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Capacity and product market competition: measuring market power in a puppy dog industry

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**Capacity and Product Market Competition:
Measuring Market Power in a "Puppy-Dog"
Industry**

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ABSTRACT

Capacity and Product Market Competition: Measuring Market Power in a 'Puppy-Dog' Industry*

In this paper we specify and estimate a structural model which accounts for competition in two variables: capacity and prices. The model has a two-stage setup. In the first stage firms make capacity decisions followed by a product-differentiated, price setting game in the second stage. Since costs are endogenized through the first stage, this has important implications for the measurement of market power in the product market. In particular, simpler one-stage specifications would result in a bias in the measurement of market power, which can be linked to the taxonomy for two-stage games given in Fudenberg and Tirole (1984). We then estimate this model - demand, cost (short and long run), and conduct - for the European Airline Industry using data for the period of 1976-1990. We perform a number of specification tests and reject a simple one-stage specification in favor of our two-stage set-up. In particular, we find that some degree of market power in the product market exists. However, market power in the two-stage set-up is significantly lower than in the more widely employed one-stage specification, which is consistent with the direction of bias in puppy-dog games. This illustrates that firms market power in the product market is significantly overestimated whenever capacity competition is not accounted for.

*

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ZUSAMMENFASSUNG

Kapazitäts- und Produktmarktwettbewerb: Die Messung von Marktmacht in einer "Puppy-Dog"-Industrie

In diesem Beitrag wird ein strukturelles Modell entwickelt und ökonometrisch geschätzt, das zwei Variablen des Wettbewerbs berücksichtigt: Kapazität und Preise. Das Modell ist zweistufig. Auf der ersten Stufe entscheiden die Unternehmen über die Kapazität, gefolgt von einem Produktdifferenzierungs- und Preissetzungsspiel auf der zweiten Stufe. Die Endogenisierung der Kosten auf der ersten Stufe hat wichtige Implikationen für die Messung der Marktmacht im Produktmarkt. Dabei ist zu berücksichtigen, daß eine einfachere einstufige Spezifikation zu einem Meßfehler der Marktmacht führen würde, was im Hinblick auf die Taxonomie der zweistufigen Spiele von Fudenberg und Tirole (1984) deutlich wird. Sodann wird das Modell anhand von Daten geschätzt, die die Nachfrage, kurz- und langfristige Kosten und Marktverhalten der europäischen Luftfahrtindustrie für die Zeit von 1976 bis 1990 beschreiben. Eine Reihe von Spezifikationstests wird durchgeführt, die zur Ablehnung der einfachen einstufigen Spezifikation zugunsten der zweistufigen Spezifikation führt. Bemerkenswert ist, daß sich empirisch zeigt, daß das Spiel in Übereinstimmung mit einer "puppy-dog"-Strategie steht. Mit anderen Worten europäische Luftfahrtgesellschaften überinvestieren in Kapazitäten, um weniger aggressiv auftreten zu müssen. Darüber hinaus zeigt sich, daß ein gewisser Grad an Marktmacht im Produktmarkt existiert. Jedoch ist die Marktmacht in dem zweistufigen Spiel signifikant geringer als in der üblicherweise angewendeten einstufigen Spezifikation. Dies wiederum ist in Übereinstimmung mit dem Bias von "Puppy-dog"-Spielen und illustriert, daß die Marktmacht von Unternehmen auf Produktmärkten beträchtlich überschätzt wird, wann immer Kapazitätswettbewerb nicht berücksichtigt wird.

1. Introduction

In this paper we specify and estimate a structural model which accounts for competition in two variables: capacity and prices. Traditional models of market power (for a survey see Bresnahan 1989) assume that the degree of market power can accurately be assessed from models where either price or quantity competition are the only endogenous variables. One of the conclusions of this literature is that significant market power, in the sense of price costs margins, exists in some concentrated industries.

Recently, more emphasize has been placed on the interactions between product market competition and other "input" markets, such as R&D, advertisement, finance, labor, and capacity. By endogenizing such input markets, which is often done by using a two-stage set-up, a number of fundamental issues need to be reconsidered. Of particular interest is the effect of imperfect product market competition on the demand for inputs. Another issue is that of endogenous costs and market structure (Sutton, 1991). A third area is anti-trust, where conventional wisdom of competition policy may not hold, once another strategic variable is introduced¹.

The purpose of this paper, which is less ambitious, is to investigate whether the inferred significant degree of market power at the product market level is sensitive to the introduction of an input variable, namely capacity. In other words, does *endogenous* capacity effect the conclusions about product market competition. If so, one needs to reassess the above conclusion that "there is a great deal of market power, in the sense of price cost margins, in some concentrated industries" (Bresnahan 1989, p. 1052) in light of properly endogenized input markets.

To account for competition in input as well as output markets, this paper analysis a two-stage setup. In the first stage firms make capacity decisions followed by a product-differentiated, price setting game in the second stage. Since costs are endogenized through the first stage, this has important implications for the measurement of market power in the product market. We apply this model to the European airline industry using data for the period of 1976-1990.

The European airline industry is a particularly good "industry case" where this argument can be tested. Firstly, there likely exists significant market power due to the

¹ An example of this is the paper by Fershtman and Gandal (1994).

regulatory aspects of the industry. The reason for this cooperative duopoly structure in most markets created by *bilateral agreements* between member states. In fact, the rationale for the "liberalization" program in the European airline industry is based on the presumption to end monopolies and bring prices down to "more competitive" level. A first and second package of measures introducing new competition rules, relaxing price controls, and opening market access were introduced in 1987 and 1989 respectively. Over time the pressure resulted in a third package, leading towards an 'in principle' open intra-European market by April 1st 1997. Many of the measures contained in these packages will take time to implement. In addition, the question of third country access, 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 potential for significant market power in the European airline industry existed. The purpose of this paper is to assess this claim by measuring market power prior to major deregulation.

The second reason for why the European airline industry is well-suited for this study is that capacity investments, such as in planes, are an important aspect of competition. It is argued that the airline industry is one in which capacity investments (say in airplanes) are substantial. In particular, the two-stage set-up of our model assumes that capacity (airplanes) are long-run decisions, whereas prices are short-run decisions. Within the context of the airline industry this is not unreasonable, since planes must be ordered in advance and delivery times may be lengthy.

The literature on measuring oligopolistic conduct includes mostly formulations that allow for only one strategic variable, such as price or quantity (an incomplete list includes Iwata (1974), Gallop and Roberts (1979), Appelbaum (1982); for a survey see Bresnahan (1989)). Specifically in the U.S. airline industry, market power has been studied by Brander and Zhang (1990)². They conclude that the Cournot model is much more consistent with the data in general than either Bertrand or cartel behavior. More recently, market power through repeated interactions has been empirically tested for. Brander and Zhang (1993) estimate a switching regime model for the U.S.

² Other important contributions on pricing in the airline industry include Borenstein and Rose (1994) who analyze price dispersion on a given flight. The effect of networks on competition and pricing are studied in Brueckner, and Spiller (1991), and empirically tested in Brueckner, Dyer, and Spiller (1992). Evans and Kessides (1994) investigate the ability to exercise market power in the airline industry through multimarket contact. They find that fares are higher on routes where the competing carriers have interroute contact.

airline industry based on the theory of repeated games. Firms are assumed to be implementing punishment strategies to enforce collusion in an uncertain environment (à la Green and Porter (1984)). Empirical observations would then be drawn from either a collusive or punishment phase. Brander and Zhang reject the constant behavior models in favor of regime-switching models, where the punishment phases are best described by Cournot competition³.

A related strand of literature suggests that market power is quite significant in the U.S. airline industry. Hurdle et al. (1989) and Whinston and Collins (1992) 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.

Our paper differs from the above literature by explicitly estimating a structural model which accounts for competition in two variables: capacity and prices. The model has a two-stage setup. In the first stage firms make capacity decisions followed by a product-differentiated, price setting game in the second stage⁴. Since costs are endogenized through the first stage, this has important implications for the measurement of market power in the product market. We then estimate this model - demand, cost (short and long run), and conduct - for the European Airline Industry using data for the period of 1976-1990. We perform a number of specification tests and reject a simple one-stage specification in favor of our two-stage set-up. Regarding the measurement of market power in the product market, we find that some degree of market power exists. However, market power in the two-stage set-up is significantly lower than in the more widely employed one-stage specification, which is consistent with the direction of bias in fat-cat games. This illustrates that a firm's market power in the product market is significantly overestimated whenever capacity competition is not accounted for.

The paper is organized as follows. Section 2 develops the model. Section 3 presents the empirical analysis, where the functional specifications are given in Sections 3.1,

³ Note that, by contrast, our paper focuses on the European airline industry, which is likely to display more collusive behavior over the sample period studied.

⁴ Contrary to several other studies (for instance Borenstein and (1994) and Evans and Kessides (1994)), our model is an aggregate model at the carrier level. We therefore do not consider specific route effects or price discrimination strategies.

consistency checks are described in Section 3.2, and interpretation is given in Section 3.3. Section 4 concludes. The data are described in Appendix-A.

2. A Model of Competition for the European Airline Industry

In this section we specify a simple two-stage game where firms make capacity decisions in the first stage, followed by a product-differentiated market game in prices. We therefore endogenize capacity decisions, which impacts on the marginal costs in the second stage and its inferred product market competition. We begin by specifying a product-differentiated, price-setting game, where each carrier faces a demand of the form⁵,

$$q_i(p_i, p_j, Z_i), \quad i = 1, \dots, N \quad (1)$$

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 prices. Z_i is a vector of country-specific, exogenous factors affecting demand⁶. The implicit duopoly assumption in (1) can be justified by the existence of *bilateral agreements*. 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 resulting duopolistic market structures created by the bilateral agreements also prevented new entry in the intra-European market.

The price elasticity implicitly defined in (1) is assumed to be negative. In other words, a small price elasticity implies that consumers consider carriers to be poor substitutes. We assume that the own-price effect is larger than the cross-price effect, i.e. $-\frac{\partial q_i}{\partial p_i} > \frac{\partial q_i}{\partial p_j} > 0$.

It is through the cost structure that short-run and long-run decisions impact firms' profitability. In the short run, firms can affect 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). Therefore, we specify firm-level long-run costs as follows,

⁵ An alternative demand specification not employed here is the one introduced in Berry, Levinsohn, and Pakes (1995) which allows for a much richer analysis of product differentiation.

⁶ We omit the time subscript for notational convenience.

$$C^{LR}(q_i(\cdot), k_i | r_i, \mathbf{w}_i) = C(q_i(\cdot) | k_i, \mathbf{w}_i) + r_i k_i \quad (2)$$

where $C^{LR}(\cdot)$ denotes the long-run cost function and $C(\cdot)$ the short-run cost function. Note that short-run costs (or variable costs) depend only on quantity, given a capital stock (k_i) and other fixed factor prices (ω). In the long-run, the quasi-fixed factor (capital) becomes variable, that is capital can be purchased at its factor prices r .

To endogenize the short- and long-run decisions, we assume that firms behave strategically: we specify a two-stage game, where firms purchase capital in stage 1, followed by price decisions in stage 2. Thus, in stage 2, each firm solves the following program,

$$\max_{p_i} p_i = q_i(\cdot) p_i - C(q_i(\cdot) | k_i, \mathbf{w}_i)$$

where $q_i(\cdot)$ is given in (1) and C denotes the short-run costs. Adopting a conjectural-variation framework, where $q \equiv \mathbb{I}p_j / \mathbb{I}p_i$, the corresponding first-order condition for firm i is given by⁷,

$$\frac{p_i - MC(\cdot)}{p_i} = \frac{1}{h_{ii} - q \frac{p_i}{p_j} h_{ij}} \quad (3)$$

where $h_{ii} \equiv -\frac{\mathbb{I}q_i}{\mathbb{I}p_i} \frac{p_i}{q_i}$ is the own-price elasticity, $h_{ij} \equiv \frac{\mathbb{I}q_i}{\mathbb{I}p_j} \frac{p_j}{q_i}$ is the cross-price elasticity, and $MC(\cdot) \equiv C / \mathbb{I}q_i$. Assuming that the parameter q is identified, it can be estimated and interpreted as the degree of coordination in a price-setting game. In particular, when $q = 0$, behavior is consistent with a Nash game in prices. In this case (3) reduces to the well-known relationship where firms price according to their own elasticities. When $q < 0$ conduct is more competitive than Nash behavior, with prices approaching marginal costs as $q \rightarrow -\infty$. Collusive behavior is consistent with $q > 0$. Joint profit maximization, i.e. cartel pricing, is associated with a q equal to one.

Let us denote the equilibrium prices defined by (3) as $p_i^*(k_i, k_j)$. The firms maximization problem for each firm i in stage 1 can then be written as,

$$\max_{k_i} p_i = q_i(p_i^*, p_j^*, z_i) p_i^* - C^{LR}(q_i(p_i^*, p_j^*, z_i), k_i | r_i, \mathbf{w}_i)$$

⁷ The second-order condition is derived in Appendix-B.

Omitting the functional arguments as well as the '*' for notational convenience, the corresponding first-order condition is⁸,

$$\frac{\mathbb{I}p_i}{\mathbb{I}k_i} q_i + (p_i - MC) \left\{ \Delta_i \frac{\mathbb{I}p_i}{\mathbb{I}k_i} + \Delta_j \frac{\mathbb{I}p_j}{\mathbb{I}k_i} \right\} - \frac{\mathbb{I}C}{\mathbb{I}k_i} - r_i = 0,$$

where $\Delta_i \equiv \frac{\mathbb{I}q_i}{\mathbb{I}p_i} + \frac{\mathbb{I}q_i}{\mathbb{I}p_j} \mathbf{q}$ and $\Delta_j \equiv \frac{\mathbb{I}q_i}{\mathbb{I}p_j}$ are the respective partial demand derivatives

including the conjectural variations. Note that under the assumptions on (1) we have that $\Delta_i < 0$ (since $\mathbf{q} < 1$). Making use of (3) reduces the expression to,

$$(p_i - MC) \Delta_j \frac{\mathbb{I}p_j}{\mathbb{I}k_i} - \frac{\mathbb{I}C}{\mathbb{I}k_i} - r_i = 0 \quad (4)$$

As is well-known (see Fudenberg and Tirole, 1984), we are left with the *direct effect* of period one investment levels on costs, $-\mathbb{I}C/\mathbb{I}k_i - r_i$, and the *(sequential) strategic effect* arising from the two-period set up, $(p_i - MC) \Delta_j \mathbb{I}p_j/\mathbb{I}k_i$. Whenever the strategic effect is zero, there is no need to specify a two-stage setup, and only the direct effect of stage one capacity decisions on (short-run) costs are considered. In this case (4) reduces to $-\mathbb{I}C/\mathbb{I}k_i = r_i$ and both capacity and pricing decisions are modeled simultaneously⁹.

Econometrically, the estimation of market power in such models should proceed by estimating equations (1), (3), and (4) simultaneously. It is clear that estimation of equations (1) and (3) alone, which assumes that capacity investment levels are exogenous, introduces potential simultaneity bias, and leads to less efficient estimates. Furthermore, estimation of equations (1), (3) and (4) which ignores the strategic two-stage set-up is subject to a potential misspecification in equation (4), leading towards inconsistent estimates of market power and other elasticities. Below we investigate whether the two-stage set-up is appropriate by testing whether the sequential strategic effect is statistically significant.

Note that since $(p_i - MC) \Delta_j > 0$, the sequential strategic effect exists whenever $\mathbb{I}p_j/\mathbb{I}k_i \neq 0$. Using the structure of the model we can solve explicitly for $\mathbb{I}p_j/\mathbb{I}k_i$.

⁸ See Appendix-B for the second-order conditions.

⁹ Note that $\mathbb{I}C/\mathbb{I}k_i < 0$, since this is the reduction in short-run costs from one more unit of capacity.

Implicit differentiation of (3) with respect to k_j and k_i and solving, yields after some manipulations,

$$\frac{\mathbb{J}p_j}{\mathbb{J}k_i} = \frac{\mathbb{J}MC}{\mathbb{J}k_i} \frac{B}{A^2 - B^2} \quad \text{and} \quad \frac{\mathbb{J}p_i}{\mathbb{J}k_i} = \frac{\mathbb{J}MC}{\mathbb{J}k_i} \frac{A}{A^2 - B^2} \quad (5)$$

where $A \equiv 2 - \frac{\mathbb{J}MC}{\mathbb{J}q_i} \Delta_i$ and $B \equiv \frac{\mathbb{J}MC}{\mathbb{J}q_i} \Delta_j - \frac{\Delta_j}{\Delta_i}$. Note that as long as $\mathbb{J}MC/\mathbb{J}q_i \geq 0$ we that $A > 0$ and $B > 0$ (this also guarantees that the second-order condition at stage 2 is satisfied). In addition, assuming own demand effect is larger than the cross-demand effect, i.e. $-\Delta_i > \Delta_j > 0$, we have that $A > B$ which implies that the cross-sequential strategic effect ($\mathbb{J}p_j / \mathbb{J}k_i$) is smaller in absolute value than the own-sequential effect ($\mathbb{J}p_i / \mathbb{J}k_i$). The fact that the own strategic effect dominates the cross strategic effect is a direct consequence of the own-demand effect dominating the cross-demand effect. Finally, note that $\text{sign}\{\mathbb{J}p_i / \mathbb{J}k_i\} = \text{sign}\{\mathbb{J}p_i / \mathbb{J}k_j\} = \text{sign}\{\mathbb{J}MC / \mathbb{J}k_i\}$.

Given the above, we can relate this to the taxonomy for two-stage games given in Fudenberg and Tirole (19984). Since the second-stage game is in prices, we have strategic complements. Whenever $\mathbb{J}MC/\mathbb{J}k_i < 0$ we have a game where stage one capacity investment makes firms "tough", since marginal costs are lower. According to Fudenberg and Tirole this implies that we have a *puppy-dog* strategy, which refers to a situation where firms underinvest in capacity in order to be a less threatening rival. Conversely, whenever $\mathbb{J}MC/\mathbb{J}k_i > 0$ we have that first stage investment makes the firms "soft", which is coined a *fat-cat* strategy, where firms overinvest in order to be less aggressive.

In sum, we have that $\mathbb{J}MC/\mathbb{J}k_i$, which is the effect of capacity on the marginal costs in stage two, determines the sign and magnitude of how the two-periods are linked. This is an important effect in the model, since whenever it is zero *there is no need to specify a two-stage game, since stage one variables have no impact on stage two decisions. In this case the (sequential) strategic effect is zero and all choices are simultaneous.* Whether the sequential setup is relevant to estimate market power can therefore be tested through the significance of $\mathbb{J}MC/\mathbb{J}k_i$.

Moreover, the sign of $\mathbb{J}MC/\mathbb{J}k_i$ will determine the direction of bias if a two-stage set-up is not used. To illustrate this, let $\mathbb{J}MC/\mathbb{J}k_i < 0$, i.e. we have a *puppy-dog* game. Suppose that in this case a certain amount of market power exists which we wish to measure. Since market power in the product market generally leads to increased capacity

investment in stage one¹⁰, marginal costs as well as prices will decline. From the second-order condition of stage 1 (see Appendix-B) we have that $\mathbb{P}_i/\mathbb{K}_i - \mathbb{MC}/\mathbb{K}_i > 0$. In other words, marginal costs decline by more than prices when capacity investment increases, which increases the price-cost margin. This implies that in the context of (3) larger price-cost margin are associated with the same degree of market power q . Consequently, ignoring such feedbacks to the capacity stage, an *upward bias in the measurement of market power* occurs.

The direction of bias is reversed whenever the capacity game is a *fat-cat* strategy. To see this let $\mathbb{MC}/\mathbb{K}_i > 0$, which implies that capacity increases marginal costs in stage two. From the second-order condition of stage 1 (see Appendix-B) we now have that $\mathbb{P}_i/\mathbb{K}_i - \mathbb{MC}/\mathbb{K}_i < 0$, that is marginal costs increase by more than prices when capacity investment increases. This implies that smaller price-cost margin are associated with the same degree of market power q . The following remark summarizes these arguments.

Remark: Whenever the capacity game can be categorized as a *puppy-dog* (i.e. $\mathbb{MC}/\mathbb{K}_i < 0$) then a one-stage game would result in an upward bias in the measurement of market power. Whenever the capacity game can be categorized as a *fat-cat* (i.e. $\mathbb{MC}/\mathbb{K}_i > 0$) then a one-stage game would result in an downward bias in the measurement of market power. Finally, whenever $\mathbb{MC}/\mathbb{K}_i = 0$ then no bias exists.

The sign and significance of \mathbb{MC}/\mathbb{K}_i will be a testable hypothesis in the empirical section below.

3. Empirical Implementation

3.1 Functional Specification, Data and Estimation

The implementation of the above model involves the simultaneous estimation of the demand equation (1) and the first-order conditions (3) and (4) subject to (5)¹¹. The endogenous variables are therefore prices, quantities, and capital (number of planes). The demand equation corresponding to (1) is specified as follows,

¹⁰ This effect is a variant of what is known as semi-collusion (see Fershtman and Gandal, 1994) and does not hold for all functional specifications.

¹¹ 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 productive efficiency.

$$q_i = a_0 + a_1 p_i + a_2 p_j + a_{22} p_j GDP_i + a_3 GASOLINE_i + a_4 GDP_i + a_5 GCONS_i + a_6 RAIL_i + a_7 NETWORK_i + e_{1i} \quad (1a)$$

where e denotes the error term. The exogenous variables influencing demand are: an index of the price of all other airlines (P_j), 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. Summary statistics of the data are given in Table 1.

To complete the parameterization we must specify two more derivatives of the short-run cost function (2). First, the short-run marginal cost equation ($\mathcal{C} / \mathcal{Q}_i$) implicitly defined in (2) is assumed to be linear in capital, two factor prices: the price of labor and materials, as well as two cost characteristics: the load factor (LOADF) and the stage length (STAGEL)¹². That is,

$$\frac{\mathcal{C}}{\mathcal{Q}_i} = MC = b_0 + b_1 k_i + b_2 PL_i + b_3 PM_i + b_4 LOADF_i + b_5 STAGEL_i$$

Second, the effect of adding capacity to short-run marginal cost ($\mathcal{C} / \mathcal{K}_i$) is assumed to be linear in output and two characteristics of capital: the percentage of wide-bodied planes in the fleet (PWIDE), and the percentage of turboprop planes (PTURBO)¹³,

$$\frac{\mathcal{C}}{\mathcal{K}_i} = g_0 + g_1 q_i + g_2 PWIDE_i + g_3 PTURBO_i, \quad (2a)$$

which must be negative. Applying Roy's identity we constrain the parameter on k_i in the short-run marginal cost equation to be equal to the parameter on output in the long-run marginal cost equation, i.e. $g_1 = b_1$. Using the above functional specifications, we can substitute $\Delta_i = a_1 + q \cdot (a_2 + a_{22} GDP_i)$ and MC into (3) yielding,

$$p_i = b_0 + b_1 k_i + b_2 PL_i + b_3 PM_i + b_4 LOADF_i + b_5 STAGEL_i - \frac{q_i}{a_1 + q \cdot (a_2 + a_{22} GDP_i)} + e_{2i} \quad (3a)$$

¹² Load factor is used here, just as it is used in most empirical studies of transportation, to proxy service quality and thus is interpreted as a characteristic of service output.

¹³ The average fleet configuration variables (percentage wide-bodied and percentage of turboprop) are interpreted as heterogeneity controls for the planes in each carrier's fleet.

where e_{2i} is the error term. For the first-order condition for capacity investments in stage one (4) we can substitute (2a) and (5) into (4), noting that under the above functional specifications $A = 2$ and $B = -\Delta_j/\Delta_i$, yielding,

$$(p_i - MC)\Delta_j b_1 \frac{\Delta_j/\Delta_i}{(\Delta_j/\Delta_i)^2 - 4} - g_0 - b_1 q_i - g_2 PWIDE - g_3 PTURBO - r_i + e_{3i} = 0 \quad (4a)$$

where MC and Δ_i are as above and $\Delta_j = a_2 + a_{22}GDP_i$. Using these functional forms we estimate the system of three equations (1a), (3a), and (4a), which endogenize prices, output, and capacity, by nonlinear three stage least squares. The results are reported in Table 2.

3.2 Consistency Checks

Before interpreting the results, we perform several consistency checks on whether the theoretical model is in line with the empirical estimates. These tests can be thought of as specification tests of having chosen the "right" structure for the data in hand. Given that we have imposed a considerable amount of structure, there are a number of conditions which need to be satisfied but have not been imposed *ex ante*. The purpose of this subsection is to investigate whether the "data reject the model".

As can be seen in Table 2, the demand estimates are in line with our maintained assumptions. Both the own-price elasticity (-1.284) and cross-price elasticity (0.289 at sample mean) have the expected signs. In addition, our maintained assumption that the own-price effect is larger in absolute value than the cross-price effect, is confirmed by the data at each sample point¹⁴. Since our theoretical model of product differentiation assumes that firms are monopolists in their respective niches, it follows that firms must price in the elastic part of their linear demand schedules (see also Panzar and Rosse (1987)). We therefore must have a point elasticity of demand above unity. Our estimate in Table 2 for the own-price elasticity of demand is -1.284, and therefore is consistent with the theory.

In addition, the estimates in Table 2 imply at all sample points that the partial own-demand effect is negative ($\Delta_i < 0$), which is sufficient for the second-order condition at stage 2 to be satisfied (see Appendix-B). Furthermore, the partial own demand effect (at all sample points) is larger in absolute value than the cross-demand effect, i.e.

¹⁴ For example at the sample mean, we have $-\mathbb{I}q_i/\mathbb{I}p_i = 2094.78 > \mathbb{I}q_i/\mathbb{I}p_j = 477.36$.

$-\Delta_i > \Delta_j > 0$. As mentioned in the previous section, this implies that the cross-sequential strategic effect ($\mathbb{P}_j / \mathbb{K}_i$) is smaller in absolute value than the own-sequential effect ($\mathbb{P}_i / \mathbb{K}_i$) and that they have the same sign.

Finally, there are some requirements for the stage one maximization problem to be well-defined. A restriction that must be met is that the effect of capacity on short-run marginal costs is negative, i.e. $\mathbb{C} / \mathbb{K}_i < 0$, which ensures that the first-order condition (4) can be satisfied¹⁵. In other words, adding capacity must lower marginal costs in order for firms to have any incentive to invest in capacity. Given the estimates in Table 2, we find that $\mathbb{C} / \mathbb{K}_i < 0$ at all sample points. Furthermore, the second-order condition for capital is also satisfied at all sample points¹⁶, since $\mathbb{P}_i / \mathbb{K}_i - \mathbb{MC} / \mathbb{K}_i > 0$ (see Appendix-B).

In sum, the estimates in Table 2 are consistent with all the restrictions and maintained assumptions of theoretical model developed above.

3.3 Interpretation of Parameters

We now interpret the results given in Table 2 in more detail. The price elasticity of demand is estimated at -1.284 which indicates an elasticity close to unity (in fact the estimate is statistically not significantly different from one). As mentioned above, since a monopolist prices in the elastic part of a linear demand function, the above finding is consistent with airlines exercising some degree of market power in their respective market niches. The cross-price elasticity depends on GDP and is estimated at 0.289 (at the sample mean) which indicates that airlines are substitutes.

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. The price of gasoline has a negative effect on airline demand, indicating that automobiles and air travel are complements. This might be explained by the fact that gasoline prices are highly correlated with fuel prices. Consumption growth has a negative but insignificant effect on demand for air travel. The cost parameters generally have the expected signs. For the marginal cost function capital has the expected negative effect (we will return to this below), the load factor raises

¹⁵ Since the remaining terms in (4) are necessarily negative, i.e. $(p_i - MC)\Delta_j \frac{\mathbb{P}_j}{\mathbb{K}_i} - r_i < 0$.

¹⁶ Evaluating at sample mean, the second-order condition is -9.292E-7.

marginal costs, whereas the stage length lowers marginal costs. Unexpectedly, the price of labor has a negative effect on marginal costs, indicating a high degree of factor substitution. Turning to the marginal cost of capital specification, we get the expected impact. An increase in wide-bodied planes lowers marginal costs, and more turboprop planes raises marginal costs.

As mentioned earlier, the effect of capital on marginal costs, $\partial MC / \partial k_i$, determines whether the two-stage model can be reduced to a one-stage model. Since this effect is negative and significant (t-stat of -1.91), we reject a one-stage model in favor of the two-stage specification. In particular, since $\partial MC / \partial k_i < 0$, we find that empirically the game is consistent with a *puppy-dog strategy*. Moreover, using a one-stage model without capacity competition, would lead to biased estimates of market power, since it ignores the strategic linkages between competition in capacity and prices. Since empirically we find that $\partial MC / \partial k_i < 0$, as well as $\partial p_i / \partial k_i - \partial MC / \partial k_i > 0$, we would expect the direction of bias to be upward. We will return to this point shortly.

Turning to the measurement of market power in this two-stage set-up we find that there is some evidence to suggest that firms achieve market power through collusion. The estimated market power index q is .646. More importantly, it is significantly different from zero (Nash behavior) as well as one (Cartel behavior). Therefore, we reject the hypothesis of Nash behavior (t-stat of 6.72) as well as Cartel behavior (t-stat of 3.68). This suggests that firms do exercise some form of market power, although there is no evidence of cartel pricing. Using equation (3) the estimated mark-up over marginal costs is equal to 91%, which is substantial. One measure of comparison is to compute the mark-up for the case of Nash behavior. Setting $q = 0$ (or equivalently $h_{ij} = 0$) in (3) we obtain a mark-up of 78%. We therefore have a 13% increase in the mark-up due to non-cooperative pricing in the product market.

As we argued above, ignoring the capacity stage would introduce an upward bias in the measurement of market power. In order to quantify this bias in the context of the empirical investigation at hand, it is interesting to compare the above results on market power to those which we would have obtained if one were to ignore the endogeneity of capital investment altogether. To do this we have re-estimated our model reducing it to a one-stage, simultaneous move pricing game. In other words we re-specify the first-order condition (3a) as,

$$p_i = b_0 + b_1 PK_i + b_2 PL_i + b_3 PM_i + b_4 LOADF_i + b_5 STAGEL_i - \frac{q_i}{a_1 + q \cdot (a_2 + a_{22} GDP_i)} + e_{2i} \quad (3b)$$

where we need to replace k_i in (3a) with the price of capital PK_i in order to have a well-specified marginal cost function¹⁷. The new model to be estimated thus consists of equations (1a) and (3b), which is the standard two-equation structural model often used to measure market power. The estimated market power from the one-stage set-up is substantially different: the market power index q is now .944, which is significantly higher than before and rather close to cartel behavior¹⁸. In addition the direction of bias is as expected.

To illustrate this bias in the estimated market power further, Table 4 summarizes the comparison between the two alternative models in terms of mark-ups. As can be seen, the estimated mark-up over marginal costs for the standard one-stage model is over 100%, which is almost 10% higher than under the two-stage specification. By contrast the difference in price-cost margins between the two specifications for non-cooperative Nash behavior is very small, with only 2.5%. This implies that while the two-stage model associates only some 13% of the estimated mark-up with non-cooperative behavior, a standard one-stage model would attribute almost 20% of the mark-up with collusion.

In sum, it appears that firms market power is significantly overestimated whenever capacity competition is not accounted for.

4. Conclusion

The purpose of this paper was to investigate whether the inferred significant degree of market power at the product market level is sensitive to the introduction of an input variable, namely capacity. In other words, does *endogenous* capacity effect the conclusions about product market competition.

To test this assessment we specify and estimate a structural model which accounts for competition in two variables: capacity and prices. We then estimate this model - demand, cost (short and long run), and conduct - for the European Airline Industry using data for the period of 1976-1990. We argue that the European Airline Industry is particularly well-suited for this purpose. We perform a number of specification tests and reject a simple one-stage specification in favor of our two-stage set-up. Regarding

¹⁷ Note that there is no difference between the short- and long-run cost function anymore, and therefore only factor prices appear in the marginal cost specification.

¹⁸ Nevertheless, we the model still rejects cartel pricing with a t-stat of 1.92.

the measurement of market power in the product market, we find that some degree of market power exists. However, market power in the two-stage set-up is significantly lower than in the more widely employed one-stage specification, which is consistent with the direction of bias in puppy-dog games. This illustrates that firms market power in the product market may be significantly overestimated whenever capacity competition is not accounted for and that the claim that "there is a great deal of market power, in the sense of price cost margins, in some concentrated industries" (Bresnahan 1989, p. 1052) may partially be due to the fact that input markets have not been properly endogenized.

There are several implications of the above findings. Combining these results with other findings that European carriers have a substantial cost disadvantage vis-à-vis their U.S. competitors (see Good, Röller, and Sickles (1993)) it seems likely that most of the benefits from European liberalization will come from the elimination of cost inefficiencies. This is especially so in light of the above model where market power is even smaller, once capacities are endogenized. Given that prices are not high because of outright cartel pricing, airline prices in Europe might come down more gradually as efficiency increases and market niches are abolished.

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 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, ground-based capital equipment, and landing fees 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 we 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. 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, 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 ton-kilometer 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 countries, which share the majority of the equity in SAS.

The price of the "other" airlines (P_j) in the duopoly model is computed by weighting all the individual prices by their respective revenue shares in the market. Gross Domestic Product (GDP) was obtained from the *Main Economic Indicators* publication of the Economics and Statistics Department of the Organization for Economic Cooperation and Development (OECD). It is 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. We thank S. Perelman for making available to us some of the more recent rail data which were not available in *Jane's World Railway*.

The retail gasoline prices (prices plus taxes) were obtained from the OECD, International Energy Agency's publication, *Energy Prices and Taxes*.

Appendix-B

Second-Order Conditions

Stage 2:

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

$$q_i + (p_i - MC)\Delta_i = 0$$

Assuming a linear demand function, the second-order condition can then be written as,

$$\Delta_i + \Delta_i \left(1 - \frac{\mathbb{I}MC}{\mathbb{I}q_i} \Delta_i \right) = \Delta_i \left(2 - \frac{\mathbb{I}MC}{\mathbb{I}q_i} \Delta_i \right) = \Delta_i \cdot A.$$

Since $A=2$ for the functional specifications assumed above, the second-order condition is met whenever $\Delta_i < 0$.

Stage 1:

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

$$\left(\Delta_j \frac{\mathbb{I}p_j}{\mathbb{I}k_i} \right) \left(\frac{\mathbb{I}p_i}{\mathbb{I}k_i} - \frac{\mathbb{I}MC}{\mathbb{I}k_i} \right)$$

Recall that $\Delta_j > 0$. When $\frac{\mathbb{I}MC}{\mathbb{I}k_i} < 0$, we have that $\frac{\mathbb{I}p_j}{\mathbb{I}k_i} < 0, \frac{\mathbb{I}p_i}{\mathbb{I}k_i} < 0$. Consequently, the second-order condition is met whenever $\frac{\mathbb{I}p_i}{\mathbb{I}k_i} - \frac{\mathbb{I}MC}{\mathbb{I}k_i} > 0$. Alternatively, when $\frac{\mathbb{I}MC}{\mathbb{I}k_i} > 0$,

we have that $\frac{\mathbb{I}p_j}{\mathbb{I}k_i} > 0, \frac{\mathbb{I}p_i}{\mathbb{I}k_i} > 0$. In this case the second-order condition is met whenever

$$\frac{\mathbb{I}p_i}{\mathbb{I}k_i} - \frac{\mathbb{I}MC}{\mathbb{I}k_i} < 0.$$

Table 1: Data Statistics

Variable	Mean	Minimum	Maximum
PI	1.151	0.740	1.855
QI	1.878	.5164	6.165
KI	90.652	23.500	241.000
PJ	1.137	0.768	1.364
PK	2.814	1.155	7.031
PL	2.454	0.368	4.583
PM	0.970	0.493	1.599
GASP	0.642	0.311	1.233
GDP	406.380	66.600	1488.210
GCONS	7.659	-0.900	23.700
PRAIL	0.048	0.0143	0.136
NETWORK	421.851	188.787	1072.390
PWIDEB	29.622	8.000	84.010
PTURBO	5.236	0	38.430
LOADF	63.805	53.489	72.700
STAGEL	11.478	6.495	19.313

For variable definitions see Appendix-A. Number of observations is 120.

Table 2: EUROPEAN AIRLINES - Two Stage Game

(NON-LINEAR THREE-STAGE LEAST SQUARES ESTIMATES)				
Variable		Estimate	t-statistic	
<i>Demand Equation</i>				
INTERCEPT		-1052.580	-2.16	
Pi		-1.284	-6.13	
Pj		0.354	7.75	
Pj*GDP		-.065	-5.89	
GASOLINE		-.665	-5.44	
GDP		0.854	8.49	
GCONS		-0.798	-0.22	
RAIL		0.487	7.87	
NETWORK		0.167	1.76	
<i>Marginal Cost - (∂C / ∂q_i)</i>				
INTERCEPT		-10.777	-0.52	
Ki		-0.024	-1.91	
PL		-17.329	-2.12	
PM		4.615	0.70	
LOADF		0.108	1.90	
STAGEL		-1.556	-1.52	
<i>Marginal Cost of Capital - (∂C / ∂k_i)</i>				
INTERCEPT		0.129	0.43	
Qi		-0.024	-1.91	
PWIDE		-9.086	-8.10	
PTURBO		2.414	2.06	
<i>Behavioral Parameters</i>			<i>NASH</i>	<i>Cartel</i>
θ		0.646	6.72	3.68

The estimates reported in the demand equation are converted into elasticities. Number of observations = 120.

Table 3: Market Power, Demand Elasticities, and Price-Cost Margins under Alternative Specifications

	Price-Cost Margin (under non-cooperative behavior, $q = 0$)	Estimated Price-Cost Margin	Market Power (q)	Demand Elasticity (h_{ii})
One-Stage Game	80.6%	100.1%	.94	1.24
Two-Stage Game	78.1%	91.3%	.65	1.28

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