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WHEN TRAINS GO FASTER THAN PLANES: THE STRATEGIC REACTION OF AIRLINES IN SPAIN¹

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Abstract

Plans for the development of high speed railways lines (HSR) in Spain are widespread. At the beginning of 2010 four HSR lines were operating in routes where the air transport mode used to be dominant. In this paper we examine through econometric means the air carriers' reaction to these HSR entrances by using data at the route level. We test whether the HSR have changed both, the airlines' frequencies and the market shares. Our results show that it has reduced on average the number of air transport operations by 17 percent. On the other hand the demand has increased substantially, though the weight of air transport in the total market has been reduced, as it has been reduced the weight of the dominant Spanish air carrier Iberia on air markets.

Keywords: Intermodal competition, Air transport, Rail transport.

J.E.L. Classification: L13, L92, L93.

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1. Introduction

High speed railways are an important driver of competition for the air transport sector. Before 1990, aircraft and railways were considered as independent modes that could not compete given their different features (Ivaldi and Vibes, 2005), but the introduction of high speed railways (HSR) modified this scenario. Thus, in spite of differences in investments financing and public participation in both sectors, the empirical literature finds that the introduction of the HRS has a significant effect on final consumers and, therefore, on air carriers. This fact is more relevant in routes with a distance lower than 800 kilometres or with a travel time by train of less than 3 hours (IATA, 2003). In addition to speed, it is the fact that most cities' railways stations are located in the city centre which gives the HSR the travel time advantage over the aircraft (Givoni and Banister, 2007).

The effects of the HSR upon the air sector are a well-known fact. Before the 90s there was at least one case, concretely the operation of a high-speed rail (Train à Grande Vitesse, TGV) in the line Paris-Lyon (1981, 450 kilometres), in which airlines reduced their participation almost 50 percent.

In Spain, the most evident case is the route Madrid-Seville with the introduction of the HSR in 1992. With 471 kilometres, this route experienced a reduction in the weight of air transport from 40% to 13%. In turn the railway mode increased his weight from 16% to 51% (Park and Ha, 2006; or EC, 1996). Currently, year 2010, there are three additional routes in which the HSR operates, though the social evaluation of such projects is quite doubtful (see De Rus and Román, 2006, for the case of the routes Madrid-Barcelona and Madrid-Zaragoza).

Competition within the air sector and the factors that affect it have been revised profusely in the literature. Nevertheless, and in spite of the HSR entering in many routes around the world, its effects upon air carriers have not been studied in the same way. This paper aims to shed some light in this regard by using a data base to the route level for the Spanish market. By econometric means we evaluate whether the high speed rail have significantly changed the frequency, the number of passengers and the market share of airlines. We carry out this analysis for air carriers as a whole and also concerning the strategic behaviour of the former Spanish flag air carrier *Iberia* in each route.³

³ The other main airlines for the sample considered (1999-2009) are Spanair and Air Europa. Low costs carriers have entered in the Spanish market quite late in our sample period (around 2008), and therefore their

After this introduction, section 2 is devoted to a review of the relevant literature for the air transport sector and on intermodal competition; in section 3 we present the data base utilized for the econometric modelling discussed in section 4. Finally, section 5 is dedicated to summary and conclusions, emphasizing the negative effect upon air carriers' operations and market share in the routes where the HSR enters.

2. Literature review

In Industrial Organization there is a vast literature analysing the influence of the market structure upon competitive variables, mainly prices and frequencies for the case of the transport sector. The air transport mode is one of the main study focuses. Most studies relate such variables at the route level with distance, demand (population and tourism mainly) and market structure (number of competitors, concentration in the route, concentration at the origin/destination airports), among others.

Some examples are the works by Borenstein (1989), Evans and Kessides (1993) or Berry *et al.* (1996), for data at the route level; and the articles by Brander and Zhang (1990), Oum *et al.* (1993), Brueckner and Spiller (1994) or Fisher and Kamerschen (2003), for aggregated data. Results in all these studies are similar: the level of concentration⁴ in the route or at the airport affects positively final prices. For the Spanish market Fageda (2006) is one of the main references.

Another research branch is related to the appearance of low cost air carriers. An important part of these works point out how such air companies discipline competition, leading to prices reduction after its entry or even making incumbent air carriers to adapt their behaviour to a low cost carrier entry threat, as described in Goolsbee and Syverson (2008). For the United States air transport market, the works by Dresner *et al.* (1996), Morrison (2001) or Daraban and Fournier (2008) may be consulted. For the European case, there are a fewer number of studies applying price equations to analyse the impact of low cost carriers. Among others we can mention the works by Alderighi *et al.* (2004), Fageda and Fernández (2009), Malighetti *et al.* (2009) or Gaggero and Piga (2010). All of them reach similar results to their United States counterparts.

impact should not be very significant.

⁴ The Herfindhal-Hirschmann index is the most usual concentration indicator applied in these papers. Both, total passengers and frequencies are the variables used to construct this index by routes.

For the Spanish market, Fageda *et al.* (2010) show how the incumbent traditional airline (Iberia) reacts to low cost carriers' competition in two ways. Firstly, by creating low costs sister companies, and secondly, trying to reduce costs at its main brand. In fact this work shows that the incumbent's pricing policy has been particularly aggressive in shorter and less dense routes.

Concerning the HSR appearance as a competitive mode for air transport, the number of references is lower. Three works that summarise the general evolution of such mode are Campos and Gagnepain (2009), Gourvish (2010) and Albalade and Bel (2010). In the first study Campos and Gagnepain summarise the empirical evidence accumulated after more than 30 years of operation of HSR lines in terms of construction, maintenance and external costs. On the other hand Gourvish (2010) summarises the characteristics of HSR networks around the world, its current situation, and its effects upon transport and future developments perspectives. Albalade and Bel (2010) review some experiences of HSR in the world and particularly in USA, focusing on its impact upon mobility, environment, the economy and urban development.

Nevertheless, the literature related to competition as exerted by HSR on airlines is more reduced than in the case of intra-modal competition for air transport. In fact most works apply choice models to determine passengers' behaviour regarding travel options, mostly in short distance routes.⁵

Bilotkach *et al.* (2010) is one exception. These authors demonstrate theoretically and empirically for a data base of European cities, the role played by the distance variable in the airlines' choice to offer frequencies taking into account the road mode as another alternative for passengers. They conclude that the higher the probability of substitution by the car mode (the lower the distance), the higher the air carrier's frequencies. Regarding the HSR's effects upon air carriers operations, their results are inconclusive for short-haul routes.

González-Savignat (2004) studies the effect of the HSR connection between Barcelona and Madrid through experimental design techniques. The author concludes that the HSR would obtain an important market share, with travel time as an important competitive factor.

⁵ The work by Capon *et al.* (2003) summarises part of this literature. López-Pita and Robusté (2003 and 2005) show also a descriptive analysis of HSR's effects on air carriers in Spain.

Ivaldi and Vibes (2005) carry out a theoretical simulation exercise to describe the behaviour of intermodal competition in which consumer select the mode and transport operator and the companies determine quality and prices. This scenario allows them to analyze competition in the route Cologne-Berlin, which is operated by a traditional airline (Lufthansa), three low cost air carriers and one railway (Deutsche Bahn AG). They also examine the impact of a possible liberalization of the railways and the entrance of a new operator. Their results show that prices decreases in all the alternatives and the air transport sector reduces operations in favour of the railways.

Park and Ha (2006) analyse the effects on domestic air transport demand in Korea after the HSR entrance, and estimated a reduction between 34% and 75%. These authors forecasted the air transport demand before the opening of the line operated by Korean Train Express in 2004, and afterwards they compare their estimates with actual demand after commencing HSR's operations. Their results point out to the train as the main driver of such a reduction.

With a cost-benefit analysis perspective, De Rus and Román (2006) analyse the Spanish routes Madrid-Barcelona and Madrid-Zaragoza. They conclude that demand levels are very low, and benefits derived from travel time savings insufficient for the social benefits of such infrastructure to justify its cost. These authors consider the road mode as another alternative.

For the route Madrid-Barcelona, Román *et al.* (2007) analyse potential competition between the HSR and the air transport mode, though with a perspective of disaggregated models of modal choice. Their results indicate that the HSR is more competitive in shorter routes like Madrid-Zaragoza and Barcelona-Zaragoza, than in other routes in which air traffic is more intense (Madrid-Barcelona). A similar analysis is conducted by Ortúzar and Simonetti (2008), who used data on revealed and mix preferences to analyse passenger modal choice among air transport, conventional trains, buses and a fictitious HSR operating the route Santiago -Concepción (Chile).

De Rus (2009) analyses some Spanish corridors comparing the evolution of different transport modes (rail, air and buses). He discusses the economic rationale for allocating public money to the construction of high-speed rail infrastructure and how the present institutional design affects the selection of projects by national and regional governments, with deep long-term effects in these corridors and beyond.

Another recent work is Behrens and Pels (2009), who utilize revealed preferences to study intermodal competition in the route London-Paris, and conclude that low cost air carriers do not compete more with HSR than with other airlines, what gives an idea of similarity between both modes of transport.

There is another research branch that argues in favour of cooperation instead of competition as a way to improve social welfare. It is the case of the work by Givoni and Banister (2006) for Heathrow airport. They conclude that the railway infrastructure should be considered as part of the airport facilities allowing obtaining efficiency gains in the slots utilization and given the reduction in environmental costs. These authors (Givoni and Banister 2007) also suggest providing an integrated transport service for medium-distance journeys (up to 800 Km.).

In summary, the main conclusion is that the analysis of competition in the air transport sector must also consider intermodal competition with the HSR, as a potential substitutive mode of transport from the consumers' point of view. This result is shared by Ivaldi and Vibes (2005), Behrens and Pels (2009) or Bilotkach *et al.* (2010).

3. Data-base

To analyse the airlines' behaviour when the HSR enters in a market, we make use of data to the route level on air carriers' frequencies, passengers and market shares in the Spanish markets for nine routes with origin in Madrid and for the period January 1999 to December 2009. All the routes are operated by air transport and train services, though only in four of them is the HSR in operation at least in part of the period considered. For the remaining five routes there are plans for the future operation of HSR services as well.

Data related to air transport services on operations and passengers were obtained from the Spanish operator of airports *Aeropuertos Españoles y Navegación Aérea* (AENA). These correspond to schedule direct flights between Madrid-Barajas airport and the other nine airports. The Iberia market share in those routes and monthly passengers and operations were facilitated by Iberia itself. Renfe facilitated yearly data on railways' passengers.

Table 1 includes descriptive statistics for main variables used in the analysis. The data base has 1188 observations corresponding to 132 months. The routes average distance is 375 kilometres, with 910 operations that move 87532 air passengers per month on average. The average monthly volume of railway passengers is around 20% lower than the air one.

Taking into account the total passengers figure in a route for air and rail transport, we can observe that the average railway market share is around 40 percent.

The variable *Percentage of international destinations* shows the weight of such destinations for a given airport on a monthly basis. It is an indicator of the opening degree of airports (or inversely, of domestic routes airport dependency). Madrid has a 77.5% of international routes, whilst for the other airports the average figure is 54.5 per cent.

Regarding concentration on the air transport market, Iberia has an average market share of operations and passengers higher than 70%, with values not lower than 43%, which shows the degree of market power of this airline on the routes analysed. It must be noted that these figures correspond jointly to Iberia and its associated company Air Nostrum.

The discrete variables try to capture the opening of Terminal 4 at Madrid-Barajas airport in February 2006, and of Terminal 3 in Barcelona airport in June 2009. They also consider the period of time in which the HSR services are in operation for the whole sample, and also for specific routes. In this regard it should be noted that only for the route Madrid-Seville is the HSR operating for the whole period of time considered.⁶

⁶ HSR services started in 1992 in this case.

TABLE 1: DESCRIPTIVE STATISTICS

Variable	Source and comments	Average	S.D.	Minimum	Maximum
Air passengers	AENA. Monthly data by route.	87532	93310.07	328	461542
Air operations	AENA. Monthly data by route.	910.5	863.5	16	4282
Train passengers	Renfe. Monthly average data by route, including all types of trains.	58945	59592	2160	222291
Distance	Air distance between airports (kilometers)	375.2	78.6	251	490
GDP per capita	INE. GDP at current prices. Sum of GDP of origin and destination airports regions divided by sum of population.(Thousand Euros)	22.8249	4.0479	14.2886	31.0555
Tourism per capita	INE. <i>Encuesta de ocupación alojamientos turísticos</i> . Sum of tourists of origin and destination airports regions divided by sum of population.	0.103	0.022	0.061	0.181
Percentage International routes Madrid	AENA.	77.5	2.16	73.8	82.2
Percentage International routes other airports	AENA.	54.5	19.7	16.7	87.6
Iberia's passengers share	Own elaboration using Iberia's data. (Only air transport).	74.4	13.8	43.6	100
Iberia's operations share	Own elaboration using Iberia's data. (Only air transport).	72.4	16.9	45.2	100
Railways' passengers share	Own elaboration using data from Renfe and AENA. Total market (train + air).	38.7	30.8	2.1	99.6
Discrete variables	Total Observations	Average	Obs. with value 1		
D ^{T4} MADRID	1188	0.356	423		
D ^{T3} BCN	1188	0.005	7		
D ^{HSR}	1188	0.214	255		
D ^{HSR} * D ^{BCN}	1188	0.019	23		
D ^{HSR} * D ^{MAL}	1188	0.021	25		
D ^{HSR} * D ^{ZAR}	1188	0.063	75		

Source: Own elaboration. S.D. is Standard Deviation.

Table 2 shows some preliminary information on the main variables per route, distinguishing, in the case of routes with HSR, the period pre and post implementation of HSR services. In such routes (Barcelona, Málaga and Zaragoza), air transport monthly operations and passengers carried are reduced after the HSR entrance. In turn, passengers transported by railway (monthly average) increased substantially. In fact the trains' market

share multiplies by a factor higher than three for the route Madrid-Barcelona, and duplicates for the route Madrid-Málaga and almost monopolized the passengers' volume in the case of Madrid-Zaragoza. Such figures are similar to the change described in Park and Ha (2006) for the route Madrid-Seville.

TABLE 2: AVERAGE MONTHLY DATA BY ROUTE

Route from Madrid to...	Air Passengers	Air Operations	Train passengers (Renfe)	Distance	Iberia's passengers share (air market)	Air transport's passengers share (air plus rail market)	Date entrance HSR
Barcelona (before HSR)	345228 (59719)	3255 (483)	51468	483	66.7	86.9	-
Barcelona (after HSR)	269217 (57966)	2806 (535)	200070		49.3	56.9	February 2008
Málaga (before HSR)	105971 (20769)	971 (132)	46406	430	60.5	69.1	-
Málaga (after HSR)	79771 (20574)	708 (176)	120404		66.6	39.6	December 2007
Zaragoza (before HSR)	7935 (1308)	232 (30)	45333	251	96.0	14.9	-
Zaragoza (after HSR)	1986 (1070)	85 (37)	96009		95.9	2.2	December 2003
Seville (HSR for all sample period)	39601 (6541)	401 (65)	189166	393	91.4	17.4	April 1992
Routes from Madrid to....(without HSR included in the period analyzed)							
Alicante	62681 (11165)	636 (70)	57904	350	70.2	51.6	No HSR
Asturias	48427 (10830)	506 (86)	6648	377	75.4	87.8	No HSR
Bilbao	71663 (13693)	813 (112)	3451	319	67.1	95.2	No HSR
Santiago de Compostela	58203 (9257)	603 (95)	5024	490	64.5	91.9	No HSR
Valencia	69660 (13979)	986 (187)	56406	284	79.2	54.9	No HSR

Source: Own elaboration. Standard deviation among brackets.

Finally, it is worth noting Iberia's behaviour concerning the starting of HSR services. The change in its air transport market share is not so clear. In fact, but for Barcelona, it maintains or even increases its weight. For routes without HSR services, as expected, the air transport mode is more relevant, especially for routes connecting Madrid with cities in the North of Spain. In what follows we aim to establish to what extent the changes observed in Table 2 are a response to the HSR entrance in the different routes.

4. Empirical strategy and estimations

4.1. The airlines' reaction: the effects on flights frequency

In this section we analyse the effect that the introduction of HSR' services has had on a relevant air carriers' competitive variable: the flights frequency. It is worth to bear in mind that an alteration of such variable has important implications for airlines as they must modify their slot policy. Airport slots are a valuable asset for air companies, if they decide to reduce the number of flights offered they would necessarily have to alter the utilization of such slots or even renounce to them in the worst case.

In addition, we will consider the introduction of HSR services in Spain as an exogenous factor regarding its relationship with the air transport market or other factors such as population or the situation of the economy. In fact, the first route that started operations was Madrid-Seville with the opening of the Universal Exposition in 1992, whilst the route Madrid-Barcelona started operations 15 years later in spite of having more passengers with higher income levels.

The first equation to estimate is the following:

$$MO_{it} = \beta_0 + \beta_1 \text{Airpassengers}_{it-1} + \beta_2 \text{Trainpassengers}_{it} + \beta_3 \text{Iberia share}_{it} + \beta_4 \text{Distance}_i + \beta_5 D_{it}^{T4} + \beta_6 D_{BCN}^{T3} + \beta_7 D_{it}^{HSR} + \beta_8 \text{Time} + \beta_9 D_i^{\text{summer}} + \sum_{h=10}^{17} \beta_h \text{Airport} + \varepsilon_{it} \quad [1]$$

Where MO_{it} is the number of monthly operations of direct commercial flights between Madrid and destination i in the period t . To explain the choice of monthly air carriers operations for each route we take as explanatory variables the following:

1. *Air passengers_{it-1}*: it is the number of air passenger carried in those operations between Madrid and destination i during period $t-1$. As expected, this variable is positively and highly correlated with the number of operations in the route. We applied a one period lag under the assumption that airlines modify their behaviour by taking into account what happened in the previous period. The number of passengers in a route is a variable that may be, in turn, affected by other variables. For this reason it has been instrumented for estimations of equation [1] (and also for equation [2] below) through the following variables:
 - 1.a. *Tourism per capita_t*: number of monthly tourists per inhabitant staying overnight in the cities analysed (sum of origin and destination of route) during period t .

- 1.b. *GDP per capita_{it}*: Gross Domestic Product per inhabitant (annual data) for the cities analysed (sum of origin and destination of route) during period t .
- 1.c. *Percentage of international routes_t*: percentage of international destinations for each airport in period t . This variable is an indicator of airports opening degree and its type of activity.
2. *Train passengers_{it}*: number of railway passengers between Madrid and destination i , in period t (average monthly data in this case). Data for Renfe was obtained on a yearly basis, being impossible to analyse its seasonality behaviour, but its evolution throughout the time and its importance with respect to air transport.
3. *Iberia's operations share_{it}*: share of air carrier Iberia in the air market, in terms of operations, in route i and month t . A higher share of Iberia in the air route should negatively affect the whole set of operations, as this means a higher level of concentration in the route.
4. *Distance_t*: number of kilometres between Madrid and destination i . As noted in Bilotkach *et al.* (2010), the relationship between distance and air carriers' frequency should be negative, though it might change in short distance routes.
5. D_{it}^{T4} : dummy variable that takes value 1 with the opening of Terminal 4 at Madrid-Barajas airport (February 2006). The opening of this new terminal meant a change of Iberia's strategy that concentrated most of its international flights at this airport that became its main hub.⁷
6. D_{BCN}^{T3} : dummy variable that takes value 1 for the route Madrid-Barcelona when the new Terminal 3 was opened (June 2009).
7. D_{it}^{HSR} : dummy variable that takes value 1 after the entrance of the HSR in route i during period t (see Table 2). Bilotkach *et al.* (2010) find for long distance routes that airlines' frequencies must be higher when they compete with the HSR.
8. Time: Variable that captures temporal fixed effects that may be present in the sample. It increases for each route with time.

⁷ Socorro and Betancor (2010) describe the reallocation process of airlines in Terminal 4 in Madrid and in Heathrow airport. The authors prove, by using a theoretical model, that such behaviour negatively affects competition among air transport companies.

9. D_i^{summer} : dummy variable that takes value 1 for months June, July, August and September in each route i .
10. $\sum_{h=1}^8 \beta_h \text{Airport}$: dummies that aim capturing destination airports fixed effects that have not been considered in previous variables.

Therefore the main objective is to observe the behaviour of variable D_{it}^{HSR} in our model. Nevertheless the result of such analysis would be general for the whole set of routes studied, being advisable the implementation of a differentiated analysis for each route. For this reason we substitute such dummy variable with three other ones. These are constructed by multiplying D_{it}^{HSR} by the specific airport dummy (BCN for Barcelona, MAL for Málaga and ZAR for Zaragoza). Such procedure allows capturing the effect of the HSR entrance in each of these routes. Therefore, the second equation to estimate would be the following:

$$\begin{aligned}
MO_{it} = & \beta_0 + \beta_1 \text{Airpassengers}_{it-1} + \beta_2 \text{Trainpassengers}_{it} + \beta_3 \text{Iberia share}_{it} + \\
& \beta_4 \text{Distance}_i + \beta_5 D_{it}^{T4} + \beta_6 D_{BCN}^{T3} + \beta_7 D_{it}^{HSR} * D_t^{BCN} + \beta_8 D_{it}^{HSR} * D_t^{MAL} + \\
& + \beta_9 D_{it}^{HSR} * D_t^{ZAR} + \beta_{10} \text{Time} + \beta_{11} D_i^{summer} + \sum_{h=12}^{19} \beta_h \text{Airport} + \varepsilon_{it}
\end{aligned} \tag{2}$$

In addition, by using Iberia's data on operations and passengers we will be able to obtain its reaction and also the reaction of remaining air carriers. To estimate both equations we proceed by applying a Two-Stage Least Square estimator (2SLS-IV) with instrumental variables. The instruments are used to explain number of air transport passengers and are detailed in a footnote in Table 3. To determine the instruments' validity we obtain the under-identification test and the Hansen J statistic for model over-identification (see last rows in Table 3).

Estimates for equation [1] are reported in column (1) of Table 3, and estimates for equation [2] in column (2). The case of the reaction of Iberia and remaining air companies are shown in columns (3) and (4) respectively. These last estimates are based on two equations that are not specified in the text for the sake of simplify. The numbers corresponding to such

equations would be [3] and [4] as well. In both equations the regressors are the same as those in equation [2]. The only difference refers to the dependent variable.⁸

TABLE 3: ESTIMATES OF THE AIRLINES' REACTION EQUATIONS (2SLS-IV)

Explanatory variables	Dependent variable			
	Total operations (1)	Total operations (2)	Iberia's operations (3)	Other airlines' operations (4)
Air Passengers (t-1)	0.0080 (0.0008)***	0.0080 (0.0008)***	0.0049 (0.0006)***	0.0040 (0.0005)***
Train passengers	0.0020 (0.0006)***	0.0020 (0.0004)***	0.0004 (0.0002)	0.0018 (0.0003)***
Iberia's share in air routes (operations)	-4.314 (0.9668)***	-4.2905 (1.007)***	5.226 (0.809)***	-8.561 (0.672)***
D ^{HSR}	-158.95 (25.93)***	-	-	-
Distance	-1.575 (0.6142)***	-2.735 (0.501)****	-0.101 (0.339)	-2.757 (0.363)***
D ^{HSRZAR}	-	-163.11 (28.26)***	-79.33 (21.05)***	-50.106 (18.11)***
D ^{HSRMAL}	-	-146.09 (39.68)***	9.318 (26.76)	-145.38 (26.40)***
D ^{HSRBCN}	-	-158.46 (154.22)	-246.44 (99.26)***	121.68 (85.55)
D ^{T4MAD}	-26.934 (20.36)	-27.43 (20.35)	-10.26 (14.52)	-4.523 (11.49)
D ^{T3BCN}	-193.45 (199.19)	-187.25 (209.23)	-91.96 (121.1)	-47.655 (103.09)
D ^{summer}	-57.71 (13.04)***	-57.80 (13.08)***	-31.56 (8.93)***	-31.48 (7.021)***
Intercept	931.08 (129.77)***	1222.25 (144.18)***	-287.42 (107.34)***	1417.57 (100.75)***
Number observations	1179	1179	1179	1179
R ² (Centered)	0.957	0.956	0.946	0.916
F-test (Joint significance)	1385.39***	1227.74***	662.87***	634.28***
Underidentification test (LM statistic)	87.37***	79.19***	79.197***	85.105***
Hansen J statistic	1.793	1.967	2.329	15.530**

Note 1: *** 1%, ** 5%, *10% significance test. Standard errors in brackets (robust to heteroscedasticity). Fixed effects are not included.

Note 2: Instruments for total lagged air traffic: tourism per capita, GDP per capita, percentage of international routes both in Madrid and destination.

The explanatory capacity of the model is relatively high (greater than 90% in all estimates), and the joint significance of variables (F-test) is accepted at 1%. The test applied to

⁸ To add robustness to the results we considered a cluster for standard errors. Nevertheless estimated covariance matrix of moment conditions not of full rank due to number of clusters is insufficient to calculate a robust covariance matrix. Despite this, both results (with an without cluster analysis) do not vary.

determine the validity of instruments are pass in all cases but for the Hansen J statistic for the case of explaining other airlines' operations that can be rejected only at 95%.

As expected, the variable *Air passengers_{it-1}* is positively correlated with the number of total monthly operations conducted by all air carriers in all models. For the case of model [1] the variable *Train passengers_{it}* is also positively correlated with airlines' frequency, what may be interpreted as an improvement in the degree of competition, probably registering decreases in prices in response to the entry of a new operator. Nevertheless we cannot be conclusive in this regard as we do not have data on prices in our data base.

In the routes in which Iberia has a higher market share, the total number of operations decreases. This result is shared by the works of Schipper *et al.* (2002), Carlsson (2004) or Bilotkach *et al.* (2010), who negatively relate the degree of concentration in a route with the number of operations offered.

The distance affects negatively as well the frequency of monthly flights. Most of the works find this type of relationship, though Bilotkach *et al.* (2010) doubt it for the case of short distance routes due to the competition effect of private cars.

The opening of the new airport terminals in Madrid and Barcelona do not seem to have modified this type of operations in any case. However operations in these routes decrease during the summer period.

Bilotkach *et al.* (2010) suggest that airlines are required to provide higher quality products to prevent travellers from using other transport modes. These authors find a positive effect of the HSR on air transport frequencies, except for routes with a distance lower than 550 kilometres. In our estimation we find evidence of just the opposite result, as the Dummy HSR is negative and statistically significant when explaining total number of operations. On average the number of air transport operations decreases by 158, out of a total average of 910, what means a 17% reduction.

In the analysis of total operations, though considering separately the effect for each route (Equation [2]), we find that with the exception of Barcelona, in the two other airports the HSR entry brought with it a reduction in the monthly frequency, though more accused in Zaragoza than in Málaga. In the case of Barcelona, the reaction is not so evident (non significant). This can be better understood by referring to estimations (3) and (4).

The reaction of the dominant air carrier is different to other airlines' reaction, as it can be observed by comparing the last two rows in Table 3. Firstly, the volume of passengers

transported by train does not seem to be a variable of interest for the whole set of operations of the Iberia company. This is not the case of other air carriers who are affected positively in their number of operations.

Secondly, Iberia's behaviour when the HSR enters in the market is to reduce its number of operations in Barcelona and Zaragoza, but its reaction for the route Madrid-Málaga is not clear. On the contrary, Biloktach *et al.* (2010) argue that Iberia reaction in the route Madrid-Barcelona was to maintain operations but with smaller planes. In this regard, it is worth to note that the Iberia Group is composed of several commercial brands like Iberia, Air Nostrum and since recently, the low cost company Vueling. As explained in Fageda *et al.* (2010) for the case of Barcelona airport, the Iberia strategy was to move operations to its low cost carrier sister company, though this is not the case of the route Madrid-Barcelona which is mostly operated by Iberia itself.

Thirdly, other airlines operations do seem to negatively respond in Zaragoza and Málaga after the HSR entrance, though their response in Barcelona is not clear. Finally, there is evidence that a greater market share for Iberia means a reduction in the number of operation of other airlines.

In general Iberia would be reducing its operations in Barcelona an 11% and a 34% in Zaragoza. The other airlines would reduce theirs a 31% in Málaga and would almost disappear in the route Madrid-Zaragoza. These results are more robust than those described in Park and Ha (2006) or in other descriptive works as other possible variables affecting the air transport operations are controlled through econometric means, allowing the delimitation of the specific effects of the HSR.

It is worth to note that such percentage values differ from those that could be inferred after a simple observation of our data base as described in Table 2. Our econometric estimates show that such descriptive results are the response to changes in several variables, including the HSR entrance, and therefore they cannot be allocated only to such entry.⁹

Finally, it is also important to realize that the presence of a dominant air carrier in an air route has an important negative effects upon other airlines operations as well that must be accounted for when examining the impact of the HSR over the airlines' frequencies. In this

⁹ In this regard, and according to data in Table 2, we might have concluded that after the entry of the HSR, air operations were reduced by Iberia a 36% in Barcelona, 19% in Málaga and 63% in Zaragoza, whilst other air carriers increased theirs a 31% in Barcelona, and decrease a 38% in Málaga and a 62% in Zaragoza. Such results would be misleading.

sense, the former flag carrier Iberia exerts a negative impact on other airlines competitive behaviour, as Iberia high level of concentration is negatively affecting other air carriers' level of operations.

4.2. The total passengers and market shares

In this section we conduct a similar empirical strategy to that applied in section 4.1, but we focus on how passengers by routes and market shares by mode change after the HSR entrance. The description of variables is also similar, but for the fact that variables are on a yearly basis. Therefore the number of observations is reduced to 99.

The aim here is to check whether the HSR entrance has favoured or not the market size in terms of passengers carried in the route, and to what extent it has altered the shares of airlines in the total market (air plus railways) and Iberia's passengers share in the air transport market. Therefore three additional estimates are reported in Table 4, corresponding to equations [5], [6] and [7].

The new variables and equations of interest are:

1. TP_{it} : It is the Total Passengers carried in route i at year t . It includes not only air passengers but also train passengers. We expect that the entry of a new operator (HSR) will increase the number of passengers carried in routes to/from Madrid. The equation to estimate in this case is equation [5]:

$$\begin{aligned}
 TP_{it} = & \beta_0 + \beta_1 \text{Population}_{it} + \beta_2 \text{Tourismpc}_{it} + \beta_3 \text{Iberia}_{it} \\
 & + \beta_4 \text{Distance}_i + \beta_5 \text{GDPpc}_{it} + \beta_6 D_{it}^{\text{HSRBCN}} + \beta_7 D_{it}^{\text{HSRMAL}} + \\
 & + \beta_8 D_{it}^{\text{HSRZAR}} + \beta_9 \text{Year} + \sum_{h=10}^{17} \beta_h \text{Airport} + \varepsilon_{it}
 \end{aligned} \tag{5}$$

2. ATS_{it} : This variable summarizes the annual Air Transport Share in terms of passengers of the total transport market (air plus railways) for route i at year t . Following our previous results reported in Table 3, we expect to find Spanish railways as relative winners of the race on market share, i.e., the air transport share reduces after the HSR entrance. Equation [6] refers to this estimation.

$$\begin{aligned}
 ATS_{it} = & \beta_0 + \beta_1 \text{Population}_{it} + \beta_2 \text{Tourismpc}_{it} + \beta_3 \text{Iberia}_{it} \\
 & + \beta_4 \text{Distance}_i + \beta_5 \text{GDPpc}_{it} + \beta_6 D_{it}^{\text{HSRBCN}} + \beta_7 D_{it}^{\text{HSRMAL}} + \\
 & + \beta_8 D_{it}^{\text{HSRZAR}} + \beta_9 \text{Year} + \sum_{h=10}^{17} \beta_h \text{Airport} + \varepsilon_{it}
 \end{aligned} \tag{6}$$

3. IS_{it} : It is the Iberia's Share in terms of passengers in the air route i at year t . In this case the relevant equation is equation [7], which tries to analyse the impact of the HSR entrance on Iberia's market share for the air market:

$$IS_{it} = \beta_0 + \beta_1 \text{Population}_{it} + \beta_2 \text{Tourismpc}_{it} + \beta_3 \text{Distance}_i + \beta_4 \text{GDPpc}_{it} + \beta_5 D_{it}^{\text{HSRBCN}} + \beta_6 D_{it}^{\text{HSRMAL}} + \beta_7 D_{it}^{\text{HSRZAR}} + \beta_8 \text{Year} + \sum_{h=9}^{16} \beta_h \text{Airport} + \varepsilon_{it} \quad [7]$$

All equations have been estimated by using the Ordinary Least Squares regression method, robust to heteroscedasticity. The endogenous variable in equation [5], i.e. Total Passengers, has been transformed into logarithms. All equations show a high R^2 and joint significance tests are not rejected.

TABLE 4: ESTIMATES OF THE TOTAL PASSENGERS AND MARKET SHARES EQUATIONS

Explanatory variables	Dependent variable		
	(Ln) Total passengers by route (air plus rail) (5)	Air transport share of total market (air plus rail) in terms of passengers(6)	Iberia's share (air market) in terms of passengers (7)
Population	-7.53e-08 (1.12e-07)	6.8e-7 (2.1e-6)	-8.7e-6 (7.1e-6)
Distance	-0.0067 (0.0007)***	0.300 (0.013)***	-0.122 (0.037)***
Iberia's share in air routes (operations)	0.0004 (0.0024)	-0.235 (0.073)***	-
Year	0.0822 (0.0417)*	-1.837 (0.944)*	3.788 (2.669)
D ^{HSRZAR}	0.4779 (0.1373)***	-14.212 (1.123)***	-5.346 (2.559)**
D ^{HSRMAL}	0.4162 (0.2149)*	-18.662 (8.397)**	2.342 (4.651)
D ^{HSRBCN}	0.8618 (0.0669)***	-33.097 (3.672)***	-15.954 (4.707)***
Tourism per capita	3.2220 (2.2404)	26.710 (40.641)	-76.646 (116.42)
GDP per capita	-0.0482 (0.0275)*	1.600 (0.693)**	-1.161 (1.742)
Intercept	-148.381 (82.702)*	3597.44 (1872.34)*	-7361.0 (5278.9)
Number observations	99	99	99
R ²	0.9842	0.9899	0.8332
F-test (Joint significance)	1069.64***	2182.38***	140.01***

Note: *** 1%, ** 5%, *10% significance test. Standard errors in brackets (robust to heteroscedasticity). Fixed effects are not included.

The entrance of the HSR in the Spanish markets has produced an important impact on demand that has increased between 41 to 86 per cent, depending on the routes. The most important effect is registered for the route Madrid-Barcelona, however we are not able to identify what part of it has been deviated from the road and what part is purely new generated demand.

On the other hand the air transport total market share has been also significantly affected. After the entry of the HSR the air transport share of the total market is about between 14 to 33 points lower, and again, the greatest impact appears for the Madrid-Barcelona route. Finally, the Iberia's share in the air markets also reduces with the operation of the HSR, and it is for the route Madrid-Barcelona where such a decrease is more important as well.

According to our results the HSR has won the race with air carriers for the Spanish transport markets. This result is very clear in the route Madrid-Barcelona. A similar result is obtained for Madrid-Zaragoza, thought being this route the shorter one, with a number of flights that were already low at the beginning of the sample period, the entry of the HSR has led the air transport mode to a mere representative role in this case. The situation in the Madrid-Málaga route is a bit different, with estimates that show a lower significance level.

As a summary, the entry of HSR in the Spanish market has brought with it the following main results: it has increased the demand substantially; in spite of such an increase, the weight of air transport in the total market has been reduced, as it has been reduced the weight of the dominant Spanish air carrier Iberia on air markets.

The analysis of remaining variables is in general quite standard. For example the analysis of the distance variable indicates that the total number of passengers in the routes reduces with distance, whilst the air transport share in the markets increases.

5. Summary and Conclusions

The HSR impacts not only on the environment, mobility or on the process of territorial integration, but also upon other competitive transport modes, especially air transport. In spite of having available a vast amount of industrial organization literature about competition on air transport markets, the references regarding the HSR's impact on the air transport sector are more reduced. The works by Park and Ha (2006), Campos and Gagnepain (2009), Gouvister (2010) or Albaladejo and Bel (2010) summarise most of the HSR experiences throughout the world, but none of them determine specifically the air companies' reaction when the HSR enters the market. As far as we know, only Biloktch *et*

al. (2010) take into account the existence (not the effect of HSR's entrance) of HSR in their analysis of the effects of distance upon competition among the air sector, private cars and railways.

The first objective of our work was to delimitate the air carriers' reaction to the entry of the HSR in terms of frequencies offered. With that aim we conduct an empirical analysis by using monthly data on air transport operations in nine Spanish routes with origin Madrid from January 1999 to December 2009.

By controlling the factors that might affect airlines' decision when offering a given operations frequency (number of passenger, level of concentration at the air route, income, tourism, distance, fixed effects, etc.) and with a Two-Stage Least Square estimator (2SLS-IV) with instrumental variables, we arrived to the following main conclusion: the entry of the HSR in Spain, a political decision exogenous to the route's features, has reduced on average the number of air transport operations by 17 %, though this result differs depending on the route and the airlines considered.

As a second objective we aimed to check whether the HSR entrance has favoured or not the market size in terms of passengers, and to what extent it has altered the shares of airlines in the total market (air plus railways) and Iberia's passengers share in the air transport market. The empirical strategy, description of variables and period of time considered was similar to that applied to get estimates for the effect on frequencies, but for the fact that variables were on a yearly basis. For this part of our work the main conclusions are the following:

On the one hand, the entry of HSR in the Spanish markets has allowed the demand to increase substantially, between 41 to 86 per cent, depending on the routes. The most important effect is registered for the route Madrid-Barcelona, however we are not able to identify what part of it has been deviated from the road and what part is purely new generated demand.

On the other hand, and in spite of such an increase, the weight of air transport in the total market has been reduced. According to our results the HSR has won the race with air carriers for the Spanish transport markets. This result is very clear in the route Madrid-Barcelona. After the entry of the HSR the air transport share of the total market is about between 14 to 33 points lower. Finally, the Iberia's share in the air markets also reduces with the operation of the HSR.

In summary, the Spanish railways appear as the winners in the race for the market: they have been able to increase the number of carried passengers and market shares, whilst air carriers have had to face just the opposite situation. The main question that arises is whether both have been competing on a level playing field or not, as far as the HSR infrastructure investments are not recovered through infrastructure access charges.

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