Concentration: The Technological Explanation and Demand Uncertainty”, *Economic Journal*, 92, 903-912.

Davies, S.W., and Lyons, B., (1996)*Industrial Organization in the European Union: Structure, Strategy, and the Competitive Mechanism*, Oxford, Oxford University Press.

Davies, S.W, Olczak, M., and Coles, H., (2011) “Tacit Collusion, firm asymmetries and numbers: Evidence from EC merger cases”, *International Journal of Industrial Organization*, 29, 221-231.

De, O., (2010) “The Internal Structures and Organisation of EC Prosecuted Cartels and the Impact on their Performance”, Doctoral thesis, School of Economics, University of East Anglia.

De Juan, R., (2002) “Entry in independent submarkets: An application to the Spanish retail banking market”, *Economic and Social Review*, 33, 109-118.

De Juan, R., (2003) "The independent submarkets model: An application to the Spanish retail banking market", *International Journal of Industrial Organization*, 21, 1461-1487.

Dick, A., (2007) "Market Size, Service Quality and Competition in Banking", *Journal of Money, Credit and Banking*, 39, 49-81.

Dixit, A., (1979) "A Model of Duopoly Suggesting a Theory of Entry Barriers", *Bell Journal of Economics*, 10, 20-32.

Dixit, A., (1980) "The Role of Investment in Entry Deterrence", *Economic Journal*, 90, 95-106.

Doganis, R., (2001) *The Airline business*, 2nd edition, New York: Routledge.

Dunn, A. (2008) "Do low-quality products affect high quality entry? Multi-product firms and nonstop entry in airline markets", *International Journal of Industrial Organization*, 26, 1074-1089.

Eaton, B. C. and Lipsey, R. G., (1979) "The Theory of Market Preemption: The Persistence of Excess Capacity and Monopoly in Growing Spatial Markets", *Economica*, 46, 149-158.

Ellickson, P.B., (2007) "Does Sutton Apply to Supermarkets?" *RAND Journal of Economics*, 38, 43-59.

Etro, F., (2006) "Aggressive Leaders", *RAND Journal of Economics*, 37, 146-154.

Evans, W., Froeb, L., and Werden, G., (1993) "Endogenous in the Concentration-Price Relationship: Causes, Consequences, and Cures", *Journal of Industrial Economics*, 41, 431-438.

Evans, W., and Kessides, I., (1993) "Localized Market Power in the U.S. Airline Industry", *Review of Economics and Statistics*, 75, 66-75.

Evans, W., and Kessides, I., (1994) “Living by the ‘Golden Rule’: Multimarket Contact in the U.S. Airline Industry”, *Quarterly Journal of Economics*, 109, 341-366.

Feinberg, R.M., (1985) “Sales-at-Risk: A test of the mutual forbearance theory of conglomerate behavior”, *Journal of Business*, 58, 225-241.

Fernandez, N., and Marin, P.L., (1998) “Market power and multimarket contact: some evidence from the Spanish hotel industry”, *Journal of Industrial Economics*, 46, 301-315;

Gabszewicz, J., and Thisse, J.F., (1979) “Price Competition, Quality and Income Disparities”, *Journal of Economic Theory*, 20, 340-359.

Gabszewicz, J., and Thisse, J.F., (1980) “Entry (and Exit) in a Differentiated Industry”, *Journal of Economic Theory*, 22, 327-338.

Geroski, P.A., and Machin, S., (1992) “The Dynamics of Corporate Growth”, mimeo, London Business School.

Gibrat, R., (1931), *Les inégalités économiques ; applications : aux inégalités des richesses, a` la concentration des entreprises, aux popolations, des villes, aux statistiques des familles, etc., d’ une loi nouvelle, la loi de l’ effet proportionnel*, Librairie du Recueil Sirey, Paris.

Giorgetti, M.L., (2003) “Lower Bound Estimation – Quantile Regression and Simplex Method: An application to Italian Manufacturing sectors”, *Journal of Industrial Economics*, 51, 113-120.

Goolsbee, A., and Syverson, C., (2008) “How Do Incumbents Respond to the Threat of Entry? Evidence from the Major Airlines”, *Quarterly Journal of Economics*, 123, 1611-1633.

Greene, W.H., (fifth edition) *Econometric Analysis*, Prentice Hall International Edition.

Hall, B., (1987) “The Relationship between Firm Size and Firm Growth in the US Manufacturing Sector”, *Journal of Industrial Economics*, 35, 586-606.

Hay, D.A., (1976) “Sequential Entry and Entry-Deterring Strategies in Spatial Competition”, *Oxford Economic Papers*, 28, 240-257.

Hart, P.E., and Prais, S.J., (1956) “The Analysis of Business Concentration: A Statistical Approach”, *Journal of the Royal Statistical Society*, (Series A), 119, 150-181.

Hotelling, H., (1929) “Stability in Competition”, *Economic Journal*, 39, 41-57.

Ijiri, Y., and Simon, H., (1964) “Business firm growth and size”, *American Economic Review*, 54, 77-89.

Ijiri, Y., and Simon, H., (1977)*Skew Distributions and the Sizes of Business Firms*, North-Holland, Amsterdam.

Jans, I., and Rosenbaum, D.I., (1997) “Multimarket contact and pricing: evidence from the US cement industry”, *International Journal of Industrial Organization*, 15, 391-412.

Jovanovic, B., (1982),“Selection and the evolution of industry”, *Econometrica*, 50, 649-670.

Latcovich, S., and Smith, H., (2001) “Pricing, Sunk costs, and Market Structure Online: Evidence from Book Retailing”, *Oxford Review of Economic Policy*, 17, 217-234.

Lederman, M., (2007) “Do Enhancements to Loyalty Programs Affect Demand? The Impact of International Frequent Flyer Partnerships on Domestic Airline Demand”, *RAND Journal of Economics*, 38, 1134-1158.

Lederman, M., (2008) “Are Frequent Flyer Programs a Cause of the Hub Premium?” *Journal of Economics and Management Strategy*, 17, 35-66.

Levine, M., (1987) “Airline Competition in Deregulated Markets: Theory, Firm Strategy and Public Policy”, *Yale Journal on Regulation*, 4, 393-494.

Lyons, B., and Matraves, C., (1996)*Industrial Concentration*, chapter 6 in Davies and Lyons (1996) *Industrial Organization in the European Union: Structure, Strategy, and the Competitive Mechanism*, Oxford, Oxford University Press.

Lyons, B., Matraves, C., and P. Moffatt, (2001) "Industrial Concentration and Market Integration in the European Union", *Economica*, 68, 1-26.

Marin, P., (1995) "Competition in European Aviation: Pricing Policy and Market Structure", *Journal of Industrial Economics*, 43, 141-159.

Matraves, C., (1999) "Market Structure, R&D and Advertising in the Pharmaceutical Industry", *Journal of Industrial Economics*, 47, 169-194.

Matraves, C., (2002) "European Integration and Market Structure in the Soft Drinks Industry", *International Journal of the Economics of Business*, 9, 295-310.

Mazzeo, M.J., (2002) "Product choice and oligopoly market structure", *RAND Journal of Economics*, 33, 221-242.

Mazzeo, M.J., (2003) "Competition and Service Quality in the U.S. Airline Industry", *Review of Industrial Organization*, 22, 275-296.

McFadden, D., (1989) "Method of Simulated Moments for Estimation of Discrete Response Models without Numerical Integration", *Econometrica*, 57, 995-1026.

Motta, M., and Polo, M., (1997), "Concentration and Public Policies in the Broadcasting Industry: The Future of Television", *Economic Policy*, 12, 295-334.

Neven, D.J., Lars-Hendrik Roller, and Zhentang Zhang, (2006), "Endogenous Costs and Price-Cost Margins: an Application to the European airline Industry", *Journal of Industrial Economics*, 54, 351-368.

Nielsen Media Research, (2007).

Oliveira, A. V. (2008) “An empirical model of low-cost carrier entry”, *Transportation Research Part A: Policy & Practice*, 42, 673-695.

Pakes, A., Pollard, D., (1989) “Simulation and the Asymptotics of Optimization Estimators”, *Econometrica*, 54, 1027-1057.

Parker, P., and Roller, L.H., (1997) “Collusive Conduct in Duopolies: Multimarket Contact and Cross-Ownership in the Mobile Telephone Industry”, *RAND Journal of Economics*, 28, 304-322.

Piloff, S.J., (1999) “Multimarket contact in banking”, *Review of Industrial Organization*, 14, 163-182.

Powell, J.L., (1984) “Least Absolute Deviations Estimation for the Censored Regression Model”, *Journal of Econometrics*, 25, 303-325.

Prescott, E., Visscher, M., (1977) “Sequential Location among Firms with Foresight”, *Bell Journal of Economics*, 8, 378-393.

Prince, J., and Simon, D., (2009) “Multimarket Contact and On-Time Performance in the U.S. airline Industry”, *Academy of Management Journal*, 52, 336-354.

Rauch, J., (1993) “Does History Matter Only When It Matters Little? The Case of City-Industry Locations”, *Quarterly Journal of Economics*, 108, 843-867.

Reiss, P.C., (1996) “Empirical Models of Discrete Strategic Choices”, *American Economic Review Papers and Proceedings*, 86, 421-426.

Reiss, P. C. and P. T. Spiller (1989) “Competition and Entry in Small Airline Markets”, *Journal of Law and Economics,* 32, S179-S202.

Reynolds, S., (1987) “Capacity Investment, Preemption and Commitment in an Infinite Horizon”, *International Economic Review,* 28, 69-88.

Robinson, W.T., and Chiang, J., (1996) "Are Sutton's predictions robust? Empirical insights into Advertising, R&D, and Concentration", *Journal of Industrial Economics*, 44, 389-408.

Rupp, N.G., Owens, D.H., Plumly, L.W., (2006) *Does Competition Influence Airline On-Time Performance?* In: Lee, D. (Ed.), *Advances in Airline Economics*, Vol. I Elsevier.

Salop, S., (1979) "Monopolistic Competition with Outside Goods", *Bell Journal of Economics*, 10, 141-156.

Schaumans, C., and Verboven, F., (2008) "Entry and Regulation: Evidence from Health Care Professions", *RAND Journal of Economics*, 39, 949-972.

Scherer, F.M., and Ross, T., (1990) *Industrial Market Structure and Economic Performance*, (3nd ed.), Boston: Houghton and Mifflin.

Schmalensee, R., (1978) "Entry Deterrence in the Breakfast Ready-to-Eat Cereal Industry", *Bell Journal of Economics*, 9, 305-327.

Scott Morton, F., (1999) "Entry decisions in the generic pharmaceutical industry", *RAND Journal of Economics*, 30, 421-440.

Scott Morton, F., (2000) "Barriers to entry, brand advertising, and generic entry in the US pharmaceutical industry", *International Journal of Industrial Organization*,18, 1085-1104.

Seim, K., (2006), "An empirical Model of Firm Entry and Endogenous Product-Types Choices", *RAND Journal of Economics*, 37, 619-640.

Shaked, A., and Sutton, J., (1982) "Relaxing Price Competition through Product Differentiation", *Review of Economic Studies*, 49, 3-13.

Shaked, A., and Sutton, J., (1983) "Natural Oligopolies", *Econometrica*, 51, 1469-1483.

Shaked, A., and Sutton, J., (1987) "Product Differentiation and Industrial Structure", *Journal of Industrial Economics*, 36, 131-146.

Shaked, A., and Sutton, J., (1990) "Multiproduct Firms and Market Structure", *RAND Journal of Economics*, 21, 45-62.

Shapiro, S.S., and Wilk, M.B., (1965) "An Analysis of Variance Test for Normality (complete samples)", *Biometrika*, 52, 591-611.

Simon, H., and Bonini, C.P., (1958) "The Size Distribution of Business Firms", *American Economic Review*, 48, 607-617.

Singal, V., (1996) "Airline Mergers and Multimarket Contact", *Managerial and Decision Economics*, 17, 559-574.

Spence, M., (1977) "Entry, Capacity, Investment and Oligopolistic Pricing", *Bell Journal of Economics*, 8, 534-544.

Spence, M., (1979) "Investment Strategy and Growth in a New Market", *Bell Journal of Economics*, 10, 1-19.

Symeonidis, G., (2000) "Price Competition and Market Structure: The Impact of Cartel Policy on Concentration in the UK", *Journal of Industrial Economics*, 48, 1-26.

Sutton, J., (1991) *Sunk Costs and Market Structure: Price Competition, Advertising, and the Evolution of Concentration*, MIT Press, Cambridge, Massachusetts.

Sutton, J., (1998) *Technology and Market Structure: Theory and History*, MIT Press, Cambridge, Massachusetts.

Tirole, J., (1988) *The Theory of Industrial Organization*, MIT Press, Cambridge, Massachusetts.

Toivanen, O., and Waterson, M.., (2000) "Empirical Research on Discrete Choice Game Theory Models of Entry: An Illustration", *European Economic Review*, 44, 985-992.

Toivanen, O., and Waterson, M.., (2005) “Market Structure and Entry: where’s the beef?” *RAND Journal of Economics*, 36, 680-699.

Vasconcelos, H., (2006), “Endogenous Mergers in Endogenous Sunk Cost Industries”, *International Journal of Industrial Organization*, 24, 227-250.