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Airlines performance in the new market context: A comparative productivity and efficiency analysis

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ABSTRACT

This paper analyses airlines' efficiency and productivity using two different methodologies: data envelopment analysis and total factor productivity, and we additionally investigate which factors account for differences in efficiency. Our main findings show that low-cost carriers are in general more efficient than full-service carriers, efficiency and the dispersion of both data envelopment analysis and total factor productivity indexes amongst airlines differ according to geographical areas, which may be a result of different legislation and de-regulation processes, and so of specific competitive conditions, labour is the only input that definitively influences productivity, and larger airlines are more efficient, suggesting the existence of economies of scale.

1. Introduction

The air transport market has undergone considerable change. De-regulation in Europe, North America and Australia, have led to a significantly increased competition, and along with de-regulation, many European airlines that were formerly state-owned have been either fully or partially privatised. Also, adjustments following the events of September 11 have affected the environment in which air services are provided. Finally, the large-scale market entry of low-cost carriers (LCCs) has increased competition and affected the fares charged by incumbent airlines. As a consequence of these and other developments, it is probable that the relative efficiency of the world's airlines has changed.

This paper performs analysis on the comparative efficiency of airlines in this new market context looking at a large sample of airlines and using two different methods of measuring performance efficiency. The sample is of 49 carriers with 2005 data. Additionally, possible factors that may account for higher productivity are examined. Data envelopment analysis (DEA) and total factor productivity (TFP) methods are used for analysis. Further, we use regression analysis to find out which factors account for productivity differences.

DEA efficiency studies of airlines are numerous. Some of the recent studies include Scheraga (2004), who, using data for 38 airlines from around the world for 1995 and 2000 found that relative efficiency had changed little. Fethi et al. (2001) looked at 17 European carriers for 1991 and 1995 and found that by 1995 it was too soon to find any improved efficiency. Oum and Yu (1995) analysed 23 airlines over the period from 1986 to 1993 and found that those that most improved their efficiency were European airlines, in particular, having had low indexes in 1986. Fare et al. (2007) studied the effects of deregulation on the productivity of 13 US airlines. Except for Sheraga, other studies used data prior to 1995 before LCCs were important and too soon in most cases to examine the medium-term effects of deregulation and liberalisation. Our analysis captures the effects of the new market environment introduced by these new conditions.

2. The airlines

Forty-nine airlines from different parts of the world are grouped by the regional classification of International Air Transport Association (IATA). These are—Europe and Russia (21 airlines), North America and Canada (11), China and North Asia (8), Asia Pacific (7), Africa and Middle East (2). The aim was to include each region's largest airlines as well as a representative sample of LCCs. Of the airlines, 10 are European, North American, and Asia Pacific LCCs. Data for 2005 are used and sources include airlines' annual reports, direct information from airlines' websites, the International Air Transport Association (various years) yearly publication (*World Air Transport Statistics*), the Association of European Airlines (2007) and *Yearbook* 2006.

Tables 1 and 2 show some of the main features of the airlines. Passenger revenues range from 49% for Eva Airways to 98% for Norwegian Airlines. As most LCCs do not carry cargo, they have the highest shares of passenger revenues. Other revenues come

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Table 1
Input and output mix

	Mean	St. dev.	Highest	Lowest
Revenue shares				
Passenger (%)	80	17	95	49
Cargo (%)	8	9	45	0
Other (%)	10	7	27	1%
Inputs cost shares				
Labour (%)	23	8	33	8
Capital (%)	11	4	18	2
Fuel (%)	25	9	57	11
Others (%)	41	10	59	13
Input use				
Labour per min ASKs	0.37	2.10	1.09	0.08
Block hours (day average)	9.90	0.21	15.3	4.7
Fuel (min gallons per billion ASKs)	7.8	8.6	13.4	3.4
Size (min ASKs)	66155	68017	283364	3067

Table 2
Per cent of inputs and outputs by airline type

Shares of output revenues	Passenger	Cargo	Other	Salaries	Capital	Fuel	Other
Full service airlines							
Average	78.1	10.3	10.9	22.2	11.3	25.3	41.5
Standard Deviation	10.6	8.5	7.2	7.8	4.0	8.4	8.5
Low-cost airlines							
Average	93.5	0.2	6.3	23.2	11.0	27.2	38.6
St. dev	4.4	0.6	4.5	10.4	4.5	12.3	14.0

mainly from selling maintenance and engineering services, catering, leasing of own aircraft, sale of fuel and sale of goods but these are a small share, and account only for 27% for Japan Airlines, the carrier with the largest share. The airlines vary considerably in size, with an average doing 66,155 million available seat kilometres (ASKs), The largest company is American Airlines doing 283,364 million while the smallest one, Cyprus Airways, registers 3067 million.

The input and output mix used in DEA is generally uniform for the airlines examined, with the only major difference being a lack of cargo carriage amongst the LCCs. The share of "other inputs" in operating costs is relatively high across the board, with a mean of 41% and a highest value of 59%, for Malev. "Other inputs" differ amongst airlines and their shares in operating revenues depends much on the company's decision between outsourcing and internalising the production of some of these services. Labour costs shares range from 8% for Eva Airways to 33% for SAS. This reflects greater international differences amongst salaries than effective labour use. As an example, Asian airlines have lower shares of salaries in costs but higher levels of employment per ASK. For example, PIA's ratio of employees per million ASKs is of 0.93, while Ryanair ratio is of 0.08. Block hours range from a maximum of 15.3 for American Airlines to a low of 4.7 for SAS.

3. Efficiency and productivity analysis

3.1. Data envelopment analysis

The DEA performance analysis applies the input-oriented Banker–Charnes–Cooper model (Banker et al., 1984), using variable returns to scale, with each airline considered as a separate decision-making unit (DMU). The model is

$$\min_{\theta, s_i^-, s_r^+} \left(\theta - \varepsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \right) \quad (1)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0}, \quad i = 1, \dots, m$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0}, \quad r = 1, \dots, s$$

$$\sum_{j=1}^{n} \lambda_j = 1, \quad j = 1, \dots, n$$

$$\lambda_0 = 0$$

$$\lambda_j \geqslant 0,\ s_r^+ \geqslant 0,\ s_i^- \geqslant 0, \quad \forall i, j, r$$

where x_{ij} is the ith input of DMU j; where; y_{rj} is the rth input of DMU j; θ is the efficiency score of the considered DMU; $\sum_{j=1}^{n} \lambda_j = 1$ is the convexity constraint in the Banker–Charnes–Cooper model: s_i^- is an input slack parameter; s_i^+ is an output slack parameter; $\lambda_0 = 0$ is a constraint for applying the super-efficiency measure.

To distinguish between airlines' efficiency and effectiveness, as well as different efficiency frontiers, several DEA sub-analyses are performed using slightly differentiated data sets, i.e. for efficiency, effectiveness and three airlines groups; all carriers, FSCs, and LCCs.

The DEA data set includes as inputs—labour (number of core business workers), fleet (number of operated aircraft) and fuel (in gallons consumed) and as outputs—ASKs, RPKs and revenue tonne kilometres (RTKs).

The DEA results are presented in Table 3. Overall, we see that LCCs perform better than full service airlines. The two exceptions are Air Tran and West Jet; both have very low efficiency and effectiveness scores. Their weaker performance or could be due to not being able to get the most of their inputs, or by the influence of factors not considered here. Among the full service companies, the lowest performance scores are for Aeroflot. In general, it is not possible to draw a simple conclusion, as to any correspondence between efficiency and effectiveness patterns. However, a number of airlines display best performance results (values of unity) in both efficiency and effectiveness cases (about 45% of these are LCCs). Geographic area of operations also seems to account for certain parallels. The majority of European and American carriers have higher effectiveness than Asia Pacific and China/North Asia airlines, which on their turn generally appear more efficient than effective. Similarly, the difference in performance between LCCs and FSCs is greater for European operators than for American ones. LCCs do not appear sensitive to either of these effects but are highly efficient across the board with no significant variations in their efficiency or effectiveness scores.

3.2. Total factor productivity analysis

We use three outputs and four inputs to look at TFP. Outputs are passenger service (measured in RPKs), cargo service (measured in RTKs) and ancillary output. This last measure includes items related to operations other than passengers and cargo and they were computed following Oum and Yu (1995). Hence, revenues are residuals of passengers and cargo services and quantities are calculated dividing residual revenues by the purchasing power parity (PPP) index obtained from Penn World Table. PPP was converted in euros and normalised to Germany's PPP.