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EUROPEAN AIRLINE INDUSTRY: A COST ANALYSIS AND ECONOMIC PERFORMANCE EVALUATION

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Abstract

The European liberalisation process introduced in the air industry has radically changed the conditions in which carriers operate in this market. The main objective of this paper is to study the cost structure of airlines, in order to evaluate how the liberalisation process has affected the productive efficiency of European carriers. By studying the existence of economies to scale or cost complementarities, we try to predict how airlines will respond to the new framework set by the European Commission.

INTRODUCTION

The European liberalisation process introduced in the air industry has radically changed the conditions in which carriers operate in this market. Before this process started, this was a market were severe limitations to competition existed both for domestic routes, which in many cases were protected by legal monopolies, and for the intra-European routes where airlines operated through bilateral agreements between states to share the market. The three liberalisation packages approved in the last decade have eliminated the legal barriers to competition and have established a situation of complete freedom to entry and exit for European carriers in any domestic or intrastate market, following the philosophy of the Treaty of Rome.

The main objective of this paper is to study the cost structure of airlines, in order to evaluate how the liberalisation process has affected the productive efficiency of European carriers. By studying the existence of economies to scale or cost complementarities, we try to predict how airlines will respond to the new framework set by the European Commission. One of the main questions is whether the size of air carriers may have an effect on efficiency gains, in order to assess how the observed trend towards mergers and groups' formation will affect outcomes. Another point analysed is the effect of privatisation on airlines' results. Some countries have gone further than others in this process of transferring airlines' ownership to the private sector, which is often claimed to have positive effects on efficiency. This question is empirically addressed here in this work.

The methodology used is based on two complementary approaches. First, a parametric analysis is performed to analyse the airlines' efficiency. Using productivity and unit cost indexes for the period 1990-95, it is detected the presence of a gap between the performance of European airlines and their American counterparts. Even though this gap was already a known fact from previous studies, the new finding here is that European airlines seem to be improving their performance on average and a trend towards convergence is observed.

The second approach used is an econometric estimation of a cost function for the air industry. Although given the characteristics of air transport one should ideally use a non-aggregated cost function, the lack of information imposes the use of an aggregated cost function. As a consequence, it is necessary to define precisely what is understood by economies of scale and how to obtain this information from an aggregated cost function. A translogarithmical cost function specification plus cost share equations are used, following a standard methodology to estimate cost functions. Residuals obtained from the estimated cost function are used to evaluate the potential cost reductions that inefficient airlines may achieve.

DATA

Data used in this study correspond to a sample of 22 airlines from Europe (13) and North America (7 from US, and 2 from Canada), and it covers the period 1990-1995. The non-European part of the sample is included in order to have a competitive benchmark of reference, since those markets have already been deregulated for some time. The criterion to select the sample was to include all main world airlines that reported financial information to the *International Civil Aviation Authority*

(ICAO) during that period. Complementary data were collected from *International Air Transport Association* (IATA) publications.

Original cost data from ICAO publications were analysed, in order to detect and filter potential errors. Some inconsistencies and outliers were indeed detected and corrected were possible. In other cases, it was decided to drop directly all observations from airlines whose reported data contained a large number of temporal inconsistencies (Aviaco, Crossair and Viva Air). Another airline excluded from the sample was Virgin Atlantic, since for the period analysed this airline was concentrated on transatlantic routes, and that makes it different in its cost structure to the rest of the sample.

After corrections and filters, the available sample for estimation is formed of 105 observations corresponding to 22 airlines for the period 1990-1995. It is not considered appropriate to use these data as a panel, since it is extremely unbalanced (most of the airlines do not report data to ICAO regularly, and only 8 companies reported data for the full period). Therefore, after conversion of all data to 1990 real values, the sample is used as a cross-section.

There exists on average a significant difference in size between European and North American airlines. A detailed analysis reveals the existence of four very large US airlines (American, United, Delta and Northwest, producing more than 20.000 million ton-km a year), while in Europe only British Airways, Lufthansa, Air France and KLM have output levels that reach the American average. Meanwhile, there are a number of small airlines in Europe, producing less than 2,000 million ton-km. In order to take into account this heterogeneity in the sample, some individual characteristics of each airline are included in the econometric estimations to control for the fact that airlines are diverse in size, type of routes in which they operate, and some other factors.

Three different types of information are included in our database: costs, outputs and structural variables. First, we have data on airlines' total costs and their distribution in different categories of expenditure, according to ICAO classifications: labour, energy, insurance, capital depreciation, interest payments, maintenance, airport and aid-to-flight charges, services to passengers, administration and other costs.

Data on outputs are the total production of airlines in terms of total seats-km/ton-km offered, and the actual passenger-km/ton-km performed. There is separate data for passenger and cargo services, and also differentiated by regular and charter services. In this work, we have opted for using measures of output that represent total *production* that airlines offer in the market, instead of choosing actual *demanded* services. Although in many studies on the industry, output is defined in terms of passengers and cargo effectively transported, we believe a correct definition of output when trying to analyse efficiency and technical characteristics must be based on the real levels of production and not on demand. Therefore, we use available ton-km as the main measure of output, which includes both passengers and cargo. For the econometric estimation, we use the two types of output separately, and there we define passengers' services output in terms of available seats-km and cargo services in terms of available cargo ton-km.

Structural variables are referred to airlines' characteristics, such as load factors, average stage length of routes, average speeds, number of departures, number of planes, and percentage of charter services, which are used as control variables in our estimations.

MODEL RESULTS

Non-Parametric Analysis

A first simple approach to the analysis of the efficiency of airlines is the computation of some ratios that allow us to study the relative position of companies in terms of unit costs and factors' productivity.

Regarding the first group, we report some results on total unit cost (total real cost/ton-km); and labour, energy and capital unit costs. All unit costs are defined as US cents per total available ton-km. Total unit cost reflects the total performance of an airline in terms of how costly is for it to produce a ton-km. but when making comparisons among airlines based on this index, it must be remembered that this is only a rough indicator for efficiency, since many factors affecting airlines' performance are left aside. The other three indexes are components of the total unit cost. They may be useful to indicate where do observed differences in total unit cost come from.

Energy cost includes aircraft fuel and oil. Capital cost is defined as the sum of flight equipment insurance, rents for leased equipment, maintenance and overhaul expenditures (excluding labour costs spent on these tasks), and depreciation and amortisation of flight and ground equipment. The difference between total unit costs and the sum of the others indexes corresponds to the unit cost of materials and other services consumed by airlines. This residual input includes flight-related charges (airport, en-route facilities and station charges); and goods used in the production of passenger services, ticketing and promotion, and general administration. Labour costs are deducted from all these categories, using reported average wages and number of workers for each category. Shares on total cost of each input are reported in table 1:

Table 1 - Average distribution of total cost by type of expenditure (1995)

	Europe	North America
Labour	31.2 %	27.6 %
- Pilots/co-pilots	(6.5 %)	(7.2 %)
- Other personnel	(24.7 %)	(20.4 %)
Energy	9.1 %	12.1 %
Capital	17.2%	18.4 %
Materials & other services	42.5 %	41.8%
- Flight-related charges	(21.3 %)	(17.7 %)

Regarding the information on productivity of factors, the following indexes are used: kilometres-flown per plane, hours-flown per pilot and available ton-km per employee. The first index represents the productivity obtained by airlines from their planes, in terms of kilometres produced. The other two indexes are related to labour productivity. The first of them identifies the productivity of pilots, who constitute one of the key categories of airlines' employees. The second offers information on the overall performance of workers, in terms of total production per capita. Unfortunately, there is no information available on the actual number of working hours for all worker categories, which would allow a more refined estimate of productivity.

It is common wisdom in the airline industry that US airlines have higher productivity than airlines in Europe and other regions, which makes it feasible for them to produce with lower unit costs. This is also a fact that has been reported in some comparative studies. As an example, Windle (1991) uses a total factor productivity approach to conclude that US airlines have a productivity advantage of 19% over European comparable carriers. In terms of unit costs, this author estimates the advantage of American firms in a 7% (data used in estimations correspond to a sample of airlines in 1983).

Our indexes indicate that in the period 1990-95 there still exists a gap between the performance of European airlines and their American counterparts, both in terms of productivity and unit costs. Although not very refined, since there are factors not controlled for, results obtained for the cost and productivity indexes easily reveals this gap.

An examination of the unit cost figures indicates that the cost advantage of US over European airlines is still significant in the 1990's. On average, in 1995 the unit cost per ton-km produced was 37.7 cents for US firms, while European firms have a cost of 49.4 cents, i.e. 31% higher. Although these figures are revealing, it must be remarked again that they should only be regarded as indicative, since they are not controlled by airlines' characteristics, namely average route distances, points served, etc. Evolution of unit cost over recent years reveals an interesting fact: there is a decreasing trend in the European airlines' cost from 1990 to 1995. Therefore, it seems that European airlines are converging in terms of costs to American levels.

The rest of unit costs also reveal some interesting findings. It is observed that a major part of the gap between both regions is due to labour costs. In 1995, a European firm spent 17.1 cents per ton-km produced on labour, while this cost was 10.4 cents for American firms. Energy costs are very similar for both groups and they present a common downward trend, although there is again a small gap in favour of American airlines. Capital unit costs were higher for European firms in 1990, but in the six-year period covered in the sample, these costs have been reduced in Europe to almost match the American level in 1995. Finally, the unit cost of materials is also higher for Europe: 19.2 cents per ton-km, against 15.8 in America.

Summing up, the gross comparison of unit costs between regions indicates that, in 1995, there is gap of 11.7 cents per ton-km in favour of American airlines. From this, 6.7 cents correspond to labour, 0.5 to energy, 1.1 to capital and 3.4 to materials and other services.

With respect to the productivity indexes, there existed information in this case to compute them for a longer period (1984-1995) than the general sample used in the study, and they also render some interesting results. Thus, the index related to the productivity of planes reveals that American airlines seem to make a more intensive use of their aircraft, with a value of 2.11 million km per plane a year, against 1.95 million for European airlines. While this index reveals a different productivity of planes, no sound inference on efficiency should be made without analysing the number and length of routes served, and the type of planes employed.

The analysis of the hours flown per pilot reveals two interesting trends. First, although during the 1980's American pilots were working more hours, during the 1990's there is no significant difference between pilots' productivity between Europe and America. This convergence has been achieved mainly by a reduction in the working time of American pilots. Second, it is observed a slow but steady rise in the productivity of European pilots. While in 1984 they were working on average 216 hours a year, in 1995 this figure has risen to 258 hours, even more than the American average for that particular year.

The more interesting fact revealed by productivity indexes is presented in Figure 2: there is a significant gap in terms of ton-km per employee between Europe and America. In 1995, while an American carrier was producing 380.5 thousand ton-km per employee, a European firm obtained only 273.8 thousand, i.e. 28% lower. This lower labour productivity explains, at least partly, the labour unit cost difference pointed out above.

European airlines seem to have achieved improvements in their values over the covered period, and especially in the 1990's. Production per employee of European carriers increased in the period 1984-

1990 at an annual average rate of 3%, while in the period 1990-1995 this rate rose to 7.2%. Meanwhile, American airlines' labour productivity has fluctuated over the period. While in some years at the end of the 1980's there was a decreasing trend, from 1990 onwards the productivity of employees has been growing steadily and it has been maintained above the European level. Technology improvements and a more efficient use of labour may be the likely explanations for this increase in employees' productivity in the airline industry as a whole during the 1990's.

ECONOMETRIC ANALYSIS

An estimation of a cost function for the airline industry is carried out in this work, in order to have a complete picture of the performance of carriers, once all possible exogenous factors are controlled for. Furthermore, the cost function provides relevant information about the industry (returns to scale and density, cost complementarity, substitution elasticities between factors) and it allows us to test some hypothesis about ownership and change of regulation effects.

A translog specification is chosen for the cost function to be estimated. This functional form is the most common in the analysis of cost structures across industries, and in particular, it has been previously applied to the air sector by many authors. Caves, Christensen and Tretheway (1984); McShan and Windle (1989), and Baltagi et al (1995) are examples of translog cost functions specifications to analyse the US air industry, while Gillen, Oum and Tretheway (1990) have used it for the Canadian market.

A two-output specification is used for the cost function, considering passenger and cargo services provided by airlines as different products. Although passenger services are the main output of the air industry, cargo services should not be considered as merely residual in the activity of general carriers (we have not included in our sample cargo-specialised firms, as Federal Express for the US market). Moreover, the inclusion of cargo services as a separate output allows the analysis of the possible existence of economies of scope.

Structural variables are included in the specification of the cost function, in order to control for factors that are somehow exogenous to firms. These are variables that may be modified by airlines in the long run, but once a network structure is chosen, they cannot be easily changed in the short run. Variables included are: average stage of length, number of points in the airline's network, load factors for passengers and cargo, and the percentage of total output performed by charter flights. The functional form we estimate then is:

$$\ln C = \alpha_0 + \alpha_{pub} PUB + \alpha_p \ln Y_p + \alpha_c \ln Y_c + \alpha_{pc} \ln Y_{pc} + \sum_i \beta_i \ln P_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij} \ln P_i \ln P_j$$
$$+ \sum_i \delta_{ip} \ln P_i \ln Y_p + \sum_i \delta_{ic} \ln P_i \ln Y_c + \lambda_p \ln LFP + \lambda_c \ln LFC + \lambda_{ch} CHART$$
$$+ \lambda_{avsl} \ln AVSL + \lambda_{net} \ln NET + u$$

which is the usual specification of a translog cost function, with two outputs plus a set of structural variables to control for individual effects. Four inputs are considered: labour (L), energy (E), capital (K) and materials/other services (M). The variables' definition is the following:

Y_p : Passengers' output (available seat-km)
Y_c : Cargo output (available ton-km, freight and mail)

P_L : Average wage (all worker categories included: pilots, other cockpit personnel, cabin attendants, maintenance and overhaul, ticketing and sales, other personnel).

P_E : Price of energy (total fuel&oil cost per kilometre flown).

P_K : Price of capital (capital cost per plane. Costs included are flight equipment insurance, rents for leased equipment, maintenance and overhaul, depreciation and amortisation of flight and ground equipment).

P_M : Price of materials and other services (cost per departure. All remaining costs not considered in the three other inputs are included here).

LFP: Passengers' load factor.

LFC: Cargo load factor.

CHART : Percentage of total output (passengers and cargo) performed by non-scheduled flights. This variable is used in levels and not in logs since for many airlines in the sample it takes a value of zero or close to zero.

AVSL : Average Stage Length (total km-flown/number of departures).

NET : Number of network points served by the airline (this information was obtained directly from the airlines, it corresponds to the actual number of network points for year 1996).

PUB : Dummy variable, value 1 if the airline is a public company. For mixed-capital airlines, the rule is to consider them as non-public only if private capital share is larger than public and there is evidence that no golden shares or other mechanisms exists for public owners to influence board decisions.

A residual u is added to the cost function specification, and it is assumed to be iid $N(0, \sigma_u^2)$. Parameters to be estimated are α_0, α_{pub}, α_p, α_c, α_{pc}, β_i, γ_{ij} (i,j =L,E,K,M), δ_{ip}, δ_{ic}, λ_p, λ_c, λ_{ch}, λ_{avsl}, λ_{net}. Since it is assumed that factor prices' cross-products are symmetric, (i.e. $\gamma_{ij}=\gamma_{ji}$), a total number of 32 parameters are to be estimated. As it was mentioned in the section describing the sample, a total number of 105 observations are available. In order to obtain more degrees of freedom, we follow the common practice of including the equations representing the share of each input over total expenditure ($S_i = P_i X_i/C$). For the translog cost function, these equations have the form:

$$S_i = \beta_i + \sum_j \gamma_{ij} \ln P_j + \delta_{ip} \ln Y_p + \delta_{ic} \ln Y_c$$

It is possible then to obtain more efficient estimators by adding disturbances to this set of equations and estimating them jointly with the cost function. Since, by definition $\sum_i S_i = 1$, only three of the four share equations may be used simultaneously.

The system of equations is estimated by full information maximum-likelihood (FIML), using the assumption that disturbances follow a multi-normal distribution. All variables are expressed as differences with respect to their means, so that elasticities and other parameters to analyse industry characteristics may be directly obtained from estimated coefficients.

Since all observations are deflated and expressed in real values, they are considered as comparable outcomes of a common industry cost structure. Estimation is then performed by pooling all observations, without any temporal dimension. As it was mentioned above, we have discarded the use of panel data techniques, since the panel is extremely unbalances, possibly yielding unreliable estimates.

Consequently, all airlines' individual effects not captured by the set of structural variables and the actual factor price levels will be present in the residual terms (u). The use of dummy variables for each company to capture individual effects did not render satisfactory results. Therefore, for the

airlines' efficiency analysis, the residuals u are used as the main tool. Although for each airline, its individual value of u for a particular year may also be affected by random shocks, we believe they are highly informative on the efficiency achieved by each company. After controlling for all possible structural factors, significant positive values for u are indicative that the cost of the airline is repeatedly above the efficient level indicated by the cost function.

Two arguments reinforce in our case the possibility of interpreting the complete residual u as the result of companies' outcomes in terms of efficiency. First, random shocks that might be affecting to airlines (e.g. depressing effect of the Gulf War on passengers' traffic, sudden price rises, etc) are likely to be affecting in a similar way to all European carriers performing international scheduled services, since all of them operate in very similar markets. And second, the possibility of observing several residuals for each company allows a reduction of the risk of making wrong inferences if a systematic pattern is detected.

Returns to density and scale

This section presents the results obtained in the estimation of the air industry cost function. A full description of estimated coefficients, standard errors and performed tests may be found in the appendix. Before studying the efficiency results, some characteristics of the industry that are derived from the estimated function are presented and compared to others in previous works.

Definitions followed here are those common in the literature, although there is an on-going debate in the profession about the more adequate measure to use. Returns to density are defined as the effect on costs of a proportional increase in all outputs considered, keeping network size and other characteristics as constant. They are measured by the inverse of the sum of the elasticities of costs with respect to outputs. Meanwhile, returns to scale are defined as the effect of a proportional increase in outputs *and* network size. For our sample, the following values are obtained:

- Returns to density: $\quad D = (\varepsilon_{Yp} + \varepsilon_{Yc})^{-1} = 1.057$ (s.d. 0.0548)

- Returns to scale: $S = (\varepsilon_{Yp} + \varepsilon_{Yc} + \varepsilon_{net})^{-1} = 1.198$ (s.d. 0.0773)

In both expressions above, ε_i represents the elasticity of costs with respect to variable i. The obtained results indicate the presence of slight economies of density and scale for airlines, similar in size to those of previous works. Caves et al (1984) report returns to density between 1.21 to 1.29 for US carriers, while Gillen et al (1990) find values that lie between 1.15 and 1.26 for Canadian firms. In our case, returns to scale are higher than returns to density, since we obtain in our sample that an increase in the number of points served results in some net cost savings.

According to Oum and Zhang (1997), these traditional measures studying the presence of economies to scale suffer from a fundamental drawback. Their point is that other structural variables apart from network size may have been traditionally overlooked in the computation of returns to scale. Changes in output or in network configuration may have an effect on some structural variables, which are supposed to be constant when analysing returns to scale. Following this idea, we have estimated complementary equations to evaluate that possibility, finding that in our case only the average stage length is positively affected by an increase in the number of points served. Taking this effect into account, our revised coefficient to measure returns to scale rises to 1.576, though its standard error is quite large (a 95% confidence interval would include values from 1.31 to 1.84).

Therefore, we conclude from our results that there seems to exist some mild returns to density in the air industry, and, more importantly, some returns to scale. According to the definition, this implies

that airlines can achieve some cost savings by producing more output on a given network, but the size and design of the network (number of connection nodes) has a relevant impact on carriers' costs.

Public Ownership

One hypothesis we are interested in testing on our sample of European and American airlines is the existence of a negative effect of public ownership on firms' efficiency. Although this question has been previously analysed by other authors, it is interesting to revise if privatisations that have taken place in some countries and the general process of liberalisation have had an impact on improving the performance of publicly owned airlines. As a benchmark of reference, Windle (1991) estimated that European airlines had 10.5% higher unit costs compared to US firms in 1983, due to government ownership.

In our cost function, we capture the effect of public ownership of airlines with a dummy variable (PUB) with value one for public firms. A positive sign for the coefficient associated to this variable (α_{pub}) will be indicating higher costs for public airlines, and moreover, we may be able to quantify the effect for an average sized carrier. From the estimated cost function:

$$\alpha_{pub} = 0.0742 \qquad \text{(s.d. 0.0653)}$$

As it is the case for the cost complementarity analysis, although the coefficient presents indeed a positive sign as it was a priori expected, its standard error is not small enough to discard completely the possibility of a null effect. A 95% confidence interval yields values for α_1 in the range (-0.056, 0.205). Although this interval is suggestive of the likely presence of a positive effect of ownership on costs, we cannot state unambiguously its presence in our sample of airlines.

Keeping in mind this caveat, if the actual estimated coefficient α_{pub} may be assumed to be valid, it would be indicating the presence of a cost difference of 7.7% between a public airline and a private one, for the average firm size in the sample (i.e. an airline with an average output level of 9,763 mill. available ton-km). Compared to the 10.5% value reported by Windle (1991) referred to 1983, the smaller value obtained in our sample for the period 1990-1995 could be indicative of an improvement in the outcomes of publicly-owned European airlines. However, the detected cost-augmenting impact of public ownership on costs would lead to recommend more privatisations in the sector for those countries that still keep their flag airlines as government-owned firms, if they want to improve their efficiency.

Efficiency results of individual airlines

Residuals obtained from the estimated cost function are used here to estimate the potential cost reductions that inefficient airlines may achieve. Since the complete value of the term u in the cost function is interpreted as departure from the efficient frontier, on the assumptions mentioned above, by definition we obtain positive values for u but negative for others. Therefore, the negative values reported in table 1 must be interpreted as the cost savings that highly efficient firms are already obtaining with respect to the average frontier in the industry.

There are some surprising results, which seem to contradict some common wisdom in the European air industry. These are namely the high efficiency values that Alitalia and Olympic exhibit, and the large potential cost reduction obtained for Lufthansa. Our reading of these results is that one should be extremely careful when interpreting comparative studies between firms from different countries, since fluctuation of exchange rates may introduce distortions on the firms' observed outcomes. For

the case of Lufthansa, Oum and Yu (1997) have concluded that an appreciation of the German mark might be the main cause of the low position in the world airlines' efficiency ranking obtained by them for this company using 1993 data, and a similar effect is found in their work for the Japanese company JAL.

Table 2 - Potential airlines' cost reductions

	Europe		North America
Air France	8.14%	Air Canada	9.72%
Alitalia	-8.88%	American	6.35%
Austrian	7.70%	Canadian	2.85%
British Airways	-5.31%	Continental	-3.44%
British Midland	-0.99%	Delta	-4.84%
Finnair	5.74%	Northwest	-3.66%
Iberia	13.69%	TWA	-5.54%
KLM	-7.63%	United	3.14%
Lufthansa	8.59%	USAir	4.35%
Olympic	-10.71%		
SAS	24.56%		
Swissair	-3.73%		
TAP	13.19%		

Our suspicion is that the same currency effect may be the cause of our results for Alitalia and Olympic, on the opposite direction to that of Lufthansa. In fact, during the period 1990-1995 both the lira and the drachma have suffered considerable depreciation against the dollar. The lira was devaluated several times and finally excluded from the European Monetary System in 1992, and since then it has followed a decreasing trend. In 1995, its value against the dollar was around 25% lower than at the beginning of our covered period. A similar pattern is observed for the drachma, which lost around 30% of its value against the dollar during this 6-year period. Estimated efficiency results for both these companies are then likely to be affected by this rapid fluctuation of their national exchange rates, and should not lead to conclude that Alitalia and Olympic are highly efficient airlines.

A final exercise performed using the residuals from our estimated cost function is to analyse the existence of some temporal variation on the efficiency patterns. This cannot be done for all individual firms, since it has been mentioned several times along the work that there are many missing observations in our sample, so that for some airlines only 2 or 3 observations out of 6 may be available. Instead, we have opted for computing for each year the average value of residuals of those companies for which data are available. This is done separately for European and American firms to compare the evolution of airlines' efficiency in both regions.

As a matter of fact, seems to indicate the presence of a decreasing pattern in the evolution of residuals' averages, both for Europe and North American airlines, although for the case of Europe the observation corresponding to year 1994 seems to lie away from the general trend. The interpretation of these trends is that airlines in both regions have been improving their outcomes in the direction of becoming more cost efficient during the period 1990-1995.

CONCLUSIONS AND POLICY IMPLICATIONS

Results obtained in the analysis of the cost structure and economic performance of European airlines allow us to derive the following conclusions. First, it is observed that airlines have improved their outcomes in terms of unit costs and productivity, specially from 1990 onwards. These improvements may be attributed to the changes introduced in the regulatory framework of the European air market, which have forced companies to adapt to a more competitive situation. Therefore, market liberalisation has had a positive effect on the productive efficiency of airlines. The pending question now is whether consumers will benefit or not from these improvements, a matter that depends on other factors, mainly on the actual degree of competition amongst airlines.

The presence of economies to scale in this sector (1.2 in our results, using the traditional definition) has some marked implications. According to this result, airlines will be able to reduce their costs by enlarging their size, either by obtaining higher shares in routes they operate or by extending operations to additional routes. Moreover, in a completely liberalised market, we can expect to observe a trend towards mergers and commercial agreements to form large airlines/groups, which can obtain cost savings derived from size. Although this trend may be positive in terms of productive efficiency, again it would only be advisable if final consumers may benefit from it. A market structure with a small number of unregulated operators could easily result in sub-optimal non-competitive outcomes, if finally there is no real competition between them.

In order to ensure that productive efficiency is achieved and at the same time consumers benefit from it, some level of at least potential competition should be guaranteed. Freedom for airlines to entry in any route should not only be a legal rule, but a feasible practice. Any barrier to competition –as the actual system of slot allocation at airports is likely to be creating– will allow large incumbent airlines to exploit their cost advantages against rivals without any benefit to consumers. It would then be recommendable to promote the maximum degree of competition by eliminating these barriers and avoiding any other oligopolistic practices.

Public ownership of airlines has been detected to be a cost-augmenting factor (7.7% in our 1990-95). The main conclusion from this result is that privatisation policies have had a positive effect on the productive efficiency of airlines and therefore should be encouraged. However, it must be remarked that a more competitive environment could also have a discipline effect on public airlines that force them to be as cost efficient as private counterparts. A revision of the estimated effect of public ownership when more recent data become available would be advisable to obtain a more definitive conclusion on this point.

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APPENDIX 1: ESTIMATION RESULTS

Method: Full Information Maximum Likelihood
Equations: Costs ShareL ShareK ShareM
Log of Likelihood Function = 929.166
Number of Observations = 105

Parameter	Estimate	Standard Error	t-statistic
α_0	8.09162	.034530	234.334
α_{pub}	.074247	.065351	1.13614
α_p	.899812	.071401	12.6023
α_c	.046165	.073606	.627194
α_{pc}	-.877938E-02	.015889	-.552553
β_L	.298475	.787987E-02	37.8782
β_E	.041686	.065702	.634469
β_K	.163176	.187522E-02	87.0168
β_M	.423682	.697966E-02	60.7024
γ_{LL}	.164447	.023266	7.06825
γ_{EE}	.478189	.426951	1.12001
γ_{KK}	.100389	.724344E-02	13.8593
γ_{MM}	.147563	.019613	7.52390
γ_{LE}	.035056	.029829	1.17523
γ_{LK}	-.047149	.740266E-02	-6.36915
γ_{LM}	-.057877	.019046	-3.03886
γ_{EK}	-.031717	.665419E-02	-4.76641
γ_{EM}	-.070314	.028228	-2.49090
γ_{KM}	-.054244	.507834E-02	-10.6814
δ_{Lp}	-.093457	.033024	-2.82999
δ_{Ep}	-.312558	.175433	-1.78164
δ_{Kp}	.015013	.738983E-02	2.03161
δ_{Mp}	.073998	.027250	2.71550
δ_{Lc}	.073590	.026576	2.76905
δ_{Ec}	.266696	.160444	1.66223
δ_{Kc}	-.920714E-02	.660879E-02	-1.39317
δ_{Mc}	-.073718	.021773	-3.38577
λ_p	-.587879	.355514	-1.65361
λ_c	-.066608	.072180	-.922806
λ_{ch}	-.118364	.363659	-.325479
λ_{avsl}	-.681593	.144055	-4.73148
λ_{net}	-.110937	.074551	-1.48807

Equation Costs
Dependent variable: LCOST
Std. dev. of dependent var. = .957915   R-squared = .991772
Sum of squared residuals = .785391   Durbin-Watson statistic = 1.97060
Variance of residuals = .747992E-02