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Economic, geographical and time-based exclusion as main factors inhibiting Spanish users from choosing High Speed Rail

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Abstract

Very few contributions in the literature have dealt with the issue of social exclusion related to High Speed Rail systems. The objective of this manuscript is to understand what are the factors excluding users from choosing High Speed Rail services considering the case study of Spain. For this purpose, a Revealed Preference survey was conducted between November-December 2015. A questionnaire was submitted to users of the Spanish transport system travelling for long-distance trips. The research aimed at investigating their perception of the High Speed Rail system and the factors inhibiting passengers or excluding them from its use. Data about their socioeconomic characteristics were collected as well. The analysis of the survey identified a relationship between social exclusion and High Speed Rail in Spain, especially in terms of geographical exclusion.

Keywords: social exclusion, High Speed Rail, geographical exclusion, accessibility.

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1. Introduction

Scial exclusion and poverty are two concepts that are often used interchangeably. In the literature, the term "social exclusion" has been explained by several authors. According to Silver (1994) social exclusion is *"a multidimensional process of progressive social rupture, detaching groups and individuals from social relations and institutions and preventing them from full participation in the normal, normatively prescribed activities of the society in which they live."*

Indeed it is generally agreed that exclusion refers to a dynamic process and not necessarily to an end-result (Lucas, 2011; 2012; Jones and Lucas, 2012; Lucas and Musso, 2014), i.e. "who" and "when" someone is excluded can change over time. The concept of social exclusion is based on inclusion into civil society. On the other hand, absolute poverty was defined by the United Nations as *"a condition characterised by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information "* (UN, 1996). Therefore, low income categories are not necessarily experiencing social exclusion, since being excluded can be a form of deprivation with innate importance in addition to its causal relations with other issues. Exclusions of the social nature can in turn lead to other deprivations that may significantly decrease the quality of life (Sen, 2000).

Social exclusion is a state in which an individual is not able to take part in activities of civil society, considered normal and expected within society. By social inclusion it is meant, on the other hand, the ability to participate adequately in society. According to Levitas (2007), social exclusion is *"the lack or denial of resources, rights, goods and services, and the inability to participate in the normal relationships and activities, available to the majority of people in a society, whether in economic, social, cultural or political arenas. It affects both the quality of life of individuals and the equity and cohesion of society as a whole."*

Poor transport options and alternatives can be a result of social exclusion and can also reinforce it. Transport could represent a factor of social exclusion since a lack of accessibility prevents people from participating in work, educational activities, community events, etc. (Kenyon, *et al.*, 2003).

Some previous interest can be identified for analyzing the potential relationship between transport systems and social exclusion. This is, for example, the case of UK, since a renewed interest in ameliorating the effects of social exclusion was observed after the election of the Labour government in 1997. A Social Exclusion Unit (SEU) was established to monitor and influence policy across all Whitehall Departments. In 2002 the Unit turned its attention to travel, transport and access, seeing these as processes implicated in the reproduction of social exclusion. In this respect, they pointed out that *"recent years have seen a growing recognition that transport problems can be a significant barrier to social inclusion"* (SEU, 2003). Likewise, in 2004 the FIA Foundation promoted a study to compare the position of the G7 countries in relation to transport and social exclusion at the urban level (FIA Foundation, 2004). In this report, it is worth noticing that no citation to HSR systems was made.

In the academic literature different approaches have been proposed to address the topic of social exclusion related to transport systems. Among other issues, it has been recommended to integrate transport systems planning with urban and social policies. One first step towards the reduction of social exclusion might be that of promoting activities to increase accessibility. At this point, the notable accessibility increases from new High-Speed Rail (HSR) services, which can play a significant role.

In the last decades, an important expansion of the HSR network has been observed in Europe. Indeed several European cities and regions are served today by HSR, and national agendas have planned significant extensions of this type of networks in the next decade. In 2016, the

European HSR network had over 8,100 km in service but it is planned to reach around 22,000 km in 2025. This shows not only the actual relevance of HSR services, but especially the central role that this infrastructure is going to achieve in the European transport policy. HSR is highlighted as a key future transport mode by the EC white paper *"Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system"*. Its recent expansion and its planned extension could induce important geographical effects (Givoni, 2006) at different territorial scales (European, national and local ones) even though the role of HSR can differ in European regions due to the fact that networks, services and improvements of accessibility are diverse depending on each country and served city.

Spending public money in the construction of HSR lines has been defended as a socially desirable public investment which produces several types of benefits such as passenger time savings, increase in comfort, generation of new trips, reduction in congestion and delays in roads and airports, reduction in accidents, reduction in environmental externalities, release of needed capacity in airports and conventional rail lines, and wider economic benefits including the development of the less developed regions (De Rus, 2008).

Although these advantages, it is relevant to highlight how expensive is building and operating the new transport system. Indeed, today most of the HSR lines in Europe are subsidized, with the consequence that there is a trade-off between economic exclusion and the economic feasibility of these systems. For instance, for the case of Spain, Betancor, *et al.*(2015) analysed the economic feasibility of the HSR network and did not recognised its economic benefit, therefore other additional social and political factors have motivated the development of the HSR services in the country.

The objective of this research is to analyse whether HSR systems can increase social exclusion for long-distance trips, taking into account that other transport alternatives are available to users. This constitutes a topic of great interest given that future transportation systems investments seem to be focused on these services, mainly in Europe. Specifically, the case study of Spain is considered since it has one of the longest HSR network worldwide.

This paper is organised as follows. Section 2 reviews the current literature addressing the link between HSR and social exclusion. Section 3 briefly introduces the Spanish HSR system. In section 4 a binary logit mode choice model is introduced in order to identify the explanatory variables potentially affecting the choice of HSR and the impact of social exclusion. Section 5 presents and discusses the results. Conclusions and further perspectives are presented in section 6.

2. Social exclusion and HSR systems

Several contributions on the social effects brought by HSR systems have been analyzed in the literature (Vickerman, 1997; Preston and Wall, 2008; Pagliara, *et al.*, 2015). However only few contributions have been conducted on the impact of HSR systems on social exclusion. Among the very few studies present in the literature, the statistical analysis of surveys carried out by Cass, *et al*. (2005) reports interesting results. It indicates that HSR has both positive and negative social impacts. The positive social impact is represented by the increased accessibility and activities for commuting HSR users. The key concept of accessibility highlights the relationship between the system of activities located in a given territory and the transport system serving it.

According to Cascetta (2009), the concept of accessibility may refer alternatively to: a) the need to carry out some activities –shopping, work, education, etc.– by an individual who is in a certain area (active accessibility), or b) the need to be physically reached by potential users –customers, employees, suppliers, etc.– for an activity that is located in a certain area (passive accessibility). The nature of accessibility is influenced by the time-space organization in households, the nature and performances of the transport system, and the nature of time-space organization of the facilities and opportunities individuals are seeking to access. According to Cass, *et al.* (2005), HSR improves trips for working purposes by providing fast rail connections between main cities. On the other hand users who cannot afford HSR or live far from stations can be socially excluded and have problems when searching for better jobs. The introduction of a public transport system plays an important role in the social exclusion or inclusion of "transport poor" populations. HSR might encourage a hyper-mobile society, which can abandon people without access to the fastest modes of transport. This can be avoided only through thoughtful policies.

The study carried out in Spain by Monzón, *et al.* (2010) highlights the role played by the selection of the commercial speed. Indeed, an increase from 220 km/h to 300 km/h, in a given corridor, results in significant negative impacts on spatial equity between locations with and without a HSR service. At this point, it is necessary to point out that HSR cannot reach certain locations due to geographical and/or economic reasons. The same authors propose an assessment methodology for HSR projects following a twofold approach, i.e. addressing issues of both efficiency and equity. The procedure uses spatial impact analysis techniques and is based on the computation of accessibility indicators. Efficiency impacts are evaluated in terms of increased accessibility resulting from HSR projects, with a focus on major urban areas. Likewise, spatial equity implications are derived from changes in the distribution of accessibility values among these urban agglomerations (Monzón, *et al.*, 2013).

For the case of China, Chen and Wei (2013) addressed the case study of the Hangzhou East Rail station. This area is undergoing a rapid industrialization and thus workers' level of income is increasing significantly. However, HSR is still not affordable for the majority of the population. Also in China, Shi and Zhou (2013) aim at analysing transportation equity issues in terms of accessibility change experienced in those cities served by the HSR network. The main research findings, from the equity assessment perspective, reveal that investments in HSR systems do not have a strong impact in fostering social exclusion in terms of being excluded from the use of the new high speed services.

The case study of Italy was treated by Pagliara and Biggiero (2017). They conducted a Revealed Preference survey to identify the main motivations influencing travellers' choice of HSR, and found that users travelling alone choose HSR because of the reduction in travel time. Moreover the cost has an impact on the choice of this service because of the early booking convenient fares, which allow saving money to those travelling within given time periods. On the other hand, for those who have not chosen HSR, the main reason is the geographical exclusion, i.e. the low accessibility to the departure/arrival station. It follows the economic exclusion, i.e. the high cost of the HSR ticket. According to the authors, the fact that both criteria are greatly perceived by low income classes can be interpreted by the residential location of travellers. Furthermore, a quantitative approach was proposed to evaluate mode choice and the perception of social exclusion, considering two main aspects: economic and geographical exclusion. The analysis concluded a significant influence of income and the perceived geographical exclusion on intercity travellers' mode choice.Some of the previous results have been confirmed by a further Revealed Preference survey in UK (Pagliara, *et al.*, 2017). In this case the main motivation for those who have not chosen HSR is the economic exclusion, followed by the low accessibility to the departure/arrival station. In addition, the results of the study suggests that the introduction of a new transport mode, available in few points of the territory, brings social inequality, mainly perceived in terms of economic and geographical exclusion. Without thoughtful policies, HSR systems will encourage a hyper-mobile society that may abandon people without access to the fastest transport modes.

3. The HSR system in Spain

Since January 2016, Spain has the world´s second longest high-speed network, after China, and the longest in Europe (MAEC, 2013), with around 3,100 km of HSR lines in operation (see Figure 1). The service of HSR in Spain –known as AVE, Alta Velocidad Española– is operated by RENFE Operadora, the Spanish national railway company. Since 2005, AVE trains run on a HSR network owned and managed by ADIF, the public company in charge of the management of most of the Spanish railway infrastructure. Although RENFE Operadora is the only company operating the high-speed trains nowadays (CNC, 2013), private companies may be allowed to operate trains in the future, in accordance with the EU legislation. It is envisaged that the Madrid-Valencia corridor will be the first case to introduce competition in the HSR services in the country.

Figure 1. Spain´s HSR network as of May 2016, and annual passengers in the main AVE lines for 2012. Source: El País (2016)

During the last 20 years, the Spanish high-speed network has rapidly developed no matter whether there was sufficient demand to justify the construction of new lines. The expansion of this network has been considered in the last National Transport Plans as an essential element to promote social and territorial cohesion among territories. Indeed, one of the traditional objectives established in the transport agenda by previous governments has been linking the capitals of the 47 provinces in the peninsula by both high capacity roads and high speed rail services.

As a consequence of this policy the system is characterized by a reduced economic feasibility, and the suitability of the investments in the Spanish HSR has been strongly questioned in several occasions (see for instance De Rus, 2012 or Albalate, *et al*., 2011). Recently, Betancor, *et al*. (2015) analysed the economic feasibility of the Spanish HSR and found that only operating costs were covered, so they concluded that the investment was not profitable neither from a financial nor from a social point of view.

The first high-speed line was opened in 1992, connecting the cities of Madrid, Córdoba and

Seville. It was designed according to the technical standards of the French high-speed TGV. In the following years, the network was extended towards the northern part of the country, with the aim to create a connection to France and thus to the European high-speed network. Despite several problems encountered during the construction process, the Madrid-French Border line reached the cities of Zaragoza (2003) and Barcelona (2008). This line connects the two most populated urban areas in Spain –separated by 620 km– in 2h 30 min, which has led to a great success. Later this line was expanded to the city of Figueras, near the French border, and Perpignan (France). In Table 1 the annual passengers in the main AVE lines have been reported for the year 2012.

Table 1. Annual passengers in the main AVE lines for 2012

AVE line	Annual passengers (millions)
Madrid – Seville	5.55
Madrid – Valladolid	3.19
Madrid – Barcelona – Figueras	5.14
Córdoba – Málaga	2.35
Madrid – Cuenca –Valencia	5.84
Orense – La Coruña	0.27
Other High-Speed services	6.04
TOTAL	28.38

Source: Adif (2013)

Furthermore, in the last few years the high-speed network has been extended to connect some of the most populated cities in the Spanish Mediterranean coast such as Málaga (2007), Valencia (2010) and Alicante (2013), with great tourist appealing, too. However, due to the shortfall of financial resources, caused by the economic recession in Spain, the government has postponed or cancelled some of the high-speed projects already approved (Pagliara, *et al.*, 2012). The most recent extensions of the network up to Palencia and León (2015) have experienced significant delays, in line with other connections already under construction to reach areas such as the Basque Country, Granada or Extremadura. In this respect, the complex topography of the territory – Spain is the second most mountainous country in Europe – combined with a deterioration in the economic context and therefore in the public budget, have caused that currently some of the Spanish regions are not accessible to HSR services.

Despite the continuous financial losses experienced in previous years, in 2013 RENFE implemented alternative pricing systems in order to make HSR services accessible to a wider range of the population. For instance, discounts up to 70% are currently offered when buying single tickets in advance for certain train services. Reduced prices (up to 60%) can also be found when buying group tickets (4 people). Alternatively, students and elderly people are offered discounts of up to 50% and 60% respectively, over the standard ticket price. This policy, promoted by the Spanish Ministry of Transportation, has resulted in an average reduction of 11% in HSR tickets and has increased rail demand substantially in the last years. In 2015, the HSR services reached a total of 31 million passengers, constituting the peak in the historic trend and almost doubling the passenger traffic in 2008 before the implementation of the general discounts policy. This strategy has also lead to further positive effects, such as a notable decrease in the financial losses experienced by the public company RENFE.

4. The methodology

As pointed out above, this research is aimed at analysing whether HSR systems can increase social exclusion for long-distance trips, taking into account that other transport alternatives are available to users. This contribution is based on the framework of factors that may limit the mobility of socially excluded people, proposed by Church, *et al*. (2000). In this paper, the following categories of exclusion connected to transport, applied for urban trips, are mentioned:

1. Physical exclusion: physical barriers, i.e. lack of disabled facilities or timetable information, limiting accessibility to transport services.
2. Geographical exclusion prevents people from accessing transport services, especially those living in rural or peripheral urban areas.
3. Exclusion from facilities, concerning the low accessibility connected with facilities, like shops, schools, health care or leisure services.
4. Economic exclusion represents the high monetary costs of travel preventing or inhibiting access to facilities or employment and thus having an impact on incomes.
5. Time-based exclusion refers to other demands on time, like combined work, household and child-care duties, reducing the time available for travel.
6. Fear-based exclusion concerns to the fears for personal safety precluding the use of public spaces and/or transport services.
7. Space exclusion is the security or space management preventing given groups having access to public spaces, like first class waiting rooms at stations.

These categories have been adapted to medium-long distance trips to properly address the aim of the paper. Based on this assumption, a Revealed Preference (RP) survey was carried out in Spain between October and December 2015. The questionnaire was created on the Google platform and 414 useful responses were collected. Users were interviewed regarding the last interurban trip they made within Spain, and reported different trip characteristics such as the transport mode chosen, including HSR.

Due to the survey method used, based on the web platform, the sample needed to be weighted. The percentages of gender and age classes, based on the 2011 Spanish Census (INE, 2015), have been considered to adjust the sample. Then, those observations with a trip length lower than 80 km have been removed from the sample since they typically correspond to regional trips, not operated by the AVE services. In this case the authors tried to avoid any bias present in the data set used to make inferences.

Table 2 includes the socioeconomic characteristics of the whole sample, reporting figures for both HSR users and non-HSR users. It is interesting to notice that both groups mainly correspond to full time/part time workers. Particularly, the highest percentage (70%) is observed for HSR users, probably because they can afford this service, while for non-HSR users the percentage is around 55%. Concerning the monthly income, it can be noticed that 70% of the sample has an income between 1,000-3,000 Euro. Among HSR users, less than 70% of them has an income higher than 2,000 Euro, while non-HSR users are less than 53%, this result seems to highlight the influence of income on mode choice.

For the trip purpose, it results that most of the users travel for personal reasons. Among the HSR users around 20% travel for work or study purposes, while the percentage is just 5% for non-HSR users. This can be explained considering that users who do not travel for systematic trips prefer a cheaper transport alternative. This result is in line with previous research on HSR and tourism in Spain, such as Pagliara, *et al*. (2015). For the whole sample, less than 70% of the respondents travel alone or with the partner, therefore no more than two persons. It is interesting to highlight that those who have travelled for work purposes together with their colleagues have chosen AVE probably thanks to the special fares proposed by RENFE.

Moreover, transport mode choices by respondents for interurban trips within Spain revealed that HSR is the most used transport mode (47.1%), followed by car (31.6%). Other transport modes such as conventional rail or plane show a lower share (4.0% and 4.1%, respectively).

Table 2 – Summary statistics of the sample

Characteristics	Categories	HSR Users %	Non- HSR Users %	Sample tot %
Age	18-19	0.0%	9.2%	5.5%
	20-29	17.3%	10.1%	13.0%
	30-39	26.0%	13.6%	18.5%
	40-49	21.6%	16.6%	18.6%
	50-64	19.8%	23.8%	22.2%
	> 65	15.4%	26.9%	22.2%
Gender	M	50.4%	48.0%	49.0%
	F	49.6%	52.0%	51.0%
Nationality	Spanish	89.5%	97.2%	94.1%
	Others	10.5%	2.8%	5.9%
Education	Degree or more	95.2%	73.5%	82.1%
	Others	4.9%	26.5%	17.8%
Occupation	Full time/part time worker	72.1%	56.7%	63.0%
	Student	10.6%	12.5%	11.6%
	Unemployed	0.0%	2.0%	1.2%
	Freelance	1.9%	2.0%	2.5%
	Retired	15.4%	26.8%	22.2%
Monthly income	< €1000	3.4%	2.7%	3.0%
	€1,000 - €2,000	29.6%	44.4%	38.5%
	€2,000 - €3,000	35.2%	30.9%	32.7%
	€3,000 - €4,000	22.2%	11.6%	15.8%
	€4,000 - €5,000	4.0%	7.1%	5.9%
	> €5,000	5.5%	3.3%	4.2%
Trip purpose	Work	15.8%	4.8%	9.2%
	Study	4.3%	0.9%	2.3%
	Holiday	43.9%	33.0%	37.4%
	Personal activities	36.0%	61.2%	51.1%
Travel type	Alone	30.2%	31.7%	31.1%
	Partner	30.4%	39.6%	35.9%
	Colleagues	14.5%	0.0%	5.8%
	Friends	14.8%	15.1%	14.9%
	Relatives	10.1%	13.7%	12.3%

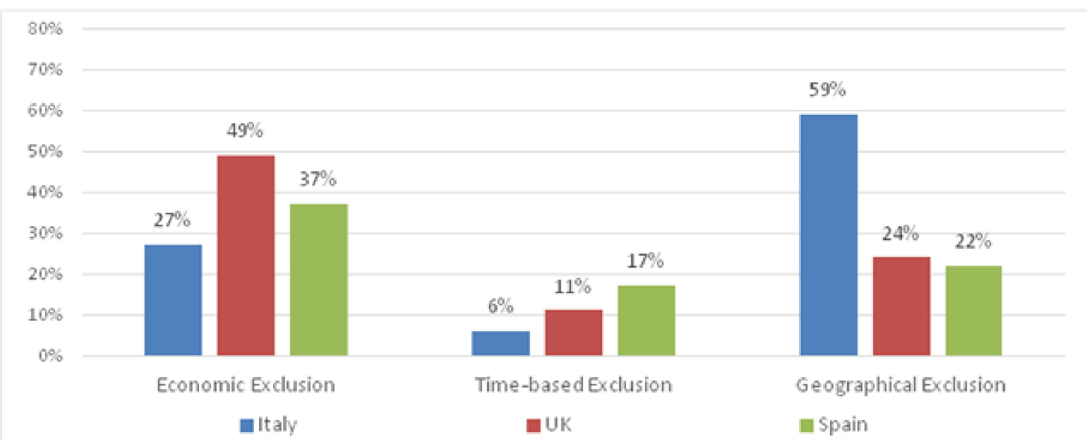
In Table 3, the choice among the seven categories of social exclusion proposed by Church, *et al.* (2000) is analysed. Specifically respondents were asked to rank their perception of each factor of exclusion from 1 (scarcely inhibiting) to 5 (highly inhibiting). As it can be seen, economic and geographical exclusion have turned out to be inhibiting users from choosing HSR, and therefore they have been the fundamental reasons for not using this means of transport by non-HSR users.

Table 3 - Church's categories of social exclusion (non-HSR users)

Economic	Time-based exclusion	Spatial exclusion	Fear-based exclusion	Geographical	Physical	Facilities
85.2%	22.6%	13.4%	2.6%	51.0%	20.8%	18.0%

These values have been compared with two similar case studies previously conducted in Italy and UK (Pagliara, et al., 2015b; 2016). In order to make the comparison properly, the values for Spain have been reported to the unit so that the total sum could be 100%. The results of the comparison (see Figure 2) show that geographical exclusion is a factor of exclusion mainly in Italy (60%) rather than in Spain and UK (less than 25%). This can be explained considering the mode choice and the different extension of the current HSR network in the three countries. In Italy, HSR is the first choice for passengers travelling long distances although the network is not extended and not capillary, in contrast to what happens in Spain, with a quite dense HSR network covering the territory in a quite homogeneous way (see Figure 2). In UK the network is not very extended, and therefore HSR is not considered as a real alternative mode for interurban trips, which could explain why geographical exclusion is less felt than the economic one in this case.

Fig. 2 - Comparison of the main components of social exclusion in HSR services for Italy, Spain and UK



Furthermore, Tables 4 and 5 show the categories of social exclusion and their relation to both trip purpose and household monthly income. As it can be seen, those who travelled for holiday or for personal reasons and have a lower income, feel excluded from HSR due to economic and geographical reasons. At this point, it should be noted that these two categories often coexist, since those individuals who have limited financial resources are also unable to live in areas accessible to HSR services, typically city centres.

Table 4 – Church et al.’s categories of social exclusion versus trip purpose (non-HSR users)

Trip purpose	Categories of Exclusion						
	Economic	Time-based	Spatial	Fear-based	Geographical	Physical	Facilities
Work	4.5%	-	-	-	5.5%	-	-
Study	35.2%	11.7%	24.1%	32.4%	44.5%	23.5%	22.8%
Holiday	1.0%	2.8%	3.0%	-	-	2.6%	3.1%
Personal activities	59.3%	85.5%	72.9%	67.6%	50.0%	73.9%	74.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table 5 – Church et al.’s categories of social exclusion versus household monthly income (non-HSR users)

Monthly income	Categories of Exclusion						
	Economic	Time-based	Spatial	Fear-based	Geographical	Physical	Facilities
Low-medium	77.9%	93.0%	67.4%	57.2%	73.8%	69.4%	55.5%
High	22.1%	7.0%	32.6%	42.8%	26.2%	30.6%	44.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

5. HSR or not HSR? That is the question

In order to explore the potential impact of HSR services on social exclusion, an econometric model has been developed based on the data collected from the survey. The model is aimed at identifying the explanatory factors determining the mode choice made by respondents, particularly whether they used the HSR or not HSR for the last interurban trip made. To that end, a binary mode choice logit model (Cascetta, 2009) has been proposed, with the binary variable choosing or not HSR as the dependent variable.

The model follows the traditional binomial logit form, widely referred in the literature. A detailed description of binary choice models is beyond the scope of this paper, so the reader is directed to Ben-Akiva, *et al*. (1999) or Ortúzar, et al. (2011) for further details.

Binary choice models are derived from the utility maximizing theory, according to which decision makers are utility maximizers. Then, the individual choose, among all the options available, the alternative measuring her/his utility, which can be determined by a number of explanatory variables. The utility (V^i_j) gained by individual *i* for choosing alternative *j* can be determined by explanatory variables X^i_{kj}, and written as shown in equation (1):

$$V_j^i(X_j^i) = \sum_k \beta_k X_{kj}^i \quad (1)$$

Economic theory assumes that the individual *i* will choose the option with the highest utility. As explained by Ben-Akiva (1985), in the general form of a binary choice model, the probability that user *i* will choose alternative *j* can be expressed as follows:

$$p[m'/oshd] = \frac{exp(V_{m\prime/oshd})}{\sum_m exp(V_{m/oshd})} \tag{2}$$

In our case, the probability of choosing HSR or other transport mode (not HSR) is here computed, from a given origin o, for a given purpose s, in the time period h and to a given destination *d*. Specifically, the dependent variable equals to 1 if the user travelled by HSR, or 0 if other transport mode was chose. The explanatory variables X_k chosen to model whether users chose HSR for interurban trips are reported in Table 6.

Table 6 - Explanatory variables included in the model specification

VARIABLES	VALUE
ALREADY-TRAV-HSR	equals to 1 if the user has already travelled with HSR; 0 otherwise.
ECO-EXC	equals to 1 if the economic exclusion inhibits the user from choosing HSR; 0 otherwise.
TIME-EXC	equals to 1 if the time-based exclusion inhibits the user from choosing HSR; 0 otherwise.
GEO-EXC	equals to 1 if the economic exclusion inhibits the user from choosing HSR; 0 otherwise.
INCOME < 2000	equals to 1 if the user has a monthly income lower than 2,000€; 0 otherwise.

Then, the binary logit approach predicts the so-called logit of the odds ratio, L_k, given multiple explanatory variables X_k. The model specification finally adopted has the classical form of a binary logit model:

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right) \tag{3}$$

where *p* is the probability of choosing HSR and the argument of the natural logarithm is called odds (Bewick, et al., 2005). The relationship between *p* and explanatory variables Xi can be written as follows:

$$\text{logit}(p) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k \tag{4}$$

where:

β_0 is the intercept, i.e. the expected value of p when all the predictors are 0;

β_i are the regression coefficients, estimated through the calibration process.

As a consequence of this linearization process, the interpretation of the β_k coefficients is different compared to standard linear regression models. The slope coefficient suggests that for a unit increase in a certain explanatory variable X_k, the weighted log of the odds in favor of a certain alternative (Y=1) increases of $e^{\beta k}$. Moreover, for a unit increase of a given explanatory variable X_k, the odds ratio in favor of happening Y=1 increases of $e^{\beta k}$. Furthermore, unlike a simple linear regression, logistic regression parameters are usually estimated with the method of maximum likelihood, an iterative process calculating small corrections until the convergence is reached.

Regarding the goodness of fit of the model, R^2 statistics refer to the entire model and indicates how useful the explanatory variables are in predicting the response variable. The Cox & Snell and the Nagelkerke R^2 are two of the most used statistics. The maximum value for Cox & Snell R^2 is less than 1 while the Nagelkerke R^2 provides a correction of this one and covers the full range from 0 to 1 and therefore is often preferred.

A preliminary analysis has been carried out to check potential collinearity between the explanatory variables ECO-EXC and INCOME < 2000. Specifically a correlation analysis based on the Chi2 test allows determining the level of relationship between both variables. With a level of significance equal to 0.05 and 1 degree of freedom, according to the Chi^2 test the alternative hypothesis is accepted and the variables are independent. Estimation results for the binary choice model specified are reported in Table 7. According to the estimates it can be observed that:

- Those users who have travelled at least once by Spanish HSR (AVE) have a higher probability of choosing it again ($\beta_{ALREADY\text{-}TRAV\text{-}HSR}$ positive and highly significant).
- Those users who feel to be economically excluded (i.e. for whom the cost of the HSR ticket is perceived high) have a lower probability of choosing HSR ($\beta_{ECO\text{-}EXC}$ negative and significant).
- Those users who feel to be time-based excluded (i.e. who feel constrained due to the impossibility of reconciling their commitments with train frequency and timetable) have a low probability of choosing HSR ($\beta_{TIME\text{-}EXC}$ negative and highly significant), keeping the rest of variables constant.
- Those users who feel to be geographically excluded (i.e. who have a lower accessibility to AVE stations) have a low probability of choosing HSR ($\beta_{GEO\text{-}EXC}$ negative and significant).
- Those users who have a monthly income under 2,000 Euro have a lower probability of choosing AVE ($\beta_{INCOME<2000}$ negative). Moreover this variable is not statistically significant (t-ratio = 1.684 < 1.960).

Table 7 - Estimation results (not all the variables significant)

	COEFFICIENTS				
	$\beta_{ALREADY\text{-}TRAV\text{-}HSR}$	$\beta_{ECO\text{-}EXC}$	$\beta_{TIME\text{-}EXC}$	$\beta_{GEO\text{-}EXC}$	$\beta_{INCOME<2000}$
Value	3.671	-1.040	-2.688	-0.844	-0.606
t-ratio	7.099	2.062	5.609	2.009	1.684
R^2	0.649				
R^2_{adj}	0.644				

Regarding the goodness of fit obtained, the Nagelkerke R^2 is quite high (around 0.65) as well as R^2_{adj}. In this respect, the explanatory variables chosen in the model seem to properly reproduce users' behaviour. Moreover, given that the variable INCOME<2000 is not correlated with the ECO-EXC variable and did not resulted statistically significant, it has been removed from the model. Then, the final model estimation is presented in Table 8, including only significant variables.

Table 8 - Estimation results (with all significant variables)

	COEFFICIENTS			
	$\beta_{ALREADY-TRAV-HSR}$	$\beta_{ECO-EXC}$	$\beta_{TIME-EXC}$	$\beta_{GEO-EXC}$
Value	3.400	-1.068	-2.691	-0.923
t-ratio	7.141	2.159	5.603	2.226
R^2	0.641			
R^2_{adj}	0.636			

In this model the values of both R^2 and R_{2adj} are quite high. Moreover this model shows how the choice of AVE is influenced by having already used it (at least once) and by the economic, geographical and time-based exclusion.

6. Conclusions and further perspectives

In this paper the relationship between HSR and social exclusion has been analysed. Following the framework proposed by Church, et al. (2000), the motivations fostering the choice of HSR in Spain have been analysed together with the factors inhibiting from the use of this service.

The results of a Revealed Preference survey have shown that only some criteria are perceived by the users when making the choice. For those who have not chosen HSR, the main reason is the economic exclusion, i.e. the cost of the HSR ticket. It follows the geographical exclusion, i.e. the low accessibility to the departure/arrival station. The fact that both criteria are greatly perceived by low income classes can be interpreted by the residential location of this type of travellers. Regarding the relationship between the perception of economic and geographical exclusion, it results that those individuals with higher incomes live in city centres, generally served by good public transport and taxi services. Indeed a good public transport system can allow an easy access to the departure/arrival stations. Likewise, improving accessibility to HSR stations outside metropolitan contexts can play a key role to reduce the geographical exclusion within the same country, even in the case of an extended HSR network as the Spanish one.

To support the results of the survey, a quantitative approach has been proposed, through the specification and calibration of a mode choice model, which aims at evaluating the perception of social exclusion. Three aspects of social exclusion have been considered (economic, geographical and time-based exclusion). Estimation results show how the choice of HSR services is influenced by having already used it (at least once) and by the economic, geographical and time-based exclusion.

Further perspectives will consider the collection of a larger data set which can support these findings and the specification and calibration of more sophisticated models. Specifically, more complex mode choice model specifications can be adopted to model users´ choices such as nested or mixed logit. These alternatives could be useful to explore additional factors such as the choice among all available alternatives (i.e, not only HSR versus non-HSR) or heterogeneity in preferences among respondents. Furthermore, a structural equation approach could be estimated to identify the specific aspects determining perceptions towards each component of social exclusion (economic, geographical, etc.) in more detail.

7. References

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