An Assessment on the Cost Structure of the UK Airport Industry: Ownership Outcomes and Long Run Cost Economies

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Plan of the presentation

- Main aims of the paper
- Background of the sector
- Data
- The model
- Econometric strategy
- Scale economies measurement
- Empirical results
- Conclusions

Aims of the paper

1. Contributing to the literature on cost differentials associated to ownership forms in the airport sector.

The recent international empirical evidence seems to find that privately owned airports are sligthly more efficient (Oum et al., 2008) than those managed as government departments. In the case of the UK airport sector, some evidence that private airports are more efficient. However, this literature has completely ignored issues related to the endogeneity of ownership status.

Aims of the paper

2. Assessing the existence of scale economies in the sector.

The evidence on this issue is scant (Tolofari et al, 1990, Pels et al 2003 and Martin et al 2009), but seems to suggest an U-shaped average cost curve. Virtually all studies assume that airports minimize total costs and are in long run equilibrium (which is a strong assumption, likely to be violated and source of biases) and most do not consider commercial revenues.

Background

- The structure of the UK airport sector defined by the 1986 Airport Act. Before 1987 the large majority of airports was under public ownership (government or local authorities). In 1987 seven BAA airports were privatized.
- In the following years other airports were (partly) privatized while others were bought by local authority owned airports. Nowadays the sector is characterized by the presence of private, mixed and public airports.
- The four largest airports (Heathrow, Gatwick, Stansted and Manchester) have been regulated by the CAA with a price cap with important rate of return regulation features.

Background

Important recent policy issues in the sector:

- abuse of market power from BAA in the London and Scottish markets (divestiture of Gatwick);
- overinvestment by some BAA airports as a deterring entry strategy or as a consequence of the rate of return features of the regulatory regime;
- possible existence of diseconomies of scale for largest airports with implications for price regulation in the sector

Data

- The dataset is balanced panel of the largest 25 UK airports observed over the period 1994-2005
- The size distribution of the sample is highly skewed to the right for the presence of Heathrow and Gatwick. In terms of passengers, the mean (median) value, in 2005, is about 5 (2.5) millions. In 1994, 12 airports were public, 12 private and one mixed; in 2005 there were 13 private airports, 6 public and 5 mixed.

Data

Heathrow	Priv	Belfast	Priv
Gatwick	Priv	Cardiff	Pub (1994); Priv (1995-2005)
Stanstead	Priv	Luton	Pub (1994-97); Mix (1998-2005)
Southampton	Priv	Blackpool	Pub (1994-2003); Mix (2004-05)
Glasgow	Priv	Bristol	Pub (1994-97); Mix (1998-2000); Priv (2001-05)
Edinburgh	Priv	Durham	Pub (1994-2002); Priv (2003-05)
Aberdeen	Priv	Exeter	Pub
Manchester	Pub	Leeds-Bradford	Pub
Bournemouth	Mix (1994); Priv (1995-2000); Pub (2001-05)	Liverpool	Priv
Humberside	Pub	London City	Priv
East Midlands	Priv (1994-2000); Pub (2001-05)	Norwich	Pub (1994-2003); Mix (2004-05)
Birmingham	Pub (1994-96); Mix (1997-2005)	Southend	Priv
Newcastle	Pub (1994-2000); Mix (2001-05)		

The Model

- We have preferred the estimation of a variable over a total cost function because the former is not based on the assumption of total cost minimization (eq 1)

$$
\begin{aligned}
\ln VC_{it} = {} & \alpha + \sum_{j=1}^{J} \beta_j \ln p_{jit} + \sum_{n=1}^{N} \beta_n \ln y_{nit} + 1/2 \sum_{j=1}^{J} \sum_{s=1}^{J} \beta_{js} \ln p_{jit} \ln p_{sit} \\
& + 1/2 \sum_{n=1}^{N} \sum_{p=1}^{N} \beta_{np} (\ln y_{nit} \ln y_{pit}) + \sum_{j=1}^{J} \sum_{n=1}^{N} \beta_{jn} \ln p_{jit} \ln y_{nit} + \beta_k (\ln k_{it}) + \\
& + 1/2 \beta_{kk} (\ln k_{it})^2 + \sum_{j=1}^{J} \beta_{jk} (\ln k_{it} \ln p_{jit}) + \sum_{n=1}^{N} \beta_{nk} (\ln k_{it} \ln y_{nit}) + \\
& + \beta_m mix_{it} + \beta_p pub_{it} + u_{it}
\end{aligned}
$$

The Model

- Applying Shephard's Lemma to equation 1, it is possible to derive the following equation (2)

$$\frac{\partial \ln VC}{\partial \ln p_i} = \frac{\partial VC}{\partial p_i} \frac{p_i}{VC_i} = \frac{p_i X_i}{VC_i} = S_i$$

- Where S_i is the share of input i in total costs and X_{i} is the optimal conditional demand of input i. After appending an error term to the cost shares, the system made up of the cost function and the labour share can be estimated, after imposing the restrictions suggested by economic theory, with an efficient SURE procedure.

Estimation strategy

- The panel data nature of the dataset could be exploited by letting the disturbance term in the cost function to be specified as the sum of two independent components:

$$u_{it} = e_i + v_{it}$$

- We could use SURE fixed effects by inserting a set of airport dummies in the cost function. Prb: very low within group variability of outputs

Estimation strategy

- Other ways to control for unobserved heterogeneity:
- 1) $$u_{it} = \delta_{jt} + v_{it}$$
- where δ_{jt} is a full set of market-year fixed effects that proxy for time varying unobserved heterogeneity in the geographic market j where the airports operate. 5 markets (London, Scotland, Northern Ireland, Northern England, Centre, South East) or, alternatively, 12 regions.

Estimation strategy

- 2) $$u_{it} = \delta_{jt} + \Psi_g + v_{it}$$

- Where Ψ_g represents "group specific" dummy variables. The inclusion of Ψ_g in the cost function should make our results robust to the existence of unobserved heterogeneity associated to managerial ability and may also pick up correlations in the residuals of airports under common ownership.
- Heterosckedasticity problems: SURE-RE model:

$$u_{it} = \delta_{jt} + e_i + v_{it}$$

- Where $v_{it} \sim \mathrm{iid}(0,\ \sigma^2_{\mathrm{v}});\ e_i \sim (0,\ \sigma^2_{\mathrm{ei}})$

Estimation strategy

- Ownership endogeneity problems. Use SURE fixed effects or 3SLS:
  - run the following regression:

$$p_{it} = \gamma_1 \Pi_{it-1} + \gamma_2 VAG_{it} + \varphi_t + \xi_{it}$$

  - use fitted values as an instrument for priv using 3SLS

- Output endogeneity problems: instrument outputs with their one-year lagged values plus population

Scale economies measurement

- The estimation of a variable cost function allows one to compute long run elasticities as

$$\varepsilon_{y_i}^{TC} = \frac{\varepsilon_{y_i}^{VC}}{1 - \varepsilon_K^{vc}}$$

- Where $\varepsilon_{y_i}^{VC}$ is the elasticity of variable costs with respect to output

- and ε_k^{vc} is the elasticity of variable costs with respect to the capital stock.

Scale economies measurement

- In the case of a multiouput technology, long run scale economies can be computed as:

$$LrSE = \left(\sum_i \varepsilon_{y_i}^{LTC}\right)^{-1} = \left[\frac{\sum_i \varepsilon_{y_i}^{VC}}{1-\varepsilon_k^{VC}}\right]^{-1}$$

Scale economies measurement

It is important that elasticities are computed at the long run value of the capital stock k^* which is defined implicitly by the envelope condition as follows:

$$\frac{\partial STC}{\partial K^*} = \frac{\partial VC}{\partial K^*} + r = 0$$

- where STC=VC+rK is the short run total cost function, r is the price of capital and $\partial VC/\partial k^*$ is the shadow price of capital, which in equilibrium needs to be equal to its market price.

Scale economies measurement

- It can be interesting to compute also short run scale economies as:

$$SrSE = \left(\sum_i \varepsilon_{y_i}^{VC}\right)^{-1}$$

- Short run scale economies may be particularly relevant when computed in the case of industries with significant fixities and they tell us what happens to variable costs when output increases given the level of capacity.

Results

- The Shankerman-Nadiri test (1986) confirms that airports are not in long run equilibrium
- Some evidence of slight undercapitalization for small and medium airports; evidence of overcapitalization, in particular for the very large regulated airports.
- The dummy *priv* is negative and statistically significant in all models (with coefficients in the range of -0.11/-0.21). In a model with fixed effects, the coefficients drops to -0.08 but it is still statistically significant.

	Model 1-Base	Model 2- Out. endg	Model 3-Tech ch.		Model 4-4 Out
k	-0.087 (3.09)	-0.173 (3.87)	-0.067 (1.66)	k	-0.095 (3.65)
w	0.413 (54.4)	0.411 (51.7)	0.407 (25.42)	w	0.412 (57.23)
wlu	0.340 (8.26)	0.361 (5.55)	0.617 (10.39)	pax	0.301 (8.21)
com	0.296 (8.81)	0.303 (5.85)	0.207 (4.50)	$cargo$	0.020 (2.18)
atm	0.294 (5.45)	0.351 (3.68)	0.050 (0.59)	com	0.38 (12.21)
$priv$	-0.158 (5.77)	-0.171 (4.94)	-0.214 (7.37)	atm	0.197 (3.95)
k^2	0.202 (4.0)	0.213 (2.0)	0.192 (3.93)	$priv$	-0.145 (5.77)
w^2	-0.259 (3.88)	-0.258 (3.64)	-0.278 (3.94)	k^2	0.223 (4.12)
wlu^2	0.177 (4.22)	0.262 (3.23)	0.082 (1.93)	w^2	-0.300 (4.72)
com^2	0.071 (11.8)	0.071 (6.88)	0.050 (7.35)	pax^2	0.139 (2.00)
atm^2	0.204 (3.52)	0.041 (0.34)	0.217 (4.01)	$cargo^2$	0.001 (0.03)
$k * w$	-0.012 (-1.08)	-0.004 (0.29)	-0.011 (1.03)	com^2	0.088 (10.91)
$k * wlu$	0.006 (0.15)	0.098 (1.50)	0.090 (2.08)	atm^2	0.472 (4.31)
$k * com$	0.001 (0.05)	0.074 (0.71)	-0.028 (0.79)	$k * w$	0.005 (0.42)
$k * atm$	-0.248 (-4.31)	-0.499 (4.79)	-0.300 (5.33)	$k * cargo$	-0.003 (0.23)
$w * wlu$	-0.001 (0.06)	-0.001 (0.05)	0.001 (0.04)	$k * pax$	0.040 (1.02)
$w * com$	0.001 (0.39)	-0.006 (0.85)	0.001 (0.26)	$k * com$	0.031 (0.96)
$w * atm$	0.001 (2.67)	-0.001 (0.84)	0.001 (1.53)	$k * atm$	-0.362 (4.78)
$com * wlu$	-0.190 (3.80)	-0.486 (3.95)	0.096 (1.85)	$w * cargo$	-0.019 (4.07)
$atm * wlu$	0.001 (0.01)	-0.001 (1.61)	0.001 (0.48)	$w * pax$	0.005 (0.69)
$atm * com$	0.205 (4.52)	0.700 (4.45)	0.133 (2.78)	$w * com$	0.004 (0.86)
$trend$	-	-	-0.014 (1.17)	$w * atm$	-0.001 (2.95)
$trend^2$	-	-	-0.001 (0.87)	$pax * com$	-0.167 (3.94)
$trend * w$	-	-	0.001 (0.39)	$cargo * com$	-0.034 (2.80)
$trend * k$	-	-	0.002 (0.49)	$pax * atm$	-0.040 (0.50)
$trend * atm$	-	-	0.025 (3.10)	$cargo * atm$	-0.036 (1.88)
$trend * com$	-	-	0.008 (1.71)	$pax * cargo$	0.012 (0.98)
$trend * wlu$	-	-	-0.035 (5.45)	$atm * com$	0.217 (4.12)

	Model 5-Priv end.	Model 6. Group dum	Model 7-Re
	3SLS	SURE	SURE-RE
k	-0.103 (3.05)	0.003 (0.10)	-0.039 (1.09)
w	0.412 (48.0)	0.412 (54.3)	0.411 (54.5)
wlu	0.314 (5.54)	0.237 (5.58)	0.260 (5.07)
com	0.365 (6.43)	0.410 (12.41)	0.346 (8.40)
atm	0.242 (4.38)	0.086 (1.87)	0.204 (3.46)
$priv$	-0.144 (1.69)	-0.149 (2.31)	-0.114 (3.51)
k^2	0.214 (3.45)	0.143 (3.10)	0.255 (5.31)
w^2	-0.171 (2.34)	-0.343 (5.32)	-0.261 (3.98)
wlu^2	0.156 (3.11)	0.067 (1.87)	0.114 (2.84)
com^2	0.199 (2.71)	0.064 (9.63)	0.066 (9.97)
atm^2	0.123 (1.86)	0.154 (3.20)	0.164 (3.15)
$k * w$	0.011 (0.79)	-0.011 (1.04)	-0.009 (0.84)
$k * wlu$	0.062 (1.16)	-0.108 (2.94)	-0.108 (2.72)
$k * com$	-0.028 (0.47)	0.014 (0.36)	-0.012 (0.33)
$k * atm$	-0.330 (4.56)	-0.022 (0.46)	-0.071 (1.24)
$w * wlu$	0.002 (0.23)	0.003 (0.34)	-0.004 (0.52)
$w * com$	-0.029 (2.08)	0.001 (0.28)	0.003 (0.68)
$w * atm$	-0.001 (0.14)	-0.001 (3.67)	-0.001 (1.90)
$com * wlu$	-0.264 (3.68)	0.020 (0.40)	-0.084 (1.56)
$atm * wlu$	-0.001 (2.75)	0.001 (1.58)	0.001 (0.22)
$atm * com$	0.355 (4.91)	-0.054 (1.20)	0.073 (1.57)

Results: technical change

- The model with the inclusion of a time trend specification suggests a positive technical change (defined as the rate at which all inputs can be reduced for a given level of outputs)

$$TC = -\frac{\partial \ln VC / \partial t}{1 - \partial \ln VC / \partial \ln K}$$

Technical change estimates

	Full sample	Priv	Pub-mix
1994-95	0.028***	0.033***	0.020
1995-96	0.028***	0.031***	0.024**
1996-97	0.018***	0.019**	0.017**
1997-98	0.015***	0.015**	0.017**
1998-99	0.019***	0.017***	0.024***
1999-00	0.020***	0.016***	0.027***
2000-01	0.017***	0.011***	0.026***
2001-02	0.018***	0.010	0.031***
2002-03	0.019***	0.010	0.034***
2003-04	0.016**	0.006	0.031***
2004-05	0.021**	0.008	0.040***

Results: technical change

- We have also allowed the trend to take on different values for private and public-mixed airports by interacting *trend* and *trendsq* with the dummy *priv*.
- Results suggests that the average rate of cost reduction for private airports declined over time, with an average rate of about 1.6%; for public-mixed airports, the rate of cost reduction increased over time, with an average of about 2.6%. If we include in the model a full set of airport fixed effects the pattern is confirmed.

Results: time varying ownership cost differential

- By interacting *trend* and *trendsq* with the dummy priv we also allow the ownership cost differential to follow a quadratic trend:
- The ownership cost differential shrank over the sample period but it remained significant even in the last sample years.
- However, in a model with fixed effects, the pattern is confirmed but in the last years we can not identify any cost differential associated to ownership

Results time varying ownership cost differential

- We have also considered whether the time pattern in technical change differs between mixed and public airports, by interacting *trend* and *trendsq* with the dummies *pub* and *mix*.
- In a model with fixed effects, the pattern of technical change is broadly similar for public and mixed airports, and the cost differential with respect to private airports shrank over time so that it was about zero in the most recent years.

Cost economies

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
10^{th}	1.88***	3.01***	1.79***	1.71***	2.37***	1.84***	1.89***
25^{th}	1.49***	1.78***	1.53***	1.55***	1.71***	1.59***	1.54***
50^{th}	1.26***	1.38***	1.22***	1.69***	1.34***	1.25***	1.28***
75^{th}	1.06	1.11*	1.10**	0.96	1.06***	1.18***	1.14**
90^{th}	0.84***	0.64***	0.90*	0.74***	0.72***	1.05	0.96

***-sign 1%; **-sign 5%; *-sign 10%. H_0 = ES are costant

Cost economies: robustness checks

	10^{th}	25^{th}	50^{th}	75^{th}	90^{th}	95^{th}
atm	1.83***	1.39***	1.16***	1.05	0.84***	0.79***
wlu	1.72***	1.40***	1.24***	1.08**	0.86**	0.79***
pax	3.13***	1.54***	1.50***	1.00	0.92*	0.82***

	small	medium	large
atm	1.66***	1.12***	0.82***
wlu	1.67***	1.14***	0.82***
pax	1.67***	1.15***	0.82***

***–sign 1%; **–sign 5%; *–sign 10%. The null hypothesis is that scale economies are constant

Estimates for atm,and wlu from Model 1; estimates for pax from Model 4

Scale economies: short run

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
10^{th}	1.82***	2.77***	1.74***	1.81***	2.49***	1.90***	1.82***
25^{th}	1.44***	1.53***	1.47***	1.52***	1.64***	1.71***	1.47***
50^{th}	1.07*	0.98	1.15**	1.11*	1.08*	1.36***	1.23***
75^{th}	1.03	0.97	1.13**	0.92	1.00	1.23*	1.10
90^{th}	0.91	0.67***	1.04	0.81**	0.74***	1.17*	0.93

***-sign 1%; **-sign 5%; *-sign 10%. H_0 = ES are costant

Cost economies

- Economies of scale tend to gradually decrease with the scale of operations, with values ranging on average between 2.08 at the 10th percentile and 0.84 at the 90th
- Overall results suggest the presence of scale economies at least up to the 75th percentile (which corresponds to an airport with about 5.6 million passengers).
- Largest airports tend to experience diseconomies of scale starting on average between the 80th and the 90th percentile, i.e. for an airport with about 14 million passengers

Main results and policy implications

1. We find that, on average, private airports have been more efficient than public-mixed ones; however, the cost differential has shrunk over time because the latter were able to cut costs more aggressively (perhaps more slack in public-mixed airports that was cut when competition increased in the 2000s?)
2. We find some evidence of overcapitalization for regulated airports.

Main results and policy implications

3. Large airports are operating in a region characterized by diseconomies of scale: this suggests that we should expect they would set prices higher than average costs, but the price scheme is in practice a sort of average price regulation.
4. When setting X for large airports, regulators should be aware they may operate under diseconomies of scale and modify the formula accordingly.

Main results and policy implications

5. Smaller airports operate in a region with significant scale economies: policymakers should consider this when required to decide on the construction of new airports that are unlikely to get to the efficient scale of operations, because the presence of non negligible scale economies may push up average costs, potentially leading to inefficient entry.