Economies of Spatial Scope in a Deregulated Airline Industry

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1. Introduction

1. The liberalisation process implemented by the European Commission changed conditions in which European airlines operated in the market.

2. Over a period of ten years: (December 87-April 97):

   - Deregulation opened domestic markets in all European countries to any European company.
   - Legal monopolies and government aids for airlines disappeared.
   - Most companies have now been privatised

3. The open sky policy has led companies to an important restructuring of their productive processes.

Figure 2. Average productivity per employee (Ton-km flown/number employees)

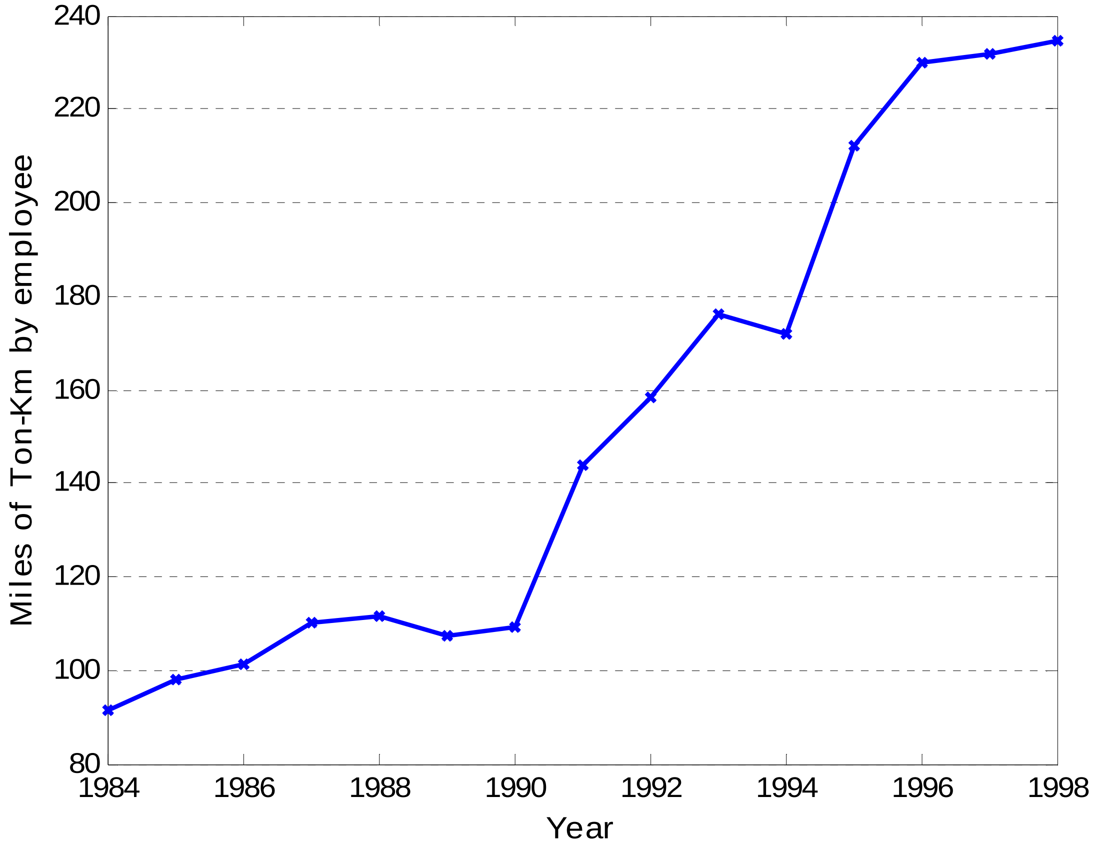
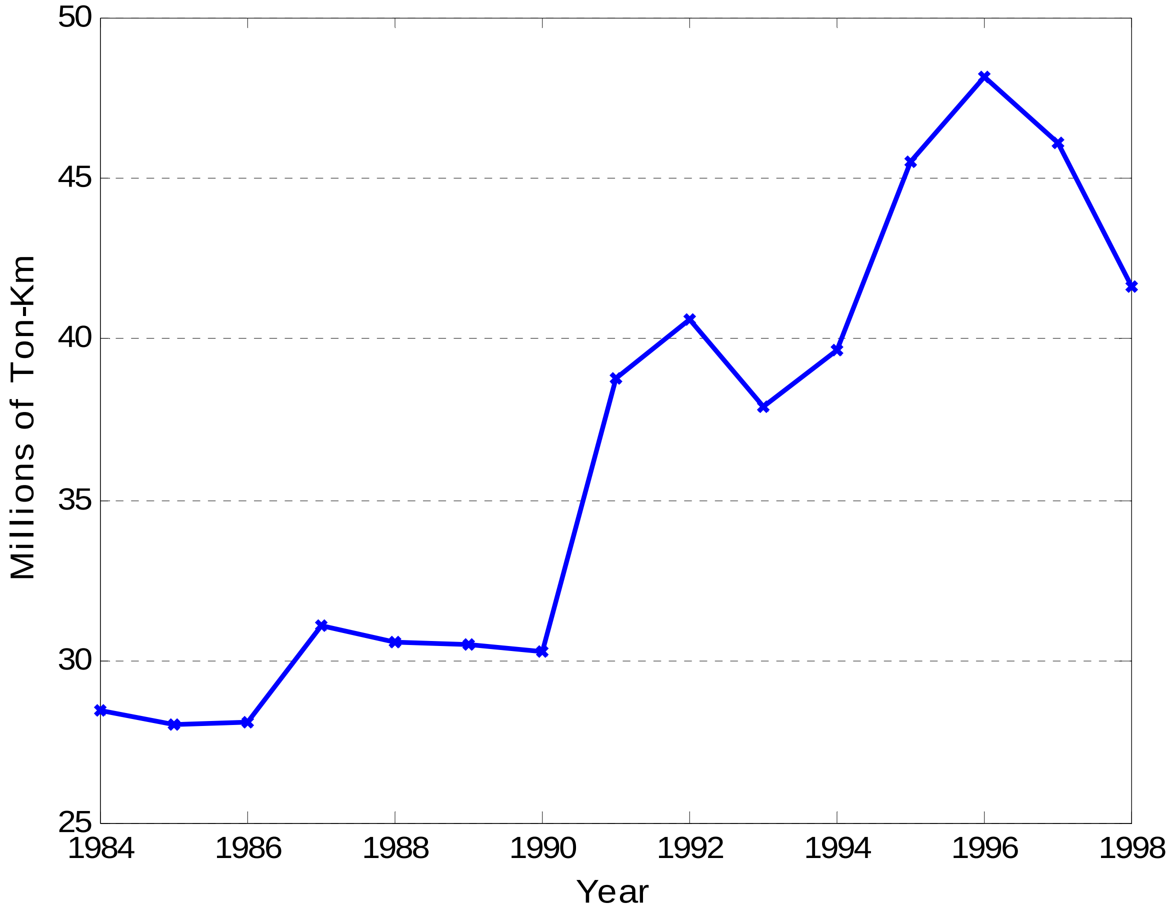


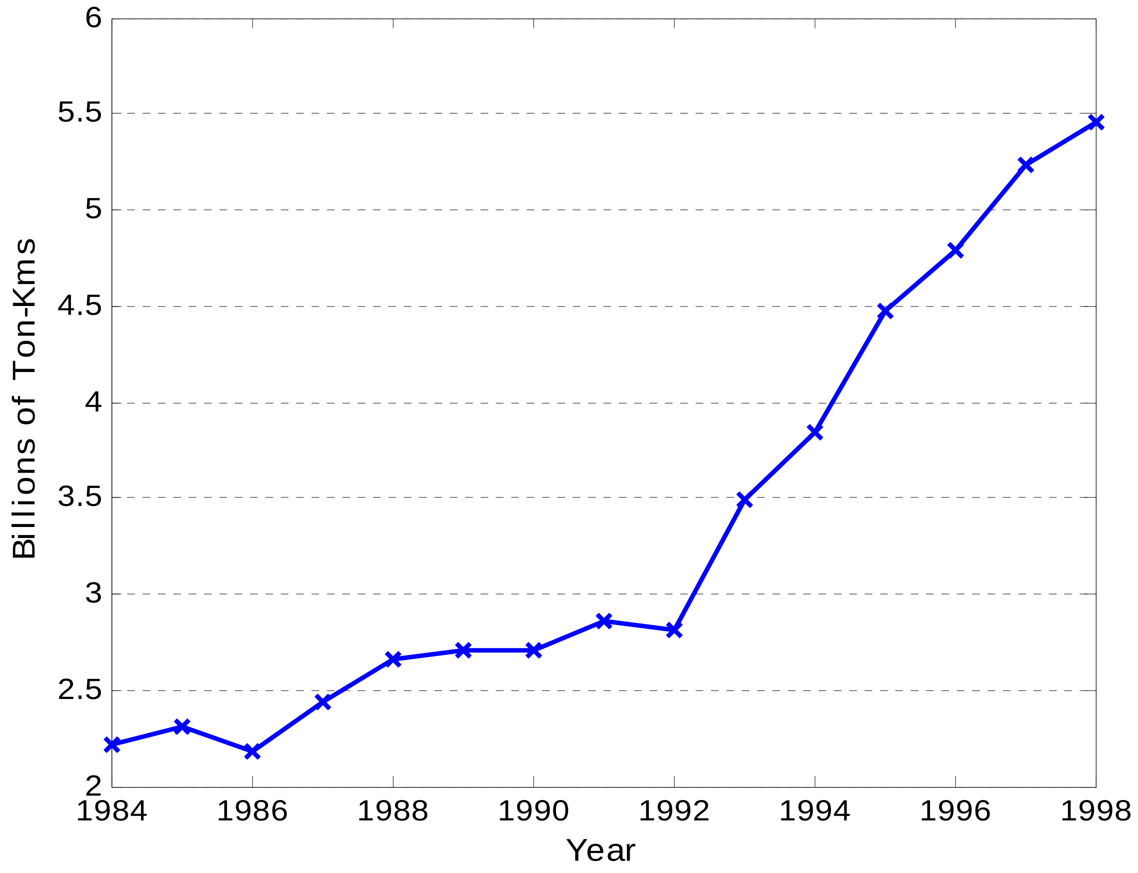
Figure 3. Average productivity per plane (Ton-km flown/number planes)



1. Introduction

4. During the period considered in this study all carriers in the data sample increased production considerably.
5. The growth was especially important in the 1990's. See FIG 1
6. Companies with the highest growth were: Virgin, KLM, British Midland, and Austrian.
7. Air France, Alitalia, British Airways, Finnair, and Lufthansa nearly tripled their production.
8. By expanding the set of products in new markets, companies became more attractive to customers and were able to exploit Economies of Scale.
9. Alliances allowed companies to:
    1. offer consumers denser routes,
    2. share cost and slots with other carriers,
    3. and avoid antitrust policies.
10. Some of these alliances converged in definitive mergers, as in the cases of <u>Lufthansa and SwissAir</u>, or <u>Air France and KLM</u>.

Figure 1. Average production for the sample 1984-98 (Ton-kms flown)



1. Introduction

11. The main objective of this paper is to determine whether the market strategies followed by European carriers are simply a consequence of marketing policies, or if there are also Economies of Scale annd Scope in costs associated with the expansion of production.

12. By modelling cost performance of European airlines with a translog cost function, we are able to determine the existence Economies of Density, Economies of Network Size and Economies of Spatial Scope for each company during the period of deregulation.

13. With these different indicators we are able to contribute with information that can help to explain the behavior of firms, and to anticipate the possible evolution of the market in the future.

14. However, we do not believe that this information is the only way to explain the behavior of companies in the market.

2. The Model.

1. To answer our question we are estimating a cost function for the European airline industry. In order to avoid the effect of other industries and regulations on our model, we only include European airlines.

2. The sample is a data panel for fourteen airlines and covers the whole period of the deregulation process in Europe.

3. We have data available from 1984 to 1998.

4. The production of these fourteen airlines is around 73% of the total European industry production for 1998.

Table 1: Description of the Industry (data 1998)

Carrier	***Ton-kms flown (000) (1)***	***Number of employees (2)***	***Number of planes***	***Kilometres flown***	***Number of routes***	***Number of Departures***	***Productivity by employee (1)/(2)***	***Hours flown per plane***
Air France	**12.239.557**	**49.092**	**203**	557.483.000	769	402.966	249.319	4.102
Alitalia	(*)5.064.512	15.501	147	299.985.000	569	278.703	326.722	3.689
Austrian	811.045	4.561	35	64.397.000	194	42.969	177.822	3.115
Brit Airw.	**15.481.175**	**55.751**	**280**	**595.864.000**	572	326.893	277.684	3.318
Brit Mid.	300.734	5.548	48	47.763.000	59	95.955	54.206	2.583
Finnair	1.441.919	9.003	57	107.394.000	189	121.532	160.160	3.323
Iberia	3.688.248	23.966	112	244.695.000	463	144.235	153.895	3.656
Klm	9.714.433	27.303	113	299.546.000	582	156.714	355.801	3.948
Lufthansa	**13.935.046**	**34.246**	**295**	**586.942.000**	1.053	502.569	406.910	3.410
Olympic	940.239	7.356	56	70.053.000	184	95.415	127.819	2.473
Sas	2.646.866	20.713	179	255.713.000	356	336.729	127.788	2.719
Swissair	4.927.396	17.111	68	219.951.000	402	165.135	287.967	4.986
Tap	1.103.253	8.500	34	78.590.000	210	53.730	129.794	3.568
Virgin	2.873.822	5.032	24	81.475.000	56	11.986	571.109	4.305

•*(*) = production of year 1997.*

2. The Model

5. We model both **total cost** (TC) and **variable cost** (VC) functions.

$$TC = f(Y, W, Q, T) \qquad VC = f(Y, Wv, Q, Z, T)$$

6. For both cost functions, we use a vector of two products (Y), **passenger-kilometers and freight-kilometres flown**, measured Tonnes both.

7. For the total cost function we use prices for four inputs (W): **energy, labour, materials and capital**.

8. In the variable cost function, we substituted the price of capital by the **number of planes** (Z) as a proxy of the size of the company.

9. As the vector of production is an aggregate measure of the real vector, we have added a set of variables (Q) to qualify the production in order to introduce more information about the production characteristics of the different carriers (Spady and Friedlander, 1978).

2. The Model

10. These variables are:
    - the **average stage length**, (A),
    - the **load factor** (L)
    - and the **number of routes served** (N).

11. **The number of routes served generates a more accurate measure of the Network Size** than number of points served, used before in the literature.

12. Suppose we have two air carriers with the same vector of production, input prices, and number of points served, but with different numbers of routes served.

13. Even when both have the same number of airports, they do not have the same network.

14. Finally we add a **time trend variable** (T) in order to capture how costs have changed over time.

2. The Model

- $$\ln TC(Y,W,Q) = \alpha_o + \sum_{i=1}^{n}\beta_i \ln(y_i/\overline{y}) + \sum_{i=1}^{m}\lambda_i \ln(w_i/\overline{w}) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij}\ln(y_i/\overline{y})\ln(y_j/\overline{y}) +$$
$$+\frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \lambda_{ij}\ln(w_i/\overline{w})\ln(w_j/\overline{w}) + \sum_{i=1}^{m}\sum_{j=1}^{n} \psi_{ij}\ln(w_i/\overline{w})\ln(y_j/\overline{y}) +$$
$$\sum_{i=1}^{r}\delta_i \ln(q_i/\overline{q}) + \frac{1}{2}\sum_{i=1}^{r}\sum_{j=1}^{r} \partial_{ij}\ln(q_i/\overline{q})\ln(q_j/\overline{q}) + \sum_{i=1}^{r}\sum_{j=1}^{n} \mu_{ij}\ln(q_i/\overline{q})\ln(y_j/\overline{y}) + \sum_{i=1}^{r}\sum_{j=1}^{m} \rho_{ij}\ln(q_i/\overline{q})\ln(w_j/\overline{w}) +$$
$$\gamma\ln(T/\overline{T}) + \kappa\ln(T/\overline{T})(T/\overline{T})$$

2. The Model

- $$\ln VC(Y,W_v,Q,Z) = \alpha_o + \sum_{i=1}^{n} \beta_i \ln(y_i / \overline{y}) + \sum_{i=1}^{m} \lambda_i \ln(w_i / \overline{w}) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \beta_{ij} \ln(y_i / \overline{y}) \ln(y_j / \overline{y}) +$$
$$\frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \lambda_{ij} \ln(w_i / \overline{w}) \ln(w_j / \overline{w}) + \sum_{i=1}^{m}\sum_{j=1}^{n} \psi_{ij} \ln(w_i / \overline{w}) \ln(y_j / \overline{y}) +$$
$$\theta \ln(Z / \overline{Z}) + \frac{1}{2}\theta \ln(Z / \overline{Z})^2 + \sum_{i=1}^{n} \nu_i \ln(Z / \overline{Z}) \ln(y_i / \overline{y})) + \sum_{i=1}^{m} \varphi_i \ln(Z / \overline{Z}) \ln(w_i / \overline{w})$$
$$\sum_{i=1}^{r} \delta_i \ln(q_i / \overline{q}) + \frac{1}{2}\sum_{i=1}^{r}\sum_{j=1}^{r} \partial_{ij} \ln(q_i / \overline{q}) \ln(q_j / \overline{q}) +$$
$$\sum_{i=1}^{r}\sum_{j=1}^{n} \mu_{ij} \ln(q_i / \overline{q}) \ln(y_j / \overline{y}) + \sum_{i=1}^{r}\sum_{j=1}^{m} \rho_{ij} \ln(q_i / \overline{q}) \ln(w_j / \overline{w}) + \sum_{i=1}^{r} \eta_i \ln(q_i / \overline{q}) \ln(Z / \overline{Z}) +$$
$$\gamma \ln(T / \overline{T}) + \kappa \ln(T / \overline{T})(T / \overline{T})$$

2. The Model

15. Using Shephard's Lemma (Shephard, 1953), taking the derivative of cost function we are able to obtain the share cost equation for each input. For the total cost function, we obtain four share cost equations as follows:

$$S_i^{TC} = \frac{\partial \ln TC(Y,W,Q)}{\partial \ln w_i} = \lambda_i + \sum_{i=1}^{m} \lambda_{ij} \ln(w_i / \overline{w}) + \sum_{j=1}^{n} \psi_{ij} \ln(y_j / \overline{y}) + \sum_{i=1}^{r} \rho_{ij} \ln(q_i / \overline{q}) \qquad \forall_i = 1,..,4$$

16. For the variable cost system we have one equation less. In this case, the share equations have the following structure:

$$S_i^{VC} = \frac{\partial \ln VC(Y,W,Q,Z)}{\partial \ln w_i} = \lambda_i + \sum_{i=1}^{m} \lambda_{ij} \ln(w_i / \overline{w}) + \sum_{j=1}^{n} \psi_{ij} \ln(y_j / \overline{y}) + \sum_{i=1}^{r} \rho_{ij} \ln(q_i / \overline{q}) + \varphi_i \ln(Z / \overline{Z}) \qquad \forall_i = 1,..,3$$

2. The Model

17. We estimate the model using Zellner's SUR method (Zellner, 1962), running a system of equations composed of the main cost equation, either the total or variable cost function, and the share cost equations.

18. Once we have obtained cost elasticities for the vector of production, we are able to obtain the Scale elasticity in order to characterize the technology for the European airline market (Panzar and Willig, 1977).

19. In order to compare our results with those obtained in the literature, we maintain the same definition of Economies of Density (*ED*) as in Caves et al (1984). We use the same definition that these authors used for Economies of Scale, but because we include the number of routes, we call this estimator Economies of Network Size (*ENS*).

2. The Model

20. ***ED*** indicates how production increases when all inputs increase in a fixed proportion. This is under the assumption of a radial analysis, and therefore holds the proportion of production vector constant,

21. ***ENS*** indicates how production increases proportionally with respect to inputs when the number of routes served increases proportionally.

$$ED_i = \frac{C(W,Y)}{\sum_i \frac{\partial C(W,Y)}{\partial Y_i} Y_i} = \frac{1}{\sum_i \frac{\partial C(W,Y)}{\partial Y_i} \frac{Y_i}{C(W,Y)}} = \frac{1}{\sum_i \pi_{y_i}}$$

$$ENS_i = \frac{1}{\sum_i \pi_{y_i} + \pi_{N_i}}$$

2. The Model

22. As we are able to estimate the total and variable cost functions, we can also obtain *EDi* and *ENSi* by using the results of the estimated variable cost function. In order to do so, we need to make the following changes:

$$ED_i^{CV} = \frac{1-\pi_Z}{\sum_i \pi_{y_i}}$$

$$ENS_i^{CV} = \frac{1-\pi_Z}{\sum_i \pi_{y_i} + \pi_{N_i}}$$

23. where πZ is the cost elasticity of Z, the vector of fixed inputs.

2. The Model

- ***The Economies of Spatial Scope***

24. Consider the case in which a company that serves two airports has the following real vector of production **YA**. When adding a new airport, the vector of potential products would change to **YD**.

Y*A=(y12,y21,0,0,0,0)*.
Y*D=(y12, y21, y13, y31, y23, y32)*.

25. We consider the question of whether it is less expensive for the company to produce all the routes together, or to create a new company for the new routes with the production vector **Y*B***, comparing the cost of producing separately *C(YA)+C(YB) with the cost of producing jointly C(YD).*

- Y*B=(0,0, y13, y31, y23, y32)*,

26. We can answer this question by considering whether the company has Economies of scope for that partition of the production (Panzar and Willig, 1981).

27. **In that case, there would Economies of scope if the cost of producing jointly is lower than the cost of producing separately in two firms.** The indicator for this is as follows:

2. The Model

$$ESS_i = \frac{1}{C(Y_i^D)}\left[C(Y_i^A) + C(Y_i^B) - C(Y_i^D)\right]$$

28. In our case if, *ESSi >0,* then there are Economies of Spatial Scope in the firm *i* with respect to partition *YA*, *YB* of the total production vector *YD*.
29. However, the information available to calculate *ESS* is incomplete. We know the aggregate vector of production for the scenario *A*, but not for scenarios *B or D*.
30. In order to estimate the cost corresponding to these new points, **we need** to have an estimate of the **number of routes** and the **total production** for points *B* and *D*.
31. One alternative **proposed by Basso and Jara (2005)** is to calculate the new aggregate level of production *YD* required to hold the **Density (d) of the actual routes served constant**.

2. The Model

32. The Density can be calculated by dividing the total number of passengers carried on each route by the number of routes served (NR).

$$d = \frac{\sum_i \sum_j y_{ij}}{N_R}$$

$$Alh = \frac{Y}{\sum_i \sum_j y_{ij}}$$

$$d = \frac{Y}{Alh \cdot N_R}$$

33. Basso and Jara-Díaz (2005) propose two alternatives: **simply hold *Alh* constant, or estimate Alh as a function of the number of points served**. They did not find large differences in the results when comparing the two cases.

34. In our case **we assume that *Alh* is held constant**. By doing so, we are able to calculate the aggregate level of production for *B* and *D*, holding the Density of the network constant, as follows:

2. The Model

$$d = \frac{Y^A}{Alh \cdot N_R^A} = \frac{Y^D}{Alh \cdot N_R^D}$$

$$Y^D = \frac{N_R^D}{N_R^A} Y^A$$

35. Once we have calculated YD, we can calculate YB as the difference between YD and YA.
36. Basso and Jara-Diaz (2005) develop this expression as a function of the number of points served instead of the number of routes, as we do.

$$Y^D = \frac{(N_P^A + 1)}{(N_P^A - 1)} Y^A$$

2. The Model

37. The difference is that they calculate the Economies of scope for a larger number of routes served - the total number of possible combinations - which is in general a bigger number than the real number of routes served.

38. Since we are using the real number of routes served as an estimation of Network Size, we hold the proportion between the real and the potential number of routes served constant for each company.

39. Hence, the number of new routes added to the network when a new airport is included is estimated by:

$$N_R = R \cdot N \cdot (N-1)$$

40. where
    1. *N(N-1)* is the number of potential combinations when N airports are in the network and
    2. *R* is the proportion of real use of routes. In our case we estimate *R* by calculating the average use of the potential number of routes, given the number of airports that each firm serves during each year of the sample.

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3. The Results

- **Results**

Table 2: Estimated Total Cost Functions

	Coefficient	Std. Error	t-Statistic	Prob.
Total Cost Function				
Passengers	**0.7247**	0.0312	23.2241	0.0000
Freight	**0.0784**	0.0272	2.8803	0.0041
Energy	0.1129	0.0021	54.0665	0.0000
Personal	0.2971	0.0044	67.5276	0.0000
Other Materials	0.5329	0.0034	157.8914	0.0000
Capital	0.0572	-	-	-
*Passenger*Freight*	0.0751	0.0180	4.1730	0.0000
Average Stage Length	-0.9530	0.0333	-28.5862	0.0000
Load Factor	-0.6317	0.1407	-4.4898	0.0000
Number Of Routes	0.1272	0.0398	3.1915	0.0015
Time	-0.0726	0.0189	-3.8454	0.0001
*Time*Time*	-0.0365	0.0116	-3.1389	0.0018

3. The Results

Table 2: Estimated Variable Cost Functions

	Coefficient	Std. Error	t-Statistic	Prob.
Passengers	0.4415	0.0494	8.9415	0.0000
Freight	0.0892	0.0272	3.2775	0.0011
Energy	0.1246	0.0023	53.0421	0.0000
Personal	0.3152	0.0052	60.8879	0.0000
Other Materials	0.5602	-	-	-
*Passenger*Freight*	0.2387	0.0689	3.4614	0.0006
Average Stage Length	-0.5788	0.0502	-11.5280	0.0000
Load Factor	-0.3536	0.1373	-2.5758	0.0102
Number Of Routes	0.1185	0.0398	2.9780	0.0030
Capital	0.3269	0.0431	7.5847	0.0000
Time	-0.1006	0.0520	-1.9338	0.0536
*Time*Time*	0.3332	0.1833	1.8174	0.0696

3. The Results

Table 4: Economies of Scale and Network Size

	ED	***p-value (ED<1)***	***ENS***	***p-value (ENS<1)***
Industry using TC Function	1.25	0.0000	1.07	0.0035
Industry using VC Function	1.27	0.0006	1.04	0.1269
By Firm [(1)]				
Air France	1.28	0.0002	1.26	0.0005
Alitalia	1.31	0.0000	1.23	0.0000
Austrian	1.49	0.0000	1.02	0.3799
British Airways	1.10	0.0455	1.18	0.0185
British Midland	1.15	0.0326	1.65	0.0141
Finnair	1.17	0.0009	1.21	0.0046
Iberia	1.50	0.0000	1.28	0.0000
Klm	1.17	0.0014	1.04	0.1134
Lufthansa	1.19	0.0024	1.19	0.0060
Olympic	1.35	0.0000	1.46	0.0012
Sas	1.17	0.0018	1.32	0.0000
Swissair	1.20	0.0000	1.01	0.4095
Tap	1.41	0.0000	1.08	0.1456
Virgin	1.05	0.2294	0.84	0.9954

(1) Using Total Cost Function

3. The Results

Table 5: Economies of Spatial Scope

	ESS
Air France	-0.0030
Alitalia	0.0000
Austrian	-0.0138
British Airways	-0.0029
British Midland	**0.1496**
Finnair	-0.0020
Iberia	**0.0091**
Klm	-0.0038
Lufthansa	-0.0027
Olympic	**0.0157**
Sas	**0.0056**
Swissair	-0.0094
Tap	-0.0087
Virgin	-0.0500

In bold Economies of Spatial Scope.

4. Conclusions

1. For most air carriers we have found evidence that Economies of Density and Economies of Network Size exist in the European airline industry. Our results also show the existence of Economies of Spatial Scope for some companies in the sample.

2. The exploration of the data and the inclusion of a time trend in our econometric model show an **important break in the tendency of productivity and cost in the year 1992,** probably as a result of the deregulation measures implemented to cover handicaps of companies. **This process allows companies to adapt their respective productive processes to the new, competitive conditions in the market.**

3. These results allows us to answer affirmatively the question that guides this research, and to provide evidence **that expansion strategies of firms are related not only to marketing and demand behavior, but also to firms' cost structures.**

4. Regulatory agencies can expect firms to continue developing strategies that help them to take advantage of the available **Economies of Scale**, which will likely continue **increasing the concentration** in the airline industry.

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