A Comparative study of the technical efficiency for Spanish Airports for the periods1992-94 and 2009-11

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A COMPARATIVE STUDY OF THE TECHNICAL EFFICIENCY FOR SPANISH AIRPORTS FOR THE PERIODS 1992-94 and 2009-11

INTRODUCTION:

In this age of global travel airports are worldwide seen by international travelers as the gateways to tourism or business in other countries or geographic zones. As a passenger stepping off a plane we tend to view airports less as operating or potentially profit-earning entities and more as hubs of activity which serve to improve our travel experience in terms of services.

The positive or negative impact of on our "so-called" travel experience at an airport is of overwhelming importance for the tourist sector and more so for a country like Spain for which the services sector and tourism represents such an important source of income and employment.

A delay in the delivery of luggage or alternatively bad transport communications with the desired destination are just two examples of the possible mishaps which the "first-time" tourist may encounter as the downside or negative of the airport experience. Just in terms of passengers whether or not these problems are a result of mismanagement or sheer inefficiency the result is an unsatisfied tourist who may on a future occasion refrain from using that airport in preference for another or even an alternative destination. Drawing a parallel with airlines instead of passengers, problems with traffic control , maintenance, continuous delays to name but a few, may deter airlines from using certain airports for their routes as airport inefficiencies invariably reflect on their own business and are perceived by their passengers as corresponding to them as airlines. The upshot is that the loss of passengers, airlines or air cargos for whatever reason, results in a reduction in the use of infrastructure and services which contribute towards making airports profitable entities.

AIRPORTS AND TECHNICAL EFFICIENCY:

Until relatively recently, airport transport has in general been a highly regulated sector due to motives such as national defence, being a public service, national security and other non-commercial reasons. However over the last decades there arose a generalised opinion that regulation could have contributed to important losses of efficiency in the services offered by airports. As a result there has been an increasing body of thought calling for greater privatisation of the sector. These privatisation and deregulation measures have been cited as the reason behind the increase in efficiency and drop in transport prices. However evidence still exists today with respect to problems of congestion and increasing numbers of travelers which have occasioned management and planning problems in many airports. (Gonenc y Nicoletti, 2000; Betancour y Jorge 1999).

Services undertaken in airports can generally be classified by groups: operative services such as the air traffic control system, telecommunications, maintenance etc.), handling services for loading or unloading luggage or the boarding of passengers and lastly commercial services. The privatisation process of many of these services (involving the activity of outsourcing) has established as one of its

principal objectives the improvement of efficiency in airport management. In line with other types of transport measuring efficiency for airports can prove fairly complicated given the difficulty in deciding upon a feasible model to include the inputs and outputs which most truly reflect the production of the sector together with the absence of market prices.

OBJECTIVE OF THE STUDY:

The present study seeks in a simple way to examine the technical efficiency in terms of changes or an overall trend relating to 38 Spanish airports for two periods 1992-1994 and 2009-2011. Given the twenty year time span it seems reasonable to offer a brief historical perspective of Spanish airports and their current somewhat precarious situation.

The results of the present paper support the findings of a study undertaken by the Foundation for Applied Economic Studies (Fundación de Estudios de Economía Aplicada (henceforth referred to as Fedea). The latter presented the 2011 panorama of Spanish airports in terms of viability and social welfare as well as classifying the AENA airports in terms of traffic, number of routes with the greatest demand and financial situation. Some of the more general findings are commented in the second part of the historical perspective section which follows below.

One thing is certain inefficiency of any kind may be maintained in the short-term but perpetuated on a longer-term horizon it results in the loss of profits and economic viability. Many entities and in particular the majority of Spanish airports have survived due to the subsidies granted to them either by the government or the autonomous communities. With the current economic crisis and the government´s austerity measures technical, economic and allocative efficiency prove of utmost importance and Spanish airports are in this sense appropriate candidates for analysis.

A HISTORICAL PERSPECTIVE OF THE INSTITUTIONAL FRAMEWORK:

As a backdrop to the Spanish airports of the early 1990´s it is important to mention the creation of the public but autonomous Company denominated Ente Público de Aeropuertos Españoles y Navegación Áerea (AENA). The latter´s principal objective was the responsibility for the administration and privatisation process of Spanish airports. One of its principal achievement has been the introduction of private financing and the liberalization of activities for handling (many of the latter are now put out to tender to specialist companies (particularly subsidiaries belonging to major Spanish construction groups). All in all the introduction of the private sector in airport operations has given rise today to the so-called commercial airport model. Today 20 years on the latter model still continues to be the centre of attention.

With 46 million inhabitants and 17 autonomous communities divided into 50 provinces (excluding Ceuta) and Melilla, Spain had 52 airports(at the time of the second part of the study), 90% of which are managed by AENA. Very few, with the exception of Ciudad Real, Lerida o Castellon and more recently the new but unopened airport of Corvera in Murcia, have been promoted by the autonomous communities, local entities and the private sector. Of those managed by the Public Entity, only eight aerodromes are officially profitable and over 20 have another airport at less than

an hour by road. Germany with a population (81 million inhabitants) almost doubling that of Spain does not require more than 39 airports.

Although Madrid and Barcelona are as expected the airports with most passenger and cargo traffic, in December 2011 a study using public data undertaken by Fedea (mentioned previously) confirmed that only eight of the 47 airports managed by AENA presented positive operating results: Palma de Mallorca, Malaga, Gran Canaria, Alicante, Tenerife Sur, Girona, Bilbao y Murcia.

Of the 39 deficit airports, Fedea saves another thirteen considered “necessary” because they absorb a large proportion of passenger and cargo traffic although they cannot be considered efficient. In view of this scenario a debate exists as to whether or not there is a need to renew these airports management models with a view to achieving operating profits. This is the case for Madrid-Barajas, Barcelona, Valencia, Lanzarote, Ibiza, Tenerife Norte, Sevilla, Fuerteventura, Menorca, Santiago de Compostela, Reus, Zaragoza y Vitoria. The last two airports are justified because they ranked third and fourth in cargo traffic for the year 2011, only surpassed by Madrid and Barcelona.

With the study data, the balance of the Spanish airport map is not sustainable with the immense price which Spain has to pay in order to maintain 26 totally ruinous airports which ironically have other alternative airports situated at less than an hour by car. Castellon for example with an initial cost of EUR 151 million and without having received any flights in the nine months following its inauguration, is less than 100 kilometers from Manises Airport in Valencia.

In 2011, the airport of Huesca with an investment of EUR 60 million aimed at capturing 160,000 passengers per year, only received 2781 passengers during the entire year. This was a ridiculous number of visitors who could have used the more proximate airport of Zaragoza at a distance of only 97 kilometres.

More than half of the airports have at least one other airport close by at less than 130 kilometeres i.e. Girona, Barcelona, Reus, Valladolid, Salamanca, Alicante, Murcia, Granada y Malaga. In other cases passengers can choose between two (Santiago de Compostela, Vigo, Coruña) at an hour and half by road. One of the most outstanding cases is the airport of Vitoria, surrounded by five airports not counting its own: Bilbao (at 73 kilometres), San Sebastián (117), Pamplona (119), Burgos (116) and Logroño (116). In this case a study should be taken as to the viability of the airport which is ranked one for the least movement in passengers (48 passengers daily in 2010). It is only surpassed by Córdoba (8.442 passengers), Albacete (8.415) and Huesca (2.781).

With the air traffic data for 2011 and taking into account that many of the airports are being maintained thanks to the subsidies of the autonomous communities, there is an obvious need to reflect upon whether the lack of passengers justifies maintaining open the airports with the largest deficits. Maintaining the “ghost airport” of Castellon airport costs 3,600 euros daily and a parallel case exists with the delay in the opening of the new Corvera airport with Murcian tax payers footing the bill. There is an obvious need to rethink whether the functioning of these airports has

an influence or not for tourism in the area and whether other more viable alternatives exist for acceding to the zone. It is worthwhile highlighting that the airport of Huelva (separated from Sevilla by less than an hour by road) and those of Antequera, Benalmádena and Jimena de la Frontera (Cádiz), are all airport projects in progress and none of which have been cancelled yet.

THEORETICAL MODEL: METHODOLOGY FOR ANALYSIS and MEASUREMENT OF TECHNICAL EFFICIENCY,

For the purpose of the study we use a stochastic parametric model based on fixed effects, which is the simplest model and considers inefficiency as an individual effect of each company which could also be correlated with the inputs. No implicit distributional assumption is made relative to efficiency the only one being that efficiency is always indicated by values ≥ 0.

The model is estimated consistently with Ordinary Least Squares (OLS) is estimated consistently with OLS as long as we rewrite inefficiency together with the independent term, $\alpha_{i,}$ and estimate it as the individual effect for each company. The model can be written as:

$$Lny_{jt} = \alpha_j + Lnx_{jt}\,\beta + v_{jt}\ ;\ j=1,.....,N;t=1,.....,T \qquad (1)$$

Where $\alpha_j = \alpha_j - u_j$ are the fixed effects of each Company. The estimation of the parameters and of the fixed effects is performed OLS with dummy variables regression (LSDV). The values of technical efficiency for each company are calculated with reference to at least one company considered to be technically efficient.

In order to do this we normalise the estimations for fixed effects obtained with the maximum value i.e., $\widehat{\alpha}j = \max j(\widehat{\alpha}j)$ calculating the technical efficiency for each productive unit as follows

$$ET_j=(-\mu_j) = \exp(\widehat{\alpha}_j - \max\widehat{\alpha}_j) \qquad (2)$$

DATA SETS and STUDY VARIABLES

FOR PERIOD 1992-94

The first set of data used we believe to have been supplied by the International Civil Aviation Organization (ICAO), an organisation existing prior to the creation of AENA and consist in panel data for 38 airports for the period 1992-94. The fact that the source is the same organization proportions a degree of homogeneity and uniformity in the data used for each of the airports used.

The data presented is expressed in monetary units (constant pesetas) for some variables and in physical units for others. The model presented in this paper will make use of variables expressed in monetary units only. Due to the numerous variables in the data we have only included a brief table of descriptive statistics for the study variables selected shown below in table 1. This said we do not observe overall missing values or apparent anomalies in the data which would invalidate their use for our estimation purposes.

TABLE 1

Summary Statistics, (for airport data 1992-94) using the observations 1:1 - 38:3				
Variable	Mean	Median	Minimum	Maximum
TOTAL_INGRESOS	1,98E+11	235712.	10714.0	2,33E+12
AMORTIZACION	531226.	216709.	26796.0	4,30E+11
Otros_Gastos	416132.	112914.	9199.00	4,19E+11
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
TOTAL_INGRESOS	4,07E+11	205.453	328.338	118.549
AMORTIZACION	764621.	143.935	288.086	919.774
Otros_Gastos	766050.	184.088	301.566	947.813
Variable	5% Perc.	95% Perc.	IQ range	Missing obs.
TOTAL_INGRESOS	18271.0	1,04E+12	1,59E+11	0
AMORTIZACION	45030.3	2,32E+11	489170.	0
Otros_Gastos	23624.5	2,47E+11	308113.	0

FOR PERIOD 2009-11

The second set of data we believe to have been supplied by AENA and consist in panel data for 48 airports for the period 2009-11. Whilst there are less variables than for the 1992-94 panel data there at least seems to be some consistency in the data supplied and several variables common to both periods. The data presented is again expressed in monetary units (constant Euros) and in physical units for a reduced number of variables.

For the purpose of estimation and with a view to comparing one period with another, regressions were performed a) for all 48 airports existing for the period 2009-11 and b) for only those airport (the initial 38) for which data was available in the previous period. This offers the benefit of viewing technical efficiency for two scenarios:

a) The individual efficiencies of the airports currently controlled by AENA and their overall average efficiency for the period 2009-11. Additionally it provides substantial evidence analysis individual relative efficiencies and overall average efficiency and to support the findings of the Fedea study.

b) A direct comparison of technical efficiency of the 38 airports today as compared to twenty or so years ago.

Some data limitations exist in comparability. For the period 1992-94 no distinction is made between the airports of Tenerife Norte and Sur and it has been assumed that the reference to Tenerife only is in fact the combination of the two airports. Since the data of both the Tenerife airports is available for 2009-11 the data has been combined as one sole airport for comparison purposes.

Likewise there are possible differences in the accounting used by the ICAO for the 1992-94 panel data and that used by AENA for the 2009-11. Here it is assumed that the variables are accounted for and calculated in a similar way but it must be pointed out that this could lead to inaccuracies in our estimation. The descriptive statistics are shown for the study variables only in table 2 below. In

general we do not observe missing values or apparent anomalies in the data which would invalidate their use for our study.

TABLE 2

Summary Statistics(for airport data 2009-11), using the observations 1:1 - 38:3

Variable	Mean	Median	Minimum	Maximum
INGRESOS_DE_EXPLOTACION	547.641	110.900	0.400000	740.740
Amortizaciones	193.405	515.500	0.270000	291.370
Otros_Gastos_de_Explotacion	259.923	597.000	0.930000	346.280
Variable	Std. Dev.	C.V.	Skewness	Ex. kurtosis
INGRESOS_DE_EXPLOTACION	120.038	219.190	386.675	158.633
Amortizaciones	499.196	258.109	439.352	193.439
Otros_Gastos_de_Explotacion	612.431	235.621	406.369	166.217
Variable	5% Perc.	95% Perc.	IQ range	Missing obs.
INGRESOS_DE_EXPLOTACION	0.617500	315.702	425.425	0
Amortizaciones	0.790000	128.868	888.750	0
Otros_Gastos_de_Explotacion	118.250	176.988	142.500	0

STUDY VARIABLES

One of the difficulties associated with models for airports is associated with how we measure their production or output which here will take the form of our independent variable Y. Many studies use number of passengers as a proxy for output but here we use *total revenue*. There are two reasons for this choice. Firstly, initial regressions with the 1992-94 data gave rise to unsatisfactory models when using *number of passengers* as the dependent variable with results showing coefficients that displayed the opposite signs to those expected. Secondly given that our intention is to compare airports in two different time periods we were limited in terms of comparable and homogenous data particularly for the 2009-11 period where we lacked a substantial number of variables (one of them being number of passengers) compared with the earlier period. Hence despite the data limitations we chose to use *total revenue* in its logarithmic form as our dependent variable. Additionally for production models it is usual to adopt a Cobb-Douglas functional form as follows:

$$Y = F(L, K, IC) \qquad (3)$$

Where Y is output and the three inputs are labour (L), capital (K) and intermediate consumptions(IC).

Again in some initial regressions using the 1992-94 data the inclusion of physical units of labour (a variable for *total personnel*) with the other variables expressed in monetary units, *amortization* and *other costs,* the independent variables to be used as proxies for capital and intermediate consumption, again produced unsatisfactory models. Likewise data for *total personnel* was not available in the 2009-11 data which of course earmarked it for exclusion as an independent variable in the estimation. The functional form used is in fact a reduced version of the Cobb-Douglas,

i.e. Y= F(K,C) which though not ideal was in terms of the study the only real option. Luckily as we will see below the results obtained from the estimation were reasonably acceptable.

ECONOMETRIC SPECIFICATION

As mentioned above the usual form of the Cobb-Douglas production function is expressed as

$$Y_{it}=A(L_{it})^{\alpha}(K_{it})^{\beta}(IC_{it})^{\gamma}e^{u_{it}} \quad (4)$$

It is selected given that it allows calculation of input elasticities with respect to the product, and with respect to the production frontier.

The function representing the production of Spanish airports can be expressed in logarithmic form as follows:

$$\ln Yit = \ln A + \alpha \ln Lit + \beta \ln Kit + \gamma \ln ICit + Uit \quad (5)$$

In line with my aforementioned comments, the present study uses the following reduced form:

$$\ln Yit = \ln A + \alpha \ln Kit + \beta \ln ICit + Uit \quad (6)$$

Where i= 1,…38 airports; t=1,….3 years and for which Y_{it} is output (*Total revenue*), K_{it} is a vector referring to the inputs in capital (proxied in the data by *amortisation*), IC_{it} is a vector referring to the input cost (proxied in the data by *other costs*) and u_{it} is the error term.

For our proposed stochastic parametric model we estimate the latter logarithmic function via the FIXED EFFECTS MODEL- OLS with dummy variables regression (LSDV).This captures the variations existing in the sample caused by the presence of different individual units with the incorporation of N-1 Dummy variables(D_i);

$$\ln Y_{it} = \ln A + \alpha \ln K_{it} + \beta \ln IC_{it} + v_{it} + \sum_{i=1}^{N} aD_{i-1};\ U_{it} = u_i + v_{it} \quad (7)$$

Where $u_i = \sum_{i=1}^{N} aD_{i-1}$

Here each of the coefficients measures the difference of the individual effects with respect to an Individual forming the basis of the comparison. Thus the technical efficiency (TE) for the i th airport will be;

$$TEi = (-\mu i) = \exp(\widehat{\alpha i} - \max \widehat{\alpha i}) \quad (8)$$

If TE has a value of 1 this is the maximum possible value corresponding to the productive unit, given a set of inputs. If TE =0 this corresponds to a productive unit or airport with the minimum possible value, given a set of inputs. For the remaining cases $0<TEi<1$.

RESULTS

Equation (7) above was estimated via ORDINARY LEAST SQUARES(OLS) using the programme GRETL. Additionally fixed and random effects models were performed with the test of Hausman validating the use of the fixed effects model.

For simplification purposes I propose presenting the results in the following order:

a) Technical efficiency for the 38 airports with data available for the period 1992-1994.

b) Technical efficiency for 49 airports with data available for the period 2009-2011.

c) Comparison of the 38 airports with data available for both the earlier and later period.

For abbreviation purposes I use the following notation with respect to the technical efficiency index for the airports evaluated under a), b) and c), namely, $TE38_{1992\text{-}94}$, $TE49_{2009\text{-}11}$ and $TE38_{2009\text{-}11}$.

a) Technical efficiency for the 38 airports with data available for the period 1992-1994:

Given the large number of dummies we have combined the results of the regressions and technical efficiency calculations in tables 3 and 4 below.

We observe that the first order coefficients display the expected positive signs. Additionally the estimated coefficients indicate the elasticity of output and their sum is approximately equal to one which permits us to deduce the possible existence of constant returns to scale. The dummy variables introduced in the model allow us to measure the individual effects of each airport with reference to that of at least one airport. We note that in this case only 15 of the 38 airports have a positive effect compared to the base airport (DU 38-Zaragoza).

The regression performed enables us to calculate $TE38_{1992\text{-}94}$ using equation (8) above. We note that for the period 1992-94 the most efficient airport is Lanzarote followed closely by Mallorca, Fuerteventura, Madrid Barajas, Tenerife, Canarias, Alicante, Barcelona and Malaga. All of these airports registered efficiencies superior to 50%. Notably they represent in the cases of the Canary and Balearic Islands the great tourist hubs for both international and national tourists and in the case of Madrid and Barcelona we attribute the efficiency to their major city status. Cordoba proved the less inefficient airport. More detailed comments will be made in section c) in the comparative study.

TABLE 3

OLS TE38 1992-94					
Model 2: Pooled OLS, using 114 observations					
Included 38 cross-sectional units					
Time-series length = 3					
Dependent variable: l_TOTAL_INGRESOS					
	Coefficier	Std. Error	t-ratio	p-value	
const	0,885549	2,27461	0,3893	0,69816	
l_AMORTI	0,574405	0,174058	3,3001	0,00149	***
l_Otros_G	0,415105	0,120143	3,4551	0,00091	***

TABLE 4- TE38 1992-94

AIRPORT	Value coefficient	ET	Significance		AIRPORT	Value coefficient	ET	Significance
ALICANTE	0,776247	0,66113779	**		MALAGA	0,576148	0,541240257	
ALMERIA	-0,0300367	0,29520752			MALLORCA	1,17046	0,980610443	**
ASTURIAS	-0,355266	0,21324661	***		MELILLA	-1,44539	0,071688137	***
BADAJOZ	-1,53388	0,06561703	***		MENORCA	0,53631	0,520102173	**
BARCELONA	0,661377	0,58939246			MURCIA_SAN JAVIER	-0,736033	0,145719316	***
BILBAO	0,440816	0,47273325	**		PAMPLONA	-1,25144	0,087031949	***
CANARIAS	0,787056	0,66832279	*		REUS	-0,455478	0,192912608	***
CORDOBA	-1,65339	0,05822561	***		SABADELL	-0,733407	0,146102478	***
CORUNA	-0,538636	0,17751929	***		SALAMANCA	-0,884573	0,125605027	***
CUATRO_VIENTOS	-0,30881	0,22338691			SAN_SEBASTIAN	-1,19682	0,091917853	***
FUERTEVENTURA	1,12307	0,93522326	***		SANTANDER	-1,17757	0,093704412	***
GERONA	-0,773828	0,14031463	***		SANTIAGO	0,123184	0,344088633	
GRANADA	-0,563496	0,17316056	***		SEVILLA	-0,00403701	0,302983476	
HIERRO	-1,1419	0,09710718	***		TENERIFE	0,948851	0,785693116	**
IBIZA	0,712389	0,62023862	**		VALENCIA	0,32081	0,419274266	
JEREZ	-0,436945	0,19652119	***		VALLADOLID	0,0119724	0,307873098	
LA_PALMA	-0,287186	0,22827003	*		VIGO	-0,554408	0,17474142	***
LANZAROTE	1,19004	1	***		VITORIA	-1,24811	0,087322248	***
MADRID_BARAJAS	0,971222	0,80346794			ZARAGOZA			

b) Technical efficiency for 49 Spanish airports with data available for the period 2009-2011:

For simplification and given the large number of dummies we have again combined the results of the regressions and technical efficiency calculations in table 5 and 6 below.

With the more limited data offered in terms of regression variables, the OLS regression gave an unsatisfactory model with non-significance for both our independent regressors and a negative sign for the coefficient of the logarithmic variable for other costs. As mentioned previously we assumed that the compilation of the variables used in accounting terms was identical for both periods but in reality we are faced with a case of unbalanced and non homogeneous data. It is probably for this reason that the resultant regression model is not what we would have desired. Despite this limitation we continued with our analysis of technical efficiency. Here Madrid Barajas topped the ranking in terms of efficiency for the period with Algeciras proving the most inefficient airport.

TABLE 5

OLS TE49 2009-11					
Model 2: Pooled OLS, using 147 observations					
Included 49 cross-sectional units					
Time-series length = 3					
Dependent variable: l_INGRESOS_DE_EXPLOTACION					
	Coefficier	Std. Error	t-ratio	p-value	
const	1,99387	0,153832	12,9613	<0.00001	***
l_Amortiz	0,058801	0,055653	1,0566	0,29337	
l_Otros_G	-0,10295	0,079644	-1,2926	0,19927	

TABLE 6- TE49 2009-11

AIRPORT	Value coefficient	ET	Significance	AIRPORT	Value coefficient	ET	Significance
ALBACETE	-3,83032	0,00018864	***	GRANCANARIA	2,64253	0,122111588	***
ALGECIRAS	-4,44036	0,00010249	***	MADRIDBARAJAS	4,74535	1	***
ALICANTE	2,7715	0,13892098	***	MADRIDTORREJON	-2,04873	0,001120388	***
ALMERIA	0,245997	0,01111619	*	MENORCA	1,15982	0,027721971	***
ASTURIAS	0,633832	0,01638289	***	MALAGACOSTASOL	3,09755	0,192472884	***
BADAJOZ	-2,31096	0,00086195	***	MELILLA	-1,45325	0,002032274	***
BARCELONAPRAT	4,13353	0,54236287	***	HUESCAPIRINEOS	-2,6871	0,000591736	***
BILBAO	1,87616	0,05674487	***	PALMAMALLORCA	3,45313	0,27466036	***
BURGOS	-3,36633	0,00030001	***	PAMPLONA	-0,952999	0,003351494	***
CEUTA	-3,53759	0,00025279	***	REUS	0,542689	0,014955727	***
CORDOBA	-2,58024	0,00065847	***	SABADELL	-2,41917	0,00077355	***
ACORUÑA	0,426017	0,01330876	***	SALAMANCA	-2,43615	0,000760526	***
ADRIDCUATROVIENTO	-1,79829	0,00143924	***	MURCIA-SANJAVIER	0,595431	0,015765693	***
FUERTEVENTURA	1,78102	0,05159503	***	SANSEBASTIAN	-0,991754	0,003224092	***
GIRONACOSTABRAVA	1,6453	0,04504695	***	SONBONET	-2,58781	0,000653505	***
FGLGRANADAJAEN	0,247382	0,01113159	*	TENERIFESUR	2,55226	0,11157146	***
ELHIERRO	-1,96183	0,00122211	***	TENERIFENORTE	1,49896	0,038914436	***
IBIZA	1,81848	0,05356443	***	SANTANDER	0,0837886	0,009451693	
JEREZDELAFRONTERA	0,514395	0,0145385	***	SANTIAGO	1,1606	0,027743603	***
LANZAROTE	1,9258	0,05963277	***	SEVILLA	1,91926	0,059244046	***
LAPALMA	0,053681	0,00917137		VALENCIA	2,13628	0,073602963	***
LOGROÑO	-2,86239	0,00049659	***	VALLADOLID	-0,721058	0,004226386	***
LAGOMERA	-2,52806	0,00069374	***	VIGO	0,0824071	0,009438645	
LEON	-1,97424	0,00120703	***	VITORIA	-0,769436	0,004026789	***

Notably, as we will explain later in general the technical efficiency of all the 49 airports existing today, has seen a substantial decline. We performed the aforementioned regression to ascertain the efficiency of the additional 11 airports for which data was not available in the 1992-94 period in part because some of the airports did not exist. Further comments in this regard will be made in section c) below where a comparison is made of the technical efficiency of the 38 airports for the earlier and later period.

c) Comparison of the 38 airports with data available for both the earlier and later period.

Using the same methodology as under a) and b) above we selected from our sample of 49 airports those analysed for technical efficiency in the period 1992-94. Again the model proved unsatisfactory for similar reasons to those mentioned above but it allowed us to observe the underlying evolution of technical efficiency for Spanish airports as it stands today. The results of the OLS regression are summarised in table 7 and 8 as follows:

TABLE 7

OLS TE38 2009-11

Model 2: Pooled OLS, using 114 observations
Included 38 cross-sectional units
Time-series length = 3
Dependent variable: l_INGRESOS_DE_EXPLOTACION

	Coefficier	Std. Error	t-ratio	p-value	
const	1,95507	0,160321	12,1947	<0.00001	***
l_Amortiz	0,050886	0,07061	0,7207	0,47338	
l_Otros_G	-0,06578	0,079894	-0,8233	0,41297	

TABLE 8- TE38 2009-11

AIRPORT	Value coefficient	ET	Significance	AIRPORT	Value coefficient	ET	Significance
ALICANTE	2,70574	0,14856986	***	MALAGA	3,01322	0,202054059	***
ALMERIA	0,23489	0,01255608	*	MALLORCA	3,36013	0,285843735	***
ASTURIAS	0,616765	0,01839503	***	MELILLA	-1,442	0,002347416	***
BADAJOZ	-2,2884	0,00100694	***	MENORCA	1,12534	0,030589453	***
BARCELONA	4,01633	0,55095067	***	MURCIA_SAN JAVIER	0,58656	0,017847711	***
BILBAO	1,83383	0,0621248	***	PAMPLONA	-0,945426	0,003856998	***
CANARIA	2,57466	0,1303177	***	REUS	0,520296	0,016703383	***
CORDOBA	-2,55552	0,00077089	***	SABADELL	-2,40416	0,00089687	***
CORUNA	0,411227	0,0149774	***	SALAMANCA	-2,40879	0,000892727	***
CUATRO_VIENTOS	-1,79096	0,00165592	***	SAN_SEBASTIAN	-0,972247	0,003754925	***
FUERTEVENTURA	1,73865	0,05648444	***	SANTANDER	0,0855792	0,010814572	
GERONA	1,61154	0,04974228	***	SANTIAGO	1,13829	0,030988163	***
GRANADA	0,23629	0,01257367	*	SEVILLA	1,87547	0,064766292	***
HIERRO	-1,95439	0,00140625	***	TENERIFE	2,80671	0,164354434	***
IBIZA	1,77539	0,05859828	***	VALENCIA	2,08558	0,079909543	***
JEREZ	0,497136	0,01632098	***	VALLADIOLID	-0,714224	0,004860257	***
LA_PALMA	0,0355997	0,01028735		VIGO	0,0634715	0,01057811	
LANZAROTE	1,87244	0,06457035	***	VITORIA	-0,774201	0,004577323	***
MADRID_BARAJAS	4,61244	1	***	ZARAGOZA			

Again we see our repeated most and least technically efficient airports i.e. Madrid and Cordoba. Whilst the expectation that Barajas airport could have appeared as one of the top ranking airports in the study the least efficient airport was open to a number of consistently inefficient candidates; Cordoba, Badajoz, Cuatro Vientos (now in almost disuse), Hierro, Melilla, Pamplona, Sabadell, Salamanca, San Sebastian, Valladolid and Vitoria all with technical efficiency levels of less than 1%. These represent almost a third (11 airports) of the 38 studied. Many of these airports are third category airports such as Cordoba which does not offer ATS air- traffic services and have no scheduled flights operating. Cordoba´s main use is local(agricultural treatment companies, transfer of organs for transplants to the Reina Sofia hospital, military flights, a few charter flights, pilot training courses etc.) It suffers a long stationary period in the summer months due to Cordoba´s hot climate rendering it one of the Spanish airports with least passenger traffic. Similar situations apply to some of the other aforementioned airports.

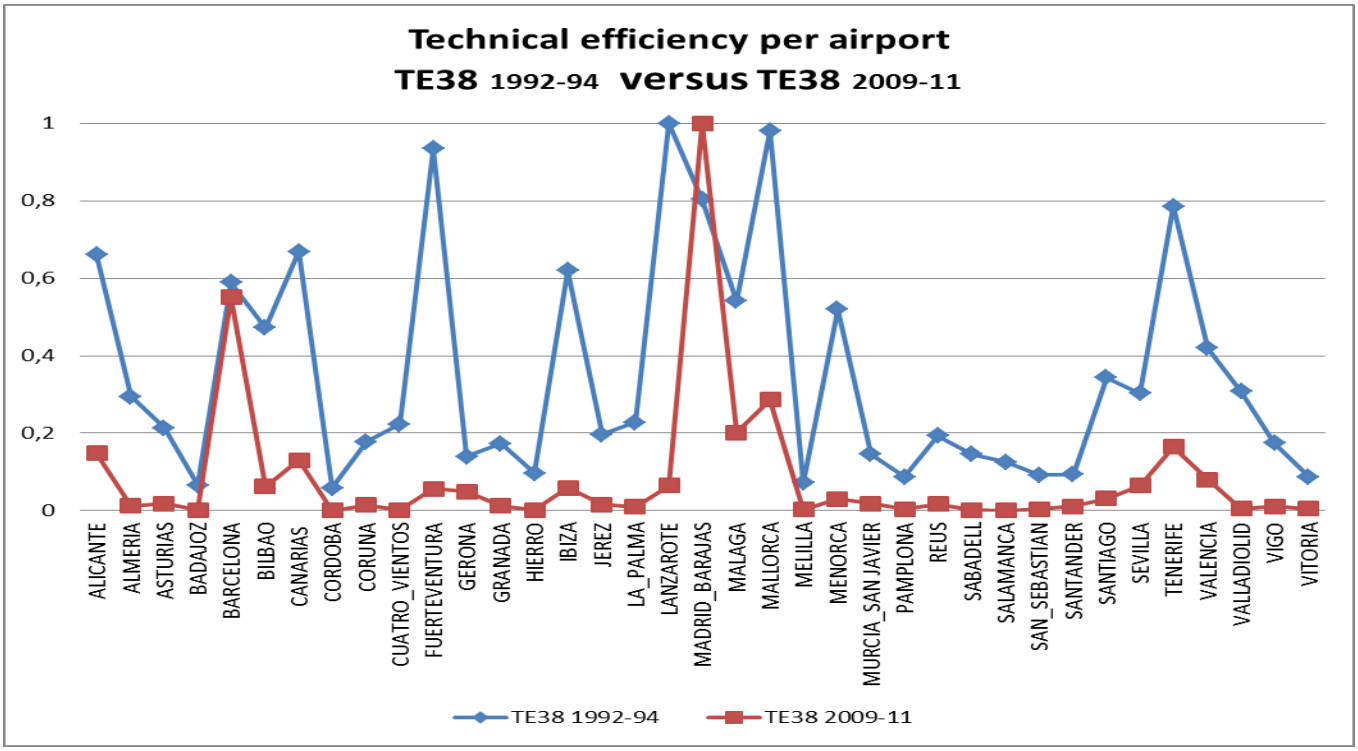
Whilst we displayed some dissatisfaction with our regression model our results appear to coincide with the findings of the Fedea study mentioned previously and their study in fact earmarks several of the airports mentioned here, such as Vitoria with a technical efficiency inferior to 1%. It is also true that our model uses as its dependent variable total income and independent variables related with costs and given that the Fedea study adopts a financial perspective with respect to Spanish airports, it seems logical that the findings here should coincide with theirs. Rather than pursue a descriptive account of the apparent downward trend in technical inefficiency of Spanish airports we propose a pictorial review in the form of a comparative table and some graphs. The following table compares the technical efficiency of the 38 airports for the two periods:

TABLE 9

AIRPORT	TE38 1992-94	AIRPORT	TE38 2009-11.
ALICANTE	0,661137793	ALICANTE	0,148569859
ALMERIA	0,295207524	ALMERIA	0,012556083
ASTURIAS	0,213246608	ASTURIAS	0,018395026
BADAJOZ	0,065617031	BADAJOZ	0,001006939
BARCELONA	0,589392461	BARCELONA	0,550950671
BILBAO	0,472733251	BILBAO	0,062124801
CANARIAS	0,668322792	CANARIAS	0,130317695
CORDOBA	0,058225609	CORDOBA	0,000770894
CORUNA	0,17751929	CORUNA	0,014977398
CUATRO_VIENTOS	0,223386907	CUATRO_VIENTOS	0,001655918
FUERTEVENTURA	0,935223258	FUERTEVENTURA	0,056484444
GERONA	0,140314633	GERONA	0,04974228
GRANADA	0,173160564	GRANADA	0,012573674
HIERRO	0,097107176	HIERRO	0,001406248
IBIZA	0,620238622	IBIZA	0,058598276
JEREZ	0,196521193	JEREZ	0,016320978
LA_PALMA	0,228270032	LA_PALMA	0,01028735
LANZAROTE	1	LANZAROTE	0,064570347
MADRID_BARAJAS	0,803467936	MADRID_BARAJAS	1
MALAGA	0,541240257	MALAGA	0,202054059
MALLORCA	0,980610443	MALLORCA	0,285843735
MELILLA	0,071688137	MELILLA	0,002347416
MENORCA	0,520102173	MENORCA	0,030589453
MURCIA_SAN JAVIER	0,145719316	MURCIA_SAN JAVIER	0,017847711
PAMPLONA	0,087031949	PAMPLONA	0,003856998
REUS	0,192912608	REUS	0,016703383
SABADELL	0,146102478	SABADELL	0,00089687
SALAMANCA	0,125605027	SALAMANCA	0,000892727
SAN_SEBASTIAN	0,091917853	SAN_SEBASTIAN	0,003754925
SANTANDER	0,093704412	SANTANDER	0,010814572
SANTIAGO	0,344088633	SANTIAGO	0,030988163
SEVILLA	0,302983476	SEVILLA	0,064766292
TENERIFE	0,785693116	TENERIFE	0,164354434
VALENCIA	0,419274266	VALENCIA	0,079909543
VALLADOLID	0,307873098	VALLADOLID	0,004860257
VIGO	0,17474142	VIGO	0,01057811
VITORIA	0,087322248	VITORIA	0,004577323
AVERAGE TE38 1992-94	**0,352370367**	**AVERAGE TE38 2009-11**	**0,085052564**

	TE
	above 50%
	10 to 20%
	above 20%
	less than 1%

The visual impact of the above table is clear- a mass of colours indicating some very high values of technical efficiency for the 38 airports studied in the period 1992-94 and a more abundant tendency towards the light blue less than 1% technical efficiency. Additionally whilst Spanish airports offered a moderate 35.2% average technical efficiency our present calculations (with the limitations which we have already discussed) now show them as registering a lower average level of technical inefficiency equal to 8.5%. The difference is shown graphically as follows:



One trend is clear- whilst displaying much lower technical efficiencies overall it is again the same airports i.e. those representing the key Spanish cities Madrid and Barcelona and the tourist hubs in the Costa del Sol, Costa Blanca and Islands that maintain higher levels of technical efficiency due to the more international nature and sheer volumes in terms of passenger traffic and scheduled national and international flights. The airports with a clear commercial vocation are those of the bigger cities such as Madrid and Barcelona given that income comes from the commercial activities housed in its installations and from international flights. An analysis of the descriptive data (not shown here) shows that for both periods the majority of the smaller airports offered evidence of substantial cost disequilibrium. This is not so much due to the lack of income from commercial activities but because the majority of their flights are of a national character resulting in less passenger traffic and a reduction in income compared with international flights.

Additionally the second period 2009-11 coincides with the generalized economic crisis in the European Union spurred by the global financial crisis which inevitably reflects a drop in passenger traffic due to less international and domestic tourists and the possible use of alternative cheaper forms of transport. In this regard many of the airports, large and small have seen keen competition from the High Speed Train network(AVE) the infrastructure of which has been extended in a major way from 1992 onwards.

CONCLUSIONS and DISCUSSION

Whether or not our study of technical efficiency can be improved with use of more precise and complete data (which proved an element of concern for the results of the estimations performed), the fact that we reach similar conclusions to the Fedea study is unquestionable. The question remains whether in the case of the technical efficiency of Spanish airports efforts should be made

to improve their situation or whether AENA needs to perform an important restructuring of the sector. The latter would with the current scenario and the comments already made in the introduction to this paper appear to be the correct route and efforts are being made in this direction. The correct route is not always the most pleasant one in terms of economic impact, loss of employment, unused infrastructures to the cities involved but it is undoubtedly, to coin a repeated phrase in this paper, the most efficient one. Whilst the sources of inefficiency are more obvious a restructuring programme would involve an important dose of cost-benefit analysis. The question is "Why are so many loss-generating and practically redundant airports being maintained in the light of austerity cuts and the eventual claim on tax-payers monies vis-à-vis the heavy subsidies provided by the Spanish government which many airports receive? In this regard is a privatisation process (signposted for the bigger cities like Madrid and Barcelona) an alternative or better route? Alternatively is it better to leave airports under AENA management but outsource to the private sector those parts of the activity which are inefficient? The latter is addressed in a recent study of Spanish airports conducted by Beatriz Tovar et al (2009).

Reverting to the case of our least inefficient airport Cordoba, does the benefit of using it as an aerodrome for the transfer of transplant organs to the city´s hospital more than compensate the cost of maintaining it open at a loss. Whilst we approach the realms of consumer welfare the example points us towards potential studies on an individual airport basis of economic impact and cost benefit analysis with a view ultimately to potential closure. As mentioned initially inefficiencies technical or otherwise are not viable in the long- term and in the cases of those airports which are important for the Spanish economy efforts should be made to improve their performance.

Whilst the foregoing comments are obviously a subject for debate, the conclusion to the paper is that the current situation of Spanish airports is unsustainable and an important review is required of their present and future feasibility in terms of profits, efficiency (technical, economic and allocative) and overall capacity to contribute towards the Spanish economy.

REFERENCES

Ofelia Betancor and M. Fernanda Viecens (November 2011) **"Hacia un nuevo modelo aeroportuario español"** (Fedea Fundación de Estudios de Economía Aplicada**)**

Beatriz Tovar, Marta Cejas, Roberto Rendeiro (2009) "**Are outsourcing and non-aeronautical revenues important drivers in the efficiency of Spanish airports?** Journal of Air Transport Management, vol. 15, issue 5, pages 217-220"