PRICE ELASTICITY OF DEMAND IN THE HIGH SPEED RAIL LINES OF SPAIN: THE IMPACT OF THE NEW PRICING SCHEME

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ABSTRACT

Reduced travel time, regional cohesion, economic development and environmental benefits were some of the reasons given to develop the High Speed network in Spain, the largest in Europe. Ever since the opening of the first High Speed line in 1992, High Speed Rail (HSR) have become a new travelling experience despite the fact that in the recent years several voices have raised concerns over a lack of demand and low occupancy rates for HS trains compared to other countries. In February 2013, RENFE implemented a new pricing scheme which reduced ticket prices by at least 11%, and introduced flexibility in their purchase in order to boost the usage of HSR. In this research, the effects of the new scheme are analyzed and the impact on the shift in the modes of transport is underpinned by considering a discrete choice model. As a consequence of this policy, occupancy rates have been hugely increased but several other findings arise from the research. Although apparently ticket price is not regarded by users as the main factor to travel by HS trains, the price elasticity of demand turns out to be high. Depending on the transport modes competing with HS the effects are quite different. For short routes connecting small and medium-size cities with big metropolitan areas the growth of demand is achieved at the expense of car and bus, whereas for long routes connecting large cities where air transport is available the growth is made mainly at the expense of air transportation, and induced demand is also triggered. Finally, when the owner of the infrastructure and the Train Operating Companies (TOC's) are both managed by the government, the rail infrastructure fee policy set may prompt unfair competition with other modes such as the bus or the plane.

1. INTRODUCTION

High-Speed Rail (HSR) has been by far the means of transportation where the Government of Spain has invested the most over the last two decades with more than €45 Billion. The first HSR line in the country was inaugurated in 1992, linking Madrid and Seville, which is the country's fourth largest city. Seville had been elected to host the 1992 Expo World's Fair and through this investment the economy of the south region was expected to be stimulated. After the first project, Spain continued building new HS lines, and now has the largest HSR network in Europe accounting 3,100 km in service —expected to reach 5,000 km in the near future—, and is the second largest in the world after China.

The HSR lines in Spain, also called AVE (Alta Velocidad Española), are very prestigious because of the punctuality of the trains is almost 99%, it has helped to promote regional cohesion and economic development, and is an environmental friendly transport mode. To have an idea of the know-how and experience gained with the HSR, it is remarkable that a consortium headed by Spanish companies, in conjunction with two Arabian companies (88% of the shareholders are Spanish), was selected to undertake an investment of around €7 Billion in the trains and superstructures of the HS from Medina to Mecca.

However, HSR has also disadvantages such as the huge investment necessary to build the infrastructure, the high maintenance costs and the low demand in many corridors that makes difficult to justify some relationships from a socioeconomic point of view *(1)*. In fact, according to the Minister of Transport some of the lines in Spain had an occupancy rate below 50% in 2012 (see press reference [1]). By the beginning of 2013, the Spanish Government decided to implement a more flexible pricing policy, as well as an overall price reduction for every kind of tickets, aimed at improving the occupancy rate of HS trains. This pricing scheme is similar to the Yield Management *(2)* technique used in airplanes, which sets the price depending on the hour of the day, the category of the user (i.e. first class or tourist), the demand expected, and how far in advance the booking is made.

The goal of this paper is to examine the effects that the reduction of prices have had on HSR demand and, where possible on the Spanish transport system. The remainder of this paper is organized as follows. Section 2 provides further literature review on the aspects influencing HSR demand compared to other transport modes. Section 3 describes and analyzes the case study of Spanish HSR pricing policy, including a discrete choice model based on a survey conducted in 2014 aimed at underpinning the results. Finally, section 4 discusses the key findings from this analysis and points out potential policy implications.

2. LITERATURE REVIEW

It is broadly acknowledged that HS Trains run at a speed above 250 km/h offering high capacity and, in some corridors, also high frequency. HSR is also regarded as an environmentally friendly substitute for travel by air and by car in medium-distance relationships. Albalte and Bel *(3)* found the distance between the railway nodes to be a key factor influencing success. In addition, HSR can replace conventional railway trains in corridors where higher capacity and less travel time is needed, improving in this way the railway service, even at the expense of other modes that end up being substituted. Nevertheless, some authors have pointed out that the investment in HSR is very

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[1] http://economia.elpais.com/economia/2013/01/29/actualidad/1359460357_382996.html

high and could not be justified based on its economic benefits since these are not certain *(4)*, but on the other hand there are examples of where HSR have good economic returns and in extreme cases could be commercial *(5)*. Indeed, De Rus *(6)* confirms that an important demand is needed to justify the investment in HSR from a CBA perspective. In the case of Spain, spatial equity was the main reason to promote HSR. The President of the government said in 2005 that all capitals of Spain's provinces should be linked with HSR so that travel times were no longer than 4 hours from Madrid. Indeed, and unfortunately, there were no debate in the political scene about the social return of HSR investment, as it is considered a symbol of modernity, enjoys the support of the public, and tickets are subsidised *(7)*. However, the government should avoid excess charges which can turn out to reduce the social benefits from a new HSR line by reducing traffic and having a smaller market share compared to air transportation *(8)*. Despite huge transport benefits mainly for existing and future rail users, the planned HSR in the UK to cover operating and maintenance costs, but a subsidy from the Government would also be needed *(9)*. The develop of a new HSR line may also be an opportunity to improve decision making processes not only for railway infrastructure, but for every kind of transport infrastructure *(10)*.

The academic literature regarding HSR is vast and diverse. Generally speaking, studies about their effects can be divided between *ex-ante* and *ex-post* interventions. The first group of studies are quite optimistic whereas the second group identifies benefits and costs in a more realistic manner *(11)*. The gains due to HSR are larger in the first cities to be connected, but also some small cities have experienced important transformations, particularly where additional investments from the public sector were implemented. However, Monzon et al. *(12)* remark that the accessibility gains are more notable in urban areas with a HSR station whilst other locations get a limited benefit (the by-pass problem) and therefore spatial equity issues could arise. In order to avoid such imbalances, Bröcker et al. *(13)* recommended considering network efficiency and spatial equity issues in the planning process of HSR. In other words, the benefits from HSR are not universal and depend on the case study, since transport is a necessary but not sufficient condition for the development of cities *(14)*.

Competition between HSR and other transport modes, particularly air transport, has also been widely studied. Strong competition between air transport and HSR can occur on routes with distance up to 1,000 km *(15)*, but this is most likely between 400 and 800 km *(16)*. Several parameters are important in the assessment of competition. For instance, Dobruszkes *(17)* found that in addition to travel time, there are other variables which may affect competition, including frequencies, fares, airlines' hubs, and geographical structures of urban regions. Pagliara et al. *(18)* noted that prices and frequency are among the most important variables to explain HSR demand coming from competing modes and check-in and security controls affects negatively airplanes demand. For the London–Paris route travel time and frequency were found to be the two main keys of travel behavior *(19)*.

Clewlow et al. *(20)* found that improvements in HSR travel time lead to a reduction in short distance air trips. In addition, urban structures have an important influence on modal share. Albalate et al. *(21)* found a reduction in the number of seats offered by airlines albeit flight frequencies were not expected to have a significant reduction, i.e. switch to smaller plains. Rail – air agreements can also bring commercial and environmental benefits, but under some circumstances the agreements can raise competition concerns from a legal perspective *(22))*.

The role of HSR in explaining tourism has also been studied, finding some differences across European capitals. Whereas in Paris HSR is considered one of the reasons for tourists to visit the city, this does not happen neither in Madrid nor in Rome *(23, 24)*. Competition between HSR and conventional trains has been also analyzed for the case of Taiwan, where the pricing strategy is a determinant factor to the profit and welfare *(25)*.

It is remarkable that HSR is usually highly regulated and unlike airlines hardly ever applies price discrimination with Eurostar and the current competitive situation in Italy as exceptions. Based on that Yang and Zhang *(26)* develop a model assuming airlines aimed at maximizing their profit whilst HSR maximize a weighted sum of profit and social welfare. The profit of air transport was found to be higher under price discrimination than with uniform pricing, whereas the profit for HSR remained unchanged, even though the welfare could vary. In a research conducted in the UK, Harvey et al. *(27)* found that willingness to pay for travel time reductions was also related to prestige and comfort.

With respect to ticketing preference, Cheng and Huang *(28)* remark that perceived benefits, perceived sacrifice and perceived ease of use are critical factors influencing passengers' retail channel preference. Moreover, they also found differences among demographic factors, trip characteristics, and how far in advance the ticket is bought.

Finally, it is noteworthy that all over Europe railway infrastructure belongs to the government and the service is mostly provided by public companies, which have to pay an annual fee for the use of the railway track. According to the European regulation (the Fourth Package), railway infrastructure should be opened to all competent in the near future. Thus, TOC's are looking for decision-support tools in the areas of pricing, yield management, schedule planning, and control to capture new users or retain the existing ones *(29)*.

For instance, in April 2012 Italy adopted the European regulation with an increase in HSR demand and train supply, albeit the results for the private operator are not so positive *(30)*. To our best knowledge the recent pricing experience in Spain is an important example of yield management in HSR, and thus constitutes an interesting case study for policy makers and regions concerning new HSR developments. The main objective of this research is to analyze this case study, explaining the impacts of the new pricing policy on other transport modes and on HS demand. Therefore, we study the transport demand in some corridors with HS as well as we develop a discrete choice model focused on explaining the reasons for users to choose HSR and price elasticity of demand.

3. CASE STUDY: IMPLEMENTATION OF A YIELD MANAGEMENT SYSTEM IN HIGH SPEED LINES FOR PASSENGERS IN SPAIN

3.1 Background: Transport for passengers in Spain

Domestic passenger transport in Spain is dominated by the road mode with more than 90% of the share over the last five years. This high value was encouraged by the vast highway network developed over the last two decades. In 2013 Spain had 15,100 kilometres (7,007 miles) of modern high-capacity roads *(31)*. The role of road transport in the international market (i.e. travellers from abroad) has become less important in recent years, decreasing from a share of 51% to 44%, whilst the air transport increased from 46% to 53%.

Rail and air transportation have not been able to threaten the road dominance for domestic use despite the fact that passengers' rail share has slightly increased from 5.2% in 2009 to 6.0% in 2013. Inland waterways transportation within Spain is very low compared with other EU countries. Rail transportation plays an almost negligible role at the international level (less than 0.2%).

Therefore, the goal of HSR investment in Spain was not to change Spanish transport modal share inside out, but rather to change modal share in specific point to point relationships.

3.2 High Speed Rail transport system in Spain

After joining the EU in 1986, Spain took advantage of European funds and its good economic growth to develop its HSR network. Indeed, in 1987 the PTF (Railway Transport Plan) considered an increase of the maximum speed from 160 km/h to 220 km/h and in 1988 the government resolved to build the first HSR line (Madrid to Seville).

This first HSR line was constructed according to the technical standards of the French high-speed network (TGV) with a gauge of 1435 mm. It entered into service in April 1992 and initially linked Madrid and Seville in 2 hours and 55 minutes compared to the formerly 7 hours required. The infrastructure also connected the intermediate cities of Ciudad Real, Puertollano and Cordoba. One year later the commercial speed was increased up to 300km/h and the travel time was reduced to less than 2hours and 30 minutes. The effects on the transport system on that corridor were large: the share of the train rose from 14% to more than 43% mainly at the expense of the airplane and by capturing additional users as well *(32)*. The next step in the HS network was the connection between Madrid and the second largest city in Spain, Barcelona, in the so called North East corridor. The construction of the HS line Madrid-Zaragoza-Barcelona-French border and the HS line Madrid-Valladolid began respectively in 1997 and 2002.

In 2003, the stretch Madrid – Zaragoza was opened at a reduced speed of 200 km/h due to the lack of the European signaling system, known by its acronym ERTMS. In 2006 and thanks to the ERTMS, the commercial speed was increased to 250 km/h. Only one year later, in August 2007, there was a new increment to 300 km/h. By the end of that year, two new stretches entered into service: Madrid – Valladolid and the stretch Cordoba – Malaga in the Northwest and South corridor, respectively. The HS to Barcelona was inaugurated in February 2008. Again, the effect on the competition with the airlines was enormous. The HSR increased the market share of trains in that relationship from 12% to 47%, and reduced the share of the airlines to 53%. In December 2010 the connection between Madrid and the third most populous city in Spain, Valencia, entered into service, reducing the travel time by train from 7 hours to 1 hour and 35 minutes. In this origin-destination pair, the modal share of the train grew from 12% to 46%. The share of air and bus transportation went down from 17.4% and 9.2% to 2.6 and 3.1% respectively. This HS line also connected small cities such as Cuenca and Albacete to Madrid. Finally, in 2011 the speed for Madrid – Barcelona was increased to 310 km/h. Other milestones were added after 2011 such as the stretch Albacete – Alicante which opened in June 2013. However, for the purpose of this research we will focus on those Main Lines and cities showed in the **FIGURE 1** below, due to the fact that the new pricing scheme was approved before, in February 2013, and therefore there are no data available to compare the effect of the new tickets price with the previous situation in the new lines.

By 2012, twenty years after the inauguration of the first HS line, more than 300 HS trains run every day in Spanish HSR tracks, serving nearly 100,000 passengers and reaching 80 Spanish municipalities.

FIGURE 1 Apps here

3.3 New pricing scheme and demand analysis in HSR corridors

In Spain RENFE is the acronym for the public operator company whereas ADIF is the name of the public company owning and managing the HSR network. Since the beginning of the HSR, RENFE had set fixed prices which depended only on the class, and type of train. Discount prices were implemented years later, but the approach was still far away from the Yield Management pricing techniques used by airplanes *(2)*. RENFE wanted to go further so in February 2013 it introduced more flexibility as well as generalized ticket price reductions aimed at improving the occupancy rate of HS trains. The main characteristics can be summarized as follows:

- Average reduction for the single ticket price by 11%. If the trip is above 650 km, the reduction is even greater. This reduction is applied to HS trains without the category of Public Service (PS), i.e. ALVIA running at 250 km/h and AVE running above 300 km/h. The trains under PS are cheaper since they can receive a subsidy, their name is AVANT and their maximum speed is 250 km/h.
- Promotional ticket with a reduction up to 70% of the single ticket price. The discount depends on the expected demand and how far in advance the booking is made. The main disadvantage of this ticket is that cancellations and changes are allowed but at a higher price than in other categories. This tariff is similar but not the same to the Yield Management technique used in airplanes. Prices are changed on a daily basis, thus this is not as dynamic as airline tickets. Moreover, when a season peak is expected RENFE usually launch special promotions with a high number of tickets falling within this category.
- Bonus for 10 trips between two cities, which can be used within the following four months after the acquisition. The discount applied is 35% with respect to the single ticket price.
- Annual young card for people aged between 14 and 26. It offers discounts over 30% of the single ticket price.
- As in the previous years, return trips are discounted by 20% compared to the single ticket price.

One of the reasons why RENFE is so popular among its users is due to their punctuality commitment which was implemented ever since the very beginning of the HS. If a train arrives 15 minutes late, RENFE will reimburse 50% of the ticket price. If the delay is above 30 minutes, RENFE will reimburse the whole ticket price. This commitment is even harder for the first line, Madrid–Seville, where the reimbursement of the whole ticket is triggered with a delay above 5 minutes.

Despite the Spanish GDP went down by 0.8% the year after the introduction of the new pricing scheme, the revenue was increased by 6.7% and the average occupancy rate of HS trains rose from 66% to 74.3%, so it met the initial objective of boosting the demand and increasing travelers by train. The results for the main lines are summarized in **TABLE 1** below**.**

Two main conclusions arise from **TABLE 1**. Firstly there has been an outstanding demand growth. Secondly, this increase has been different among types of OD pairs. Therefore, the trips are classified according to the distance travelled and the competing transport modes, as described below.

3.3.1 Short distance below 100 Km

In this kind of corridor three transport modes compete: bus, HSR and car. The route links small and big cities, and the total travel time is usually below 1 hour. Two OD pairs are in this category, Madrid – Segovia and Madrid – Toledo. Many of the users of this relationships are either commuters, who live outside Madrid but work in Madrid, or tourists. It is important to note that the pricing scheme has not been reflected in an appreciable way because most of the users fall within PS trains (AVANT trains) which always have the same cheaper price. In fact, in Segovia there has been a shift from AVE and ALVIA to AVANT, making a total growth in the corridor of around 2%. In Toledo only AVANT trains are available. The economy of these two cities strongly depend on tourism so, the difference in the train demand growth can be explained by RevPAR (Revenue per available room) which decreased in Toledo by 10.9% and increased in Segovia by 4.4%. In other words, the price elasticity of this kind of corridor is very low and their trips rely very much on GDP growth.

TABLE 1 Apps here

3.3.2 Distances between 150 km and 400 Km without planes

This kind of corridor links small and medium-size cities, with the only exception of Zaragoza, which is a medium/large city of around 650 thousand inhabitants. Again, three transport modes — bus, car and HSR— compete for passengers. The reduction of Madrid – Valladolid is explained by the AVANT trains running in the corridor. As with the case of Segovia, there has been a shift from AVE and ALVIA to AVANT. AVANT trains growth by 2.5% and the total growth in the corridor was 0.5%. In fact, since the introduction of AVANT trains in 2009 this shift has been produced at a steady pace. So in corridors where PS is available, the reduction of ticket prices seems to be negligible since users tend to prefer to travel using cheaper and invariable price of PS trains. It is also noteworthy that travel time with AVANT trains is only 5 minutes more than with AVE trains and it is the same as with ALVIA trains.

The huge growth of Albacete – Madrid trip could be influenced by the fact that other kind of trains offering a longer distance and travel time at a cheaper price from Madrid were still running, and therefore a shift of users from those trains could have happened. With respect to the other modes, HSR growth in this corridor was reached at the expense of car and bus users. No additional demand was recorded in these corridors.

3.3.3 Distances above 350 km with airplanes

This kind of corridor connects large cities with metropolitan areas above 1.5 million inhabitants. In these OD pairs HSR mostly competes with air transportation. Focusing just on the rail–air market the share of HS trains is around 80% whilst the share of airplanes is around 20%. The ticket reduction has increased the share of HS trains, reduced the share of air transportation, and prompted induced demand in the corridor.

The case of Madrid – Barcelona corridor is quite interesting because it was opened in 2008 and competition between air and AVE has been fierce ever since. In fact, 2012 was the first year in which HSR transported more users than air transportation (2.688 Million users vs. 2.573 Million users). It is remarkable that the growth of AVE demand in the Madrid – Barcelona pair has been mainly at the expense of airplane users while new users were also induced. Whereas travelers by car and bus slightly went down by 1.2% and 3% after the Yield Management Price was implemented, that was not the case with airplane and HS travelers. HS users increased by 16%, while airplane users were reduced by 14%. Despite the economic recession, the total travelers in the corridor increased by 0.5%. This kind of corridor is the only one where, despite of the economic recession, overall demand ultimately grew.

3.3.4 Long distance journeys

For the two trips in this category, the in–vehicle travel time by airplane is around 1 hour and 30 minutes, whereas by HSR it is 5 hours and 30 minutes. The effect of the new pricing scheme has been enormous since the huge increase of demand has been done at the expense of airplanes. In this case the total demand in the corridor went down substantially.

As previously explained, the pricing scheme had a huge impact on other transportation modes. Particularly the airplane and the bus endured a decline due to a shift of passengers to HSR along with the economic downturn. In fact, in some corridors HS trains were found to be cheaper than bus services. After a complaint made by bus companies (see press reference[2]) which are highly priced by taxes and special fees *(33)* and several conversations with air companies, RENFE decided to keep the same prices as in the previous year in order to fairly compete with other transportation modes. Indeed, the Spanish Court of Auditors recognized that the annual fees paid by RENFE to ADIF only cover around 50% of total infrastructure cost, albeit maintenance cost are totally covered.

3.4 The effects of Yield Management pricing policy in the transport system of High Speed Rail in Spain

3.4.1 Methodology

The study of the choices that consumers make when confronted with different alternatives is of the utmost importance. In the transportation field, the individual preferences of consumers, and the distribution of these preferences across the population have been widely taken into account by considering discrete choice models.

Discrete choice models have been developed and applied in disaggregated analysis of travel choice behavior since the beginning of the 1970s. In fact, progress towards the choice of the transportation mode were carried by several researchers such as Domencich and McFadden *(34)*; and McFadden.*(35)*. As a result, discrete choice models have been applied to describe the behavior of consumers when they are faced with a variety of mutually exclusive choices *(36)*.

Discrete choice modeling assumes that the utility of each alternative is probabilistic, with error terms that follow the Gumbel distribution. The best-known probabilistic discrete choice model is the Logit model because it provides a convenient representation of the degree of heterogeneity of consumer tastes among existing models of product differentiation. As previously pointed out, the underlying force driving the implementation of a Yield Management pricing policy in the context of demand levels is the price. This section examines through a discrete choice modeling to what extent the new pricing policy implemented has made a difference in the HS passenger transport segment.

3.4.2 Revealed and stated preferences surveys

In order to comply with the objective of this research, we intend to develop a comprehensive database. In this sense, two different types of data collection could be conducted for such an analysis to identify: (i) why certain choices were made by travellers through Revealed Preferences (RP) surveys; and (ii) to identify how respondents' choices vary in different hypothetical situations by considering Stated Preferences (SP) analyses.

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[2] http://www.eleconomista.es/interstitial/volver/cetelem/transportes/noticias/5474387/01/14/Renfe-congela-la-bajada-de-precio-del-AVE-para-no-danar-a-autobus-y-avion.html#.Kku8HvGDecAfd11

As part of a research project developed in 2014, a survey was conducted to determine the reasons why the passengers have made their journey (e.g. origin, destination, travel time, cost, and income), and to understand through SP surveys the relative importance given by travellers to various characteristics of their journey such as cost to change the transport mode they use. The survey was made at the main HSR station in Spain, the Atocha HSR station in Madrid. It was conducted face to face by filling a questionnaire with both RP and SP surveys.

With regard to the survey, respondents answered a paper questionnaire that had been tailored to better meet the evidence of actual market behavior (i.e. High Speed Services), and the hypothesized scenarios. The first part of the questionnaire asks the respondents to describe their RP preferences taking into account current journey and it includes questions on the following aspects: (1) Journey's origin and destination; (2) Journey purpose; (3) Journey duration; (4) Whether the respondent was travelling alone; (5) Type of ticket the respondent was travelling on; (6) Who was paying for the respondents' journey; (6) Journey cost; and (7) Respondents' socio-economic profile (income). The second part of the questionnaire describes the SP exercise. In that questionnaire a hypothetical cost scheme was briefly introduced and asks whether the respondent would choose other mode, and which costs would influence their decisions. The cost variable was varied over four levels, and those values were the same regardless of the HSR service evaluated.

Both RP and SP surveys were conducted in March 2014. We collected 220 complete RP+SP interviews focused exclusively on HS travelers, with representation of men (61%) and women (39%) chosen randomly. The key outputs regarding the trip maker are the following: the main socioeconomic characteristics shows that 61% of the respondents earned more than € 1,000 per month. Users between 25 and 50 years old were the most represented ones. Forty percent of the users in the sample were singles while 60% were partnered. The majority of respondents traveled in a group, mostly with a partner or relatives (55% of the sample) and 45% were traveling on their own. Fifty percent of the respondents had a university degree. The sample mainly comprised employees (62%), with lower percentages of students (18%). For 16% of the sample, the income was higher than €2,500 per month, while the income was lower than € 500 per month for 28% of the travelers. Finally, the three most important reasons for choosing HSR were: speed of the trip by train, comfort, and frequency.

Regarding the journey characteristics (door to door), the survey results show that the HSR is the mode with lower travel time followed by the air transport mode. The third mode with low travel time is the car, and finally the coach has the largest travel time.

Although the interview was designed to have a higher response rate with the intention of assure more accurate results, it should be noted that the respondents who provided data are a representative sample of the population using HS lines as described above. It obviously does not allow for other analysis such as purpose, income, conventional inter-city rail, or other.

3.4.3 Logit model development for the High Speed services choice

The selection of a Logit model for explaining HSR choice will provide us with an approach to assess strategic key variables for users to choose a certain transportation mode such as price, travel time, or income. The Logit model predicts the choice among possible transportation mode alternatives taking into account data from each choice obtained from the survey described above. The Logit model considers that the utility function is decomposed in two parts: the part known defined over observable characteristics V_j^m, and the other part ε_j^m being the differences of members of the subpopulation (see expression 1).

$$U_j^m = V_j^m + \varepsilon_j^m \quad (1)$$

Ben-Akiva et al. *(37)* claim that early applications of discrete choice analysis used RP surveys, but SP may be used too. In this sense, they provide analysis and advice when both data are available by considering: (i) one model for each case; and (ii) joint estimation method for both surveys. Indeed, the implementation through the combination of RP and SP have been undertaken in different ways, such as the valuing of environmental amenities, opening of new subway lines, or mode choice –see more details in *(38–40)*.

In addition, Hensher *(41)* claims that that the combination of the both data sources allow to estimate models using data not available in one of the sources available (an alternative is present within the SP component of a data set but not within the RP component). Indeed, we previously considered this situation in our research, and then we proceed with the field work.

As suggested above, we developed the Logit model by considering the joint estimation of the revealed and stated preference data since they have complementary characteristics by considering the cross-sectional survey for the identification of factors that otherwise would not be known. As an illustration, to comply with the joint analysis, some researchers – see *(41)*– have proposed as a common practice to use a two-level Nested Logit (NL) model with one branch including all the RP alternatives and a second branch for the SP alternatives. NL models overcome problems detected in the single level multinomial Logit formulation as the independence of irrelevant alternatives issue. Both RP and SP utility functions are expressed as follows:

The RP model

$$V_{HSR}^{RP} = \beta_1 Cost + \beta_2 TTime \quad (2)$$

The SP model

$$\begin{aligned} V_{COACH}^{SP} &= \beta_1 Cost + \beta_2 TTime + \gamma_1 COACH^{SP} \quad (3) \\ V_{CAR}^{SP} &= \beta_1 Cost + \beta_2 TTime + \gamma_2 CAR^{SP} \\ V_{AIR}^{SP} &= \beta_1 Cost + \beta_2 TTime + \gamma_3 AIR^{SP} \end{aligned}$$

The NL model reported –see **TABLE 2**– has resulted from the comparison among four models ─for instance, one which may have additional variables included in the model (e.g. Income level of the interviewee), and the other without these variables. The selected model is reported below. The NL model parameter estimates were obtained using the NLOGIT software considering the maximum likelihood method. For the performance of coefficients we consider both the signs and the significance of each parameter.

TABLE 2 Apps here

Overall, the estimated coefficients have the expected signs because they have a negative effect on utility of an alternative according to economic theory. The significance of coefficients was checked through the *t-statistic* significance test (values in brackets). These values reject in most cases the null hypothesis that the coefficient is zero with a level of 90% confidence (see the *p-values*). Also, in discrete choice models, it is convenient to measure goodness of fit analogous to those in linear statistical models. Indeed, the likelihood ratio test ─McFadden Pseudo R^2 (ρ^2)─ provides a convenient basis for comparing different models when estimating more than one alternative.

Although the Pseudo R^2 is analogous to R^2 in linear regressions (ranges between zero to one), but it cannot be analysed in the same way and it should be used with some caution. In fact, the relationship between the indices R^2 and Pseudo R^2 are provided in *(34)*. Within this context, several researchers have suggested that Pseudo R^2 values tend to be much lower, and a Pseudo R^2 value around 0.2 is good *(35, 41–43)*. Moreover, Ben-Akiva and Lerman *(44)* claim that statistical tests cannot be used as the only criteria for acceptance or rejection of a model.

Additionally, direct and cross-point elasticities are reported in **TABLE 3** by applying NLOGIT effects option**.** These values reflect the relationship between the change of cost of the alternative (HS rail) and the change in demand share. For instance, taking the elasticity on the train alternative, the direct effect is -0.58. This means that under *ceteris paribus* a 1 percent increase in train cost will decrease the probability of selecting the train alternative by 0.58 percent. The remaining elasticities represent the cross-elasticity effects. As explained above, a 1 percent increase in train cost will result in a 0.61 percent increase in the choice probabilities for the coach.

TABLE 3 Apps here

With these values, we note that the direct effect of cost elasticity for the train is relatively inelastic while the cross-elasticity effects of cost on the coach, car and air alternatives will result in the increase of the choice probabilities of them. Similarly, the remaining elasticities confirm the expectations, an increase in cost is likely to increase the demand for competing goods or services. However, in spite of these unquestionable achievements, cross elasticities are nonetheless beset by bias in the answer due to the fact that the same person answered several questions about his journey *(45)*.

Before making any comparison of the estimation results with those of the literature and of project studies it is important to bear in mind that this comparison is difficult since this research is focused on the demand changes experienced in Spain HS rail lines. This means that the results of Table 3 are valid for Spanish HS users and in order to conduct an accurate comparison it would be necessary to carry out a survey for every type of traveller. Nevertheless, as explained below, the elasticities found only differ in the order of magnitude but not in the expected sign.

Roman, Espino and Martin *(46)* conducted a SP and RP survey with a total of 3,143 valid observations for all type of users in the corridor Madrid – Zaragoza – Barcelona. The elasticity of HS services with respect to price was -0.55 for the route Madrid – Zaragoza and – 0.72 for Madrid – Barcelona, which is fairly consistent with the results obtained here. The cross elasticity of HS with respect to car was 0.12 for Madrid – Zaragoza (in our case study 0.047), and was 0.7 with respect to Air services in the route Madrid – Barcelona (0.097 reported in Table 3 for our case study). Nombela and Martin *(47)* used a much bigger sample of 12,500 travellers of all transport modes to forecast the impact of HS in the whole country. The airplanes elasticity with respect to price was -1.216 and the HS elasticity was -0.432, so slightly less than in our study (-1.537 and -0.583 respectively). Regarding the elasticities and cross elasticities of the remaining transport modes, all had the same sign but were lower than in the present research. There are several potential explanations for this outcome, such as changed preferences after the economic crisis or biased sample because of the small number of respondents, to name but two.

For some pairs of European cities, Adler et al. *(48)* found the direct elasticities for business users of HS and air ranked from -0.71 to -0.92. These direct elasticities turned out to be much higher in the case of leisure users, with a range from -1.11 to -1.94. Matas et al. *(49)* also pointed out a higher elasticity for leisure than business travellers. Therefore, the high elasticities found could also be explained by a relatively high proportion of around 53% of leisure/family purposes users.

4. CONCLUSIONS

In order to foster the use of HSR and increase the occupancy rates of trains, the Government of Spain reduced tickets prices by at least 11% and at the same time introduced a flexible pricing approach. In this paper we analyze the effects of the new tariff scheme recently implemented in the Spanish HS system. Four main policy lessons arise from this research.

Firstly, although users do not choose just based on ticket price, it is noteworthy that price elasticity turns out to be high. In fact, price has been identified as one of the most important reasons to travel by train along with travel time, comfort and frequencies. These four factors in conjunction with RENFE's punctuality commitment makes HSR in Spain to be regarded as a friendly mode compared to other public transportation modes.

Secondly, for the Spanish case, this price elasticity in the short term can be set around 0.6, but the effects of the new pricing approach are different depending on the type of corridor and the competition with other modes. In corridors where HS is the dominant mode the price elasticity is lower than in corridors where many travel options are available for the users. In other words, the larger the number of travelers and the fiercer the competition in the corridor the greater the ability of HSR to draw users from other modes and to induce additional demand.

Thirdly, in transport systems where both infrastructure manager and train operator companies are controlled by the government, the implementation of the new tariff approach could harm the rules of fair competition between transport modes and introduce perverse incentives such as a cheaper ticket price in the AVE than in the Bus while the TOC does not cover the total infrastructure cost through fees.

Last, HS trains can replace buses, other kind of train services and compete with car for short – medium distances up to 400/500 km. This is also the case for travel time trips below 2 hours. In very long-distance journeys, competition is mainly with the airplane whereas car users seems to be not so affected.

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LIST OF TABLES

LIST OF FIGURES

TABLE 7. HS and airplane demand changes after one year of the new pricing scheme

Corridor	Services	Surface Distance (km)	HS Demand Variation (%)	Airplane Demand Variation (%)
Northeast	Madrid – Barcelona (B,C,A)	621	+16.0	-14
	Madrid – Zaragoza (B,C)	307	+10.0	-
	Zaragoza – Barcelona (B,C)	314	+9.6	-
South	Madrid – Seville (B,C,A)	472	+8.2	-32
	Madrid – Cordoba (B,C)	344	+9.0	-
	Madrid – Malaga (B,C,A)	500	+9.5	-30.7
Madrid-Toledo	Madrid – Toledo (B,C)*	80	-1.2	-
Northwest	Madrid – Segovia (B,C)*	90	-4.8	-
	Madrid – Valladolid (B,C)*	190	-3.4	-
West	Madrid – Valencia (B,C,A)	400	+7.4	-3.7
	Madrid – Cuenca (B,C)	195	+12.0	-
	Madrid – Albacete (B,C)	321	+19.2	-
Long distance journeys	Barcelona – Seville (C,A)	1,093	+88.0	-18
	Barcelona – Malaga (C,A)	1,121	+47.0	-22.7

(B, C, A) – Bus, Car and Air transportation available
(B, C) – Bus, and Car transportation available
* Denotes AVANT trains are available

TABLE 8. Logit model for the High Speed Rail services choice

Variable Description	**Alternatives**	**Coefficient Estimate**	***t* statistic**	***p* value**
β_1 (Cost - €)	All	-0.0212541	(-4.728)	0.000
β_2 (Travel Time - min)	All	-0.0049389	(-1.613)	0.107
γ_1 ASA Coach - SP	Coach	-0.8315303	(-1.018)	0.309
γ_2 ASA Car -SP	Car	-1.7701313	(-1.996)	0.046
γ_3 ASA Air - SP	Air	-1.6246795	(-1.581)	0.114
Inclusive Value	RP	1.0000000	Fixed Parameter	
Inclusive Value	SP	0.74319539	(3.144)	0.001
Summary Statistics				
Number of Observations	220			
$\hat{L}(\hat{\beta})$	-229.3376			
$\hat{L}(0)$	-266.4604			
$\rho^2 - Pseudo\ R^2$	0.14			

TABLE 9. Direct and Cross-Point Mode Choice Elasticities for the High Speed Rail services choice changing Cost

Cost	HS	Coach	Car	Air
HS	**-0.583**	0.608	0.632	0.692
Coach	0.205	**-0.662**	0.406	0.424
Car	0.047	0.088	**-0.480**	0.102
Air	0.097	0.169	0.197	**-1.537**

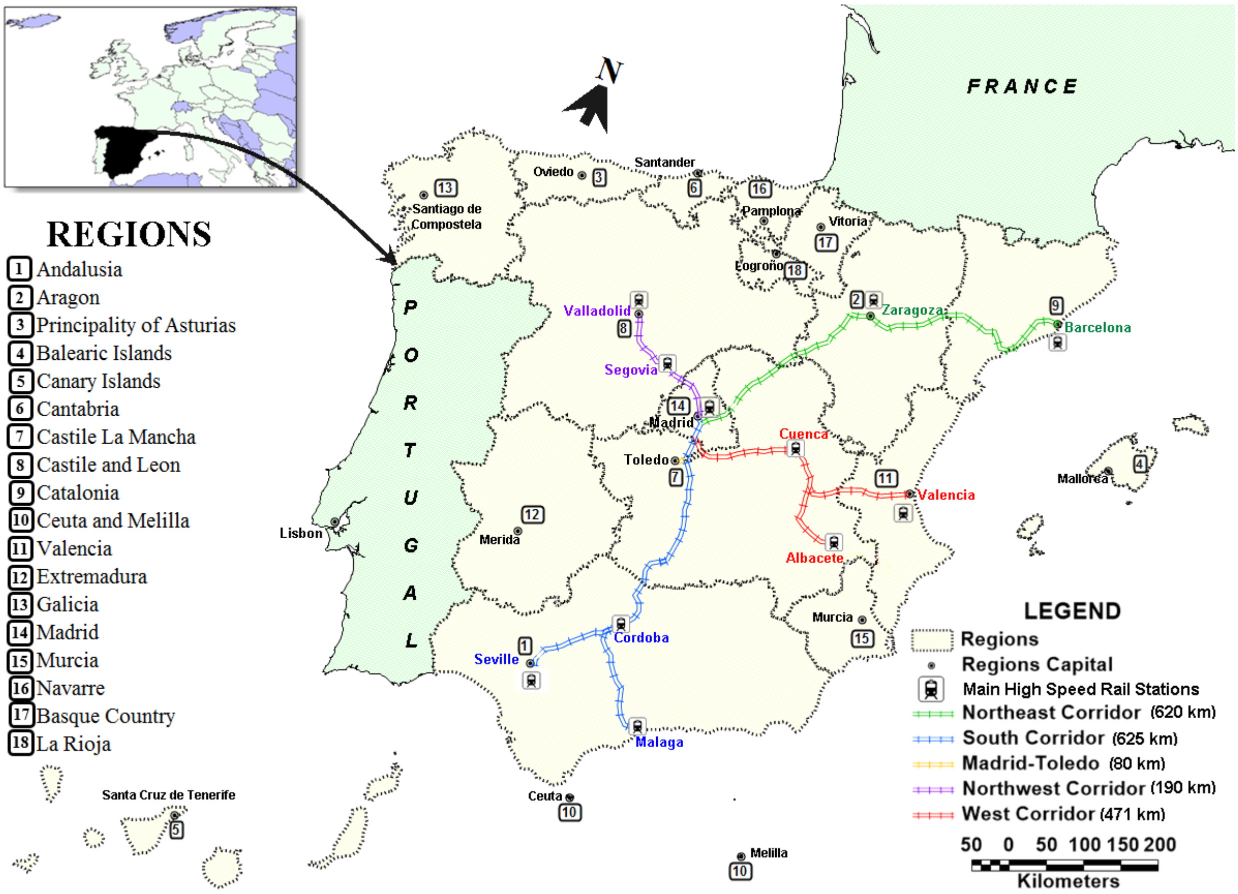

FIGURE 1 High Speed Corridors