Competition and E¢ciency in European Aviation

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Abstract

Economic studies on the European airline industry have been committed on the evaluation of market power and the effect of liberalization on the industry's operating costs. The aim of this paper is to make these two approaches coincide. We construct and estimate a structural model of competition that includes a system of demand, capacity, costs, and price equations. The cost equation accounts for the inefficiency of the transport operator and its cost reducing effort, which depends on the incentives provided by the state of the liberalization. The structure of the model depends on the package of liberalization under consideration. Using a non-nested test and observations on the nine largest European flag carriers between 1985 and 1999, it is shown that a model of competition that does not account for inefficiency and effort is always rejected. Moreover, the package of regulation introduced at the begining of the 90's appears to be the one that has affected firms behavior the most.

Keywords: Competition, Efficiency, Airline, Deregulation and Market power

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1 Introduction

Structural empirical models of competition are built around a demand and a price equation. The price equation shows that prices are determined as a mark-up on marginal costs that depends on the toughness of competition. These models are normally used to measure competition in an industry in one moment of time, determine if competition has varied after some structural change, identify price wars, etc.

In these models, marginal costs are represented by a more or less well defined cost function that assumes that firms are efficient and treats observed costs as exogenous. This is in contradiction with a long tradition of empirical literature related to the measurement of efficiency through the estimation of production and cost functions (see Kumbhakar and Knox Lovell, 2000). In particular, cost function specifications include an error term with two components independent of each other: a symmetric component that measures random variations of the frontier across firms and captures the effects of measurement error, other statistical noise and random shocks outside the firm's control, and a one-sided component that captures the effect of global inefficiency relative to the stochastic frontier. Note that the so-called global inefficiency includes pure technical inefficiency that is exogenous to the actions of the firm as well as endogenous cost-reducing activities. Moreover, more recent literature on incentives and informational asymmetries has proposed a theoretical framework in order to account for the effect of cost-reducing actions of the firm and has, therefore, shed new light on costs endogeneity. The new theory of regulation (See Laffont, 1994) suggests that the endogenous effort of the producer closely depends on the constraints exerted by the regulatory environment it faces. Empirical works

on this latter topic have not been numerous so far.[1]

These two elements, technical inefficiency and effort, are of particular importance when comparing industries subject to different incentives, or changes in firms' behavior after a structural change in the rules governing the market. Exogenous differences among markets or shocks that can change the incentives to compete in one market can be related to regulation, competition policy or international trade policy.

This is the case of the European airline industry. At the beginning of the eighties European aviation was regulated by bilateral air service agreements between the countries concerned. Each route was served by the two national flag carriers that used to jointly set a single price and evenly split the demand. In the absence of entry, and with price and capacity agreements, competition was not possible and a lack of incentives to improve efficiency characterized the industry. This situation allowed firms, in many cases subsidized by their governments, to increase costs inefficiently.

Several authors have attempted to account for cost endogeneity problems. Among them, Neven and Röller (1996) and Neven, Röller and Zhang (2001) develop a competition model where firms face workers unions and market pressures that may affect operating costs. They apply this model to the European airline industry for the period 1976-94, that mainly coincides with the regulated period, and show that the model that accounts for costs endogeneity supports a more competitive result than the standard one. Additionally, Ng and Seabright (2001) use a panel of European and American carriers from 1982 to 1995 and a

[1] See Dalen and Gomez-Lobo (2003) and Gagnepain and Ivaldi (2002 a and b) for an analysis of alternative regulatory mechanisms applied to Norwegian and French urban transport networks.

reduced cost-form in order to show that state ownership substantially leads to higher operating costs.

Under the pressure of the US "Open skies" policy started in 1978, that followed their domestic deregulation, several changes took place in the European market. First, some governments started renegotiating their intra-European bilateral agreements. In 1984, the UK and the Netherlands signed the first liberal bilateral agreement, that in 1985 was complemented with further deregulatory measures. Subsequently, some other governments signed similar liberal bilateral agreements, e.g. UK-West Germany (1985), UK-Belgium (1985) and UK-Ireland (1986), among others.[2] As a result, entry and price reductions were possible in several European international routes, allowing for more competition.

Second, after several reports in favor of liberalization provided by the European Economic Commission,[3] the European Community introduced a package of measures at the end of 1987 that allowed for less restrictive capacity sharing agreements, limited price reductions, and regulated entry on the busiest routes. These measures were extended by a second and a third package in 1990 and 1992, respectively. In particular, the 1992 package of measures allows for free entry by European carriers in any international European route, and forbids agreements on either frequency, capacity or prices. By April 1997, the same rules had to be applied to domestic routes within any EU country. This process of gradual liberalization left the industry open to international competition, introducing a significant variation in firms' incentives.

Simultaneously, European flag carriers were privatized and explicit permis-

[2] Marín (1995) provides evidence on the effects of these liberal bilateral agreements on route level competition.

[3] See European Economic Commission (1984).

sion by the EU authorities was required to receive any form of public subsidy. The new competitive pressure became the strongest incentive for carriers to reduce costs and improve e¢ciency. Additionally, during the second half of the nineties, European carriers organize themselves around code-sharing agreements and international alliances that emerged after long and complex processes of negotiation.

In this paper we analyze the impact of the liberalization process on European airline companies' e¢ciency and competition. To achieve this goal, we construct and estimate a structural model of competition where airlines take simultaneous decisions on prices and cost reducing e¤ort. The model includes a system of several equations that accounts for the pricing habits of the carriers, the capacity constraint that relates the supply of the service to consumers' demand, and the technology of each transport operator. Technology is described through a cost function that includes a non observable parameter accounting for the exogenous technical ine¢ciency faced by each …rm and a cost reducing e¤ort. Cost reducing e¤ort can be expressed by taking into account the regulatory constraints impinging on the activity of each carrier. We are thus able to de…ne a particular cost structure for each type of regulatory regime. The objective of our work is twofold: First, using a non-nested procedure, we test several scenarios of incentive pressures against each other in order to identify the one that …ts better the data. We show that competition has increased signi…cantly only after the introduction of the last package of deregulatory measures in 1993, since the liberal bilateral agreements had very limited e¤ects and the 1987 EC package of deregulatory measures had no e¤ect on …rms' behavior. Second, we compare our results with those that had been obtained from a standard model

of competition with no endogenous e¤ort and/or no exogenous ine¢ciency. It is shown that they are signi…cantly di¤erent from each other and that a model accounting for technical ine¢ciency and e¤ort is always preferred. The standard model would undermeasure the toughness of competition.

Thus, our aim in this paper is to show that a proper modelization of the incentives provided by regulatory pressures allows a better evaluation of competitive forces. The next section presents the cost, supply, and demand systems under consideration in the model. Section 3 focuses on the construction of the endogenous cost function, that depends on the state of the regulation, and the pricing structure proposed by airline carriers. Functional forms and the estimation procedure are developped in Section 4. Results and comments are provided in Section 5. Section 6 concludes.

2 Determining the ingredients of the model

In what follows we specify a model for airlines' behavior that encompasses situations of fully regulated as well as liberalized competitive markets. We are concerned with the e¤ect of liberalization on market competition and …rms' ef…ciency and the interconnection between these two decisions. Accordingly, in the context of our model, airlines take simultaneous decision about their cost reducing e¤ort and their pricing policy.

A modelling approach followed by several authors consists on assuming that …rms make individual decisions for each route they serve.[4] This approach allows for route speci…c policies. The advantage of this is that it takes into account

[4] See Borenstein (1989) for the American domestic market, among others, and Marín (1995) for the European international market.

route characteristics that may affect firms' behavior, such as the number and identity of the competitors or the length and density of the route. An alternative approach followed in previous contributions assumes that companies take corporate decisions that affect their entire netwe d ¤

be implemented through a short-run dual cost function. Denoting by w_L and w_M the price of labor and materials, the program of the firm can be translated into the following terms:

$$
\begin{aligned}
\min_{L,M} C_i &= (w_L L + w_M M)\exp(\theta - e), \\
&\quad \text{subject to} \\
Q_i &= Q(L_i, M_i, K_i, z_i, t, \rho)
\end{aligned}
$$

where t is a trend, and ρ is a vector of parameters denoting technology.

Note that C_i are observed operating costs (which are different from efficient operating costs), θ and e denote firms' individual inefficiency beyond the control of the firm, and effort, two parameters that are unobservable.[6] Thus, it is assumed that technical inefficiency prevents the firm from reaching the required output level Q_i, and this may result in upward distorted costs. Cost reducing effort can be undertaken by managers to counterbalance the effect of inefficiency. For instance, managers may spend time and effort in improving the location of inputs within the network, monitoring employees, solving potential conflicts, etc. The associated short-run cost function, conditional on capital installed, inefficiency and effort is

[6] It might be usefull to note at this stage that the inefficiency term θ should be viewed as a measure of relative inefficiency rather than absolute inefficiency. A measure of absolute inefficiency includes a component that can be explained by exogenous factors that may be captured by various explanatory variables (for instance, the size of the network and the average stage lenght defined in the following sections). Hence, the parameter θ should be rather considered as the unobservable part of the absolute inefficiency, not captured by the explanatory variables.

$$C_i = C(Q_i; \omega_i; K_i; z_i; \theta_i; e_i; \beta); \qquad (1)$$

where β is a vector of parameters to be estimated. Assume moreover that cost reducing effort involves some internal cost or disutility that can be represented through a convex function $\Psi(e_i; \mu)$. Cost reducing effort is endogenous and depends on the regulatory constraint impinging on the activity of the airline carrier.

Supply

Before moving to the demand side, we should notice that in transit industries, costs and revenues are driven by two different measures of output. Costs are determined by capacity supplied, i.e., available seat-kilometers, that in turn, depends on fleet capacity (measured by the number of seats available), and total mileage performed by the airplanes. However, available seat-kilometers are only an intermediate output that is used by consumers to produce the final output, revenue passenger-kilometers (see Berechman, 1993). This final output, q_i, determines carriers' revenues. Still, capacity and demand are closely related by a function that may change with time, t, with the technology available,

$$Q_i = \Phi(q_i; t; \lambda); \qquad (2)$$

where λ is a vector of parameters.

Demand

On the demand side, firm i's demand depends on own and competitors price, p_i and p_j respectively, as well as market exogenous characteristics, m_i. A limited number of competitors meets in each route, with the combination of competi-

tors changing from one route to another. Di¤erent competitors supply alternative products which di¤er in time schedule, number of stops, availability of interconnections with other ‡ights, etc. Accordingly, the services o¤ered by different airlines can be regarded as imperfect substitutes. Actually, a small set of competitors meets in each individual market. By assuming the same cost reducing e¤ort and pricing policy for all the routes served by one company, we are implicitly saying that p_j represents the average price asked by the di¤erent competitors that …rm i meets in the routes it serves. Accordingly, each carrier faces a demand of the form,

$$q_i(p_i; p_j; m_i; t; ®); \qquad i = 1; :::; N \tag{3}$$

where ® is a vector of parameters.

3 Regulatory rules and pricing

This section focuses on the construction of the structural cost function and the de…nition of the pricing rules. We are interested in testing whether a proper accounting of the incentive e¤ects on costs has a signi…cant impact on competition measures. Note that such competition measures will depend on whether incentive e¤ects are considered when estimating marginal costs. The pricing structure itself is independent of the nature of the regulatory pressures impinging on the activity of the …rm.[7] For this reason, incentive e¤ects and pricing by

[7] The particular structure we use to incorporate technical ine¢ciency and e¤ort parameters allows the incentive-pricing dichotomy principle to hold. (See La¤ont and Tirole, 1993). It means that the same pricing formula applies whether we assume strong or soft regulatory pressures.

firms can be presented separately. Although prices and effort are determined simultaneously in the decision process, we choose such an approach for ease of exposition.

Effects of deregulation on the cost structure

During the second half of the eighties, the European airline industry has switched from bilateral air service agreements to more competitive markets. This might have influenced cost reducing activities. We propose to account for these regulatory pressures through the cost function (1) that is conditional on the cost reducing parameter e: Deriving the equilibrium level of e and plugging it back into the primal cost expression allows us to account for endogenous effort and derive a structural cost form that can be estimated. The aim of such an approach is twofold. First, different scenarios associated to the different waves of market deregulation can be tested against each other in order to figure out what measures had significant effects on the behavior of European airline carriers in terms of cost reduction. Second, accounting for changes in regulation through the cost structure enables us to reduce the source of misspecification, which in turn, should avoid bias in the estimation of the technological parameters. This will allow us to assess in a more satisfactory way the impact of regulatory constraints on the degree of competition of the industry.

Any firm that is residual claimant for cost savings is willing to provide effort e in order to reduce its operating costs, C_i, in a significant manner. Since the cost reduction activity is costly, the firm sets the optimal effort level e that maximizes its profit π_i. Denoting by p_i the price of the service to be sold, the profit is simply defined as the difference between revenue $R_i = q_i(\cdot)p_i$ and total cost $TC = C_i(e_i; :) + ª(e_i; :)$. The program of the firm is

$$\max_{e} \pi_i = q_i(\cdot)p_i - C_i(\Phi(q_i(\cdot);\cdot); \omega_i; K_i; z_i; \theta_i; e_i) - \Psi(e_i). \quad (4)$$

Note that since revenue R_i is independent of effort e, this program is equivalent to the one where the firm sets the optimal effort level e that minimizes TC. The first order condition of this program is

$$-\frac{\partial C_i}{\partial e_i}(\Phi(q_i(\cdot);\cdot); \omega_i; K_i; z_i; \theta_i; e_i) = \Psi'(e_i); \quad (5)$$

which implies that the optimal effort level equalizes marginal cost savings and the marginal disutility of effort.

On the other hand, a firm that is not residual claimant for cost reductions has no incentives to provide costly effort. Therefore the optimal effort of a non-residual claimant firm is supposed to be equal to 0.

Before deregulation, European airline carriers were mainly public entities regulated by bilateral service agreements. Subsidies would generally allow these firms to completely cover costs. It is therefore assumed that before deregulation, any operator would behave as a non-residual claimant firm and would not provide any effort at all. Denote by e^R such an effort level. After deregulation, as already mentioned, the new competitive pressure as well as the abandon of subsidizing practices would provide the operating firms with perfect incentives for cost and inefficiency reduction. We consider then that the optimal effort provided by a deregulated firm is given by the condition (5) and is denoted as e^D. Given these two effort levels, we can write the cost function as

$$C^s(\Phi(q_i(\cdot);\cdot); \omega_i; K_i; z_i; \theta_i; e^s); \quad (6)$$

the two cost structures,.where s denotes the regulatory regime, that can be either regualtion, R, or deregulation, D.

To conclude this subsection on costs, the reader should notice that a more complicated model where the effort level e depends on the degree of competition (hereafter defined as ν) in a continuous manner is difficult to implement in our particular context. The discrete nature of the intervention of effort in the cost structure (e^R or e^D) is based on the assumption that switching from a regime with regulated bilateral service agreements to a partially/completely deregulated market is equivalent to transforming a monopolistic structure into an oligopolistic one. This suggests that the menu of organizational market structures under observation is limited and can be restricted to a two-items one.

Pricing

We turn now to the pricing program of each airline carrier. Again, we need to distinguish the period of state regulation from the period of deregulation during which firms are set free to choose prices in order to maximize their profit. We start with the deregulation period.

In a deregulated environment, provided with the cost and demand functions, each firm solves the following program,

$$\max_{p_i} \pi_i = q_i(\cdot)p_i - C^D(\Phi(q_i(\cdot);\cdot);\omega_i;K_i;z_i;\theta_i;e^D) - \psi(e_i); \tag{7}$$

where p_i is the optimal price to be chosen.

Accordingly, the first order conditions for firm i are given by

$$q_i + (p_i - MC_i^D(\Phi(q_i(\cdot)))\,\Phi'(q_i(\cdot)))\,\Delta_i = 0; \qquad (8)$$

where

$$MC_i^D(\cdot) = \frac{\partial C_i^D}{\partial Q_i}; \quad \Phi'(q_i(\cdot)) = \frac{\partial Q_i}{\partial q_i}; \quad \Delta_i = \frac{\partial q_i}{\partial p_i} + \frac{\partial q_i}{\partial p_j}\frac{\partial p_j}{\partial p_i}$$

First-order condition (8) represents the pricing policy of the firm. We denote by $\nu = \frac{\partial p_j}{\partial p_i}$, the conjectural variation or the market conduct parameter. Recall that $\nu = 0$ is consistent with a Nash price in games. In this case expression (8) simplifies to the well know Ramsey rule where firms set prices according to their own price elasticity. The case where $\nu < 0$ represents more competitive situations that Nash behavior, with price approaching marginal costs as $\nu \to -\infty$. Collusive behavior is consistent with $\nu > 0$ with joint profit maximization for the specific case $\nu = 1$. If ν can be identified, we are able to estimate the degree of coordination in the price setting game between firms competing in the industry after deregulation.

Before deregulation, i.e., when firms are still state owned and regulated, the maximization program presented in (7) is irrelevant. During this period, prices result from bilateral agreements set by public authorities and are under the control of the firms only partially. We could think about alternative programs for this period, such as social welfare maximizing or monopoly pricing. This would however go beyond the scope of the paper since our intention is to focus on firms' competitive practices after deregulation.

Taken together, the two periods of regulation and deregulation allow us to identify the cost reducing activity (i.e., effort) in the model since a different

cost structure (a different technology) for each period is considered. Hence, the technology and the technical inefficiency can be estimated. Once this is done, a precise evaluation of the nature of competition in the industry after deregulation can be obtained in a second step.

4 Empirical Implementation

The next step consists in proposing specific functional forms for the cost and demand functions, as well as the cost reducing effort and the engineering relationship between demand and supply. Our aim is to obtain a set of structural equations to be estimated.

We assume a Cobb-Douglas specification for the cost function in (1). This specification retains the main properties desirable for a cost function and provides a sufficiently precise description of the technology, while remaining tractable for our purpose.[8] Alternative more flexible specifications such as the translog function lead to cumbersome computations of the first order conditions when effort is unobserved. The cost function is then specified as

$$C_i = \beta_0 \, \omega_{Li}^{\beta_1} \omega_{Mi}^{\beta_2} Q_i^{\beta_3} K_i^{\beta_4} z_i \exp(\beta_t \, t + \theta_i - e_i + u_{ci}) \qquad (9)$$

where ω_{Li}, ω_{Mi}, K_i and z_i denote wages, price of materials, capital installed and network exogenous characteristics that affect the cost function, and t is a trend.[9] Additionally, e_i represents effort, θ_i is the inefficiency term, and u_{ci} is an error term. Note that θ has a density function $f(\theta)$ defined over an interval $[\theta_L; \theta_U]$, where θ_L (θ_U) denotes the most efficient (inefficient) firm.

[8] See Marín (1998) for details on the same choice for the airline industry

[9] The data and their construction are described in detail in the Appendix.

For our empirical specification we assume that z_i includes measures of airlines' network size, NET_i, and average stage length, ASL_i,[10] and has the following shape:

$$z_i = NET_i^{\beta_5} ASL_i^{\beta_6} \tag{10}$$

Provided with (9) and (10) it is easy to derive the short-run marginal cost equation ($\partial C/\partial Q_i$), as well as $\partial C/\partial e_i$, included in first order conditions (5) and (8), respectively.

With respect to the internal cost of effort and the engineering relationship between demand, q_i, and supply, Q_i, represented in (2), we assume the following functional forms,[11]

$$\Phi(e_i) = \exp(\mu e_i) - 1; \quad \mu > 0; \tag{11}$$

and

$$Q_i = \lambda_0 q_i^{\mu} \exp(\lambda_t t + u_{Qi}); \tag{12}$$

respectively, where u_{Qi} is an error term.

The demand equation corresponding to (3) is specified in linear form as follows

[10] See Marín (1998) and Neven et al. (2001) for discussions on the introduction of these two variables in the cost function and for evidence on their effects on airlines' productivity. A measure of airport concentration was included in an alternative specification but it turned out to be highly correlated with the size of the network.

[11] Notice that $\Phi(e_i)$ is a convex function, with $\Phi(0) = 0$, $\Phi'(e_i) > 0$ and $\Phi''(e_i) > 0$.

$$q_i = \alpha_0 + \alpha_1 p_i + \alpha_2 p_j + \alpha_3 GCONS_i + \alpha_t t + u_{qi} \tag{13}$$

where p_i and $GCONS_i$ are firm i's weighted average price, and consumption growth in its home country, as a measure of economic activity,[12] p_j is an index of the price of all other airlines, t is a time trend and u_{qi} is an error term.

Now, using the functional forms for operating cost (9), internal cost of effort (11), and the first order condition (5) on effort activity, we are able to express the effort level under both regulation and deregulation periods. Note that the first order condition regarding optimal effort under deregulation e^D can now be written as

$$C_i(\cdot) = \mu \exp(\mu e_i^D) \tag{14}$$

Substituting (9) and (10) in (14), we can solve for e^D, as:

$$\begin{aligned} e_i^D = {} & \frac{1}{\mu + 1}(\ln \beta_0 + \beta_1 \ln Q_i + \beta_2 \ln \omega_{Li} + \beta_3 \ln \omega_{Mi} + \beta_4 \ln K_i + \\ & \beta_5 \ln NET_i + \beta_6 \ln ASL_i + \theta - \ln \mu + u_{ci}); \end{aligned} \tag{15}$$

while

$$e_i^R = 0. \tag{16}$$

[12] Some alternative measures of economic activity where included in this expression in either with or without GCONS. The inclusion of several variables was leading to multicolinearity problems. When only one of the variables was included, no one was providing a better fit that GCONS. Accordingly, we decided to drop alternative variables and leave GCONS only.

As predicted by the new theory of regulation, the effort level of the residual claimant firm increases with θ, i.e., a more inefficient carrier needs to be more active in cost reducing activities than a less inefficient one in order to reach the same cost level. Note moreover that these carriers are willing to provide lower effort levels when effort is more costly (the cost reducing technology μ is more costly). Substituting back e^D and e^R into the primal cost structure (9) allows us to obtain the final forms to be estimated $C^R(\cdot)$ and $C^D(\cdot)$: Substituting (10) and either (15) or (16) into (9), we obtain

$$C_i^D = c_0\, \omega_{Li}^{\beta'_1}\omega_{Mi}^{\beta'_2}Q_i^{\beta'_3}K_i^{\beta'_4}NET_i^{\beta'_5}ASL_i^{\beta'_6}\exp\zeta(\beta_t\, t + \theta_i + u'_{ci}); \qquad (17)$$

and

$$C_i^R = \beta_0\, \omega_{Li}^{\beta_1}\omega_{Mi}^{\beta_2}Q_i^{\beta_3}K_i^{\beta_4}z_i\exp(\beta_t\, t + \theta_i + u_{ci}); \qquad (18)$$

where $\zeta = \frac{1}{1+\mu}$, $c_0 = \exp[\zeta(\ln\beta_0 + \frac{\ln\mu}{\mu}]$, $\beta'_k = \zeta\beta_k$, and $u'_{ci} = \zeta u_{ci}$.

The cost function to be estimated is then

$$\begin{aligned} C_i \quad = \quad & \xi_i^D\left[c_0\, \omega_{Li}^{\beta'_1}\omega_{Mi}^{\beta'_2}Q_i^{\beta'_3}K_i^{\beta'_4}NET_i^{\beta'_5}ASL_i^{\beta'_6}\exp\zeta(\beta_t\, t + \theta_i + u'_{ci})\right] + \\ & \xi_i^R\left[\beta_0\, \omega_{Li}^{\beta_1}\omega_{Mi}^{\beta_2}Q_i^{\beta_3}K_i^{\beta_4}z_i\exp(\beta_t\, t + \theta_i + u_{ci})\right]; \qquad (19) \end{aligned}$$

where ξ_i^D takes value 1 if the firm operates in a deregulated industry and 0 otherwise, while ξ_i^R takes value 1 if the firm operates in a regulated industry and 0 otherwise. In the estimations, several vectors ξ_i^D and ξ_i^R will be assumed depending on the nature of the various deregulatory measures introduced in the European airlines market, and their results will be tested against each other in order to unravel their effects on competition.

Finally, using the expressions of demand (13), supply (12) and costs (9), the price first-order condition can be rewritten as

$$0 = q_i + \left(p_i - \frac{\lambda_1 Q_i MC_i(\cdot)}{q_i}\right)(\alpha_1 + \alpha_2 \gamma). \qquad (20)$$

The system of equations formed by (12), (13) and (19) is determined simultaneously, accordingly and in order to avoid endogeneity problems, these equations are estimated by the Instrumental Variables Estimation Method. The cost function (19) includes a non-observable parameter, namely θ, characterized by a Half-Normal density function $f(\theta)$. When estimating this cost-function, one needs to compute the integral of the joint density function of θ and u_{ci} over $[0; \infty]$.[13] Note that the system is identified and all parameters can be recovered, given that by homogeneity of degree 1 in input prices, $\beta_1 + \beta_2 = 1$.

In a second step, a set of values for γ is recovered for the deregulated period. In particular, the estimates from the cost function allow us to obtain measures of marginal costs. Putting them together with our estimates of the own- and cross-price elasticities and the capacity-demand elasticity, as well as the observed values for supply, demand and prices, we can solve for γ, that remains as the only unknown in equation (20). The results found under different scenarios are tested against each other to evaluate whether a significant improvement can be obtained with our estimation procedure.

[13] For more details, the reader should refer to Kumbhakar and Knox Lovell (2000).

5 Results and interpretation

Tables 1 to 4 provide the results for the econometric model. We emphasize in this section the two main arguments that are discussed in this paper: First, depending on how deregulation is interpreted, di¤erent cost structures can be estimated. Then, a non-nested test helps us to choose the best cost structure in the sense that it is the one that …ts the data the best. Second, having the most adequate cost estimates in hands, we are capable of providing measures that characterize the degree of competition in the industry. Our results are then compared to what would have been obtained if cost endogeneity had not been taken into account.

Supply and demand

Table 1 presents the results for the demand equation. The coe¢cients of all the variables are signi…cant and have the expected sign. Table 2 presents the demand-capacity relationship. Again, the coe¢cients are signi…cant and have the expected sign. In both cases, the overall …t of the regression is very satisfactory. The main interest of these equations is to provide instruments for capacity and demand.

Choosing the best cost structure

Table 3 presents the estimates for the cost function as well as the e¤ort disutility parameters, obtained from the estimation of equation (19). In order to test the e¤ect of liberalization on …rms' collusion and cost reducing e¤ort, this equation is estimated under alternative scenarios related to the deregulatory packages introduced by the EU and the liberal bilateral agreements signed by the UK with other countries. In all cases but (1), we include the term μ to measure ine¢ciency. Additionally, the following distinctions are made: 1) model with

no e¤ort and no ine¢ciency term, 2) …rms do not make any e¤ort to reduce ine¢ciency after the introduction of deregulatory measures, i.e., the e¤ect of deregulation is not accounted for, 3) deregulation a¤ects …rms' behavior after the third EC package of measures in 1992, and 4) deregulation a¤ects the behaviour of the …rms a¤ected by the introduction of liberal bilateral agreements, which are British Airways, KLM, Lufthansa, and Sabena, after 1985, and the remaining companies in 1993.[14] The comparison between scenarios (3) and (4) allows us to identify whether the liberal bilateral agreements has any e¤ect on …rms' behavior.

Additionally, in order to test whether the EC deregulatory measures started having e¤ect in 1987, i.e., after the introduction of the …rst package of measures, we also try two alternative scenarios: 3') deregulation a¤ects …rms' behavior after the …rst EC package of measures in 1987, and 4') deregulation a¤ects the behaviour of the …rms a¤ected by the introduction of liberal bilateral agreements after 1985, and the remaining companies in 1987. Finally, given that some new competitors like Easy Jet and Virgin, not included in the sample, started operating a signi…cant number of international European routes during the period 1997-99, and this could bias our measure of rivals' prices, we construct scenario (3") that is as scenario (3) but excluding the last two years of observations, namely 1998 and 1999.

The variable capital has been dropped from the regressions because the correlation coe¢cient between output and capital is 0.91, causing multicollinearity

[14] Scenario (4) that allows British Airways, KLM and Lufthansa to change behavior after the introduction of liberal bilateral agreements in 1985, has been selected after comparison with any other sensible combination of …rms being a¤ected by the agreements. The results are presented in Table A1 in the Appendix.

problems.[15] Additionally, running a maximum likelihood test, it was not possible to reject the model without capital against a model including it at any sensible con…dence level.[16] Moreover, scenarios (3') and (4') cannot be estimated due to convergence problems with the coe¢cient ¹. This indicates that the models are clearly misspeci…ed. This suggests that the deregulatory measures included in the …rst EC package had no e¤ect on …rms' behavior, probably due to their limited scope. This result is consistent with Ng and Seabright (2001).

For the remaining scenarios, the variables are signi…cant and have the expected sign. Costs are increasing with wages and production. The alternative scenarios are tested against each other applying the test of nonnested hypothesis proposed in Vuong (1989). The test shows that scenario (4) cannot be rejected against scenario (3), but the sign of the test indicates that scenario (3) …ts the data better. This suggests that liberal bilateral agreements had a limited e¤ect on …rms' behavior, probably because they regarded only a reduced number of routes. In addition, the results for scenario (3") are consistent with those for scenario (3).

Scenarios (1) and (2) are rejected against scenario (3), which includes an inef…ciency measure and assumes that deregulation a¤ects …rms' behavior after the introduction of the third EC package of deregulatory measures in 1992. Given that scenario (1) represents the standard approach proposed by the literature focusing on oligopolistic competition, its rejection advocates the construction of

[15] This correlation problem is common to most empirical studies dealing with the estimation of short run costs functions.

[16] We also estimated a long run cost function where capital was regarded as a variable input. Accordingly, a measure for the price of capital was computed from the companies' accounting data and included in the cost function. This variable was not signi…cant at any con…dence level.

models incoporating these components and indicates that we have to be cautious when interpreting the results derived from other models. More in particular, rejection of scenario (2) shows the importance of accounting for the effects of deregulation on firms' technology and inefficiency.

One could also compare the results regarding inefficiency that had been obtained if a model with no effort had been estimated, i.e., scenario (2), with those obtained with scenario (3). We observe that inefficiency had been overestimated for all the companies. The average firm's inefficiency level is 0.212 (0.368 resp.) under scenario (3) (scenario (2) resp.) The two values are significantly different as measured by a t-test ($H_0 : \theta_{(2)} - \theta_{(3)} = 0$) whose statistic is equal to 6.646.

Accounting for liberalization effects on competition

Table 4 compares the results regarding collusion obtained under scenario (1) and those recovered using scenario (3). Recall that a value for γ_i equal to zero is consistent with Nash behaviour, greater than zero implies a collusive behavior and smaller than zero denotes more competition. Again the results suggest that the degree of competition is significantly underestimated by scenario (1) as shown by a t-test ($H_0 : \gamma_{(1)} - \gamma_{(3)} = 0$) whose statistic is equal to 4.279 for the set of carriers.

By looking at the results for scenario (3), we can observe that, not surprisingly, the companies with a more competitive behavior (denoted by LBA) correspond to countries that pioneered the liberalization process and signed liberal bilateral agreements with other EU countries and the US. Namely Germany, the Netherlands and the UK. These values are significantly different as shown by the t-test for the null hypothesis $H_0 : \gamma_{(LBA)} - \gamma_{(Other)} = 0$, whose statistic is equal to 4.285. In addition, the measure of competition, γ, is significantly

lower than zero for both groups (the t-tests for the null hypothesis H_0 : º = 0, present statistics equal to 9.85 and 4.32 for the LBA and the other carriers groups, respectively), indicating that competition goes beyond Nash behavior.

6 Conclusion

The results obtained in this paper have proved fruitful on both methodological and institutional sides. First, it has been shown that a cost-supply-demand structure that accounts for …rms' technical ine¢ciency and cost reducing activities …ts better to the data than the usual model proposed by the literature focusing on oligopolistic competition. Moreover, our application of this methodology to the airlines industry shows that the results obtained under the standard oligopoly model would be seriously biased and could lead to the wrong conclusions about e¢ciency and competition in the industry.

Second, it is suggested that the 1992 European deregulation package introduced a signi…cant change in the behavior of airline carriers regarding e¢ciency improvement. We show that competition has increased signi…cantly only after the introduction of the last package of deregulatory measures in 1993, since the liberal bilateral agreements had very limited e¤ects and the 1987 EC package of deregulatory measures had no e¤ect on …rms' behavior. We also show that estimated competition is tougher than if obtained from a standard oligopoly model. This result is consistent with previous contributions in the same industry that take into account cost endogeneity in di¤erent manners.

This model could be improved or extended in di¤erent ways and directions. First, in this paper we only have two alternative situations that represent dif-

ferent degrees of competition. This is due to the fact that we work with …rms' aggregate data. However, by looking at route level data it could be possible to propose a more ‡exible menu of competitive situations, and test how e¤ort is a¤ected. Second, a set of alternative models representing competition in the regulated period could be tested against each other, in order to test if there is a dominance of private versus public objectives. Third, in this paper we analyse the e¤ects of deregulation, and the subsequent cost reducing e¤ort, on short run price competition. However, e¤ort can be devoted to reorganise the network structure of the …rm. A careful analysis of the changes in carriers' network structure after the deregulatory process could be of great interest.

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Appendix. Data description and construction of the variables.

The dataset has been constructed for the period 1985-1999 from raw data included in Digest of Statistics published by International Civil Aviation Organization (ICAO), World Air Transport Statistics published by International Air Transport Association (IATA), and Economic Outlook published by the Economics and Statistics Department of the Organization for Economic Co-operation and Development (OECD). The companies under study are the flag carriers from the largest European countries affected by the European liberalization process, namely, Alitalia, Air France, Air Portugal, British Airways, Iberia, KLM, Lufthansa, Sabena and SAS.

The variables have been constructed as follows. In the cost function, production, (Q_i), wages (ω_{Li}), capital (K_i) and average stage length (ASL_i) correspond to total operating expenses (ICAO), seat-kilometers available, flight crew salaries and expenses and maintenance and overhaul expenses over number of employees, fleet total number of seats, and total aircraft kilometers over total aircraft departures, respectively. With respect to total costs, companies report one single figure that corresponds to passengers, freight and mail activities. The distribution of operations among these three activities can vary significantly among companies. However, it is easy to obtain information on the total number of tonne-Kilometers performed that correspond to passengers (including baggage), freight and mail, respectively. We multiply total costs reported by each company by the share of tones-kilometers performed corresponding to passengers in order to compute our cost variable (C_i). The data needed to construct these variables have been retrieved from different issues of Digest of

Statistics published by ICAO, apart from number of employees that are published by IATA. NET_i is constructed by the total number of route kilometers an airline operates on (IATA). Finally, the price of materials ($!_{Mi}$) has been constructed as the average fuel prices for the carrier's home country and the OECD (published by OECD), weighted by the company's domestic and international operations respectively (ICAO).

On the demand side, demand (q_i) corresponds to passenger-kilometers performed and …rm i's weighted average price (p_i) is measured as passenger revenues over passenger-kilometers performed . Rivals's price (p_j) is the average price of the remaining companies in the database, weighted by total seat-kilometers available. All of them from ICAO. Consumption growth ($GCONS_i$) corresponds to domestic private consumption (OECD). Finally, t the time trend, is equal to one in 1985 and incremented by one each year.

Table 1: Demand function. Dependent variable: q_i .
Instrumental Variables Estimation Method

Variable	Coefficient	Estimate
Constant	α_0	0.01 (0.09)
p_i	α_1	-3.55 (0.52)
p_j	α_2	4.52 (0.82)
$GCONS_i$	α_3	0.0005 (0.00)
T	α_t	0.01 (0.003)
Standard Deviation of the error term		0.12 (0.01)
R^2		0.76

Note: Standard deviations in parentheses.

Table 2: Demand-Capacity relationship. Dependent variable: $ln(Q_i)$.
Instrumental Variables Estimation Method.

Variable	Coefficient	Estimate
Constant	λ_0	5.31 (0.78)
$Ln(q_i)$	λ_1	0.68 (0.05)
t	λ_t	0.05 (0.01)
Standard Deviation of the error term		0.45 (0.03)
R^2		0.67

Note: Standard deviations in parentheses.

Table 3. Cost function. Dependent variable: $ln(C_i^*)$. Instrumental Variables Estimation Method.

Variable	Coeff.	(1)	(2)	(3)	(4)	(3'')
Constant	β_0	0.57 (0.70)	0.06 (0.52)	-0.37 (0.59)	-0.48 (0.69)	-0.59 (0.58)
w_{Li}	β_1	0.47 (0.06)	0.41 (0.04)	0.36 (0.06)	0.42 (0.07)	0.36 (0.07)
Q_i	β_3	0.81 (0.06)	0.85 (0.08)	0.94 (0.05)	0.95 (0.06)	0.97 (0.05)
NET_i	β_5	-0.14 (0.08)	-0.10 (0.10)	-0.24 (0.07)	-0.34 (0.08)	-0.40 (0.09)
ASL_i	β_6	-0.36 (0.08)	-0.41 (0.06)	-0.39 (0.08)	-0.24 (0.07)	-0.26 (0.07)
T	β_t	0.07 (0.04)	0.09 (0.03)	0.26 (0.05)	0.12 (0.04)	0.27 (0.05)
e_i	$\ln(m)$	-	-	3.87 (0.21)	4.83 (0.48)	4.04 (0.23)
Standard Deviation of q		-	0.44 (0.04)	0.27 (0.06)	0.35 (0.06)	0.28 (0.05)
Standard Deviation of the error term		0.25 (0.01)	0.04 (0.03)	0.15 (0.03)	0.12 (0.04)	0.12 (0.03)
R^2		0.88				
Vuong test. Scenario (3) against alternative scenarios		2.932	2.835		1.460	

Notes: Standard deviations in parentheses.
Values for the Vuong test below –2 favor the alternative model against model (3), and above 2 favor model (3) against the alternative model.

Scenarios:
(1) Deregulation has no effect (e_i=0), and the model does not account for one-side inefficiency (q_i=0).
(2) Deregulation has no effect.
(3) Deregulation affects firms' behavior after 1992.
(4) Deregulation affects firms' behavior after 1985 for British Airways, KLM, Lufthansa, and after 1992 for the remaining companies.
(3'') As scenario (3) but dropping the observations for the last two years (1998-1999).
In all scenarios but (1) the model accounts for one-side inefficiency term ($q_i \geq 0$).

Table 4. Predictions for the collusion parameter n .

	Scenario (1)	Scenario (3)	$H_0 : n_{(1)} - n_{(3)} = 0^{**}$
All carriers	-0.958 (6.27)	-2.496 (7.67)	4.279
LBA*	-2.014 (10.89)	-4.056 (9.85)	4.521
Other carriers but LBK	-0.403 (2.68)	-1.649 (4.32)	3.040
$H_0 : n_{(LBA)} - n_{(Others)} = 0^{**}$	6.758	4.285	

Notes: t-statistics are in parenthesis.

* LBA stands for Liberal Bilateral Agreements and includes British Airways, KLM and Lufthansa.

** t-statistics reported.

Appendix.

Table A1. Cost function. Alternative scenarios.

	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Constant	-0.22 (0.70)	-0.49 (0.69)	-0.31 (0.65)	-0.19 (0.65)	-0.20 (0.66)	-0.32 (0.63)	-0.35 (0.68)
w_{Li}	0.40 (0.07)	0.42 (0.06)	0.40 (0.06)	0.40 (0.07)	0.43 (0.07)	0.40 (0.06)	0.42 (0.08)
Q_i	0.93 (0.06)	0.95 (0.06)	0.93 (0.06)	0.93 (0.06)	0.92 (0.06)	0.92 (0.05)	0.93 (0.06)
ASL_i	-0.36 (0.08)	-0.32 (0.08)	-0.37 (0.08)	-0.36 (0.08)	-0.32 (0.08)	-0.37 (0.08)	-0.22 (0.04)
NET_i	-0.23 (0.08)	-0.26 (0.08)	-0.21 (0.07)	-0.22 (0.07)	-0.24 (0.07)	-0.21 (0.07)	-0.34 (0.08)
T	0.11 (0.04)	0.13 (0.04)	0.11 (0.04)	0.11 (0.04)	0.13 (0.04)	0.11 (0.04)	0.12 (0.04)
e_i	5.48 (1.17)	4.55 (0.40)	5.55 (0.86)	5.36 (0.82)	4.62 (0.41)	5.37 (0.65)	4.82 (0.44)
Stand Dev q	0.37 (0.07)	0.30 (0.06)	0.39 (0.05)	0.37 (0.06)	0.31 (0.07)	0.39 (0.05)	0.36 (0.06)
Error st. dev.	0.11 (0.05)	0.15 (0.04)	0.09 (0.04)	0.11 (0.05)	0.15 (0.04)	0.09 (0.03)	0.11 (0.04)

Vuong tests

	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(3)	-	1.460	2.154	2.284	1.805	3.165	2.040	4.848	1.589
(4)	-	-	0.696	0.522	1.881	4.618	0.360	3.406	1.530
(5)	-	-	-	0.198	0.432	2.500	-0.127	4.164	0.039
(6)	-	-	-	-	0.176	1.751	-0.952	5.126	-0.070
(7)	-	-	-	-	-	6.297	-0.340	2.712	-1.365
(8)	-	-	-	-	-	-	-1.968	1.437	-6.011
(9)	-	-	-	-	-	-	-	4.955	0.086
(10)	-	-	-	-	-	-	-	-	-2.908

Notes: Standard deviation in parenthesis.
Vuong Test, line (i) against column (j), i.e., values for the Vuong test below –2 favor the model in column (j), and above 2 favor the model in line (i).
Scenarios:
(5) Deregulation affects firms' behavior after 1985 for British Airways, and after 1992 for the remaining companies.
(6) Deregulation affects firms' behavior after 1985 for British Airways and KLM, and after 1992 for the remaining companies.

(7) Deregulation affects firms' behavior after 1985 for British Airways and Lufthansa, and after 1992 for the remaining companies.
(8) Deregulation affects firms' behavior after 1985 for British Airways and Sabena, and after 1992 for the remaining companies.
(9) Deregulation affects firms' behavior after 1985 for British Airways, Sabena and KLM, and after 1992 for the remaining companies.
(10) Deregulation affects firms' behavior after 1985 for British Airways, Sabena and Lufthansa, and after 1992 for the remaining companies.
(11) Deregulation affects firms' behavior after 1985 for British Airways, KLM, Lufthansa and Sabena, and after 1992 for the remaining companies.