"COMPETITION, MARKET NICHES, AND EFFICIENCY: A STRUCTURAL MODEL OF THE EUROPEAN AIRLINE INDUSTRY"

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94/02/EPS

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December 1993

Abstract

In this paper we specify and estimate a structural model of competition for the European Airline Industry in order to assess the potential for price reductions if competition increases. The model has two distinguishing features (i) we allow for firms to make short- and long-run decisions by explicitly estimating a structural, two-stage game. In that sense, our model allows for dynamics that do not rely on the switching regime literature. Unlike some of the other contributions in the literature, we also explicitly estimate the entire structural model, that is demand, cost (short and long run), and conduct. Second, our paper distinguishes between domestic market niches and competition at the international level, by specifying a product-differentiated game in the second stage. This distinction carries important policy implications. In general we find that relatively little market power is due to price collusion. In fact, firms compete significantly more than a standard Nash game would suggest. On the other hand, significant monopoly power is identified in domestic markets. Given that prices are not high because of cartel pricing, airline prices in Europe might come down more gradually as efficiency increases and market niches are abolished.

*This paper was written while the first author was visiting the Graduate School of Business at Stanford University. We like to acknowledge the Association of European Airlines and DG VII of the European Community for helpful discussions and information. We also like to thank Garth Saloner, Andrea Shepard, Robert Marks, and Horst Albach for their comments. We acknowledge financial support from the C.V. Starr Center at New York University, INSEAD research grant No. 2024R, and Indiana University.

1. Introduction

The airline industry in Europe is undergoing an ambitious liberalization process. For almost 30 years after the signing of the Treaty of Rome the air transport sector has been excluded from the jurisdiction of the European Commission. This changed in April 1986 when the European Court of Justice ruled that the competition rules spelled out in the Treaty of Rome must also be applied to the air transport industry. This historic decision opened the way towards European airline liberalization. In December 1987 the Council of Ministers adopted a first package of measures introducing new competition rules, relaxing price controls, and opening market access. Over time the pressure to further deregulate airlines resulted in a second phase of "Euroliberalization" in 1989. A third package, leading towards a 'in principle' open intra-European market, has just been put into effect this year. Many of the measures contained in these packages will take time to implement; policy makers talk about a pre- and post 1993 phase. In addition, the question of third country regulation, i.e. opening up markets for competitors from non-EC countries and vice-versa, is still to be addressed more completely and remains in the public debate. The road to deregulation is still uncertain, but it is rather clear that the industry is going through radical changes.

The European airlines have felt the impact of the new "liberalization" laws. To provide a buffer against the inevitable price wars that followed the U.S. deregulation, the European airlines have begun to restructure themselves as well as the industry. Many of the internal restructuring programmes currently being implemented or considered by the European carriers focus on improvements in their cost structure. Corporate renewal and restructuring takes time, as well as a good amount of pressure from the markets. The case of Lufthansa might be a typical example. The carrier is undergoing a very ambitious restructuring process, similar to the one British Airways underwent 10 years earlier. In addition strategic alliances with other European carriers, as well as U.S. carriers are being implemented or considered. The necessary reorganization and reduction in the labor force is another matter. Other cost cutting measures are to be implemented. However there are certain institutional, legal, and political constraints, not under the control of Lufthansa and its management, which will make it more difficult to arrive at a competitive cost structure. At the beginning of 1993 Lufthansa launched a major marketing initiative, slashing prices on selected routes. It is not clear, however, that these price reductions will lead to sustainable welfare gains for travellers. Whether they will depends partially on the existence of significant monopoly rents. If no such rents are currently being earned, price cuts can only occur if costs are reduced.

In this paper we will assess the potential for price reductions if competition increases within Europe, holding the cost structure constant. The question we address is whether there is any likely *sustainable* price reduction possible for the European carriers, given the carriers existing cost structures. If European carriers do not enjoy significant monopoly rents in the pre-liberalization period we will be analyzing (1976-1990), then it is unlikely that more competition will allow them to lower prices much. In this case we would expect prices to move downwards as efficiencies and costs are improved. Thus, potential benefits from liberalization are primarily realized through increased efficiency.

In order to address these issues we need to estimate the existing price-cost margins in the industry, and simulate the effect of increased competition. We do this by estimating a structural model of competition with the following two basic features. First, each carrier is assumed to operate in a protected domestic niche on the one hand (its home market), and compete with other carriers on inter-European routes on the other hand. Our model therefore differentiates between market niches and collusion. It is assumed that the niche is geographical, and equivalent to the carriers national territory. This is reasonable in the context of the existing regulatory environment during the study period (1976-1990) for at least two reasons: first, it is relatively easy and appropriate to associate a European carrier with a European country in this way, and secondly, prior to the third package (effective in January of 1993) little competition on domestic routes took place. On inter-European routes, however, competition existed to a somewhat greater extend, in particular after January 1988 when the first "package" of EC Council legislation was adopted. Even though various capacity sharing and joint price-setting schemes continued to exist, these were successively abolished, at least on paper. One interesting empirical question is then whether these old habits have been effectively broken, or just replaced by other structures[1].

The second basic feature of our model is that we allow for firms to make both short-run and long-run strategic decisions. In the short-run firms are assumed to compete in prices,

[1]Given the historical developments in the European Airline Industry one could doubt the 'successful' transition from a regulated cartel to more competitive behavior. Theories of collusion often predict a less competitive environment if the game lasts for a long time, and the players do not change frequently. European airlines had ample time to get to know each other. There has been relatively little change in the identity of the major carriers or its executive boards. Many carriers are national flagships, and subsidized as well as sometimes managed by their governments.

whereas long-run decisions are modelled to be capital investments, both physical and human. The differentiation between the short-run and long-run in this way is particularly reasonable in the context of European industry. Clearly, planes must be ordered in advance and delivery times are lengthy. Moreover, European labor laws are very liberal, making it rather difficult for airlines to layoff employees. "Golden Parachutes" and early retirement is often the only socially acceptable (and legal) option[2]. By differentiating between the short- and long-run, our model endogeneizes investment in physical and human capital. As we will see below, this distinction has important implications.

The literature on structural estimation or calibration of oligopolistic conduct included mostly static formulations (an incomplete list includes Iwata (1974), Gallop and Roberts (1979), Appelbaum (1982); for a survey see Bresnahan (1989)). Most relevant for this paper is the work by Brander and Zhang (1990) who analyze market conduct in the U.S. airline industry. They conclude that the Cournot model is much more consistent with the data in general than either Bertrand or cartel behavior[3]. More recently, dynamic specifications have been analyzed. Brander and Zhang (1993) (see also Porter (1983)) estimate a switching regime model for the U.S. airline industry based on the theory of repeated games. Firms are assumed to be implementing punishment strategies to enforce collusion in an uncertain environment (see Green and Porter (1984), Abreu (1986), Saloner and Rotemberg (1986)). Empirical observations would then be drawn from either a collusive or punishment phase. They reject the constant behavior models in favor of the regime-switching models, where the punishment phases are best described by Cournot competition. Other empirical contributions in a dynamic game context includes Bresnahan (1987) and Slade (1987, 1992).

A related strand of literature include Hurdle et al. (1989), Whinston and Collins (1992), and which study the hypothesis of contestability of the U.S. airline industry. Overall they find that the airline market is not contestable and that excess profits are being earned. In addition, Berry (1990, 1992) and Borenstein (1989, 1990) argue that airlines are able to increase average prices through strong airport presence and hub dominance. This would

[2]For instance, Lufthansa employees enjoy a status similar to a government employee, which makes them virtually impossible to layoff. Therefore, the ambitious cost cutting programme now underway at Lufthansa is focusing on layoffs through retirement options. Full privatization of Lufthansa would make layoffs easier to administer, since German labor laws for private companies are somewhat more flexible.

[3]Other important contributions on pricing in the airline industry include Borenstein and Rose (1992) who analyze price dispersion on a given flight. The effect of networks on competition and pricing are sudied in Brueckner, and Spiller (1991), and empirically tested in Brueckner, Dyer, and Spiller (1992).

suggest, especially in the European context, that dominant airlines will be able to maintain higher prices in their home markets.

Our paper differs from the above literature in three regards. First, we allow for firms to make short- and long-run decisions by explicitly estimating a structural, two-stage game. In that sense, our model allows for dynamics that do not rely on the switching regime literature. Unlike some of the other contributions to the literature mentioned above, we also explicitly estimate the entire structural model, that is demand, cost (short and long run), and conduct. Second, our paper distinguishes between protected market niches and competition, by specifying a product-differentiated game. This distinction carries important policy implications. Finally, the paper focuses on the European airline industry.

The paper is organized as follows. The next two sections briefly summarize the institutional environment in place during the sample period, followed by an empirical assessment of efficiency differences under airline deregulation in the U.S. and Europe. Section 4 develops a structural model of competition, followed by a section explaining the empirical implementations and results. Section 6 concludes.

2. The European Airline Industry: Institutional Developments

While the European carriers were engaged in moderate competition in Trans-Atlantic travel, the domestic scheduled market remained heavily regulated through bilateral agreements until the mid-eighties. The European airlines were mainly public airlines or majority government owned. They enjoyed the duopolistic situation created by the bilateral agreements and prevented new entry in the intra-European market. Through these bilateral agreements, the airlines pooled revenues and shared capacity, thus eliminating any competition between themselves on these routes.

The European Commission had recommended opening aviation to competition as early as 1972, the strong objections from the European governments tabled this discussion till 1979, when it published the Civil Aviation Memorandum Number 1. It recommended among others, that airlines needed to offer cheaper fares; that there was a need to develop new cross-frontier services connecting regional centers within the community; a clear universal policy was required on government subsidies; and that full freedom of access to all markets was desirable. The transportation ministers worked on these measures in the early-eighties, which did result in a marginal improvement with regard to competition and cheaper fares in late 1982. The emergence of "bucket shops" that allowed airlines to increase their load-factors by selling heavily discounted tickets indirectly to the public through pseudo-travel agents and a marginal increase in cabotage traffic were examples.

The larger European nations, however, were very reluctant until the mid-eighties, to abandon the protected status of their national carriers by advocating more liberal competition policies. These governments directly or indirectly subsidized their carriers, the extent of which varied from country to country. Financial assistance was provided to: (1) compensate airlines for the imposition of a public service obligation; (2) develop and operate domestic services; (3) provide service to economically underdeveloped regions; (4) encourage the acquisition and operation of specific airplanes (Airbus' in Europe); or (5) simply to cover an airline's operating loss (Taneja, 1988). Further, the governments often used their airlines as instruments of employment policy.

New competitors were denied access to the market by a set of stringent laws specifically designed to protect these national airlines. This operation resulted in a very inefficient allocation of resources as the airlines consistently suffered losses. In December 1986, British Airways (BA), with most of its equity wiped out by sluggish performances year after year, was sold to the private sector, thus joining Swissair as the only other privately owned airline in Europe. In early 1987, British Airways waged a highly nationalistic campaign to "rescue" British Caledonian from foreigners, namely, the Scandinavian Airline Systems and "took over" its only serious domestic rival. With declining profitability in its European operations, BA signed a marketing accord with United Airlines. It integrated United's flight schedules and networks in America with BA's transatlantic services to American cities. The agreement enabled the airlines to share passengers and increased the quality of service for time conscious business travellers. As a result, BA's load-factor on the transatlantic sector increased by almost 40 percent (The Economist, 1989). These innovative enterprises enabled British Airways to rebuild its equity in just over a year.

In May 1987, Peter D. Sutherland, the European Community (EC) competition policy commissioner, threatened to take the 12 major airlines to the European Court for operating an illegal cartel in violation of the competition rules of the Treaty of Rome. In June 1987, European transport ministers met in Brussels to agree on a package that would have allowed some flexibility on setting fares. After months of tough negotiations, the transportation ministers adopted an aviation legislative package to free competition on

December 7, 1987. This package allowed airlines to offer "deep" discount fares - ranging between 65 and 90% of the economy class fares - provided that this was accepted by the Member states. It also allowed for an increase in capacity shares on a route provided that the shares split between two countries were not outside the range of 55 to 45% up to October 1, 1989, and 60 to 40% thereafter. This was an historic agreement. It had taken more than twenty five years for the European countries as a group to agree on a multilateral agreement, however minimal the legislation. This gave the impetus to the ministers to push for even less restrictions. The latest round of liberalization talks ended on June 22, 1992 in Luxembourg where after ten years of hard negotiations, the European Community had finally agreed on issues that would finally create a more competitive environment in European skies[4].

A criticism against the European airlines has historically been that the price on most routes has consistently been higher than prices charged for similar distances in the U.S. The reason for this has been attributed to the shared monopolies in most markets created by bilateral agreements between member states. The whole "liberalization" movement started in an effort to end these monopolies and bring prices down to a "more competitive" level. In the next section we test for the presence of monopoly pricing.

3. Airline Efficiency: Europe vs U.S.

Before turning to our model of competition we briefly discuss the available empirical evidence on efficiency in U.S. and European airlines. The effects of liberalization in Europe are undoubtedly quite different in scope and magnitude than in the U.S. This is due to the political realities on the one hand and to structural and geographical differences on the other. Nevertheless, it is possible to obtain a measure of the *potential* benefits from liberalization due to changes in costs by comparing the efficiency of European carriers to their counterparts in the U.S., as well as Asia. Presumably, if European deregulation truly

[4]The five major areas of liberlization include (i)*Fares:* Airline will be able to set their own prices, subject to some controls, (ii)*Routes*: Consecutive cabotage rights to add a domestic leg on to a flight originating from a carriers home base to a foreign destination, provided that the load factor on the domestic leg, did not exceed 50% of the total of the main flight, (iii)*Flights*: Agreement to the sixth freedom, (which has been in dispute since the Chicago Convention), where airlines could fly passengers to two destinations, while stopping at a third country which was the airlines base, (iv)*Domestic services*: Starting from April 1, 1997, any carrier from any EC country can operate internal flights in any of the twelve member states, (v)*Licensing*: Common rules governing safety and financial requirements on capital adequacy for new entrants to the market. Once satisfied, they would be able to fly on any EC route under the above package.

becomes a reality, and competition amongst international carriers (or strategic alliances of multiple carriers) determines survival, fares, services, and ultimately market structure, then it can be expected that cost structures must converge to a certain extend.

Table 1 reports new efficiency scores for selected U.S. and European Carriers from 1976 to 1990. Efficiency scores are measured relative to the most efficient carrier. They are defined by a stochastic production function frontier, and measure the distance to that frontier. The relative efficiency scores reported in Table 1 are controlled for various other environmental variables, such as the network characteristics, the load factor, and technological characteristics of the fleet[5] .

Insert Table 1 about here

The results in Table 1 are quite striking. The only carriers in the U.S. to significantly reduce their efficiency was Eastern while the only European firms to significantly increase their efficiency were Alitalia, British Air and Sabena. The steady but not dramatic increase in efficiency by the U.S. carriers - the industry increased its efficiency from 0.75 to 0.82 during the sample period - suggests a convergence towards a common efficiency standard (defined by Northwest) during deregulation in that firm heterogeneities became less pronounced. Absent carriers Eastern and Pan Am, which exited the industry soon after the end of the sample period, the industry average in 1990 would have been almost 0.86, a 15% increase in the level over its 1977 figure. This is also consistent with the conventional wisdom that U.S. carriers lost their protected niches and non-systematic network restrictions. Pan Am, for example, had been the designated U.S. carrier for several European routes. Under deregulation the carrier lost this position, and without a reliable feeder network in the U.S. was unable to compete effectively and left the industry.

European carriers, on the other hand, had initial efficiency levels which averaged about 0.56 and ended the sample period with an average of 0.53, a reduction of 7%, and of the three firms whose efficiency increased Alitalia, British Air, and Sabena - only Sabena's 1990 figure approached the average of the U.S. carriers in 1976. Moreover, several of the carriers, in particular Air France and Alitalia, received direct subsidies from their governments. The notable exception in terms of explicit subsidies is British Air which in

[5]For details on the above model and data see Good, Nadiri, Röller, Sickles (1993). See also Encaoua (1991) for another study on productivity in the European airline industry.

1976 was last in efficiency rankings just as it was emerging from a merger of BOAC with BEA. Subsequent restructuring eliminated routes and personal. This streamlining invariably raised the efficiency of the firm. Table 1 shows an annual compound rate of increase in relative efficiency of 3.95% per year, the highest rate for any of the carriers in our sample. British Air was the exception rather than the rule for the European carriers. The U.S. experience under deregulation was clearly not duplicated by their competitors in European during the same time period. In fact, European carriers appeared to diverge while they fell further behind those in America.

What are the costs of these inefficiencies? Good, Röller, and Sickles (1993) find that the European airline industry has lost approximately $4 billion in 1986 due to inefficient operations relative to U.S. firms. This amounts to some 16% of the total operating costs. If output were to remain constant, this would imply a loss of 42 thousand jobs in the airline industry.

One could argue that the above estimates represent an underestimate of the potential benefits stemming from the elimination of inefficiencies in Europe for two reasons. First, the U.S. industry might itself not be fully efficient. As Bailey and Kirstein (1989) point out in her comments on Morrison and Winston's paper (1989), "the full benefits of airline deregulation (in the U.S.) have not been enjoyed". Morrison and Winston (1986, 1989) also support this view; they estimated that deregulation increased consumer welfare by $6 billion 1977 dollars annually due to fare decreases and increased flight frequency but that this value falls short of the socially optimal value by another $2.5 billion because the industry is not completely competitive. Recently, Borenstein (1992) offers numerous insights into many of the occurrences since deregulation. In particular, he discusses the effects of computers, hubbing, congestion, on-time performance, and safety (see also Gordon 1992 and Rose 1990). In addition, Good and Rhodes (1991) compare U.S. carriers to Asian carriers. They find that there is a substantial efficiency gap between U.S. and Asian carriers. This is to say that a comparison between the European and Asian carriers would produce an even larger efficiency gap. Second, the above estimates do not take into consideration any allocative inefficiencies. However, estimates of allocative inefficiencies require a more sophisticated specification of the production technology[6]. Finally, an important assumption underlying the above estimates is that the quantity demanded as well as the demand for airline services is not going to change dramatically.

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[6]The above model uses a Cobb-Douglass specification, which constraints the elasticity of substitution to unity.

Clearly, under deregulation potential for lower prices does exist. The next section will build a model of competition and empirically assess the potential for price reductions.

4. A Model of Competition for the European Airline Industry

In this section we address the question of whether there is any likely *sustainable* price reduction possible for the European carriers, given the carriers existing cost structures. If European carriers do not enjoy significant monopoly rents in the pre-liberalization period we will be analyzing (1976-1990), then it is unlikely that more competition will allow them to lower prices much. In this case we would expect prices to move downwards as efficiencies and costs are improved.

In order to address these issues we need to estimate the existing price-cost margins in the industry, and assess the effect of increased competition. We do this by estimating a structural model of competition (see Bresnahan (1989) for a survey). Each carrier is assumed to operate in a protected domestic niche, its home market. It is assumed that the niche is geographical, and equivalent to the carriers national territory. Across markets firms are assumed to compete with each other.

4.1 The Basic Model

To allow for a protected home market as well as inter-European competition we specify a product-differentiated, price-setting game. Each carrier faces a differentiated demand of the form[7],

$$q_i(p_i, p_j, Z_i), \qquad i = 1,..,N \tag{1}$$

where N is the number of carriers (or countries), q_i is the quantity demanded, p_i is a price index for carrier i, and p_j is a price index of the competitors price. Z_i is a vector of country-specific, exogenous factors effecting demand (see the next section). The price elasticity implicitly defined in (1) can be interpreted as a measure of how protected the niche is, and is assumed to be positive. In other words, a low price elasticity implies that consumers consider carriers to be poor substitutes. This might be for reasons of unavailable service by other carriers due to the regulatory environment, a perceived quality

[7]We omit the time subscript for notational convenience.

differential, or for loyalty towards the national carrier.[8] Throughout the paper, we will maintain the assumption that the own-price effect is larger than the cross-price effect, i.e. $-\frac{\partial q_i}{\partial p_i} > \frac{\partial q_i}{\partial p_j} > 0$.

Costs are modelled by taking into account short-run and long-run decision variables. In the short run, firms can effect costs (as well as demand and profitability) only through changes in prices. In the long-run carriers can vary their cost structure through changes in the capital stock (planes) and labor (employees). To differentiate between short- and long-run factors, we specify the following firm-level cost structure,

$$C^{LR}(q_i(.),k_i,l_i|\omega_i,R_i) = C^{SR}(q_i(.)|k_i,l_i,\omega_i,R_i) + \omega_{k_i}k_i + \omega_{l_i}l_i \qquad (2)$$

where short-run costs (or variable costs) depend only on quantity, given a capital stock (k_i), labor force (l_i), factor prices (ω), as well as a vector of exogenous cost characteristics R_i (see below). In the long-run, fixed factors become variable, that is capital and labor can be altered as well.

To incorporate the short- and long-run set-up strategically, we specify a two-stage game, where firms make capital and labor decisions in stage 1, followed by choosing prices in stage 2. Firms are assumed to maximize profits. Given the above cost and demand conditions we will solve for the subgame-perfect equilibrium. Therefore, in stage 2, firms solve the following program,

$$\max_{p_i} \pi_i = q_i(.)p_i - C(q_i(.)|k_i,l_i,\omega_i,R_i) \qquad i = 1,..,N$$

where $q_i(\cdot)$ is given in (1) and C denotes short-run costs. The corresponding first-order conditions are given by[9],

$$p_i - MC(.) - \theta \cdot \frac{p_i}{\eta} = 0 \qquad i = 1,..,N \qquad (3)$$

[8]In order to keep the model relatively parsimonious, we avoid individual cross-price effects in (1). Clearly, one could focus on a richer specification than (1), allowing for individual effects. This approach would bring out some of the differences and possibly identify sub-groups of competing airlines. Specifying (1) in this way effectively imposes symmetry on the demand structure.

[9]The second-order condition is derived in Appendix-B.

where η is the elasticity of demand and MC(.) are marginal costs, defined by $\partial C / \partial q_i$. The parameter θ measures the degree of collusion in the second stage price-setting game. If $\theta = 0$, prices equal marginal costs and the industry is perfectly competitive. $\theta = 1$ is consistent with Nash behavior, whereas θ 's larger than one imply collusive price setting.

Let us denote the equilibrium prices that solve (3) by $p_i^*(k_i, l_i)$. Then, in stage 1, the firms maximization problem can be written as,

$$\max_{k_i, l_i} \pi_i = q_i(p_i^*, p_j^*, .)p_i^* - C^{LR}(q_i(p_i^*, p_j^*, .), k_i, l_i | \omega_i, R_i) \qquad i = 1,.., N$$

Omitting the functional arguments as well as the '*' for notational convenience, the corresponding first-order conditions are[10],

$$p_i \frac{dq_i}{ds_i} + q_i \frac{\partial p_i}{\partial s_i} - \frac{dC}{ds_i} - \omega_{s_i} = 0, \qquad i = 1,.., N \tag{4}$$

where $s_i = k_i, l_i$, and

$$\frac{dC}{ds_i} = MC \frac{dq_i}{ds_i} + \frac{\partial C}{\partial s_i} \quad \text{and} \quad \frac{dq_i}{ds_i} = \frac{\partial q_i}{\partial p_i}\frac{\partial p_i}{\partial s_i} + \frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial s_i} \tag{5}$$

Substituting (5) into (4), making use of (3), we can rewrite (4) after some simplifications as,

$$\frac{\partial p_i}{\partial s_i} q_i (1-\theta) + (p_i - MC)\frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial s_i} - \frac{\partial C}{\partial s_i} - \omega_{s_i} = 0 \tag{6}$$

Note that when $\theta = 0$, using (3), (6) reduces to $\frac{\partial p_i}{\partial s_i} q_i - \frac{\partial C}{\partial s_i} - \omega_{s_i} = 0$. This means that when the second stage is perfectly competitive, first-stage investments are taken non-strategically, balancing the effect of s_i on marginal revenue and marginal costs in the sequential set-up. If $\theta = 1$, the first term in (6) disappears and the initial investment in s_i

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[10]See Appendix-B for the second-order conditions.

might be larger than when $\theta = 0$. The changes in first stage investment, output and prices when θ changes are discussed in more detail below.

Returning to the development of the model, recall that the sequential strategic dependence is captured through $\partial p_i / \partial s_i$ and $\partial p_j / \partial s_i$. Rather than specifying specific functional forms, we use the structure of the model to solve explicitly for $\partial p_i / \partial s_i$ and $\partial p_j / \partial s_i$ in order to obtain efficient estimates of the structural parameters. Implicit differentiation of (3) with respect to s_i and s_j yields,

$$\frac{\partial p_i}{\partial s_i} = \frac{\frac{\partial MC}{\partial s_i}\frac{\partial q_i}{\partial p_i} - \theta\frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial s_i}}{(1+\theta)\frac{\partial q_i}{\partial p_i}} \quad \text{and} \quad \frac{\partial p_j}{\partial s_i} = -\frac{\theta\frac{\partial q_j}{\partial p_i}\frac{\partial p_i}{\partial s_i}}{(1+\theta)\frac{\partial q_i}{\partial p_i}} \tag{7}$$

Conditions (7) imply that as long as θ is not zero, the cross-sequential effect ($\partial p_j / \partial s_i$) is smaller in absolute value than the own-sequential effect ($\partial p_i / \partial s_i$), and they have the same sign. The fact that (sequentially) the own effect dominates the cross effect is a direct consequence of our maintained assumption that the own-demand effect is larger (in absolute value) than the cross-demand effect. When θ is zero $\partial p_j / \partial s_i = 0$ and $\partial p_i / \partial s_i = \partial MC / \partial s_i$, that is when markets are perfectly competitive, firm i can not effect firm j's pricing decision, and can only effect its own pricing through costs. At this point it should be pointed out that in the empirical analysis below, we do not impose any of these conditions on the estimation, but rather specify them as testable hypothesis. Solving equations (7) yields,

$$\frac{\partial p_i}{\partial s_i} = \frac{\partial MC}{\partial s_i}(1+\theta)\frac{\partial q_i}{\partial p_i}\frac{\partial q_j}{\partial p_j} / \Re \quad \text{and} \quad \frac{\partial p_j}{\partial s_i} = -\frac{\partial MC}{\partial s_i}\theta\frac{\partial q_i}{\partial p_i}\frac{\partial q_j}{\partial p_i} / \Re \tag{8}$$

where $\Re = (1+\theta)^2 \frac{\partial q_i}{\partial p_i}\frac{\partial q_j}{\partial p_j} - \theta^2 \frac{\partial q_i}{\partial p_j}\frac{\partial q_j}{\partial p_i}$. Note that $\frac{\partial MC}{\partial s_i}$ is the effect of s_i on marginal costs in stage two. This is an important effect in the model, since whenever it is zero there is no strategic link between the two periods (see (8)) and a simple one-stage game is appropriate. Moreover, from (8) and our maintained assumptions it follows that $\partial MC / \partial s_i < 0$ implies $\partial p_i / \partial s_i < 0$ and $\partial p_j / \partial s_i < 0$, which in turn implies (via (5)) that $dq_i / ds_i > 0$. In other words, an increase in stage one capacities by firm i, decreases prices in both markets, and increases output and consumer surplus in both markets. The reverse is the case whenever $\partial MC / \partial s_i > 0$. The sign and significance of $\partial MC / \partial s_i$ will be a testable hypothesis in the empirical section below.

Collusion in stage one could also be introduced parametrically. Joint profit maximization would alter condition (6) by adding the term $d\pi_j / ds_i$, which can be shown to be negative under the above assumptions[11]. Thus, joint profit maximization will reduce the initial capacity investments.

4.2 Short- and Long-Run Effects

Using the above model, we know investigate how changes in θ effect up-front capacity investment, and ultimately prices and output. It should be noted that there are two separate effects on final stage prices in this model. The direct effect of a change in θ on price (implicitly defined in (3)) and an indirect effect (through $\partial p_i / \partial s_i$). The indirect effect follows from the two-stage set-up, since changes in θ will result in changes in stage one capacity investments, which in turn will effect prices. We can therefore decompose the total effect on prices due to a change in competition in the following way,

$$\frac{dp_i}{d\theta} = \frac{\partial p_i}{\partial s_i}\frac{\partial s_i}{\partial \theta} + \frac{\partial p_i}{\partial s_j}\frac{\partial s_j}{\partial \theta} + \frac{\partial p_i}{\partial \theta}$$

The first two terms represent the indirect effect through the up-front capacity investments. This can also be interpreted as a long-run effect on prices. The last term represents the direct effect on prices (short-run). These two effects are analyzed below in more detail. Anticipating results a bit, it is theoretically possible that the indirect effect not only goes into the opposite direction, but also dominates the direct effect. In this case, an increase in the competitive nature of the pricing game (lower Θ) will result in higher prices. The following proposition characterize the *total* effect on prices further[12].

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[11]From the profit function for firm j we get $\frac{\partial \pi_j}{\partial s_i} = p_j \frac{dq_j}{ds_i} + q_j \frac{\partial p_j}{\partial s_i} - \frac{\partial C}{\partial q_j}\frac{dq_j}{ds_i}$, which can be rewritten by using the first-order condition for firm j as $\frac{\partial p_j}{\partial s_i} q_j (1-\theta) + (p_j - \frac{\partial C}{\partial q_j})\frac{\partial q_j}{\partial p_i}\frac{\partial p_i}{\partial s_i}$, which is negative.

[12]In the remainder of this section we assume that $\frac{\partial MC}{\partial s_i} < 0$, since this is the empirical prediction of the next section. The analysis for the case when $\frac{\partial MC}{\partial s_i} > 0$ is analogous.

Proposition 1: The more competitive the second stage pricing game (low θ), the lower the prices, i.e. $\frac{dp_i}{d\theta} > 0$, *if and only if* $\frac{\partial s_i}{\partial \theta} < q_i / \frac{\partial MC}{\partial s_i}\frac{\partial q_i}{\partial p_i}$.

Proof: We begin by re-writing the first-order condition at stage 2 as,

$$(p_i - MC)\frac{\partial q_i}{\partial p_i} + q_i\theta = 0$$

Totally differentiating with respect to θ yields,

$$(p_i - MC)\frac{d}{d\theta}(\frac{\partial q_i}{\partial p_i}) + \frac{\partial q_i}{\partial p_i}(\frac{dp_i}{d\theta} + \frac{dMC}{d\theta}) + \frac{dq_i}{d\theta} + q_i = 0$$

Using symmetry and substituting $\frac{dq_i}{d\theta} = \frac{dp_i}{d\theta}(\frac{\partial q_i}{\partial p_i} + \frac{\partial q_i}{\partial p_j})$ and $\frac{dMC}{d\theta} = \frac{\partial MC}{\partial q_i}\frac{dq_i}{d\theta} + \frac{\partial MC}{\partial s_i}\frac{\partial s_i}{\partial \theta}$, and rearranging yields,

$$\frac{dp_i}{d\theta} = (\frac{\partial MC}{\partial s_i}\frac{\partial s_i}{\partial \theta}\frac{\partial q_i}{\partial p_i} - q_i) / (\frac{\partial q_i}{\partial p_i} + (p_i - MC)(\frac{\partial^2 q_i}{\partial p_i^2} + \frac{\partial^2 q_i}{\partial p_i \partial p_j}) + (\theta - \frac{\partial MC}{\partial q_i}\frac{\partial q_i}{\partial p_i})(\frac{\partial q_i}{\partial p_i} + \frac{\partial q_i}{\partial p_j})),$$

which is positive under the condition in the proposition and any concave demand function. For the semi-log demand specification used in the next section the expression reduces to,

$$\frac{dp_i}{d\theta} = (1 - \frac{\partial MC}{\partial s_i}\frac{\partial s_i}{\partial \theta}\alpha_i)[\alpha_i(\frac{\partial^2 C}{\partial q_i^2}q_i(\alpha_i - \alpha_j) - 1)]^{-1}, \text{ where } \alpha_s = \frac{\partial \log(q_i)}{\partial p_s}$$

which is positive under the above condition .Q.E.D.

To isolate the direct effect on prices, we need to partially differentiate the stage 2 first-order condition, which leads to the following corollary.

Corollary: For a given level of stage 1 investment s_i, *the more competitive the second stage pricing game (low θ) the lower the prices, i.e.* $\frac{\partial p_i}{\partial \theta} > 0$.

Proof: As in Proposition 1, substituting $\frac{\partial s_i}{\partial \theta} = 0$. For the semi-log demand specification we thus obtain,

$$\frac{\partial p_i}{\partial \theta} = [\alpha_i(\frac{\partial^2 C}{\partial q_i^2}q_i(\alpha_i - \alpha_j) - 1)]^{-1}, \text{ where } \alpha_s = \frac{\partial \log(q_i)}{\partial p_s}$$

which is positive under the maintained assumptions.Q.E.D.

Proposition 1 and the Corollary show that the combined effects on prices depends on the sign and magnitude of $\partial s_i / \partial \theta$. Whenever $\partial s_i / \partial \theta < 0$, both effects work in the same direction, and the total effect on prices is even larger than the direct effect $(dp_i / d\theta > \partial p_i / \partial \theta)$. By contrast, whenever $\partial s_i / \partial \theta > 0$, the total effect on prices is reduced. Intuitively, this is due to the dynamic up-front investment effect: with lower margins in the pricing game, firms tend to invest less up-front, contracting their operations in the long-run[13]. Finally, it might theoretically be possible (whenever $\partial s_i / \partial \theta$ is large) that a more competitive market yields higher prices.

In sum, we find that the combined effect on prices is crucially dependent on the sign and magnitude of $\partial s_i / \partial \theta$. In particular, we can identify three possible scenarios from the above discussion: (i) $\partial s_i / \partial \theta < 0$, that is the total effect on prices is larger in the long-run, (ii) $0 < \partial s_i / \partial \theta < [\alpha_i(\partial MC / \partial s_i)]^{-1}$, effect on prices is reduced, and (iii) $\partial s_i / \partial \theta > [\alpha_i(\partial MC / \partial s_i)]^{-1}$, indirect effect overtakes direct effect and a more competitive market yields higher prices. However, it is not clear from our theoretical model developed above that $\partial s_i / \partial \theta$ can fall into all three categories. In order to assess this further, we explicitly derive $\partial s_i / \partial \theta$ in Appendix-C. This is done by implicitly differentiating the stage 1 first-order condition with respect to θ. We show, by example, that all three scenarios are theoretically feasible. We find that $\partial s_i / \partial \theta > 0$ whenever costs are rather convex in quantities, i.e. case (ii) and (iii). This finding makes intuitive sense, as firms respond to changes in θ through capacity investment, since costs are rather convex in quantities. Furthermore, we show that the magnitude of $\partial s_i / \partial \theta$ is a decreasing function of the convexity in capacities, i.e. if costs are very convex in both quantities and capacities we are in case (ii). Again this result is rather intuitive, since strong convexity in capacity will reduce the incentive to change up-front investment.

Since we can not determine the effect of increased competition on prices beyond these observations, we now turn to the empirical implementation of the model.

[13] This result is similar to the one found by Krishnan and Röller (1993). They show that in a capacity investment game with a collusive facilitating device (in this case firms where 'colluding' through sharing capacity), collusion could lead to higher up-front capacity investments and lower overall prices.

5. Empirical Implementation and Results

The implementation of the above model essentially involves the simultaneous estimation of the demand equation (1), the first-order condition (3), and the two first-order conditions (6) subject to (8)[14]. The endogenous variables are therefore prices, quantities, labor (i.e. number of employees), and capital (number of planes). The demand equation is specified as semi-logarithmic[15]. The exogenous variables influencing demand are: an index of the price of gasoline (GASOLINE), an index for the price of rail transportation (RAIL), a measure of country size (GDP), a measure of economic activity - consumption growth (GCONS), and a measure of the size of the carriers network (NETWORK). The data and their construction are described in more detail in Appendix-A.

The short-run marginal cost equation ($\partial C / \partial q_i$) implicitly defined in (2) is assumed to be a linear functional form of output, capital, labor, the price of materials, and a variety of cost and quality characteristics: the load factor (LOADF), the stage length (STAGEL), the network characteristic variable (NETWORK), the percentage of wide-bodied planes in the fleet (%WIDEBODIED), and the percentage of turboprop planes (%TURBO). The long-run marginal costs ($\partial C / \partial s_i$) are also assumed to be linear in output and s_i. For consistency we constrain the parameter on s_i in the short-run marginal cost equation to be equal to the parameter on output in the long-run marginal cost equation.

Using these functional forms we estimate the system of four equations (1), (3), and (6) by three stage least squares. The results are reported in Table 2. Since the parameter capturing the effect of k_i on marginal costs is insignificant (i.e. $\partial MC / \partial k_i \approx 0$) we have constrained it to be zero[16]. In order to allow for behavior other than Nash in the first stage, we introduce an additional parameter (δ) into (6) by replacing ω_{s_i} with $\delta \cdot \omega_{s_i}$. Clearly, if δ is greater than one, firms invest less in labor than under the Nash assumption. This could be interpreted as firms colluding in stage one. On the other hand, a δ smaller than one is consistent with firms "over investing" in labor.

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[14] The cost equation (2) could also be estimated. However, this increases the number of parameters to be estimated substantially, depending on the specific functional form used. On the other hand, estimation of the cost function would allow a more complete analysis of the productive efficiency.

[15] If demand and marginal costs are both linear then θ is not identified.

[16] The parameter turns out to be insignificant, but positive. The fact that the parameter is positive determines most comparative statics in the model (see above) and moreover would violate the second-order conditions. In order to eliminate this "knife-edge" we constrain the parameter to be zero.

Insert Table 2 about here

Before interpreting the results, we perform a few consistency checks on our model. In general, the results in Table 2 are consistent with the theoretical model developed in the previous section. Our maintained assumption is indeed empirically satisfied, that is the own-price effect has the expected sign, is significant (t-stat of -3.63), and is larger in absolute value than the cross-price effect. As mentioned in the previous section, this implies that the own-sequential effect dominates the cross-sequential effect. Moreover, we also find that the second-order conditions for stage 1 and 2 are all satisfied. In particular, costs are convex (t-stat of 4.89) which ensures that the stage 2 optimization is well-defined. The second-order condition for capital is met, since costs are convex in capital (t-stat of 2.18)[17]. Finally, for the labor input, we find that costs are convex in labor (t-stat of 2.98), and a significant and negative impact on marginal costs (t-stat of -3.18), i.e. $\partial MC / \partial a_i < 0$. Evaluating the expression derived in Appendix-B we find that the second-order condition for labor is satisfied as well[18].

Many of the remaining parameters have the expected signs. For the demand equation GDP, the price of railroad transportation, and the size of the network all have positive and significant effects. Surprisingly, the price of gasoline and consumption growth have negative effects on demand for air travel. This might be explained by the fact that gasoline prices are correlated with fuel prices.

As mentioned earlier the effect of labor on marginal costs determines whether the two-stage model can be reduced to a static model. Since this effect is negative and significant (t-stat of -3.18), we reject a one-stage model in favor of the two-stage specification. Using a one-stage model would thus lead to inconsistent estimates of the structural parameters, since it ignores the strategic linkages between long-term investments and pricing. It is interesting to compute the elasticity of the sequential strategic effects. In other words, by how much are prices lowered if labor investments increase. Using (8) and

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[17]This follows from Appendix-B and realizing that for the capital equation we have $\frac{\partial p_i}{\partial s_i} = \frac{\partial p_j}{\partial s_i} = 0$, since $\frac{\partial MC}{\partial s_i} = 0$.

[18]Evaluating at sample mean, the second-order condition is -.372E-6. Moreover, the condition is satisfied for all sample values.

Table 2 we find that the own sequential strategic elasticity[19], defined as $\frac{\partial p_i}{\partial s_i}\frac{s_i}{p_i}$, is equal to -.1781. This implies that a 10% increase in the labor force of a carrier reduces its prices by about 1.78%. Similarly, a 10% increase in the labor force reduces prices of a competitor by only .17%. These elasticities are rather small, indicating that prices are unlikely to come down by much through increased capacity investments. In addition, it seems highly unlikely, for political and economic constraints, that large capacity expansions are feasible in Europe.

The own-price elasticity[20] is estimated at -.655, which implies that overall demand for each individual national carrier is rather inelastic. A substantial amount of market power seems to be present due to product differentiation for the average European carrier, i.e. we find rather strong market niche effects. By contrast, no evidence exists to suggest that firms achieve market power by collusion. The estimated θ is .316, and it is significantly different from zero as well as one. Therefore, we reject the hypothesis of perfect competition (t-stat of 2.82) as well as the noncoorporative Nash behavior (t-stat of 6.10, see Table 2). This suggests that firms do not collude over and above their "natural market niches". However these market niches might be very significant indeed. Using equation (3) the estimated mark-up over marginal costs, i.e. $(p-MC)/p=\theta/\eta$, is equal to 48%. To be sure, one has to include fixed cost, which might be very significant indeed. In fact, given the recent financial troubles of many European carriers it is not clear that pricing is much above average costs. In sum, it seems that most benefits in consumer surplus due to increased competition would accrue from the elimination of market niches, not from the elimination of collusive pricing practices.

Another reason for prices not to fall dramatically when competition heats up is the up-front investment effect. As price-cost margins decrease, i.e. θ decreases, firms might want to reduce their capacities in the long-run, which would tend to increase prices. Using the results from Table 2, we find that firms indeed reduce capacity investments as competition increases ($\partial s_i/\partial\theta>0$, see Table 3). We estimate the price elasticity with respect to θ at .544. This means that a 10% reduction in θ would result in a 5.44% reduction in the labor force in the long-run. Moreover, we find that the total effect on prices will be smaller, but positive (i.e. we are in case (ii)). We estimate the direct effect

[19]Evaluated at sample mean

[20]Recall that the demand equation parameters reported in Table 2 are from a semilog specification. To obtain the elasticities we multiply the parameter estimate by the sample mean price.

of a change in competition on prices at an elasticity of .384 (see Table 3). The long-run effect (total effect) on prices, however, is only .283. This means that a 10% reduction in θ, will trigger a 3.84% reduction in prices in the short-run, whereas in the long-run prices are reduced by only 2.83%. In sum, given that we find $\partial s_i / \partial\theta > 0$, a model that does not allow for this long-run effect would over-estimate the impact of increased competition on price reductions - in our case by some 35%.

Insert Table 3 about here

As European liberalization has progressed significantly in recent years, we now test whether our conclusions are significantly different for the post 1987 period, which is when the first package of liberalization measures was implemented. In order to test whether any inroads have been made in eliminating market niches we introduce a dummy variable on the own-price effect and on θ. The results are in Table 4. It can be seen that the own-price effect prior to 1987 is -.615 (elasticity is equal to -.707), whereas post 1987 the own-price effect decreases to -.483 (elasticity of -.555). This is to say that the elasticity of demand has become less elastic, which would indicate more market power due to market niches. On the other hand θ is declining (although not significantly) after 1987, indicating that price competition is increasing. This is consistent with the institutional developments surrounding the first package, which did not really allow firms to effectively compete in each others domestic markets, but allowed some increased price competition (double disapproval rule).

Insert Table 4 about here

Finally, δ is estimated at .19 (see Table 2) indicating substantial over investment in labor. This result is consistent with other findings of significant allocative inefficiencies in U.S. airlines. Moreover, it is also consistent with the institutional environment in many European countries, where labor laws, political circumstances, and social demands make it rather difficult to be allocatively efficient.

6. Conclusion

In this paper, we have empirically assessed the potential benefits of liberalizing the European airline industry by focusing on the removal of market power. We develop a model that differentiates between market niches and price competition, and endogeneizes short- and long-run decision variables through a two-stage game. Using data from 1976-1990 we reject the simple one-stage model in favour of the two-stage model. Our empirical findings include that relatively little market power is due to price collusion. In fact, firms compete significantly more than a standard Nash game would suggest. Moreover, even if competition where to increase, we find little evidence that prices will be dramatically reduced, in particular when one considers long-run factors. On the other hand, significant monopoly power is identified in domestic markets. These domestic niches might be explained by various types of entry barriers such as hub dominance, government protectionism of the national flag carriers, or even consumer loyalties.

Combining these results with other findings that European carriers have a substantial cost disadvantage vis-a-vis their U.S. competitors, it seems likely that most of the benefits from European liberalization will come from the elimination of cost inefficiencies and market niches. Moreover, it seems reasonable that the managerial, structural, political, and even social changes necessary to achieve these benefits are not easily accomplished. Given that prices are not high because of cartel pricing, airline prices in Europe might come down more gradually gradually as efficiency increases and market niches are abolished.

It is clear that there are several aspects of the airline industry that the above model does not address. For instance, it is quite likely that route-specific effects, especially on prominant and profitable routes will produce very different price reductions as competition increases. To the extend that certain routes are more profitable one might expect prices reduction to be more pronounced. Another element not addressed explicitly in our model is the characteristics of networks on competition (see Brueckner, Dyer, and Spiller, (1992)).

The relevant question to ask then is how these changes can be accomplished and the benefits be realized. Clearly, the liberalizations currently under way are a step in the right direction. If the U.S. experience is any guide, we would expect a move towards convergence in efficiency and cost structure in Europe. Problematic in this convergence process might be the apparent heterogeneity in the industry. This is largely due to some carriers getting ready for an open skies policy, where others are not. British Airways seems to have achieved an important first-mover advantage, while others are trying to catch up. This historic asymmetry in the carriers competitive standings coupled with national interests will make it difficult to achieve quick convergence.

Competition policy in Europe should allow strategic alliances to be formed[21]. The main criterion for mergers or strategic alliances should be cost savings and increased international competitiveness. Another potent source of competition should come from third parties. The European Commission is currently working on a coherent policy towards non-EC carriers. A potential stumbling bloc towards opening up Europe for third party competitors is the poor competitive posture of European carriers vis-a-vis U.S. and especially Asian carriers.

[21]Recently, many stratigic alliances amongst European carriers, as well as with one U.S. partner, are being negotiated. In many cases, these alliances are still being negotiated with mixed sucesses.

Appendix-A

Data Description and Construction

This study uses a panel of the eight largest European carriers - Air France, Alitalia, British Airways, Iberia, KLM, Lufthansa, SABENA and SAS - and the eight largest U.S. carriers - American, Continental, Delta, Eastern, Northwest, Pan American, TWA, United - with annual data from 1976 through 1990.

The data can be organized into three broad categories: production and cost data, network data and demand data.

Production and cost data: The primary source for the production data is the *Digest of Statistics* from the International Civil Aviation Organization (ICAO). Good, Röller, and Sickles [1993] constructed a set of three airline inputs: Labor, Materials and Aircraft Fleet. The labor input is an aggregate of five separate categories of employment used in the production of air travel. Included in these categories are all cockpit crew, mechanics, ticketing, passenger handlers and other employees. Information on annual expenditures and the number of employees in each of the above categories were obtained from the International Civil Aviation Organization (ICAO) *Fleet and Personnel Series*. These indices are aggregates of a number of sub components using a Divisia multilateral index number procedure [Caves, Christensen and Diewert, 1982].

Expenditures on supplies, services and ground-based capital equipment are combined into a single input aggregate called materials. It is not necessarily true that the purchasing power of a dollar or its market exchange rate equivalent is the same in all countries. Consequently they use the purchasing power parity exchange rates constructed from Heston and Summers [1988]. These are adjusted by allowing for changes in market exchange rates and changes in price levels. Use of airport runways is constructed by using landing fee expenses and using aircraft departures as the quantity deflator. The service price for owned ground based equipment is constructed by using the original purchase price, 7 % depreciation and the carrier's interest rate on long term debt. Fuel expenses are given for each carrier in ICAO's Financial Data Series. Unfortunately, there are no quantity or price figures given in that source. There are two possible solutions. The first is to estimate fuel consumption for each aircraft type in the fleet, given the consumption of U.S. carriers on similar equipment for the specific number of miles flown and adjusting for stage length.

Alternatively, fuel prices for international traffic in several different regions is available through ICAO's Regional Differences in Fares and Costs. The airline's fuel price is then estimated as a weighted average of the domestic fuel price (weighted by domestic available ton-kilometers), and regional prices (weighted by international available ton-miles in the relevant region). This method explicitly recognizes that for international carriers not all fuel is purchased in the airline's home country. As with the labor input, these sub components are aggregated using a multilateral index number procedure and are termed materials.

A very detailed description is available for aircraft fleets. These data include the total number of aircraft, aircraft size, aircraft age, aircraft speed, and utilization rates are also constructed. This information is available over the course of a year from ICAO and a calendar year's end inventory is available from IATA's *World Air Transport Statistics*. Asset values for each of these aircraft types in half-time condition is obtained from Avmark, one of the world's leading aircraft appraisers. This data source provides a more reasonable measure of the value of the fleet since it varies with changing market conditions. Jorgenson-Hall user prices for the fleet are constructed by using straight line depreciation with a total asset life of 20 years and the relevant long term interest rates.

Data on output (both services available and services provided) is obtained from ICAO's *Commercial Airline Traffic Series*. They disaggregate airline output along physical dimensions (classification into passenger output and cargo (classification into available output and purchased output), along utilization dimensions output, along functional dimensions (classification into scheduled and non-scheduled output), and finally on geographic dimensions (classification into domestic and international output). This leads to 16 sub aggregations of airline output.

The revenues for the carriers are obtained from the - *Digest of Statistics (Financial Data - Commercial Air Carriers)* from the International Civil Aviation Organization (ICAO). Revenues are available for passenger, freight, mail and non-scheduled output. The price is calculated as a ratio of the carrier's passenger revenues (including excess baggage) to passenger tonne-kilometre miles performed.

Network and Fleet Specific Data: The primary source for the network data is the *World Air Transport Statistics* publication of the International Air Transport Association (IATA).

Three characteristics of airline output and two characteristics of the capital stock are calculated. These included load factor, stage length, a measure of network size, the percent of the fleet which is wide bodied, and the percent of the fleet which uses turboprop propulsion. Load factor provides a measure of service quality and is used as a proxy for service competition. Stage length provides a measure of the length of individual route segments in the carrier's network. The number of route kilometers, provides a measure of total network size.

Both the percent of the fleet which is wide bodied and the percent using turboprop propulsion provide measures of the potential productivity of capital. The percent wide bodied provides a measure of average equipment size. As more wide bodied aircraft are used, resources for flight crews, passenger and aircraft handlers, landing slots, etc. do not increase proportionately. The percent turboprops provide a measure of aircraft speed. This type of aircraft flies at approximately one-third of the speed of jet equipment. Consequently, providing service in these types of equipment requires proportionately more flight crew resources than with jets.

Demand Data: The demand data for the same period was collected for the respective countries - France, Italy, Great Britain, Spain, Netherlands, Germany, Belgium and the three Scandinavian countries, Denmark, Sweden, Norway. The different data series for Denmark, Sweden and Norway are weighted by their respective GDP's in order to create single representative indices for the Scandinavian, which share the majority of the equity in SAS.

The Gross Domestic Product (GDP) were obtained from the *Main Economic Indicators* publication of the Economics and Statistics Department of the Organization for Economic Cooperation and Development (OECD). They are reported for the above countries, in billions of dollars.

The OECD Economic Outlook publication, *Historical Statistics* is the source of the growth in private consumption expenditure data. They are reported as an implicit price index with year to year percentage changes. The annual short-term interest rates were also obtained from this publication. The rates are reported by the respective countries on the basis of the following financial instruments: Belgium (three-month Treasury certificates), Denmark (three-month interbank rate), France (three-month Pibor), Germany (three-month Fibor), Italy (interbank sight deposits), Netherlands (three-month Aibor), Norway (three-month Nibor), Spain (three-month interbank loans), Sweden (three-month Treasury discount notes) and the United Kingdom (three-month interbank loans).

Jane's World Railway is the source of the rail data. Rail traffic is reported in four categories: passenger journeys, passenger tone-kilometers, freight net tone-kilometers and freight tones. The three revenue categories are passengers and baggage, freight, parcels and mail, and other income.

To be consistent with the price of air travel, the rail price was calculated as the ratio of passenger (and baggage) revenue to passenger tone-kilometers.
The retail gasoline prices (prices plus taxes) was obtained from the OECD, International Energy Agency's publication, *Energy Prices and Taxes*.

Further, an index of the "other" airlines prices was computed by weighting the individual prices in a certain market by their respective revenue shares in the market.

Appendix-B
Second-Order Conditions

In this appendix we discuss the conditions under which the second-order conditions in stage 1 and 2 hold. We start with stage 2 by re-writing (3) as,

$$(p_i - MC)\frac{\partial q_i}{\partial p_i} + q_i\theta = 0$$

The second-order condition can then be written as,

$$p_i\frac{\partial}{\partial p_i}\left(\frac{\partial q_i}{\partial p_i}\right) + \frac{\partial q_i}{\partial p_i} - \frac{\partial MC}{\partial p_i}\frac{\partial q_i}{\partial p_i} - MC\frac{\partial}{\partial p_i}\left(\frac{\partial q_i}{\partial p_i}\right) + \theta\frac{\partial q_i}{\partial p_i} < 0$$

or

$$(p_i - MC)\frac{\partial^2 q_i}{\partial p_i^2} + (1+\theta)\frac{\partial q_i}{\partial p_i} - \frac{\partial MC}{\partial q_i}\left(\frac{\partial q_i}{\partial p_i}\right)^2 < 0$$

which is satisfied for any concave demand functions or convex cost functions. For the semi-logarithmic demand specification used in Section 4, this expression reduces to,

$$\frac{\partial q_i}{\partial p_i}\left(1 - \frac{\partial MC}{\partial q_i}\frac{\partial q_i}{\partial p_i}\right) < 0$$

which is satisfied for convex costs.

The second-order condition for stage 1 can be obtained from (4) as,

$$p_i\frac{d^2 q_i}{ds_i^2} + 2\frac{dq_i}{ds_i}\frac{\partial p_i}{\partial s_i} + q_i\frac{\partial^2 p_i}{\partial s_i^2} - \frac{d^2 C}{ds_i^2} < 0$$

This condition would become rather cumbersome if one now were to substitute partial derivatives for the total derivatives. Instead we invoke our functional form assumptions discussed in Section 4. That is, we assume that demand is semi-logarithmic (and separable) in its arguments and that marginal costs are linear. Using these assumptions, and substituting (3) into (6), we can re-write the stage 1 first-order condition as,

$$\frac{\partial p_i}{\partial s_i}q_i(1-\theta) - \theta\frac{\alpha_i}{\alpha_j}q_i\frac{\partial p_j}{\partial s_i} - \frac{\partial C}{\partial s_i} - \omega_{s_i} = 0, \text{ where } \alpha_s = \frac{\partial \log(q_i)}{\partial p_s}$$

Substituting $\frac{\partial p_i}{\partial s_i} = \frac{\partial MC}{\partial s_i}(1+\theta)\alpha_i^2 / \Re$ and $\frac{\partial p_j}{\partial s_i} = -\frac{\partial MC}{\partial s_i}\theta\alpha_i\alpha_j / \Re$ yields,

$$q_i\frac{\partial MC}{\partial s_i}[\alpha_i^2 + (\alpha_j^2 - \alpha_i^2)\theta^2] / \Re - \frac{\partial C}{\partial s_i} - \omega_{s_i} = 0.$$

The second-order condition can then be written as,

$$\frac{dq_i}{ds_i}\frac{\partial MC}{\partial s_i}\left[\frac{\alpha_i^2 + (\alpha_j^2 - \alpha_i^2)\theta^2}{\Re} - 1\right] - \frac{\partial^2 C}{\partial s_i^2} < 0, \text{ where } \frac{dq_i}{ds_i} = \frac{\partial q_i}{\partial p_i}\frac{\partial p_i}{\partial s_i} + \frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial s_i},$$

which are satisfied if costs are convex enough in capacities.

Appendix-C

Derivation of $\partial s_i / \partial\theta$ and Examples

In order to derive the exact conditions determining $\partial s_i / \partial\theta$, we need to implicitly differentiate (6) with respect to θ. To keep the problem in line with the empirical implementation (and tractable), we restrict attention to the semi-log demand and linear marginal costs specifications. As in Appendix-B we substitute (3) into (6), making use of (8), and re-write the first-order condition as,

$$q_i \frac{\partial MC}{\partial s_i}[\alpha_i^2 + (\alpha_j^2 - \alpha_i^2)\theta^2]/\Re - \frac{\partial C}{\partial s_i} - \omega_{s_i} = 0.$$

Implicit differentiation with respect to θ and rearranging gives,

$$L + \frac{2\theta[\theta\alpha_j^2 - \alpha_i^2(1+\theta)]}{\Re}\frac{dq_i}{d\theta} - \frac{\partial^2 C}{\partial s_i^2}\frac{\partial s_i}{\partial\theta} = 0 \ ,$$

where $L = q_i \frac{\partial MC}{\partial s_i}[2\theta\Re(\alpha_j^2 - \alpha_i^2) - (\alpha_i^2 + \theta^2(\alpha_j^2 - \alpha_i^2))(2(1+\theta)\alpha_i^2 - 2\theta\alpha_j^2)]/\Re^2$. Note that L>0 for small θ under the maintained hypothesis. This above condition implies that $\partial s_i / \partial\theta$ must be positive whenever $dq_i / d\theta$ is positive (note that $\Re > 0$), which is consistent with Proposition 1. The reverse is false however, that is, it is possible for $\partial s_i / \partial\theta$ to be positive and $dq_i / d\theta$ to be negative.

Substituting $\frac{dq_i}{d\theta} = \frac{dp_i}{d\theta}(\frac{\partial q_i}{\partial p_i} + \frac{\partial q_i}{\partial p_j}) = (\frac{\partial p_i}{\partial s_i}\frac{\partial s_i}{\partial\theta} + \frac{\partial p_i}{\partial s_j}\frac{\partial s_j}{\partial\theta} + \frac{\partial p_i}{\partial\theta})(\frac{\partial q_i}{\partial p_i} + \frac{\partial q_i}{\partial p_j})$, into the above condition, solving for $\partial s_i / \partial\theta$, and rearranging yields,

$$\frac{\partial s_i}{\partial\theta} = \frac{T_1}{T_2} = \frac{\frac{\partial MC}{\partial s_i}\frac{2q_i}{\Re^2}[\alpha_i^2(\alpha_i^2(1+\theta)^2 - \alpha_j^2\theta(2+\theta)) + \theta(\alpha_i^2(1+\theta) - \theta\alpha_j^2)\frac{\partial p_i}{\partial\theta}(\alpha_i + \alpha_j)\Re]}{(\frac{\partial MC}{\partial s_i})^2\frac{2\theta\alpha_i q_i}{\Re^2}(\alpha_i^2(1+\theta) - \alpha_j^2\theta)(\alpha_j\theta - \alpha_i(1+\theta))(\alpha_i + \alpha_j) - \frac{\partial^2 C}{\partial s_i^2}}$$

Before interpreting the above condition, let us recall that $\partial MC / \partial s_i \equiv \beta < 0$, $\partial^2 C / \partial q_i^2 \equiv c_1 > 0$, and $\partial^2 C / \partial s_i^2 \equiv c_2 > 0$ are simply parameters due to the assumption of linearity of marginal costs. We now show by example that the following three cases are theoretically feasible scenarios: (i) $\partial s_i / \partial\theta < 0$, (ii) $0 < \partial s_i / \partial\theta < [\alpha_i\beta]^{-1}$, and (iii) $\partial s_i / \partial\theta > [\alpha_i\beta]^{-1}$.

To show that case (i) is feasible let c_2 be large enough such that set $T_2 < 0$. Thus, we need to show that $T_1 > 0$. Set $c_1 = 0$ (note that $\partial T_1 / \partial c_1 > 0$). Then we can write,

$$T_1 = \frac{2\beta q_i}{\Re^2}[(\frac{\alpha_i}{\alpha_j})^5(\theta^4 + 3\theta^3 + 2\theta^2 - \theta - 1) + (\frac{\alpha_i}{\alpha_j})^4(\theta^4 + 3\theta^3 + 3\theta^2 + \theta)$$
$$-(\frac{\alpha_i}{\alpha_j})^3(2\theta^4 + 3\theta^3 - 2\theta^2) - (\frac{\alpha_i}{\alpha_j})^2(2\theta^4 + 3\theta^3 + \theta^2) + \frac{\alpha_i}{\alpha_j}\theta^4 + \theta]$$

which is positive for large α_i / α_j and large θ.

To show that cases (ii) and (iii) are feasible, let $c_1 \to \infty$, which implies that $T_1 < 0$ since $\lim_{c_2 \to \infty} \frac{\partial p_i}{\partial \theta} = 0$. Define $\bar{c}_2$ such that $T_2(\bar{c}_2) = 0$. Then for all $c_2 > \bar{c}_2$ we have $T_2 < 0$, and therefore $\partial s_i / \partial \theta > 0$. Case (ii) follows since $\partial s_i / \partial \theta$ can be made arbitrarily small through the choice of c_2 since $\lim_{c_2 \to \infty} \frac{\partial s_i}{\partial \theta} = 0$. Case (iii) follows since $\partial s_i / \partial \theta$ can be made arbitrarily large through the choice of c_2 since $\lim_{c_2 \to \bar{c}_2^+} \frac{\partial s_i}{\partial \theta} = \infty$. Note that $\partial s_i / \partial \theta$ is a decreasing function of c_2. In conclusion, we find that cases (ii) and (iii) exists whenever costs are rather convex in quantities (large c_1). If costs are very convex in capacities as well (large c_2), case (iii) does not exist.

Table 1. Estimates of Technical Efficiency (percent)

Airline	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
AIR FRANCE	57.19	56.45	55.71	54.98	54.27	53.56	52.86	52.17	51.49	50.82	50.16	49.50	48.86	48.22	47.60
ALITALIA	55.84	56.43	57.03	57.63	58.24	58.85	59.47	60.10	60.74	61.38	62.03	62.68	63.35	64.02	64.69
AMERICAN	77.83	77.70	77.60	77.44	77.31	77.18	77.05	76.92	76.79	76.66	76.53	76.41	76.28	76.15	76.02
BRITISH AIR	43.17	44.89	46.69	48.55	50.49	52.50	54.60	56.78	59.04	61.40	63.85	66.40	69.05	71.81	74.67
CONTINENTAL	76.88	77.26	77.65	78.04	78.44	78.83	79.23	79.63	80.03	80.43	80.83	81.24	81.65	82.06	82.47
DELTA	80.36	80.26	80.16	80.06	79.97	79.87	79.77	79.67	79.58	79.48	79.38	79.28	79.19	79.09	78.99
EASTERN	78.01	76.87	75.74	74.63	73.53	72.45	71.39	70.34	69.31	68.29	67.29	66.30	65.33	64.37	63.42
IBERIA	50.81	50.94	51.07	51.19	51.32	51.45	51.57	51.70	51.83	51.96	52.08	52.21	52.34	52.47	52.60
KLM	76.30	74.35	72.45	70.60	68.79	67.03	65.31	63.64	62.01	60.43	58.88	57.37	55.91	54.48	53.08
LUFTHANSA	60.51	60.65	60.78	60.92	61.06	61.20	61.33	61.47	61.61	61.75	61.89	62.03	62.17	62.31	62.45
NORTHWEST	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
PAN AM	72.03	72.63	73.22	73.82	74.43	75.04	75.65	76.27	76.90	77.53	78.16	78.80	79.45	80.10	80.76
SABENA	55.73	57.05	58.41	59.79	61.21	62.66	64.15	65.67	67.23	68.83	70.46	72.13	73.84	75.59	77.39
SAS	63.00	62.16	61.33	60.50	59.70	58.90	58.11	57.33	56.57	55.81	55.06	54.32	53.60	52.88	52.17
TWA	72.10	72.73	73.36	74.00	74.64	75.29	75.94	76.60	77.26	77.93	78.61	79.29	79.98	80.67	81.37
UNITED	77.14	77.54	77.94	78.34	78.74	79.14	79.55	79.96	80.37	80.78	81.19	81.61	82.03	82.45	82.87

Table 2 - EUROPEAN AIRLINES - Two Stage Game
(NON-LINEAR THREE-STAGE LEAST SQUARES ESTIMATES)

Variable	Estimate	t-statistic	
Demand Equation:			
INTERCEPT	6.225	29.98	
PRICE	-0.570	-3.63	
CROSS-PRICE	0.222	6.79	
GASOLINE PRICE	-1.150	-6.82	
GDP	0.689	5.62	
GCONS	-0.008	-1.91	
RAIL	5.704	5.11	
NETWORK	0.733	3.79	
Marginal Cost - short run ($\partial C / \partial q_i$)			
OUTPUT	0.171E-03	4.89	
LABOR	-.104E-04	-3.18	
PRICE OF MATERIALS	0.518	11.06	
LOAD FACTOR	1.109	3.70	
STAGE LENGTH	-0.534	-8.87	
NETWORK	-0.175	-1.20	
%WIDEBODIED	0.029	0.16	
%TURBO	0.234	1.68	
Marginal Cost - long run ($\partial C / \partial s_i$)			
Capital			
INTERCEPT	-3.293	-13.91	
CAPITAL	0.5194E-02	2.18	
Labor			
INTERCEPT	-0.621E-02	-2.02	
OUTPUT	-0.104E-04	-3.18	
LABOR	0.412E-06	2.98	
Behavioral Parameters		*P.C.*	*NASH*
θ	0.316	2.82	6.10
δ	0.196	2.41	9.89

Std. error of regression:

Demand	*2nd stage FOC*	*1st stage FOC (capital)*	*1st stage FOC (labor)*
0.215	0.118	1.043	0.002

Number of observations = 120. Standard Errors computed from quadratic form of analytic first derivatives (Gauss)

Table 3 - EFFECTS OF θ ON PRICES: DECOMPOSITION

			Elasticity
Labor	$\frac{\partial s_i}{\partial \theta}$	44324.1	0.545
Direct Effect	$\frac{\partial p_i}{\partial \theta}$	1.399	0.384
Total Effect	$\frac{dp_i}{d\theta}$	1.031	0.283

Evaluated at sample means. Entries in the table are calculated from Table 2 and Appendix C.

Table 4 - EUROPEAN AIRLINES - Two Stage Game
(NON-LINEAR THREE-STAGE LEAST SQUARES ESTIMATES)

Variable	Estimate	t-statistic	
Demand Equation:			
INTERCEPT	6.070	31.21	
PRICE (prior 1987)	-0.615	-4.48	
PRICE (Δ in 1987)	0.132	2.81	
CROSS-PRICE	0.274	8.45	
GASOLINE PRICE	-1.478	-7.68	
GDP	0.652	5.62	
GCONS	-0.003	-0.67	
RAIL	4.386	3.99	
NETWORK	0.731	4.06	
Marginal Cost - short run ($\partial C / \partial q_i$)			
OUTPUT	0.834E-04	2.83	
LABOR	-0.401E-05	-2.30	
PRICE OF MATERIALS	0.567	11.02	
LOAD FACTOR	-0.277	-0.55	
STAGE LENGTH	-0.545	-7.71	
NETWORK	-0.181	-1.33	
%WIDEBODIED	0.221	0.12	
%TURBO	0.219	1.53	
Marginal Cost - long run ($\partial C / \partial s_i$)			
Capital			
INTERCEPT	-3.265	-13.96	
CAPITAL	0.4914E-02	2.09	
Labor			
INTERCEPT	-0.165E-02	-0.69	
OUTPUT	-0.401E-05	-2.30	
LABOR	0.250E-06	2.33	
Behavioral Parameters		*P.C.*	*NASH*
θ (prior 1987)	0.812	3.10	0.72
θ (Δ in 1987)	-0.119	-1.50	1.76
δ	0.056	0.87	14.67

Std. error of regression:

Demand	*2nd stage FOC*	*1st stage FOC (capital)*	*1st stage FOC (labor)*
0.215	0.118	1.043	0.002

Number of observations = 120. Standard Errors computed from quadratic form of analytic first derivatives (Gauss)

Bibliography

Abreu, D., 1986, "External equilibria of oligopolist supergames", *Journal of Economic Theory* 39, 191-225.

Appelbaum, E., 1982, "The estimation of the degree of oligopoly power", *Journal of Econometrics* ,19, 287-299.

Bailey, E. E. and D. M. Kirstein, 1989, "Can Truth in Airline Scheduling Alleviate the Congestion and Delay Problem," in Transportation Safety in an Age of Deregulation, edited by L. Moses and I. Savage, Oxford University Press.

Berry, S., 1990, "Airport presence as product differentiation", *American Economic Review* (Paper and Proceedings) 80, 394-399.

Berry, S., 1992, "Estimation of a model of entry in the airline industry", *Econometrica* ,60, 889-917.

Borenstein, S., 1989, "Hubs and High Fares: Dominance and Market Power in the U.S. Airline Industry," *RAND Jounal of Economics*, Vol. 20, 344-365.

Borenstein, S., 1990, "Airline Mergers, Airport Dominance and Market Power," *American Economic Review* , 80, 400-404.

Borenstein, S., 1992, "The Evolution of U.S. Airline Competition," *Journal of Economic Perspectives* , 6, 45-73.

Borenstein, S., and Nancy L. Rose, 1992, "Competition and Price Dispersion in the U.S. Airline Industry," working paper, September.

Brander, J. A. and A. Zhang, 1990, "Market Conduct in the Airline Industry: An Empirical Investigation", *Rand Journal of Econmics*, Vol. 21, 567-583.

Brander, J. A. and A. Zhang, 1993, "Dynamic Oligopoly Bevavior in the Airline Industry", *Internatioanl Journal of Industrial Organization*, Vol. 11, 407-436.

Bresnahan, Timothy F., 1989, "Empirical Studies in Industries with Market Power," in Handbook of Industrial Organization, Vol. II, 1011-1058.

Bresnahan, T.F., 1987, "Competition and Collusion in the American Automobile Industry: The 1955 Price War", *Journal of Industrial Economics*, 35, 457-482.

Brueckner,J.K. and P.T. Spiller, 1991, "Competition and Mergers in Airline Networks", *International Journal of Industrial Organization*, Vol. 9, 323-342.

Brueckner,J.K., N.J. Dyer, and P.T. Spiller, 1992, "Fare Determination in Airline Hub-and-Spoke Networks", *Rand Journal of Economics*, Vol. 23, 309-333.

Caves, D.W., L.R. Christensen, and W.E. Diewert, 1982, "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity", *Econometrica*, 50,1393-1413.

Encaoua, D., 1991, "Liberalizing European Airlines: Cost and Factor Productivity Evidence", *International Journal of Industrial Organization*, Vol. 9, 109-124.

Gollop, F. and M. Roberts, 1979, "Firm interdependence in oligopolistic markets", *Journal of Econometrics*, 10, 313-331.

Good, D. and E. Rhodes, 1991, "Productive Efficiency, Technological Change and the Competititveness of U.S. airlines in the Pacific Rim", *Journal of the Transportation Research Forum*, Vol. 31, 347-358.

Good, D. M.I. Nadiri, L-H. Röller, and R. C. Sickles, 1993, "Efficiency and Productivity Growth Comparisons of European and U.S. Air Carriers: A First Look at the Data," forthcoming in the *Journal of Productivity Analysis*, special issue edited by J. Mairesse and Z. Griliches.

Good, D., L-H. Röller, and R.C. Sickles, 1993, "U.S. Airline Deregulation: Implications for European Transport", *Economic Journal*, 103, 1028-1041.

Gordon, R., "Productivity in the Service Sector," in Output Measurement in the Service Sectors, edited by Z. Griliches, University of Chicago Press, 371-422, 1992.

Green, E.J. and R.H. Porter, 1984, "Noncooperative collusion under imperfect price information", *Econometrica*, 52, 87-100.

Hurdle, G.J., R.L. Johnson, A.S. Joskow, G.J. Werden and M.A. Williams, 1989, "Concentration, potential entry, and performance in the airline industry", *Journal of Industrial Economics* 38, 119-139.

Iwata, G., 1974, "Measurement of conjectural variations in oligopoly", *Econometrica*, 42, 949-966.

Heston, A. and R. Summers, 1988, "Comparison of Price and Gross Domestic Product for Several Countries", *Review of Income and Wealth*, 34, 1-28.

Krishnan, M. and L.-H. Röller, 1993, "Entry Game with Resalable Capacity," *The RAND Journal of Economics*, Vol 24., 479-502.

Morrison, Steven A. and Clifford Winston, 1986, "The Economic Effects of Airline Deregulation", Washington: Brookings.

Morrison, Steven A. and Clifford Winston, 1989, "Enhancing the performance of the deregulated air transportation system. Brookings papers on economic activity, Microeconomics, pp. 61-112.

Porter, R.H., 1983, "A study of cartel stability: The Joint Executive Committee, 1880-1886", *Bell Journal of Economics* 14, 301-314.

Rose, Nancy L., 1990, "Profitability and product quality: economic determinants of airline safety performance", *Journal of Political Economy*, 98 (October), pp. 944-964.

Rotemberg, J. and G. Saloner, 1986, "A supergame-theoretic model of price wars during booms", *American Economic Review,* 76, 390-407.

Slade, M.E., 1987, "Interfirm rivalry in a repeated game: An empirical test of tacit collusion", *Journal of Industrial Economics,* 35, 499-516.

Slade, M.E., 1992, "Vancouver's Gasoline-Price Wars: An Empirical Exercise in Uncovering Supergame Strategies, *Review of Economic Studies*, Vol. 59, 257-276, 1992.

Taneja, N., 1988, The International Airline Industry: Trends, Issues and Challenges, Lexington Books.

Whinston, M.D. and S.C. Collins, 1992, "Entry, contestability, and deregulated markets: An event study analysis of People Express". *Rand Journal of Economics* ,23, 445-462.