Measuring the Efficiency of European Airlines: An Application of DEA and Tobit Analysis[1]

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Abstract

The liberalisation movement in European airlines industry was initiated in the late 1980s to create a more competitive environment. This has aimed to result in an increase in efficiency and productivity of the industry. The radical changes which have occurred since then have given risen to the need to evaluate the efficiency in the early phases of the liberalisation process. This study utilises Data Envelopment Analysis (DEA) to assess the effic iency of airlines. The Tobit model applied to the second stage is conducted in an effort to identify the effects of various explanatory variables on efficiency. Applying DEA with Tobit models to detect the efficiency and the determinants of (in)efficiency serves a variety of policy purposes and aimed at improving performance. Our analysis is based on a panel data set of 17 airlines European airlines over the period of 1991-1995.

Keywords: Efficiency; Data Envelopment Analysis; Tobit model; European Airlines

1. Introduction

The majority of Europe's major airlines were established by the states, or with the state support, as they exercised their right of sovereignty over airspace. The carriers were regarded as symbols of independence and, to a great extent, of national prestige. They were also used for economic purposes, such as promoting trade, providing employment and offering services to small and remote communities. In some states, large-scale government involvement was justified on the grounds that air transport required large capital investments which could only be financed by the states. Given the existence of risk, in its early days, the industry could only attract small number of private initiatives.

However, in recent years, the European air transport industry has been going through a gradual period of economic liberalisation. States are showing a tendency to reconsider their ownership positions, introduce more liberal regimes, and thus promote efficiency in the industry. There are clear forces driving this thrust. These include poor financial performances; efficiency concerns; national debt considerations; the massive need of investments and the moves towards global consolidation.

The industry has often been criticised on the grounds that it is inherently less efficient than the US carriers owing to having higher production costs. To confirm this, many studies have compared their efficiencies and shown that the deregulated US airlines are more efficient than their highly regulated European counterparts (Windle, 1991; Good *et al.* 1993, 1995). The deregulation reforms in the US increased competition, lowered prices and brought substantial benefits for consumers and increased productivity in the industry (Bailey and Panzar, 1985; Kasper, 1988).

The demonstrable effects of successful US deregulation and ongoing inefficiency in the industry may have influenced the European Commission to introduce certain reforms to promote competition and thus increase the efficiency and productivity of the European airlines. This process is called liberalisation. Starting in 1987, subsequent reform packages were introduced to provide flexibilities in pricing, capacity sharing and market access. The First Liberalisation Package of measures provided for limited freedom to compete on cheap fares, but offered multiple designation on the busier routes, and less restrictive capacity sharing agreements, which entitled either country to operate up to 60% of capacity (Vincent and Stasinopoulus, 1990).

The Second Package of reforms allowed more flexible conditions on setting fares and improving market access. Deep discount fares, for example, were introduced without requiring government approval. The lower limit was reduced from 45% in the 1987 package to 30% of the reference economy fare. Restrictions imposed on capacity shares were gradually removed and aimed to be fully eliminated by January 1993 – the date of the Single Market for European aviation (Stasinopoulos, 1992).

Integrating aviation within the overall framework of the EC policies for the Single Market forced the EC to agree the Third Liberalisation Package with more drastic measures. It was aimed to create a more competitive environment for European aviation. Airlines could set their own tariffs freely, subject to the safeguards against the predatory pricing or excessive prices. The opening of access to all intra-Community routes, i.e. the cabotage rights, was to be gradual and completed in 1997. With respect to licensing there would not be any discrimination in favour of flag carriers. Any technically and financially sound Community airline can obtain license and fly on any EC route (Stasinopoulos, 1993).

During the early phase of liberalisation process along with some privatisation experiences, the European airlines industry provides a fascinating case study to investigate the recent performance record and assess the determinants of performance. The co-existence of public and private airlines in a competitive environment constitutes an opportunity to examine the claim that private ownership of an airline leads to higher efficiency than public ownership. There may be other factors such as consolidation or service competition which could determine efficiency differences. Studying these factors may be of use for formulating relevant policies for the industry, which is seeking to improve its performance whilst passing through critical restructuring.

The issue of the relative efficiency of public and private firms has continuously fascinated economists. Many academics and policy makers draw their conclusions for privatisation and deregulation from the comparative studies on the relative technical efficiency differences between these two ownership types. Technical efficiency reflects the ability of a firm to obtain maximal output from a given set of inputs. It is widely believed that the technical efficiency of private firms is higher than the public firms.

Several interrelated strands of theories have been influential in creating such a consensus. These are property rights, public choice and regulation theories. According to the property rights literature which could be associated with the names of Alchian (1965) and Alchian and Demsetz (1972), the attenuation of property rights in public firms leads to monitoring problems and adverse behavioural incentives, creating mismanagement and inefficiency. A second strand, public choice theorists, following Niskanen (1971) argues that public sector managers, bureaucrats and politicians operating under insufficient competitive environments maximise their budgets. This self-interested conduct decreases cost reducing incentives. The final strand suggests that regulatory authorities, which may consist of self-seeking bureaucrats, are 'captured' by special interest groups and serve the producers' interest more than the 'public interest'.

Though all three sets of theories conclude that private firms are more efficient than public ownership, the existing empirical studies on various industries provide mixed evidence (Millward and Parker, 1983; Boardman and Vining, 1989). In our opinion, any study on the airlines efficiency and productivity is an empirical question which necessitates industry specific studies.

This study focuses on the early performance results of the liberalisation reforms in the European airlines industry. Section 2 discusses the recent methods to measure efficiency and explain efficiency differences between airlines. Section 3 classifies the determinants of efficiency. In particular, the potential determinants of efficiency in the European airlines industry. The airlines included in our sample are briefly described in Section 4. The empirical results are reported in Section 5. Finally, Section 6 concludes.

2. The Methodologies for Efficiency Measurement

The idea of measuring efficiency was originally developed by Farrell (1957) who used the non-parametric frontier approach to measure efficiency as a relative distance from the frontier. This measure, known as productive or technical efficiency by economists, was later extended by operational researchers, notably Charnes, Cooper and Rhodes (1978). They named the technique the Data Envelopment Analysis (DEA).

The non-parametric strength of DEA has become increasingly popular in applications where there are multiple inputs and outputs. The technique allows efficiency to be measured without having to specify either the production function or the weights used for the inputs and outputs. The DEA method measures the relative efficiency by estimating an empirical production frontier, employing the actual input and output data. The efficiency score of a Decision Making Unit (DMU) is then measured by the distance between the actual observation and the frontier obtained from all the DMUs under evaluation. Throughout the study, the term efficiency refers to technical efficiency, which is the distance of a DMU from the production frontier. Also, an input-oriented efficiency, that is, providing outputs with minimum input consumption, is specified. The reason for this choice is that in a growing competitive market for air transport the outputs are less likely to be under the control of the individual airlines than their choice of inputs.

The DEA method has been extensively used in empirical studies to analyse both cross-section and panel data. (See Seiford, 1996 for a current bibliography). A method for applying DEA to panel data is provided by the Windows analysis methodology of Charnes *et al.* (1985). DEA Windows analysis is a dynamic approach which detects the efficiency trends of each DMU relative to a technology.

The performance of each DMU is compared through time whereby a DMU within each time period is treated as a different DMU. The subsets of the data are evaluated through a moving window, which is constructed in a way that provides the series of overlapping sub-periods or windows to examine the DMU efficiency over a period of time.

In this method the whole set of time periods, T, is divided into 'windows', or sub-periods for i = 1,...*I* DMUs whereby the width of each window, p, is always equal. In the first assessment, the first window consists of n DMUs within the time period of (1,…,p). The second window then has periods of (2,…p+1) and this goes on to the last period (T-p+1,…,T). Each unit in the sub-periods is treated as a different unit.

Let $Y_{it} = [\, y_{1it}, ..., y_{Mit}]$ be a M*I vector of outputs of DMU i = 1,...*I* in period t = 1,...T, and let $X_{it} = [\, x_{1it}, ..., x_{Sit}]$ be a S*I vector of inputs of DMU i = 1,...*I* in period t=1,...T. An input-oriented DEA envelopment problem for DMU_c in period t can be presented as follows:

$$\min q$$

$$\text{subject to } \; Y_{ct} \leq \sum_i Y_{it}\, l_{it}$$

$$q\; X_{ct} \geq \sum_i X_{it}\; l_{it} \qquad (1)$$

$$\lambda_{it} \geq 0$$

Windows analysis increases the number of DMUs available for assessment from *I* to *I**p. The DEA problem is solved *I**p times for every sub-period or window. This is an important feature of windows analysis since solving DEA problem for *I**p increases the number of times the population is sampled, and improves the discriminatory power of the results.

Having measured the relative efficiencies, it is also of considerable interest to explain the DEA efficiency scores by investigating the determinants of technical efficiency when the results are expected to guide policies aimed at improving performance. In such cases, it has been customary to use a two-stage procedure. In the first stage, technical efficiency is assessed on a reference technology whilst in the second stage, the DEA efficiency scores, are explained by relevant variables not directly included in the DEA analysis. As defined in equation (1) the DEA score falls between the interval 0 and 1 ($0<h^{*}\leq 1$), making the dependent variable a limited dependent variable. The Tobit model (Tobin, 1958) is suggested as an appropriate multivariate statistical model in the second stage to consider the characteristics of the distribution of efficiency measure (Grosskopf, 1996:165).

In recent years, many DEA applications have employed a two-stage procedure. For example, Luoma *et al.* (1996) and Chilingerian (1995) conduct both DEA and Tobit analyses in health sector applications to estimate both inefficiency and the determinants of inefficiencies. Viitala and Hanninen (1998) apply DEA with Tobit models for the public forestry organisations in Finland. The study by Bjurek *et al.* (1992) uses a similar approach to measure the performance of public day care centres in Sweden. Another recent study by Kirjavainen and Loikkanen (1998) applies both DEA and Tobit for the Finnish senior secondary schools.

A similar procedure is conducted in transportation studies. For example, Oum and Yue (1994) use DEA efficiency scores with a Tobit model to analyse the influence of certain variables on the performance of European railways as did Kerstens (1996), who evaluates the performance of French urban transit companies.

In the same way, Gillen and Lall (1997) analysed the airport productivity. Thus, all these studies use a two-stage procedure, first to determine the efficiencies and then for policy purposes, use Tobit model to explain the efficiency distributions.

Following Gillen and Lall (1997) and Chilingerian (1995) the Tobit censored regression model[2] is used in this study to accommodate the censored DEA efficiency scores. There would be a concentration of variables at unity. For computational purpose, Greene (1993) suggests the use of censoring at zero. Therefore using the formula in (2), the DEA efficiency scores are transformed and thus censoring point is concentrated at zero. DEA efficiency scores computed by the equation (1) are used as dependent variables. Recall that solving DEA windows problem increases the number of measured efficiencies, thus the discriminatory power of the results. The DEA score is obtained by taking the reciprocal of DEA score minus one:

$$y_i = (1/q) - 1 \qquad (2)$$

The best practising airline with an efficiency score of 100% is transformed to zero. With this transformation, airlines, which have efficiency scores less than 100% become any positive value. Thus, transformation bounds the DEA score in one direction and censors the distribution at zero value.

For this purpose, the standard Tobit model can be defined as follows for observation i:

$$\begin{aligned} y_i^* &= b' x_i + e_i \\ y_i &= y_i^* \text{ if } y_i^* \succ 0, \text{ and} \\ y_i &= 0, \text{ otherwise,} \end{aligned} \qquad (3)$$

where e_i ~ N(0, σ^2), x_i and b are vectors of explanatory variables and unknown parameters, respectively. The y_i^* is a latent variable and y_i is the DEA score.

The likelihood function (L) is maximised to solve b and s based on 51 observations of y_i and x_i is

$$L = \prod_{y_i=0}(1-F_i) \prod_{y_i>0} \frac{1}{(2ps^2)^{1/2}} \times e^{-[1/(2s^2)](y_i - b'x_i)^2} \qquad (4)$$

where

$$F_i = \int_{-\infty}^{b'x_i/s} \frac{1}{(2p)^{1/2}} e^{-t^2/2}\, dt$$

The first product is over the observations for which the carriers are 100% efficient (y = 0) and the second product is over the observations for which carriers are inefficient (y >0). F_i is the distribution function of the standard normal evaluated at $b'x_i/s$.

As a result, in this study we apply a standard DEA model which does not disaggregate scale and pure technical efficiency. This is in keeping with one subsequent Tobit analysis which incorporates factors related to both scale and scope in explaining the relative efficiency scores.

3. Determinants of Efficiency

The determinants of efficiency can be classified under five broad headings (Caves, 1992; and Mayes *et al.* 1994). First, lack of competition is believed to induce inefficiency. Three measures are used to estimate the effects of competitive conditions on inefficiency: firm concentration; openness of the market; and the rate of contestability. Second, managerial and organisational factors may influence the activities of any firm. These factors include the ownership structure and the extent to which the organisation is unionised, among others. Third, the structural heterogeneity between organisations can lead to structural efficiency differences. This may include heterogeneity in production processes. Fourth, dynamic factors are thought to foster efficiency. These include R&D facilities, innovations and market growth. Finally, public policy may influence the incentives to improve efficiency. Government regulations as well as the subsidies are policies, which could adversely influence the productive efficiency of activities.

It is important to note that these determinants are not clear in predicting the extent of inefficiency in each industry. They are not increasingly expressed in terms of technical inefficiency in the strict sense of Farrell (Mayes *et al.* 1994). Thus the theoretical foundation for explaining technical efficiency may be imprecise relative to the methodologies for measuring it. However, it is essential to go beyond performance measurement for a much more systematic study of the causes of inefficiency. This could assist in developing policies towards improving performance while exploring the determinants of inefficiency.

3.1 Potential Determinants of European Airlines Performance

The potential explanatory variables for this analysis are determined according to the framework set above. It is worthwhile to note that the specification of the relevant variables is constrained by data availability.

3.1.1 Competition

First, the main hypothesis for competitive conditions is that there is less scope for inefficiency in a competitive environment. However, bilaterally imposed restrictions in the European airlines industry could severely limit the competitive behavior and increase the level of air transport prices, and, thus, inefficiency in the industry (see, for example, Sawers, 1987). Some pressures to change this regulatory framework were initiated at the beginning of 1980s with liberalised bilateral agreements.

The evidence indicates that the liberalisation can provide substantial benefits to consumers where liberalisation has been followed by significant entry. Contrary to what is proposed by the contestable theory, evidence shows that actual competition on a route is more effective than potential competition in securing these benefits (Abbott and Thompson, 1991). Even though there has been new entry into the industry, the economies of density may restrict the number of airlines on a certain route (Pryke, 1991). In fact, there has been a tendency observed in Europe towards concentration.

Some notable examples are the mergers between the British Airways and British Caledonian in 1988 and between Air France, UTA and Air Inter in 1990. Most of the other European airlines are also engaged with strategic alliances in and out of Europe. The impact of concentration on performance is *a priori* unclear. On the one hand, there were fears that such alliances could act as monopoly and prevent the entry of potential competitors. On the other hand, it has been argued that they may promote and accelerate the restructuring process which could lead significant cost savings (see Comité des Sages, 1994). A concentration variable (DUMCON) is included into the model by using a dummy, taking the value of unity to identify each year during which a strategic alliance among the affected airlines is in operation.

3.1.2 Managerial and Organisational Factors

Managerial and organisational factors can affect efficiency. The effect of ownership structure, for example has been extensively discussed by economists. The literature of property rights pointed out the costs of state ownership (Alchian, 1965). European airlines are mostly owned by the state. It is usually claimed that the state ownership of airlines is more prone to government interference, which can weaken the market-oriented approach to decision-making (OECD, 1997). Therefore, they are blamed for the inefficiency in the industry.

In the late 1980s there has been a privatisation movement. For example, the national carriers of the UK and the Netherlands were sold to the public. Whilst the government has fully privatised the company, the Netherlands government reduced its share to 38.2% in the KLM. According to Rapp and Vellas (1992), sixteen countries in Europe were involved in privatisation, either by full privatisation or by a policy for reducing the government shares. The ownership status (OWN) is available for each airline in the sample, and is defined as the percentage of state ownership. Since there is no consensus among the empirical evidence on the superiority of private firms' performance, it is safer to assume that it is *a priori* unclear how state ownership affects efficiency.

3.1.3 Heterogeneity

The heterogeneity in the production process is postulated to be lower when the proportion of output produced in the principle product industry is greater (Mayes *et al.,* 1994). This is called specialisation. The degree of specialisation in airlines operations is thought to affect the demand patterns, thereby increasing the airline efficiency. Airlines may specialise on scheduled, charter and cargo flights. Each call for different product and marketing facilities. The relationship between specialisation and airlines efficiency is, however, a neglected research area due to the problem of quantifying the influence (Morrell and Taneja, 1979). The available information is incorporated by defining the three markets: the percentages of scheduled, charter, and cargo flights in total traffic. However, the highest proportion of output produced by all firms is in the scheduled operations. This is included in the model as the percentage of scheduled flights flown (SCHED) in kilometres in total traffic.

As an alternative to the specialisation variable (SCHED), the heterogeneity can be accounted for by considering the spatial disparities, which may occur through demand. This can be defined by the proportion of scheduled destinations concentrated in geographical operation areas. The available information can be categorised by defining three areas: the proportion of destination within Europe, international and within any country. The first two categories, Europe (EUR) and international (INTER), are the principal operation areas, and are hence included in the model as additional explanatory variables. The affects of heterogeneity are therefore estimated as increments on the within country heterogeneity.

Furthermore, it seems useful to include spatial, quality and temporal characteristics of the services to support the traditionally used output aggregates

(Kerstens, 1996). Whilst there are data limitations on the temporal characteristics, spatial characteristics of the network can be accounted for by a number of variables. First, the average stage length (STAG) is one of the most widely used measures. This may influence the route pattern, and thus efficiency. It is computed by dividing total aircraft-kilometres performed by aircraft departures. Stage length is mostly used in explaining the airlines operating costs. However, the evidence suggests that its influence on production or profitability is ambiguous (See for example Caves *et al.* 1981; Tretheway, 1984).

Second, it is possible to interpret the changes introduced by airlines in response to deregulation by incorporating the route network density (ROUT) into the model (Distexhe and Perelman, 1994). This variable concerns the intensity of traffic flows and is computed as the average number of aircraft departures per 100,000 kilometre. An immediate consequence of the deregulation is the restructuring of airline route networks and the emergence of hubs (Bailey *et al.* 1985). European airlines evolved in the direction of low-density networks either as a result of mergers and takeovers or with the introduction of wide-body planes. The impact of route density on performance could be negative (Morrell and Taneja, 1979).

Finally, the measure of service quality should be considered whenever possible. The load factor (LOAD) is often used as a proxy for service competition (Good *et al.* 1995). It is computed as the percentage of total capacity available for passengers, freight and mail which is actually sold and utilised. There is evidence that the load factor has a positive effect on performance (Caves *et al.* 1981, 1983).

3.1.4 Public policy

The effects of government regulation and subsidies need to be considered for the European airlines. Until the 1980s air transport was heavily protected by national and international regulations where major institutional changes recently liberalised the sector. With the US deregulation in 1978, which removed rate and route regulations, certain reforms were also introduced in Europe to provide flexibility in pricing, capacity sharing and market access. The third liberalisation package introduced in 1993 was the most decisive and designed to move from protecting existing airlines to enhancing efficiency and responding to consumer interests.

However, with the disappearance of traditional forms of regulatory practices, the importance of state aids for the state owned carriers also increased (Comité des Sages, 1994). On one hand, state aids may discriminate in favour of the state owned airlines, thereby severely contributing to overcapacity and uneconomic pricing. On the other hand, state aids may be imperative in alleviating an airline's financial situation while passing through the restructuring process. The effects of liberalisation and subsidies policies are incorporated into the model by using dummies to reflect the periods when a major change occurred.

The impact of liberalisation is represented by the dummy, DUMYE. This takes the value of zero for the years, 1991-3 before the third liberalisation made its impact. The following years, 1994 and 1995 are represented with the values of unity. It is believed that the impact in the first year will not be as strong as in the following years. Further, the subsidised airlines between 1993 and 1995 (DUMSUB) are represented by a unity value and zero otherwise.

4. Data

To specify the inputs and outputs for the DEA, the model by Schefczyk (1993) is adopted. Each of the inputs and outputs in the model reflects the operational characteristics of the airline industry. The inputs are available tonne kilometre (ATK); operating cost (OC); and non-flight assets (NFA). The two outputs are revenue passenger kilometre (RPK) and non-passenger revenue (NPR). ATK models the aircraft capacity including both passenger and non-passenger inputs. Operating cost is obtained by excluding the capital and aircraft costs already reflected in ATK. In addition, non-flight assets are included to reflect all assets not already reflected by ATK. These assets are mainly the reservation systems, hotels and other facilities. RPK is used as a proxy for the passenger-flight related output whereas non-passenger revenue reflects all other output that is not passenger-flight related, such as cargo.

The data are based on three sources. ATK and RPK are obtained from International Air Transport Association (IATA) World Air Transport Statistics; NFA are from the annual reports of the companies and the rest are from the International Civil Aviation Organisation (ICAO) Financial Data Series. For all monetary conversions, purchasing power parities by OECD are used.

The analysis is based on a data set consisting of seventeen airlines over the period 1991-1995. The seventeen airlines included in this study are as follows: Aer Lingus (Ireland), Air France (France), Air Malta (Malta), Alitalia (Italy), Austrian Airways (Austria), British Airways (United Kingdom), Cyprus Airways (Cyprus), Finnair (Finland), Iberia (Spain), Icelandair (Iceland), KLM (The Netherlands), Lufthansa (Germany), Sabena (Belgium), SAS (Scandinavia), Swissair (Switzerland), Air Portugal (Portugal) and Turkish Airlines (Turkey).

Except British Airways and Icelandair, the rest in the sample have varying degrees of state ownership. All carriers in the data set are members of the AEA whose duty is to promote co-operation amongst members and represent their interests to the EC and other international organisations. Except Air Malta, Cyprus Airways and Turkish Airlines, the rest of the sample is EC airlines. Because of data limitations, eight AEA airlines were excluded from the sample.

As mentioned before the DEA inefficiency score is employed as a dependent variable in the Tobit analysis. The data on the independent variables is based on the following sources. DUMCON, OWN, EUR and INT are obtained from the Association of European Airlines (AEA) Yearbooks; LOAD is from the AEA Statistical Appendices; ROUT, STAG, and SCHED are derived from the IATA World Air Transport Statistics; and DUMSUB is from Sixth Survey on State Aids published by the EC. Table 1 below presents the descriptive statistics for the DEA inefficiency scores and the potential explanatory variables outlined in the previous section.

Table 1 Descriptive statistics for Tobit variables

	Mean	**Std.Dev.**	**Minimum**	**Maximum**
INEFF	0.215539	0.220429	0	1.03957
LOAD	0.630098	0.070597	0.46	0.741
OW	0.645076	0.343151	0	1
EUR	0.51589	0.134643	0.320346	0.83871
INTER	0.337138	0.173229	0.088235	0.611765
ROUT	86.2077	29.4765	30.1275	172.717
STAGE	1291.92	454.857	578.98	3319.22
SCHED	0.920691	0.080011	0.567185	1
DUMCON	0.588235	0.49705	0	1
DUMSUB	0.235294	0.428403	0	1
DUMYE	0.666667	0.476095	0	1

5. Explaining Inefficiency of European Airlines: Tobit Results

A preliminary analysis reveals that there is multicollinearity (r = 0.86) between route network density (ROUT) and average stage length (STAG). It could be argued that these two may measure the same phenomenon since the stage length can influence the route pattern. Therefore they are not included into the model together, but incorporated in different models. Also, the specialisation variables (EUR), (INT) and (SCHED) can be employed interchangeably.

The results for the Tobit estimation are summarised in models 1 to 4 in Tables 2-5. Computations were conducted using LIMDEP. It is important to note that the dependent variables in all models are the inefficiency, which were obtained by transforming the DEA efficiency scores. Thus the sign of the coefficients are reversed – a *positive* coefficient implies an *inefficiency increase* whereas a *negative* coefficient means an association with *inefficiency decline* or *increased efficiency*. The results of the regression are significant at 95% level or higher and the overall variation explained in the models 1-4 are 0.37, 0.38, 0.38 and 0.39 respectively.

All coefficient signs in models 1-4 are in close agreement. However, only the year dummy (DUMYE) appears significant in all models. The overall load factor, state ownership and concentration dummy along with the year dummy are significant in models 1 and 3. In those models where scheduled operations are used as specialisation variable, none of the above variables (except the year dummy) appear significant.

The sign of the coefficient for overall load factor is as expected. Increasing the overall load factor can increase the efficiency. Indeed, the new regulations appear to have created a more competitive airline industry in Europe, which fostered service quality. This indicates that airlines with higher load factors tend to attain a higher efficiency.

The percentage of state ownership has a statistically significant negative coefficient. This finding suggests that state ownership cannot be associated with the efficiency decline. It is however evident that in the 1990s most of the airlines, whether private or public, are challenged by the globalisation of economic activities. In order to survive in the dynamic aviation market, both public and private airlines tend to operate on a more commercial basis, rather than with non-economic political objectives.

On the other hand, the concentration dummy has statistically significant positive coefficient, which may indicate that increasing number of mergers and alliances may increase the inefficiency. Even though the global competitiveness of the European airlines industry is greatly supported, the overall potential advantages of such arrangements may results in significant dominant positions, which lead inefficiency in the industry.

Likewise, the subsidies dummy has a statistically significant positive coefficient. This result may reveal that increasing subsidies can increase the inefficiency. It is important to note that subsidies may have competitive distorting effects. If airlines are ensured that they will be protected any time when they face financial problem, they will have less incentive in cutting their costs and improving the efficiency. Due to lack of information, our analysis did not distinguish amongst the types of subsidies and on which terms they were provided.

The year dummy is negative and statistically significant, showing the positive effects of the third liberalisation package on efficiency. It is also important to note that this result is consistent with the measured Malmquist efficiency change, 6 % which shows an upward trend (Fethi, 1999). One can conclude that reduced subsidies and greater market liberalisation can encourage efficiency in the European airlines industry.

Looking at the marginal effects, the best thing that could be done to improve efficiency is to attract higher load factors. It is evident however that the third liberalisation package, brought an increase in discount-fare traffic, thus resulted in higher load factors in the industry. Throughout this period, the increase in load factors substituted wide-bodied aircraft for narrow-bodied planes to realise the economies of scale of the larger jets.

Table 2 *Estimation results: Tobit model 1*

Variables	**Coefficients**	**t-ratio**	**Marginal**
Constant	1.54896	3.85825	1.36700
Overall load factor	-1.4239	-2.64695	-1.25663
State ownership	-0.20227	-2.12499	-0.17851
European flights	-0.62215	-1.79995	-0.54906
International flights	-0.30713	-0.6846	-0.27105
Route network density	0.00078	0.51112	0.00069
Concentration dummy	0.18867	2.23845	0.16651
Subsidies dummy	0.15318	1.97521	0.13519
Year dummy	-0.15546	-2.82294	-0.13719
Sigma	0.17521	9.91838	
R^2	0.3747		
Log-lik	17.2327		
Number of observations	51		

Table 3 *Estimation results: Tobit model 2*

Variables	Coefficients	t-ratio	Marginal
Constant	0.11935	0.19485	0.10562
Overall load factor	-0.98601	-1.86648	-0.87260
State ownership	-0.09297	-0.89643	-0.08227
Route network density	0.00076	0.86168	0.00067
Scheduled flights	0.7923	1.83077	0.70117
Concentration dummy	0.12237	1.70276	0.10830
Subsidies dummy	0.07762	0.96066	0.06869
Year dummy	-0.17032	-3.09923	-0.15072
Sigma	0.17489	9.88057	
R^2	0.38498		
Log-lik	17.6558		
Number of observations	51		

Table 4 *Estimation results: Tobit model 3*

Variables	Coefficients	t-ratio	Marginal
Constant	1.66674	4.42681	1.46784
Overall load factor	-1.41687	-2.82381	-1.24779
State ownership	-0.20133	-2.16305	-0.17730
European flights	-0.50955	-1.46799	-0.44874
International flights	-0.13798	-0.34129	-0.12151
Stage length	-0.00012	-1.1498	-0.00010
Concentration dummy	0.16093	1.95551	0.14172
Subsidies dummy	0.14655	1.9116	0.12906
Year dummy	-0.15203	-2.80923	-0.13388
Sigma	0.174066	9.92418	
R^2	0.3753		
Log-lik	17.2592		
Number of observations	51		

Table 5 Estimation results: Tobit model 4

Variables	**Coefficients**	**t-ratio**	**Marginal**
Constant	0.340714	0.543977	0.30140
Overall load factor	-0.94939	-1.81288	-0.839866
State ownership	-0.09173	-0.89117	-0.0811517
Stage length	-9.44E-05	-1.42575	-0.0000834
Scheduled flights	0.727546	1.67265	0.64361
Concentration dummy	0.120407	1.69031	0.10651
Subsidies dummy	0.077112	0.963573	0.0682157
Year dummy	-0.16819	-3.07896	-0.1487911
Sigma	0.173638	9.89335	
R^2	0.3870		
Log-lik	17.7412		
Number of observations	51		

6. Conclusion

This study examined the determinants of efficiency in the European airlines industry. First we used a general framework for explaining the determinants of firms' performance. Accordingly, some of the determinants for the European airlines were specified. As was mentioned in the introduction, this study may provide insights for the policy debates.

The empirical findings confirm the detrimental effects of concentration and subsidy policies. Airlines confronting competition may seek to exploit economies of scope and of density. Therefore they look favourably to the alliances and mergers. However, it seems evident that concentration can impede competition, results in excessively high fares and inefficiency. Subsidies also drive inefficiency by providing distorting competition in European aviation. In recent years, it has been strongly argued by the EC that all state aids for the state-owned carriers be eliminated except in very rare circumstances.

Moreover, the empirical findings reveal that the state ownership did not provide an impediment for being efficient in this sample. When airlines operate on a commercial basis from which political objectives are excluded, being privately or publicly owned does not matter. Further, in order to remain competitive and efficient, the European airlines need to maintain their service quality – increase the load factors.

This analysis, however, is the first attempt to investigate Tobit analysis in the airline efficiency literature. Therefore additional studies are imperative to confirm or falsify the detected determinants in this study. The empirical work here suggests that future research may need to concentrate on the dynamic factors, i.e. the R&D

facilities and innovation which could play a significant role in an industry's performance.

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Endnotes:

[1] The earlier version of this paper was presented at the 2000 Annual Meeting of the European Public Choice Society, Siena, Italy, 26-29 April, 2000.

[2] "The model is *censored* if one can at least observe the exogenous variables and *truncated* if the observations outside a specified range are totally lost" (Amemiya, 1984:3).