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High speed rail effects on tourism: Spanish empirical evidence derived from China's modelling experience



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ARTICLE INFO

Article history:

Received 8 May 2016

Received in revised form 18 August 2016

Accepted 25 September 2016

Available online 3 October 2016

ABSTRACT

China and Spain are currently among the top tourist destinations, coming third and fourth place in the 2014 world ranking of tourist arrivals, behind France and the US. Tourism is crucial for the economies of Spain and China, and both countries have the longest high speed rail (HSR) networks in the world. What role has HSR infrastructure played in the development of tourism in both countries?

Little research has been done to date, even in Europe, to estimate empirically how tourism indicators are affected by new HSR lines. In 2012 a multivariate panel analysis by Chen and Haynes was applied to 27 Chinese regions, and confirmed that emerging high speed rail services (during the period 1999–2010) had significant positive impacts on boosting tourism in China. No similar empirical tool has ever been tested in Europe.

The aim of this paper is to analyse and validate this tool when applied to the Spanish context, and to develop a comparative analysis with the Chinese case study. The methodology is applied to 47 Spanish provinces during the period 1999–2015, and the results clearly reveal a positive but lower-value link (compared to China) between the increase in certain tourism outputs (foreign arrivals and revenues) and HSR network construction. However, further research is needed into the model's limitations, namely the availability of suitable tourism indicators in the official databases, the HSR explanatory variables considered, and the ability to detect "circular cause-effects" between HSR and tourism.

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1. Introduction

Due to the recent climate of financial instability, the discussion of evaluation methodologies for high-speed rail (HSR) projects is now a key issue for transport planners, both in countries without HSR and in those with long experience in HSR operation. The transport project evaluation methodologies and public sector investment assessment in the literature review follow two main frameworks: broad CBA (Cost Benefit Analysis) and Multi-Criteria Analysis (MCA). Both methodologies must consider all the economic activities that are reinforced by HSR, among other variables.

CBA methodologies are most frequently used in the literature for estimating HSR profitability (Coto-Millan et al., 2007; de Rus and Nombela, 2007; Betancor and Lobet, 2015), although in the last ten years MCA has become more widespread as a method for evaluating transport projects, and offers the possibility of including indirect and long-term HSR impacts (Guirao and Campa, 2015). Macharis and Bernardin (2015) reported that –after a more general category– passenger transport (such as HSR rail) and notably mobility management are

the public administrations' most common types of transport project decisions handled by MCA. Within the CBA methodologies, De Rus and Nombela (2007) were the first to calculate the required minimum level of demand at which investment in HSR could be considered profitable from a social perspective. They used real costs of construction, maintenance and rolling stock for European HSR lines currently in operation, in addition to potential time savings, standard time values and predicted growth in demand. Although this approach has been generally accepted by the scientific community, the wider economic benefits of high speed are clearly hard to gauge, as they are swamped by many – not inconsiderable – external factors such as territorial impacts. Territorial impacts may lead directly to social and economic benefits, and despite the problems of estimating and analysis, some attempts have been made to study them, especially in the case of Spain (Gutierrez, 2001; Ureña et al., 2009; Ortega et al., 2012).

In this context, the tourism impact of HSR implementation has recently emerged as an important issue in the scientific literature, as it represents a possible benefit variable to support new investment in HSR lines. However tourism is a complex phenomenon (Sinclair and Stabler, 1997; Caccomo and Solonandrasana, 2001), as it is a form of complementary demand for which the main components are transport, food, and accommodation (Morley, 1992), making it very difficult to separate the effects of transport on tourism from other territorial effects.

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The literature review described in Section 2 shows how tourism has affected HSR demand. Little research has been done so far, even in Europe, to estimate empirically the opposite effect: how tourism indicators are affected by new HSR lines. Many authors agree that the expansion of HSR networks and services brings new opportunities to cities, metropolitan areas, coastal and mountain regions, and other types of tourist destinations in Europe. It also reinforces the expectations of local tourism stakeholders by improving the attractiveness of places for visitors, although no systematic patterns have been observed. Most of the published studies describe specific HSR experiences (case studies) and some observed HSR effects on tourism, but do not lead to a general conclusion.

China is one of the scenarios that has focused the highest number of methodologies to assess the impact of HSR on tourism (Wang et al., 2012; Chen and Haynes, 2012; Chen and Haynes, 2015). Today, China has the world's longest HSR network (with over 19,000 km of track in service in January 2016), more than the rest of the world's high-speed rail tracks combined. When the Chinese government began construction of HSR in 2004, the main objective was to promote economic growth through four north–south and four west–east HSR trunk lines. Since the completion of a few sectional mainline projects, the impact of HSR on tourism demand has increasingly come under the spotlight, given its political significance for regional economic growth.

Using a multivariate panel analysis, Chen and Haynes were the first to investigate the impact of a high-speed rail system on the tourism industry, selecting only the numbers of incoming foreign tourists and tourism revenue as the dependent variables. The results of this research confirmed that the fledgling high-speed rail services significantly boosted tourism in China between 1999 and 2010, and that provinces with high-speed rail services were likely to have approximately 20% more foreign arrivals and 25% higher tourism revenues than provinces without these systems. Concurrently with Chen and Haynes's first empirical works on HSR impacts on China's tourism industry, the research of Wang et al. (2012) demonstrated that the Chinese HSR system affected tourism demand by redistributing tourism centres and transforming the tourist market. However, this research methodology was not empirical so did not contribute to understanding the impact of HSR on tourism; Chen and Haynes were thus the first to address this issue in the literature.

The most logical first step in the search for a new and systematic tool to evaluate the integral impact of HSR on the tourism industry would therefore appear to be to establish the suitability of applying the Chinese experience to other European case studies. Spain, with over 20 years of HSR experience, and operating the longest HSR network in Europe (3100 km), is a good scenario for the analysis and application of this panel data model, as tourism is one of the country's key industries, accounting for 10.9% of its gross domestic product (GDP) for the year 2014 (INE, 2016a).

This paper contributes to the limited existing literature by analysing the empirical impact of a HSR network on tourism indicators. The added value of this research lies in the fact that it is the first assessment of the multivariate panel data model tested in the Chinese scenario when applied to a European country: Spain. The paper is divided into the following sections: Section 2 contains a review of the literature on tourism and HSR. Section 3 gives an explanatory description of the tourism sector in China and Spain. Section 4 includes the model equations, the application to the Spanish case and a discussion of the results obtained compared to China. Section 5 presents a study of the city of Toledo (Spain) at the local level to analyse in greater detail the “circular and cumulative causation” between HSR and the evolution of tourism indicators. Finally, the main conclusions are summarised in Section 6.

2. HSR impacts on tourism: An overview

The link between tourism and transportation infrastructure has been widely analysed in the literature (Chew, 1987; Martin and Witt, 1988; Abeyratne, 1993; Khadaroo and Seetanah, 2007, 2008). There is a general consensus that an increase in accessibility to the tourism

destination usually leads to an increase in tourism demand (Della Corte et al., 2013), and is a critical factor in the overall number of tourists a destination receives. Once the tourist has arrived at the destination, local transportation is also an important issue as it facilitates tourist mobility, although it has received less attention.

There is practically no literature on empirical methodologies to assess the effects of new HSR lines on tourism. High-speed rail (HSR) is a relatively new mode of transportation in the contemporary transportation technology revolution, and has been promoted in various countries around the world (Albalade and Bel, 2012). In contrast, the extensive literature on the link between air transportation and tourism (Dobruszkes and Mondou, 2013) has produced evidence of the significant effect of low-cost airlines on tourist outcomes (Rey et al., 2011). Most of the published studies in the literature on the tourism effects of HSR describe specific HSR experiences (study cases) and some observed HSR effects on tourism, but do not point to a systemic methodology or a general conclusion (Guirao and Soler, 2008; Bazin et al., 2011). In HSR commuting relations it is important to take account of the fact that the possibility of returning within the same day can reduce the average length of the visitors' stay. This type of HSR service is quite common in some European countries such as France and Spain (see Ureña et al., 2009), and may affect the interpretation of the main statistical tourism outputs (tourism revenues, number of overstays, etc.). For example, Bazin et al. (2011) studied the impact of HSR on urban and business tourism in French cities connected to Paris such as Lyon, just 2 h away from Paris by TGV (Train à Grande Vitesse), and discovered that the daily expenditure of business tourists may be up to four times greater than that of leisure travellers. Bazin et al. (2011) pointed out that business tourism can be a key strategic orientation for cities and large urban areas, but the possibility of returning within the same day affects the average length of the tourists' stay. Guirao and Soler (2008) used a survey approach to examine the impact of tourism in Toledo on traffic from the new Madrid–Toledo line. Commuters and tourists were the main users of the line and tourism accounted for over 30% of weekday HSR ridership.

Apart from these isolated case studies applied to HSR, we can distinguish three types of tools that are generally used to study the impact of transportation on the tourism industry: the choice destination approach, economic geography models, and econometric models to estimate tourism demand. The choice destination approach is based on Rugg's model. Rugg (1973) was the first to introduce a time constraint, the modification of the budget due to the transportation cost between alternative destinations, and the modification of the time constraint resulting from including the time cost between alternative destinations. Assuming that tourists usually have a fixed holiday budget, Prideaux (2000) developed a model to demonstrate the dynamic relationship between holiday expenditure categories and the tourists' point of origin. The first approach to study the effects of HSR on tourist destination choice was developed by Delaplace et al. (2014) in Paris and Rome. The data collected from a survey of tourists in both cities were used for a quantitative analysis using regression models. The results showed that HSR influenced destination choice in different ways in the two cities, with tourism in Paris being more dependent on HSR. This interesting contribution was continued by Pagliara et al. (2014, 2015) using Madrid as a case study, and also based on a revealed preference survey. The preliminary results showed that the Spanish HSR system appeared to have a significant effect on tourists' decision to visit other cities connected to Madrid, but the choice of Madrid as a tourist destination (as in Rome) was not influenced by the presence of HSR. Although these results are quite illustrative, the notion that destination choice may be influenced by HSR does not prove that the construction of a new line will automatically increase total tourism demand or tourist sector revenues at the destination (accommodation, restaurants, museums and so on).

Economic geography models, like the *core-periphery model* introduced by Krugman (1991), have also played an important role.

Krugman (1991) showed that a change in transport cost induces a change in the intensity of spatial competition, which in turn influences the location of firms. Masson and Petiot (2009) used Krugman's core-periphery model to explore the influence of the southern European high-speed railway line (HSR) between Perpignan (France) and Barcelona (Spain) on both tourism activity and economic development. Using Krugman's theory (through a theoretical rather than an empirical discussion), they argued that HSR can facilitate the development of tourism activities, and particularly business and urban tourism. Crampon (1966) first introduced the gravitational model into tourism research, and the only application of this approach to a HSR scenario dates from 2012: the projected effects (not validated) of Chinese HSR on tourism were examined by applying the iso-tourist line from a time-space replacement concept (Wang et al., 2012). They forecasted the effects of the HSR network on three aspects: the redistribution and transformation of the tourist market, market competition on a larger scale, and the reallocation of the urban tourism centre. However, the results obtained by Wang et al. were not empirical, and it is therefore important to quantify the increase in tourism demand in order to assess the influence of the new infrastructure.

In addition to economic geography models and the choice destination approach, the existing **literature on tourism demand** is dominated by econometric models that tend to follow a single-equation time-series approach (Lim, 1997; Song and Li, 2008; Song and Wong, 2003). The only approach of this type applied to HSR corridors was developed by Chen and Haynes (2012). Through a multivariate panel analysis, they investigated the impact of Chinese high-speed rail systems on the tourism industry, selecting only the numbers of incoming foreign tourists and tourism revenue as the dependent variables. Chen and Haynes classified their independent variables into three groups: "policy variables" (all related to rail infrastructure and ridership), "origin variables" (related to the economic relation between foreign countries of origin and destinations) and "destination variables" (local site features or special events at the destination). Although the model does not consider domestic tourism (this data was not publicly available in China at the provincial level), the results of the research confirmed that policy variables have major significance in the model. The study concluded that during the period between 1999 and 2010, Chinese provinces with high-speed rail services were likely to have approximately 20% more foreign arrivals and 25% higher tourism revenues than provinces without these systems. The authors empirically demonstrated that the presence of HSR services in each province boosted tourism in China more significantly than other local variables such as the number of World Heritage Sites or museums. In 2015, a variation of this original model was developed by Chen and Haynes over the period 1997–2012, but using a panel of 21 source countries for tourism in China instead of provincial data. Other explanatory variables such as network density or number of stations were added in the equations and produced similar results, particularly for the network density variable.

Although this type of model is fairly dependent on the availability of a solid database, and despite the fact that the Chinese context is quite different from the European one, the results obtained and the consistency of the model structure used by Haynes and Chen have encouraged the authors of this paper to extrapolate the methodology to the Spanish case study. The Chinese scenario is among the most sustained attempts to systematize the study of HSR impact on tourism (see also Wang et al., 2012) and in the literature, the transfer of this methodology to the European scenario could be an important step towards obtaining extrapolated results.

Section 3 below examines the main figures representing the structure of tourism in China and Spain in order to understand and discuss the results of applying the model to the Spanish case study in Section 4.

3. Tourism in China and Spain

Spain is one of the most popular tourist destinations worldwide, occupying fourth place in 2014 in the **world ranking of tourist arrivals**, behind France, the US and China (UNWTO, 2015). While Spain has traditionally been a tourist country, international tourism arrivals in China started to grow after the Open Door policy was implemented in 1979. From 1980 to 2014, China's inbound tourist arrivals and tourism revenues grew at an average annual rate of 9.6 and 11% respectively (calculated with data from the National Tourism Administration of China NTA, 2002 to 2015). Currently ranking as the world's third most popular tourist destination, China is expected to attract 130 million tourists annually by 2020, taking it to number one (UNWTO, 2015).

The **physical environment** positively influences the choice of Spain for tourism. The country has 108 days per year of temperatures above 25 °C, and 2451 h of sunshine – equivalent to 6.7 h of sun a day. It boasts 8000 km of coastline, and the highest number of Blue Flag beaches in the world. This is why leisure and holidays (84%) are the main motivations for the majority of arrivals. Moreover, 24% of Spanish territory is classified as a protected area (third in the European ranking) and it has a total of 45 World Heritage monuments and sites, the third highest in the world.

Unlike Spain, where "sun and beach" holidays are the main motivation for the majority of arrivals, tourist resources in China fall into two main groups: natural sites, and historical and cultural sites. China has 50 World Heritage Sites to date; of these 35 are cultural sites, 11 are natural sites, and 4 are cultural and natural (mixed) sites, ranking second in the world after Italy (51 World Heritage sites). Most are located in coastal regions, which are also the hub of Chinese economic power. China's mounting economic growth since 1978 has caused increasing disparity between the coastal and inland areas in almost all the major economic indicators (Pedroni and Yao, 2006). In spite of the concentration of tourist resources in the coastal areas, the country's vast extension (9,597,000 km² versus 505,000 km² of Spain) means the distances between them are higher than in Spain, and aviation and HSR lines are the main transportation infrastructures on which foreign tourism is based.

China's vast extension also means that seasonal weather conditions vary widely from region to region (with temperatures as low as –40 °C in the north and as high as 40 °C in the south), with major climate shifts limiting tourism during certain months of the year. Another issue influencing tourism demand is the high level of air pollution in China's major urban and industrialised areas, which may aggravate visitors' bronchial, sinus or asthmatic conditions. There is scientific evidence (Beckena et al., 2016) of the damage to destinations and risk perception that urban air pollution is causing to China's inbound tourism.

The **origin countries of foreign tourism** in both Spain and China are predominantly the neighbouring states. In case of Spain, United Kingdom (19.40%), Germany (16.87%), France (11.16%) and Italy (5.4%) accounted for more than 42% of tourist arrivals in 2014 (INE, 2016b). EU residents provide 71% of international arrivals, in addition to a notable contingent of US (4.80%) and Russian (2.98%) tourists. Spain also receives tourists with a high degree of loyalty to the destination, measured as the number of times international tourists have visited the country on previous occasions: in 2012 the official Frontur Report from the Instituto Turístico Español (ITE, 2013a) showed that 80.2% of visitors claimed to have visited Spain before.

In 2014, 26.3608 million foreigners visited China, of whom the largest group – a total of 16.3313 million – were Asian (61.95%) (National Bureau of Statistics of China, 2015), most from South Korea (25.6%). The second largest share was from Europe, which contributed 5.5143 million visitors, accounting for 20.90% of the total. While the numbers of Asian visitors is currently growing, the European market, headed by Russia, has been declining since 2013. In third position was the US market, with a total of 2.7603 million visitors (10.5%). Most visitors came to China for sightseeing or leisure activities, while the second largest group

comprised those attending conferences and business meetings, accounting for 20.69%.

Domestic tourism also reveals differences between Spain and China. In 2014, Spain registered a balanced split between non-resident (51%) and resident (49%) tourists, while domestic tourism in China represented over 90% of total visitors (National Bureau of Statistics of China, 2016). There are also significant differences in the evolution of these figures: in Spain, the balance of non-resident and resident tourists has remained stable, with a slight increase in the number of foreign visitors. The number of domestic tourists in China was 3611 million in 2014, with a 200% increase in the period 2004–2014 (1102 million in 2004) due to the country's vast population and rising standard of living, particularly in the last 30 years. It should be noted that in most official national databases the number of foreign and domestic tourists is linked only to hotel stays (overnights), meaning that the total domestic visitors in both cases (China and Spain) has been undervalued, as there is no information on the number of tourists staying in apartments or second homes.

In terms of the **territorial distribution of HSR** (Fig. 1) and its relation with the main local tourist destinations, Spain's network is structurally radial, with the centre located in Madrid. It has been extended mainly towards the more populated eastern and southern cities (Barcelona, Valencia, Malaga, Seville), most of which are located in the coastal area with high tourist attractiveness. China's network is concentrated mainly in the coastal area (where all the major economic indicators are higher), with four north-south lines, two of which are fully operative (Beijing-Harbin; Beijing-Shanghai) and the rest still in only partial operation (Beijing-Guangzhou-Shenzhen-Hong Kong; Hangzhou-Fuzhou-Shenzhen). These four lines cover most of the tourist destinations (Beijing, Hong Kong and Shanghai) or can be used as transport links to other remote destinations. There are also two east-west lines which are still only partially operated (Qingdao-Taiyuan; Shanghai-Wuhan-Chengdu).

The key issue in the **interurban transport system** when comparing China to Spain concerns road infrastructure and conventional trains. Although China has invested heavily in transport infrastructure in the last twenty years, Spain had more than double the density of high-capacity roads (0.030 km/km²) than China (0.012 km/km²) in 2015. If HSR is considered together with conventional interurban rail lines, this figure is even slightly higher (0.031 versus 0.012). This partly explains why the impact of HSR on the current transport system could be even higher in China than in Spain. Accessibility to the main tourist destinations in Spain before HSR started operation in 1992 was already guaranteed at a medium-high quality level. At the urban level, Europe has a longstanding tradition of using and operating public transport, and Spanish public transit is of significantly higher quality than its Chinese counterpart, particularly in medium and small sized cities. While transport and tourism infrastructure in Spain is balanced between inland and

coastal provinces, many inland destinations in China have natural resources that could potentially represent a regional competitive advantage were they endowed with the necessary infrastructure conditions, but have had difficulty in drawing both domestic and international visitors away from the popular coastal gateways (Jackson, 2006).

Although the Chinese tourism sector is currently experiencing one of its highest ever levels of growth, **public strategies** to improve quality levels in the tourism offer are new and being implemented at great speed. Spain, in its traditional role as a “beach holiday” country, has developed innovative tourism policies by promoting inland areas of the country and diversifying into other spheres such as rural and urban tourism, gastronomy, shopping and health tourism (OECD, 2016). There is even a Spanish Rural Tourism Promotion Plan for 2014, which is already producing results, and a Shopping Tourism Plan focused on Asian markets. A new health tourism cluster has also been created, and is promoted internationally through the combined efforts of several ministries and the private sector. Other areas of diversification include golf tourism, ecotourism and religious tourism.

Spain can therefore be said to have a greater density of tourist destinations per km², in addition to a wider diversification of tourism activities than China. This latter point is interesting from a territorial point of view, as HSR rail is not a permeable transport infrastructure (like roads), and the “city to city” link conditions the type of tourism itinerary. The density of transport infrastructure is also higher in Spain, thereby increasing the accessibility to tourist destinations and supporting the HSR system by using HSR stations as useful intermodal nodes.

The following section describes the application of a multivariate panel data analysis to Spain at the provincial level to explain the evolution of several tourism indicators, using HSR among other destination variables. The results are compared to those obtained in the Chinese case study using the same methodology, and the final analysis is supported by the tourism data provided in this section.

4. The model applied to the Spanish case study

Spain, with more than 20 years of HSR experience and 3100 km of track in service, offers a good opportunity to apply the Chen and Haynes model (2012), even though the direct application of this methodology to the Spanish case poses several difficulties, mainly concerning the adaptation of the statistical database to the variables used in the Chinese case study. The proposed model is based on a multivariate panel analysis at the provincial level. Spain is administratively divided into 17 regions and 50 provinces, and all the provinces were considered (except those located outside the Iberian Peninsula), in the period from 1999 to 2015. As the first HSR line started operation in 1992 (Madrid-Seville branch) and was the only one (Table 1) for over ten years, this period covers most of the Spanish HSR experience. Fig. 1 highlights the

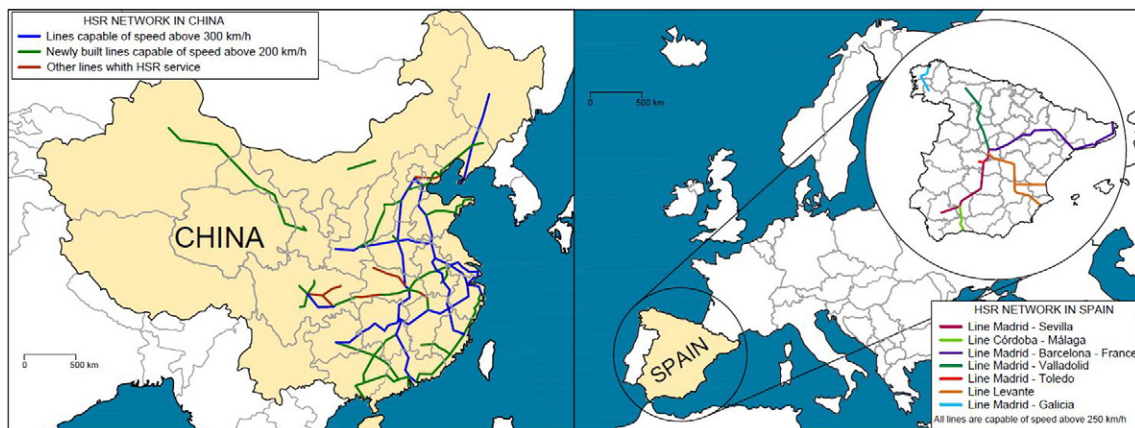


Fig. 1. Spanish and Chinese HSR network in 2015 (the same scale is used in both maps).

differences between the Spanish and Chinese HSR networks, and shows the extension of both countries.

The criteria used to select the tourism output (the dependent variable) in China focused on the availability of the related database: number of foreign tourist arrivals (*taf*) and tourism revenue (*tr*). Two different models – using the same structure but a different tourism output – were tested in order to quantify the impact of HSR lines on tourism in China. It should be noted that data (at the provincial level) for domestic tourism demand was not publicly available so was not considered in the research.

Table 2 shows the independent variables (and their main descriptive statistics) used by Chen and Haynes in their model. They are classified into “policy variables”, “origin variables” and “destination variables”. The policy variables are all related to rail transportation features such as:

- **Passenger rail ridership (rider)**, measured in 10,000 people per year, introduced to capture the impact of the generic passenger railway system, including both normal and high speed trains.
- **Length of railway (rlen)**, introduced as an alternative to reflect the impact of railway investment, as no actual investment data is available at the provincial level.
- **A HSR dummy variable (HSR)** equal to one for the year and province that has a HSR service, and zero otherwise. This variable is perhaps the most relevant data to measure HSR effects, as there were no itemised statistics available per line and province.

Origin and destination variables are always present in demand transport models together with impedance variables (travel time or distance). As origin variables the authors use only the annual nominal exchange rate (*exc*) from the US dollar to the RMB (*RenMinBi*), the Chinese legal tender. A long list of destination variables is given in Table 2, which can be perfectly extrapolated to case studies in other countries (hotels, number of World Heritage sites, museums, and others). Although this model does not consider trip features such as travel time or distance, it does take into account impedance variables such as the number of accidental pollution leaks (*pollution*) or the dummy variable associated to the outbreak of SARS (Severe Acute Respiratory Syndrome) which originated in China in 2003. Two special event dummy variables (*Bjolympic*, *SHexpo*) were also introduced to monitor the influence of the 2008 Beijing Olympic Games and the 2010 Shanghai Expo respectively.

In accordance with this approach, tourism output (the dependent variable) in Spain focused on similar tourism demand variables, bearing in mind that the Spanish National Institute of Statistics (INE) uses the term “number of tourists” rather than “tourist arrivals” to quantify the tourists visiting each province, and calculates the figures from the data

Table 1
Main features of Spanish long-distance HSR lines.
Source: Ministerio de Fomento, 2013.

Origin	Destination	Distance (km)	Year service opened	HSR travel time (min)	Passengers 2011	Passengers 2013
Madrid	Barcelona	621	2008	150	2,545,907	3,070,184
Madrid	Valencia	391	2010	100	1,836,500	1,858,436
Madrid	Seville	471	1992	150	2,137,026	2,175,808
Madrid	Zaragoza	306	2003	75	1,175,053	1,176,841
Madrid	Malaga	513	2007	150	1,433,361	1,533,363
Barcelona	Zaragoza	260	2008	90	600,511	623,555
Madrid	Cordoba	345	1992	105	800,679	757,673
Madrid	Valladolid	180	2007	56	1,083,590	1,212,632
Madrid	Lérida	442	2003	125	238,754	231,582
Madrid	Tarragona	521	2006	150	294,702	300,918
Madrid	Albacete	322	2010	90	248,992	238,495
Seville	Malaga	270	2008	110	104,317	96,480

Table 2
Descriptive statistics of the variables used in the Chinese case study (Chen and Haynes, 2012).

Variables	Definition	Mean	S.D.
tat	Number of total overseas tourist arrivals (10,000 persons)	173.271	359.405
taf	Number of foreign tourist arrivals (10,000 persons)	94.425	120.324
tr	Tourism revenue from overseas tourist arrivals (2005 million \$)	822.995	1419.954
rider	Passenger railway ridership (10,000 persons)	3946.763	2847.747
rlen	Railway length (kilometre)	2396.565	1517.768
gpppc	Gross Provincial Product per capita (2005 \$)	2159.243	1690.715
hotel	Number of five-star hotels	9.202	12.445
resta	Number of starred restaurants	357.952	521.354
whs	Number of World Heritage Sites	2.118	3.217
artc	Number of art galleries	62.263	44.397
lib	Number of libraries	89.105	42.915
museum	Number of museums	54.358	37.288
exchange	Exchange rate (US \$ to RMB)	7.831	0.600
pollution	Number of environmental accidents	41.570	67.786
SARS	A dummy variable equal to one for 2003	0.083	0.277
Bjolympic	A dummy variable equal to one for 2008	0.083	0.277
SHexpo	A dummy variable equal to one for 2010	0.083	0.277
HSR	A dummy variable equal to one for the year and province with a HSR service	0.083	0.277

for overnight stays provided by hotels. Unlike China, data on domestic tourism demand is publicly available in Spain at the provincial level, so the tourism output variables selected in the Spanish case study were: foreign tourists, domestic tourists and revenues from foreign tourism. In Table 3 these variables are referred to as: *taNR* (number of non-resident tourists), *taR* (number of resident tourist) and *tr* (tourism revenue from non-resident tourists in Spain). Three different models using the same structure but different tourism outputs were tested in order to quantify the impact of HSR lines on Spanish tourism.

The following policy variables (all related to rail transportation features) were used in the Spanish case study: *rlen* quantifies the national rail length (including the conventional rail network), *rider* is the total rail ridership (including conventional rail traffic) and HSR (dummy variable) is the HSR presence at the provincial level. It was more difficult to design the origin variables. As only foreign tourism was considered in the Chinese study, the authors used the annual nominal exchange rate (*exc*) from the US dollar to the RMB (*RenMinBi*). According to statistics from INE (INE, 2016b), in 2014 more than 71% of foreign tourism in

Table 3
Descriptive statistics of the variables used in the Spanish case study.

Variables	Definition	Mean	S.D.
taNR	Number of foreign (non-resident in Spain) tourists (10,000 persons)	48.620	98.684
taR	Number of domestic (resident in Spain) tourists (10,000 people)	84.232	89.884
tr	Tourism revenue from foreign tourists (1999 million \$)	494.736	963.052
rider	Railway ridership (10,000 people)	2122.441	421.862
rlen	Railway length (Km.)	14,713.679	1383.290
gpppc	Gross Provincial Product per capita (1999 € x 1000)	15.672	3.543
hotel	Number of four- and five-star hotels	23.671	33.542
whs	Number of World Heritage Sites	0.721	0.750
lib	Number of libraries	133.146	124.466
museum	Number of museums	29.731	31.844
exchange	Difference between Gross Product per capita in Euro Zone and the Spanish Provincial value (1999 € x 1000)	1.983	4.329
Forum	Dummy variable equal to one for 2004	0.059	0.235
AmCup	Dummy variable equal to one for 2007	0.059	0.235
ExpoZ	Dummy variable equal to one for 2008	0.059	0.235
HSR	Dummy variable equal to one for the year and province with a HSR service	0.214	0.410

Spain came from the European Union. Our exchange variable is therefore defined as the difference between the provincial and European (Eurozone) GDP, referring to 1999 currency to avoid the effect of inflation. The origin of domestic tourism is more difficult to determine, and no origin variable related to GDP was used.

Table 3 shows the rest of the independent variables (and their main descriptive statistics) added to the Spanish models. Apart from the local economic variable used in the Chinese case study – the Gross Provincial Product per capita (gpppc) –, significant efforts were made to collect the same multidimensional features of local tourism used in the original model: number of World Heritage sites (whs), starred restaurants (resta), museums (museum) and public libraries (lib). Art galleries are included in the museum database. In the Spanish case, 4-star hotels are the most popular with both domestic and foreign visitors (INE, 2016b), so the hotel variable (hotel) included the number of 4- and 5-star hotels (unlike the Chinese case study). In the time period considered (1999–2015), no special impedance variables were taken into account, such as accidental pollution leaks or the outbreak of SARS in China. It was decided to overlook these variables as no comparable cases have occurred in Spain, and owing to the high degree of loyalty of visitors to Spain (Spanish Institute of Tourism, 2012). Instead, three special dummy variables relating to major international cultural and sporting events were introduced as attracting indicators: the Forum 2004 in Barcelona (Forum), the America's Cup in Valencia in 2007 (AmCup), and the International Exhibition in Zaragoza in 2008 (expoZ). These events have been recognised for their relevance in the research work of Renau (2010) in Spain. There is another additional variable in the model (called year), not linked to origin, destination or policy features, which groups the sequence of observations and measures time trends.

Before designing the equations for the Spanish case study, the preliminary multicollinearity data analysis found high correlations between the explanatory variables *rider* and *rln*. As in Chen and Haynes' research, this led the authors to present two separate models per output variable. Eqs. 1 and 2 show the general structure of the multivariate analysis using panel data. Subindices *i* and *t* denote destination provinces and time period respectively, while *Y* represents the dependent variables (number of domestic tourists, number of foreign tourists and total foreign tourist revenue). A fixed effects model (FE) was developed for the unobserved individual effect in a panel model, consisting of a

statistical model that represents the observed quantities in terms of explanatory variables that are treated as if the quantities were non-random.

$$\ln Y_{it} = \alpha_1 + \beta_{1_} \ln rider_{it} + \beta_{2_} \ln gpppc_{it} + \beta_{3_} \ln hotel_{it} + \beta_{4_} whs_{it} + \beta_{5_} lib_{it} + \beta_{6_} museum_{it} + \beta_{7_} exchange_{it} + \beta_{8_} forum_{it} + \beta_{9_} AmCup_t + \beta_{10_} ExpoZ_t + \beta_{11_} Year + \beta_{12_} HSR + \epsilon_{it} \quad (1)$$

$$\ln Y_{it} = \alpha_1 + \beta_{1_} \ln rln_{it} + \beta_{2_} \ln gpppc_{it} + \beta_{3_} \ln hotel_{it} + \beta_{4_} whs_{it} + \beta_{5_} lib_{it} + \beta_{6_} museum_{it} + \beta_{7_} exchange_{it} + \beta_{8_} forum_{it} + \beta_{9_} AmCup_t + \beta_{10_} ExpoZ_t + \beta_{11_} Year + \beta_{12_} HSR + \epsilon_{it} \quad (2)$$

Table 4 shows the determinants of the number of foreign tourists in Spain compared with the results of Chen and Haynes (2012). Model 1 considers rail ridership as a policy variable, while model 2 uses network length. This multivariate analysis methodology is repeated again in Table 5 to study the determinants of foreign tourism revenue in Spain (model 3 with ridership, model 4 with length). Table 6 shows the results for the output “number of domestic tourists” obtained from two multivariate analysis applied to the Spanish panel data, one using the independent variable *rln* and the other using *rider*.

In the case of **foreign tourism (models 1, 2, 3 and 4)**, the first finding in the Spanish study concerns local site characteristics such as the number of 5-star hotels, starred restaurants, World Heritage sites and museums. These variables were not statistically significant in China in any of the models designed, while in Spain some indicators such as the hotel variable are statistically significant at the 1% level. The hotel variable coefficients in the four models range between 0.941 and 0.591. Other local site characteristics such as museums and libraries show high levels of significance, although their coefficients are much lower than for the hotel variables. These results are consistent with the Spanish offer at the destination: not only “beach and sun” attractions, but a greater diversification of areas such as rural and urban tourism, gastronomy, shopping, museums, health tourism, eco-tourism and others, all concentrated in the same physical location or within an easily accessible radius of influence using the transport system. Our

Table 4
Determinants of the number of foreign tourists in Spain. Comparison with Chen and Haynes' results (2012).

Model 1			Model 2		
China case study		Spain case study	China case study		Spain case study
Dependent	Itaf	Dependent	ItaNR	Dependent	ItaNR
	FE		FE		FE
Irider	0,082	Irider	1626	Irider	
	(0,107)		(3745)		
Irlen		Irlen		Irlen	0,040 (0,086)
Igpppc	0,459**	Igpppc	3000***	Igpppc	0,495** (0,231)
	(0,222)		(0,755)		
Ihotel	0,078	Ihotel	0,938***	Ihotel	0,056 (0,057)
	(0,050)		(0,030)		
Iresta	0,054	Iresta		Iresta	0,062 (0,057)
	(0,054)				
whs	-0,003	whs	0,003	whs	-0,003 (0,010)
	(0,010)		(0,010)		
artc	0,000	artc		artc	0,000 (0,001)
	(0,001)				
lib	-0,001	lib	0,071***	lib	-0,004 (0,006)
	(0,002)		(0,018)		
museum	-0,002	museum	-0,027**	museum	-0,001 (0,002)
	(0,001)		(0,013)		
exchange	0,241***	exchange	0,084**	exchange	0,204** (0,081)
	(0,078)		(0,033)		
pollution	0,000	pollution		pollution	-0,001* (0,000)
	(0,000)				
SARS	-0,447***	Forum	-0,002	SARS	-0,459*** (0,055)
	(0,057)		(0,003)		
Bjolumpic	0,028	AmCup	-0,002	Bjolumpic	0,014 (0,067)
	(0,066)		(0,002)		
Shexpo	-0,055	ExpoZ	-0,003	Shexpo	-0,046 (0,068)
	(0,069)		(0,003)		
Year	0,089***	Year	-17,887	Year	0,083** (0,026)
	(0,024)		(24,957)		
HSR	0,201**	HSR	0,012**	HSR	0,188** (0,074)
	(0,073)		(0,005)		
cons	-180,954***	cons	13,186	cons	-168,258*** (51,544)
	(46,067)		(22,706)		
R-adj	0,810	R-adj	0,744	R-adj	0,794
No. of obs	313	No. of obs	799	No. of obs	295

Figures in parentheses are standard deviation. ***, **, * denote coefficients significant at the 1%, 5% and 10% statistical level respectively.

provinces with HSR services were likely to have approximately 25% more tourism revenues than provinces without. In Spain, the highest coefficient (see models 3 and 4 in Table 4) is 0.017, indicating that provinces with HSR services were likely to have 1.7% more tourism revenues. The highest HSR coefficient in China in foreign tourism demand models (models 1 and 2, Table 4) is around 0.201, suggesting that provinces with HSR services were likely to have 20.1% more tourists, while this percentage is only 1.3% in Spain. These results can be explained by the fact that, as mentioned in Section 3, distances between tourist destinations are greater in China than in Spain, and the transport alternative to HSR is a lower density network (high-capacity roads and conventional trains). Accessibility to the main tourist destinations in Spain before HSR started operation in 1992 was already guaranteed at a medium-high quality level, and the impact of HSR on tourism indicators is thus less important.

In the case of **domestic tourists (models 5 and 6)** and local site features –as in the case of foreign tourists–, the only significant variables are the number of hotels and the number of libraries (this latter with a low coefficient). Neither the variable *whs* or *museum* is statistically significant, highlighting the importance of Spanish coastal destinations for this type of tourism. In support of this argument, data from the Familitur Report (ITE, 2013b) revealed that the three major destinations for domestic tourism were Andalusia, Catalonia and the Region of Valencia, accounting for almost 50% of visitor share. These three regions have a considerable extension of coastline, and the temperatures are excellent for “sun and beach” tourism. The only significant event variable is ExpoZaragoza in 2008, with a high significance (1%). Nevertheless, as in the foreign tourism models, the value of the coefficient (between 0.003 and 0.005) reveals its low real impact on the domestic tourist sector. The economic explanatory variable *gpppc* has the highest significances (lower than 1% in both rider and *rln* models), and high coefficients (0.214 and 0.215 respectively). This finding underlines the considerable importance of tourism for the Spanish provincial economy and its significant and positive role for regional economic growth, as noted by previous studies (Cortés-Jiménez, 2008).

In relation to policy variables, neither ridership nor the length and existence of HSR are significant, (not even at 10% significance). According to the Familitur Report (ITE, 2013b), in 2012 the private car represented over 84% of the modal split in domestic tourist trips, indicating that the improvement in the speed and comfort of the rail network is not sufficient on its own to modify the mobility patterns of Spanish families. This may be explained by the higher costs perceived by travellers in comparison with the private car when more than one person is travelling (which is very common in family tourism patterns).

In conclusion, the results show that HSR in Spain has positively affected foreign tourism outputs (especially revenues), although its impact is not as important as in China. There is no clear evidence of its effect on domestic tourism. HSR impacts on tourism in a country like China, where the alternative interurban transport network is less developed than in Europe, are of a higher magnitude and easier to detect with an econometric model.

Further research is required on the use of HSR variables, which need to describe not only the existence of lines at the provincial level, but also the connectivity and territorial distribution of the HSR network, and the service conditions offered by the operating companies (fares, timetables and frequency). For example, in Spain and France, some HSR lines are used by commuters, and in some cases tourism is an important trip purpose. None of these commuter visitors stay in hotels, and therefore do not appear as tourists in the official statistics. In conclusion, the model would benefit from a greater level of data disaggregation and a better understanding of the territorial distribution of HSR lines through new explanatory variables relating HSR operating conditions, and including new tourism outputs based on overstay in hotels and number of visitors to the main tourism attractions, or disaggregated revenues per sector (restaurants, museums and others).

Apart from the abovementioned drawbacks of the methodology applied to both China and Spain, there is another issue arising from this research. After applying the model to the Spanish case, it still remains to be clarified whether HSR development and tourism have a simultaneous effect and whether this system is really endogenous. Although a “circular and cumulative causation” between HSR demand and tourism demand is always expected in these territorial systems, it is essential to separate any crossover effects, or at least identify which has the greater impact (HSR on tourism indicators, or tourism on HSR demand). In the next section a simple empirical analysis of endogeneity is applied to a specific Spanish destination (Toledo), in order to demonstrate by example that this separation can be achieved and derived from empirical data.

5. Study at the local level: Madrid-Toledo

In order to test endogeneity between HSR demand and tourism indicators, we selected Toledo, a mid-sized tourist city in central Spain with almost 78,000 inhabitants, as a case study. Toledo is located 70 km south of Madrid and has been linked to Madrid by a HSR line since November 2005. It was declared a World Heritage site by the UNESCO in 1986 for its extensive cultural and monumental heritage, and the historical co-existence of Christian, Muslim and Jewish cultures. Before construction work started on the new line, rail traffic in the previous conventional line was not insignificant (over 800,000 passengers in 2002), and rose to over 1,300,000 passengers in this decade, as shown in Fig. 2. The Madrid-Toledo HSR line is successful in terms of traffic, not only due to the HSR link to Madrid and its attractiveness to tourists, but also because of the type of service provided by the operating company. Since 2005, Toledo has enjoyed AVANT services with over ten daily HSR shuttles (30 min' travel time), and is also favoured by the availability of monthly tickets which are economically highly advantageous compared to ordinary one-way tickets. If the schedules are compatible with work timetables, this frequency enables their use for commuting, with the result that over 60% of users of the Madrid-Toledo HSR line have been found to be commuters.

The first indicator we quantified was the evolution of the number of tourists in Toledo, drawing on tourism data provided by the Spanish National Statistical Institute (INE), covering 50 provinces and a limited number of *tourist points* within a time span of 15 years (1998–2013). Data at the provincial level were used to calibrate the multivariate regression model in Section 3, but more detailed data are available as Toledo is considered a *tourist point* by the INE. In both database sources, the “number of tourists” indicator is calculated by the INE using only the results of the Survey of Hotel Occupancy, so this analysis must take into account that visitors to these cities who do not spend at least one night at the destination are still not registered as “tourists”. In the case of Toledo the number of tourists comprises two thirds of the visitors at the provincial level, and disaggregation between resident and non-resident tourists in Spain has only been available from 2005 in the tourist point INE database.

In addition to the evolution of the number of tourists in Toledo, we studied other indicators such as the number of museum visitors (Htickets sold) and its evolution before and after the implementation of the new HSR line. As the church of Santo Tomás – the home of the famous painting “The Burial of the Count of Orgaz” – is one of the most visited museums in the city, we recorded the data for tickets sold per year. Fig. 2a also shows the number of tourists and overnight stays in Toledo (before and after the inauguration of HSR services in 2005) together with the evolution of rail passengers and the main museum visitors. An average of 26% of tourists are non-resident in Spain.

There was a sharp rise in the number of travellers after the opening of the HSR line. Bearing in mind that commuters account for 60% of HSR traffic, the increase in both the number of tourists and number of visitors to the Santo Tomás museum is much more limited and appears to be more a result of other factors, revealing no clear evidence of the

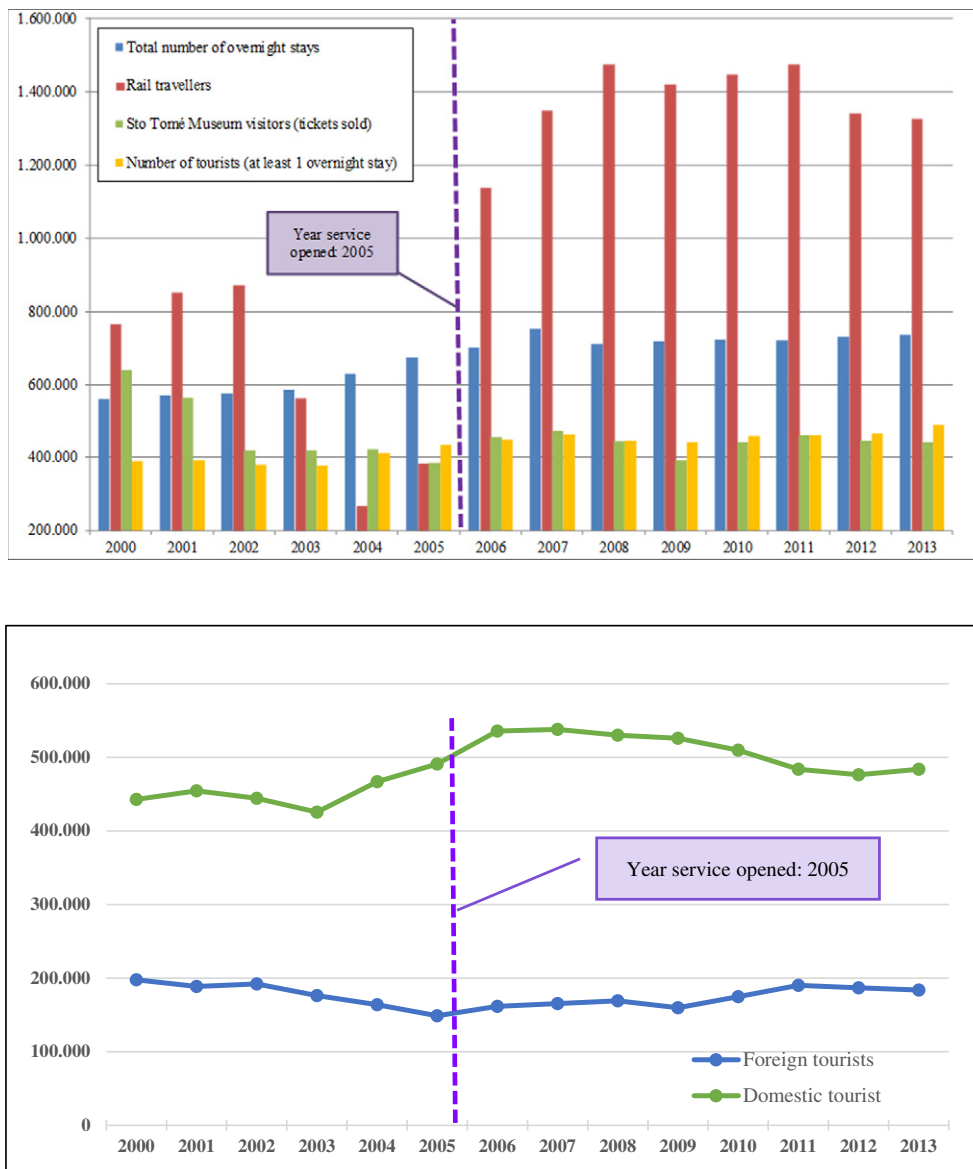


Fig. 2. Toledo case study. Evolution of rail travellers versus the evolution of certain local tourism indicators (above, Fig. 2a). Evolution of the number of foreign and domestic tourists at the provincial level (below, Fig. 2b).

influence of HSR on these tourism variables. Fig. 2b shows the evolution of the number of resident and non-resident tourists in the province of Toledo for 2000–2013 (the period 2000–2005 is not covered at this disaggregation level by the INE's urban database of tourist points). There is no appreciable influence of HSR on residents, while a slight positive influence can be observed on non-residents. This is consistent with the results of the model applied to Spain in Section 4: foreign tourism in Spain is more positively affected by HSR than domestic tourism, although the Spanish financial crisis (which started in 2005) may have influenced this fact. The fall in all the variables since 2008, with a greater impact on the number of visitors to the Santo Tomé museum than on the number of travellers or the number of visitors, can be explained by the Spanish financial and socioeconomic climate after 2005.

This data context highlights the difficulties of assessing the influence of HSR on tourism indicators, but reveals that its influence may even be negligible for some types of tourism. In the case of Toledo, the road infrastructure between Madrid and Toledo is perfectly covered by both a free dual carriageway (A-42) and a toll motorway (AP-41), while regular bus services offer frequencies of 30 min and travel times of 60 min

(HSR travel time is 30 min with a frequency of 60 min). There are multiple alternatives to HSR.

In order to find more empirical evidence on “circular and cumulative causation”, we also analysed the evolution of the number of restaurant licenses in the city of Toledo from 2000 (530 licenses) to 2013 (800 licenses), which revealed that the annual growth rate was fairly continuous regardless of the opening of the HSR line. Additionally, it is difficult to assess in the short term whether HSR contributes to improving the image of a tourist city. Apart from the Madrid-Seville line, most Spanish HSR lines have been in operation for under ten years, which is too soon to analyse or model this kind of indirect effect. Toledo was an important Spanish tourism destination before 2005, despite its lack of HSR. In any case, the improvement of the image of a tourist city in the long run will be seen in the increase in most of the tourism outputs and revenues.

After studying the local case of Toledo, we can state that within this “cause-effect” relation the effect of tourism on HSR demand may be much more important than the effect of HSR infrastructure on tourism indicators. Evidently, tourism will always be an object of trip generation, but when a tourism destination already has a high rate of transport accessibility, a new mode does not add a large number of new tourists but

produces a new transport modal split in the access to destination. This example shows how this cause-effect relation may be totally unbalanced towards the benefits of HSR demand. In other destinations, this fact will depend on the alternative transport modes for accessing the tourist destination and the type of tourism affected –resident or non-resident– as they clearly behave in a different way. Lastly, local strategies to promote tourism are also important. Toledo is clearly a cultural destination, but gastronomy, and rural and ecotourism have also been publicly promoted at the provincial level in recent years. HSR is only one of the possible “gateways to the destination”, but depending on the country and the province concerned, this can either be the optimal gateway, or simply a complement to other existing ones.

6. Conclusions

The literature review shows how tourism has affected HSR demand, although little research has been done to date to empirically estimate the opposite effect of HSR on tourism indicators. Chen and Haynes were the first to study this impact through a multivariate panel analysis, obtaining positive results and showing that in the period between 1999 and 2010, fledgling high-speed rail services significantly boosted tourism in China. The analysis considered only foreign rather than domestic tourism due to the lack of data available at the provincial level.

The most effective first step for obtaining a systematic tool to evaluate the integral impact of HSR on the tourism industry is to conduct a detailed study of the applicability of the Chinese experience. With Spain and China coming top of the rankings for the most visited tourist countries (along with France and the US) and the longest HSR networks in operation, Spain can be considered the most suitable country for validating this tool. The tourism structure in both China and Spain was studied in order to define the main differences and gain a greater understanding of the modelling results, and the following key issues were identified: tourism motivations, levels of transport accessibility to tourism destinations, weather limitations, evolution of domestic tourism and public strategies to promote tourism. The authors have made considerable efforts to adapt the Spanish database to the variables defined in the Chinese analysis, introducing new variables when necessary and eliminating any that are not applicable to the Spanish scenario. Six different models were designed using the following dependent variables: number of foreign visitors, number of domestic visitors and foreign revenue. For each dependent variable, two equations were defined (one using ridership and other railway length).

The rail variables (the key issue in this research) show that while ridership and length are not really significant, the HSR dummy variable plays a clear positive role in the increase in both the number of foreign tourist arrivals and revenues, and is highly significant with a positive sign. Nevertheless, the coefficients obtained for Spain are surprisingly low compared to China, and reveal that Spanish provinces with HSR receive about 1.3% more tourists and 1.7% more revenues (20.1% and 25.0% respectively for China). These differences are explained by the greater distances between tourist destinations in China, combined with the fact that the transport alternative to HSR is a lower density network (high-capacity roads and conventional trains). Accessibility to the main tourist destinations in Spain before HSR started operation in 1992 was already guaranteed at a medium-high quality level, and HSR impact on tourism indicators is thus less important.

In the case of domestic tourism, neither ridership nor the length and existence of HSR are significant, (not even at 10% significance). It can therefore be concluded that the improvement in the speed and comfort of the journey implied by HSR is not sufficient on its own to modify the mobility patterns of Spanish residents (in 2012 the private car represented over 84% of the modal split in domestic tourist trips), and that the higher costs perceived by travellers in comparison with the private car is crucial in determining domestic mobility patterns.

Another interesting finding deriving from the modelling is the differing significance of the destination variables (number of hotels,

museums and libraries) that positively influence foreign tourism in Spain but not in China, suggesting that the reinforcement and favourable complementarity of the “destination” variables are especially good public strategies to promote tourism. Combined with a higher density of tourist destinations per km² and greater accessibility to them, this defines a different scenario for Spain, in which HSR plays a secondary role.

Notwithstanding the limitations of the tourism databases (focused mainly on hotel occupancy), further research is required on the use of HSR variables, which should describe – in addition to the existence of lines at the provincial level – the connectivity and territorial distribution of the HSR network, and the service conditions offered by the operating companies (fares, timetables and frequency). The model's ability to analyse “circular and cumulative causation” between HSR and tourism has also been discussed as a drawback of the methodology used in this research. Although a cause-effect analysis would require a longer-term database series than available at present (over 20 years of HSR operation), this approach could be a first step towards improving the modelling. In order to clarify this issue, the authors have completed their research with a local case study (Toledo, Spain) with more disaggregated data to demonstrate how the effect of HSR on tourism indicators is ultimately less important than the impact of tourism on HSR demand.

For some countries and cities, tourism can represent a real priority and a source of income, and the validated methodology presented in this paper will ultimately provide authorities and policymakers with useful tools to estimate the real contribution to tourism development of a new or existing HSR line, without requiring the use of an a priori unfounded hypothesis.

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