INTERNATIONAL JOURNAL OF TRANSPORT ECONOMICS
ISSN 0391-8440 · E-ISSN 1724-2185
VOL. XLII · NO. 3 · SEPTEMBER 2015

DOES HIGH-SPEED PASSENGER RAILWAY INCREASE FOREIGN TRADE? AN EMPIRICAL ANALYSIS

Salvador Gil-Pareja* · Rafael Llorca-Vivero**
Jordi Paniagua***

Abstract: High-speed passenger railway (HSR) transport reduces travel time for travellers and it may well also have a positive effect on freight transport. The construction of many of these lines, which run in parallel to conventional railways, has significantly reduced the commute time between interconnected cities. Moreover, deployment of the HSR network has freed capacity of the low-speed tracks, which have absorbed most of the freight railway traffic. Therefore, HSR infrastructure represents an advantage for exporting companies, which benefit from higher slot availability and greater efficiency in terms of railway freight management. This empirical paper uses the gravity equation to analyse the impact of HSR on international trade with a dataset of 119 countries during the period 1960-2012. The estimation results suggest an overall positive but moderate impact of HSR on international trade. However, a country-specific analysis reveals certain heterogeneity.

Keywords: International trade; high-speed passenger railway; transport infrastructure; gravity equation.

JEL Classification: F1, F14, H54.

1. Introduction

This paper studies the economic impact of high speed trains from a new perspective: the effect of high-speed passenger railway (HSR) lines on international trade. The deployment of the HSR network in many regions may have a positive effect on foreign trade. HSR consists of specially built high speed lines equipped for speeds generally equal to or greater than 250 km/h (UIC, 2014). In many countries the new HSR lines run parallel to conventional railway tracks. Consequently, countries with HSR experience redundancy for railway freight traffic. Railway freight represents a significant share of the different cargo transport modes. In 2011, railways transported close to 5,707.5 million t·km worldwide

- Last version: June 2015.

* University of Valencia; salvador.gil-pareja@uv.es
** University of Valencia.
*** Catholic University of Valencia "San Vicente Mártir".

Acknowledgements: Salvador Gil-Pareja and Rafael Llorca-Vivero gratefully acknowledge funding from The Ministry of Economy and Competitiveness (project ECO2012-38040) which is part-funded by the European Regional Development Fund (ERDF) and *Generalitat Valenciana* (PROMETEOII/2014-053).

(World Bank, 2013).[1] In Europe, trains transport around 18% of total freight, whereas rail share in China and the USA more than double this figure, with 58% and 42% respectively. This paper uses a global panel dataset to capture the effect of HSR on international trade.

The economic analysis of HSR has not been free from academic controversy. Researchers who analyse the economics of transport argue that the costs of HSR outweigh its social and economic benefits (De Rus, 2011), while others argue that HSR may have a perverse effect on the geographical distribution of economic activity and regional inequalities (Albalate, Bel, & Fageda, 2012; Bel, 2011). Unlike the existing literature on the cost-benefit analysis of HSR, few studies delve into the international repercussions of the HSR transport infrastructure and so this paper seeks to fill this gap.

This study connects two established bodies of economics literature – international trade and transport – by providing an empirical estimate for the effect of HSR on international trade. In this paper we calculate various effects of HSR on bilateral trade by means of the gravity equation, a typical methodology in analysing the determinants of international trade flows. The estimation results suggest a positive but moderate effect of HSR on international trade. However, a country-specific analysis shows certain heterogeneity.

The relevance of transport infrastructure for productivity and economic growth is well accepted in the literature (Aschauer, 1989; Banister, 2012; Bougheas, Demetriades, & Mamuneas, 2000; Deng, 2013; Egger & Falkinger, 2006; van den Berg, van Klink, & Pol, 1996). However, the literature on transport and trade is considerably smaller (see, for example, Cantos, Gumbau-Albert & Maudos, 2005; or Martínez-Zarzoso, García-Menéndez & Suárez-Burguet, 2003). Better transport infrastructure may lower transport costs for exporting companies. In turn, companies facing lower transport costs and higher availability of transport infrastructures are better able to compete in international markets. Consequently, difference in transport infrastructures among countries may partially account for variation in bilateral trade across borders.

Several studies show a positive relationship between transport infrastructures and trade. Bougheas, Demetriades & Morgenroth (1999) posit a positive relationship between the level of infrastructure and the volume of trade. The authors assume that transport costs depend inversely on the level of infrastructure and show those countries with an optimal investment in infrastructure. Limão and Venables (2001) investigate the dependence of transport costs on geography and infrastructure. Their analysis of bilateral trade data confirms the importance of infrastructure on trade, especially for landlocked countries. Recently, Duranton, Morrow & Turner (2014) estimate the effect of interstate highways on the level and composition of trade for US cities. Highways within cities significantly affect the weight of city exports with an elasticity of approximately 0.5.

[1] A ton-kilometre equals cargo weight transported multiplied by the distance transported.

Facing public budget constraints, however, governments prioritize investment in passenger related infrastructures over freight lines (Tzanakakis, 2013b). The government welfare function accounts both for the equity-efficiency trade-off and for deviations from this rule arising due to political factors (Behrman & Craig, 1987). Therefore, specific regional infrastructure needs and political factors both represent important elements in the allocation of infrastructure investment (Castells & Solé-Ollé, 2005). For example, the European Directive 96/48/EC incorporates dedicated infrastructure in the planning and development of the trans-European High Speed system (Roll & Verbeke, 1998). The vision behind the trans-European High Speed system was to promote economic growth, employment and increase the technological capabilities of European firms through the construction of the HSR system (European Commission, 2001).

The high levels of public investment in HSR has prompted a series of papers analysing its effectiveness in terms of promoting general economic welfare but this research into the impact of HSR presents mixed results (Albalate & Bel, 2012; Campos & de Rus, 2009). Early studies identified an economic boost due to newly built HSR lines. Theoretically, HSR contributes to the general welfare by reducing commuting time and harmful emissions while simultaneously generating new jobs and economic growth (Givoni, 2007).

However, an ex-post cost-benefit analysis reveals that for some HSR lines (in Spain and France, for example) the costs associated with the construction and operation of HSR outweigh the social benefits (Givoni, 2006). For instance, Europe's oldest HSR, which runs from Paris to Lyon, is a rather modest contributor to French economic and social welfare (Offner, 1993). Researchers argue that negative perceptions of the environmental impact influence the deployment and planning of HSR (Marincioni & Appiotti, 2009).

The HSR network has a direct impact on other means of transport, particularly short haul flights (Clark, Jørgensen, & Pedersen, 2009) and automotive traffic between HSR connected cities (Tzanakakis, 2013a). Despite the potential benefits stemming from airport-railway integration (Socorro & Viecens, 2013), empirical evidence suggests that HSR has led to lower prices and revenues for airline companies (Yang & Zhang, 2012). To the best of our knowledge, no previous research has looked into the effect of HSR on international trade.

The analysis of some empirical regularities invites us to delve deeper into the relationship between HSR and trade. Since the opening of the first *Shinkansen* HSR line between Tokyo and Osaka in the 1960s, enthusiasm for HSR has swept across the world. Furthermore, the HSR network has drawn closer to the world's major trade hubs. FIGURE 1 shows that there is an extensive presence of HSR in high performance exporters in Europe and South Eastern Asia.

FIGURE 1. HSR network. Source: UIC (2014).

More specifically, a total of 100 HSR lines have been built in 15 countries adding up to more than 21,000 kilometres in total (UIC, 2014). These figures are described in detail in TABLE 1. Additionally, the last column of TABLE 1 reports the ranking of each country's share of world trade (World Bank, 2013). All top-10 countries in the trade outcome ranking have deployed HSR transport lines.

TABLE 1. Descriptive data on HSR and Trade Outcome.

Country	HSR			Trade Outcome
	Kms in 2012	First line in operation	Number of lines	Ranking of total trade share of total world trade
China	9,867	2003	26	3
*Japan***	2,664	1964	15	4
Spain	2,515	1992	15	11
France	2,036	1981	9	5
Germany	1,334	1988	11	2
Italy	923	1981	9	7
Turkey	444	2009	2	29
South Korea	412	2004	2	9
*United States**	362	2000	1	1

Country	HSR			Trade Outcome
	Kms in 2012	First line in operation	Number of lines	Ranking of total trade share of total world trade
*Taiwan***	345	2007	1	19
Belgium	209	1997	4	12
Netherlands	120	2009	1	8
United Kingdom	113	2003	2	6
Austria	93	2012	1	22
Switzerland	35	2007	1	18
Total:	21,472		100	

Notes:
* Non-exclusive HSR line (max. speed 240 km/h)
** Connects the island from north to south with no redundancy

Moreover, most countries built dedicated lines for HSR running parallel to traditional railways, and the latter absorb most of the cargo transit. For example, the HSR grid in Europe overlays the low-speed network (see Figure 2) and this network railway redundancy has freed resources from the traditional train lines, which can then be used for cargo in a more efficient manner. These basic facts motivate a deeper empirical analysis to study the effect of HSR on international trade.

Figure 2. HSR lines in Europe. Source: UIC (2014).

The remainder of the paper is structured as follows: section 2 describes the empirical methodology; section 3 describes the data used in the analysis; section 4 discusses the results; section 5 presents a case study of the Spanish HSR and, finally, section 6 concludes.

2. Methodology

The empirical suitability of the gravity model in explaining various types of flow variables (trade, tourism, migration, FDI) has led to its broad application in the international trade literature. In this paper, we follow this methodological approach. While the gravity model initially lacked theoretical foundations, since 1979 it has been fully grounded in theory.[1] The gravity model of trade relates bilateral trade flows to economic size (GDP), distance and other factors affecting trade barriers. We estimate the following equation:

$$lnX_{ijt} = \beta_0 + \beta_1 lnY_{it} + \beta_2 lnY_{jt} + \beta_3 lnDist_{ij} + \beta_4 Cont_{ij} + \beta_5 Island_{ij} + \beta_6 Landl_{ij} + \beta_7 Lang_{ij} + \beta_8 Colony_{ij} + \beta_9 ComCountry_{ij} + \beta_{10} Creligion_{ij} + \beta_{11} RTA_{ijt} + \beta_{12} HSR_{ijt} + \lambda_t + u_{ijt} \quad (1)$$

where i and j denote trading partners, t is time, and the variables are defined as follows: X_{ijt} are the bilateral export flows from i to j in year t, Y denotes Gross Domestic Product, D denotes the distance between i and j, *Cont* is a dummy variable equal to one when i and j share a land border, *Island* is the number of island nations in the pair (0, 1, or 2), *Landl* is the number of landlocked areas in the country-pair (0, 1, or 2), *Lang* is a dummy variable which is unity if i and j have a common language, *Colony* is a binary variable which is unity if i ever colonized j or vice versa, *ComCountry* is a binary variable which is unity if i and j were part of the same country in the past, *Creligion* is an index of common religion,[2] *RTA* is a binary variable which is unity if i and j belong to the same preferential trade agreement,[3] *HSR* is our variable of interest (approximated with three alternative variables), λ_t are time dummies and u_{ijt} is the error term.

Firstly, we have considered as our variable of interest the number of countries in the pair with HSR infrastructure in year t. That is, the variable will take the values 0, 1 or 2. Secondly, we have decomposed it into two dummies: those pairs with only one country with an HSR line (the dummy variable *HSRone*) and those pairs with both countries having an HSR line at the same time (the dummy variable *HSRboth*). Our aim is to discern whether the impact on international trade is reinforced when

[1] See, among others, Anderson (1979), Anderson & Van Wincoop, (2003), Deardorff (1998), Eaton & Kortum (2002), Evenett & Keller (2002), Helpman, Melitz & Rubinstein (2008).

[2] The index is defined as: (% Protestants in country i * % Protestants in country j) + (% Catholics in country i * % Catholics in country j) + (%Muslims in Country i * % Muslims in country j).

[3] The term RTA in this paper refers also to other agreements involving a higher degree of economic integration. In fact, most economic integration agreements considered in the sample are free trade agreements.

both partners have this infrastructure. Finally, given that we have data on the number of kilometres in operation for each country and year, we have also considered the log transformation of the variable (the log of the number of kilometres plus one) which, in addition, provides us with the estimation of the elasticity of trade with respect to the length of the network (variables *lnHRSKM*, *lnHRSKMone* and *lnHRSKMboth* in the tables).

Conventional OLS estimation of equation (1) is likely misspecified for several reasons. Firstly, it ignores the theoretical foundations of the gravity equation first developed in Anderson (1979). Anderson and van Wincoop (2003) illustrate the omitted variables bias introduced by ignoring "multilateral resistance" (price) terms in gravity equations. As these authors emphasize, gravity model theory implies that one must take into account not only the trade resistance between any two countries (the bilateral resistance, which is a function of distance, language, contiguity, etc.), but also the fact that different countries have different multilateral resistance to trade. The usual solution to control for such multilateral resistance terms is to include country fixed effects (CFE) for both the exporter and the importer countries when estimating gravity equations. Secondly, there may be unobservable characteristics of the country pairs that are invariant over time and have an impact on bilateral exports. Unobserved bilateral heterogeneity is usually controlled for by the inclusion of country-pair individual effects. Thirdly, Silva & Tenreyro (2006, 2010) focus on econometric problems resulting from heteroskedastic residuals and the prevalence of zero bilateral trade flows. These authors show that OLS estimators are biased in the likely presence of heteroskedasticity in trade data. Therefore, they propose a non-linear Poisson model to estimate the gravity equation which, in addition, accounts for the presence of zeros in bilateral trade flows. Finally, many authors treat the average of two-way bilateral trade as the dependent variable (see, for example, Glick & Rose, 2002; Rose, 2000 and 2004; and Tomz, Goldstein & Rivers, 2007) a procedure that Baldwin and Taglioni (2006) refer to as the *silver medal* mistake. However, all theories that underlie a gravity-like specification yield predictions on unidirectional bilateral trade rather than two-way bilateral trade. In this paper, we use unidirectional trade data and, therefore, our specification is more closely grounded in theory.

3. Data

The trade data for the dependent variable (export flows from country *i* to country *j*) are taken from the "Direction of Trade" (DoT) dataset built up by the International Monetary Fund (IMF). The data comprise bilateral merchandise trade between 119 countries over the period 1960-2012. The list of countries is found in Table A1 in the Appendix. The DoT dataset provides free on board exports in US dollars. These series are converted into constant terms using the American GDP deflator taken from the Bureau of Economic Analysis (US Department of Commerce).

The independent variables come from different sources. GDP data in constant US dollars are taken from the World Development Indicators (World Bank). The CIA's World Factbook provides data on country location (geographical coordinates), used to calculate Great Circle Distances, as well as data for the construction of the dummy variables for physically contiguous neighbours, island and landlocked status, common language, colonial ties, common religion and common country background. The indicator for regional preferential trade agreements has been built using data from the World Trade Organization.

Finally, data on the number of HSR network kilometres in operation for each country and year come from International Union of Railways (UIC). Table 1 presents the countries and the total number of kilometres in 2012. In our regressions we have excluded Japan, Taiwan and USA because there is no redundancy of tracks, which is the premise for this study. Additionally, we have excluded the United Kingdom, Austria and Switzerland, because the length of their lines are testimonial in relation to their respective countries' area.

4. Empirical results

We begin by estimating the impact of HSR on trade using OLS with country fixed effects (CFE in the tables). The specification includes a full set of year-specific intercepts added to correct for common shocks and trends. The results are reported in column 1 of Table 2. As usual, the gravity equation works well in explaining about three-quarters of the variation in bilateral exports flows. Moreover, the sign and size of all the estimated coefficients make intuitive sense and are both economically and statistically significant. In particular, economically larger countries trade more and distance negatively affects trade. Landlocked countries trade less, whereas a common border, a common language, a common religion, or shared membership in a preferential trade agreement increases trade. In a similar way, the existence of colonial ties encourages trade, as does being islands or having formed part of the same country in the past. With regard to our main variable of interest (HSR) defined as the number of countries in the pair with this infrastructure in year *t*, we find an estimated coefficient that is positive (0.501) and statistically significant at the 1 per cent level.

Table 2. Estimations of the HSR effect on trade. Sample period 1960-2012.

Variables	**CFE (1)**	**CPFE (2)**	**PPML CPFE (3)**	**PPML CPFE (4)**	**CFE (5)**	**CPFE (6)**	**PPML CPFE (7)**	**PPML CPFE (8)**
lnYi	1.369 (0.037)***	1.483 (0.011)***	1.094 (0.092)***	1.108 (0.090)***	1.368 (0.038)***	1.481 (0.011)***	1.070 (0.091)***	1.086 (0.089)***
lnYj	1.034 (0.035)***	1.172 (0.010)***	0.833 (0.083)***	0.847 (0.079)***	1.031 (0.035)***	1.172 (0.010)***	0.811 (0.081)***	0.830 (0.077)***
lnDist	-1.093 (0.024)***				-1.093 (0.024)***			
Border	0.623 (0.099)***				0.632 (0.098)***			
Comlang	0.598 (0.046)***				0.598 (0.046)***			

Variables	**CFE** (1)	**CPFE** (2)	**PPML CPFE** (3)	**PPML CPFE** (4)	**CFE** (5)	**CPFE** (6)	**PPML CPFE** (7)	**PPML CPFE** (8)
Colony	1.056 (0.099)***				1.052 (0.099)***			
Comctry	2.607 (0.133)***				2.606 (0.133)***			
Island	0.533 (0.129)***				0.533 (0.129)***			
Land	-0.599 (0.085)***				-0.602 (0.085)***			
Religion	0.449 (0.056)***				0.451 (0.056)***			
RTAs	0.504 (0.037)***	0.391 (0.009)***	0.081 (0.042)***	0.082 (0.042)***	0.504 (0.037)***	0.391 (0.009)***	0.080 (0.043)**	0.085 (0.042)**
HSR	0.501 (0.027)***	0.291 (0.011)***	0.162 (0.031)***					
HSRone				0.121 (0.043)***				
HSRboth				0.356 (0.057)***				
lnHSRKM					0.088 (0.005)***	0.045 (0.002)***	0.028 (0.008)***	
lnHSRKMone								0.023 (0.008)***
lnHSRKMboth								0.052 (0.009)***
Adj-R^2	0.76	0.50	-		0.76	0.50	-	
Time Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Dummies	Yes				Yes			
Country-Pair Dummies		Yes	Yes	Yes		Yes	Yes	Yes
No observ.	304,464	304,467	431,584	431,584	304,464	304,467	431,584	431,584

Notes: The regressand is the log of real bilateral exports in columns (1), (2), (4) and (5) and the value of bilateral export flows in levels in columns (3) and (6). Robust standard errors (clustered by country-pairs) are in parentheses.* significant at 10%; ** significant at 5%; *** significant at 1%. CFE indicates exporter and importer fixed effects. CPFE indicates country-pair fixed effects. Coefficient estimates for CFE and CPFE are not reported for brevity.

The estimation with OLS including country dummies (CFE) is not able to deal with unobserved bilateral heterogeneity, which is extremely likely to be present in bilateral trade flows and so, there may be omitted variables at the country-pair level that affect bilateral trade. Results including Country–Pair Fixed Effects (CPFE) are reported in column 2. Again, the variable of interest (HSR) presents an estimated coefficient that is positive (0.291) and statistically significant at the 1 per cent level.

Estimations in columns 1 and 2 use the sample of countries with positive trade volumes between them. As suggested by Santos Silva & Tenreyro (2006 and 2010), disregarding countries that do not trade with each other may produce biased estimates. Additionally, the likely existence of heteroskedasticity is also a source of bias. Therefore, in column 3 we present the results accounting for the presence of zero trade flows and heteroskedastic residuals using the Poisson-Pseudo Maximum-Likelihood (PPML) estimator recommended by these authors. We again account for unobserved bilateral heterogeneity including CPFE.[1] This is our preferred specification because it controls for all potential sources of omitted variables bias considered in this paper. The estimated coefficient of the variable of interest is, once again, positive (0.162) and highly statistically significant but smaller in magnitude than when we do not account for zero trade flows. Given that [*exp(0.162)* -1] equals 0.175, that coefficient estimate implies that HSR infrastructure, on average, increases trade by 17.5 per cent. In column 4 we distinguish whether the HSR infrastructure is located in only one of the countries in the pair or in both at the same time. As can be observed, the impact is higher in the latter case showing a kind of synergy across countries which reinforces the impact on trade.[2]

Columns 5 to 8 show the results when we use the logarithm of the number of HSR network kilometres in each country and year (*lnHSRKM*). In this case, we are measuring elasticities. As before, the greatest impact is found when we only control for multilateral resistance terms (0.088) and the smallest when we take into account unobserved bilateral heterogeneity and zero trade flows (0.028). Nevertheless, in all cases the estimated coefficients are statistically significant at the 1 per cent level. According to our preferred specification, doubling the length of the HSR network increases trade by 2.8 per cent on average. Again, the impact is considerably higher when both partners have this infrastructure in the same period of time. Obviously, these values may mask heterogeneous results across countries with an HSR network.

The natural next step is to investigate possible differences in the impact of HSR on trade across countries. To that end, we have split the *lnHSRKMone* and the *lnHSRKMboth* variables into nine separate variables, respectively, one for each country. Poisson estimates of the variables of interest are reported in Table 3. As can be observed, Spain shows the highest impact, followed by Turkey. There is a fairly similar impact in the cases of Belgium, Germany, Italy and The Netherlands (elasticities ranging between 0.024 and 0.041), and the results for these countries are not affected by whether or not the partner also has this infrastructure.[3] No impact is detected in France and Korea and a mixed result is found in China, where there is a positive impact in cases where the partner also has an HSR network.

[1] We use the Stata command "xtpqml".
[2] The Wald test rejects the null hypothesis of equal coefficients.
[3] All these comments are supported by the respective test of equality of coefficients.

TABLE 3. Poisson estimates (PPML) with country-pair fixed effects. Sample period 1960-2012.

(1)		(2)	
Variables	**Coefficient**	**Variables**	**Coefficient**
lnHSRKM-BELG_one	0.024 (0.012)**	lnHSRKM-BELG_both	0.017 (0.008)**
lnHSRKM-FRAN_one	0.007 (0.009)	lnHSRKM-FRAN_both	0.011 (0.008)
lnHSRKM-GERM_one	0.025 (0.009)***	lnHSRKM-GERM_both	0.032 (0.008)***
lnHSRKM-ITALY_one	0.041 (0.013)***	lnHSRKM-ITALY_both	0.040 (0.011)***
lnHSRKM-NETH_one	0.022 (0.010)***	lnHSRKM-NETH_both	0.034 (0.011)***
lnHSRKM-SPAIN_one	0.065 (0.015)***	lnHSRKM-SPAIN_both	0.094 (0.012)***
lnHSRKM-CHINA_one	0.014 (0.016)	lnHSRKM-CHINA_both	0.043 (0.013)***
lnHSRKM-KOREA_one	-0.027 (0.013)**	lnHSRKM-KOREA_both	-0.020 (0.013)
lnHSRKM-TURKEY_one	0.061 (0.008)***	lnHSRKM-TURKEY_both	0.070 (0.010)***

Notes: The regressand is the value of bilateral export flows (X_{ijt}). Robust standard errors (clustered by country-pairs) are in parentheses.* significant at 10%; ** significant at 5%; *** significant at 1%.

Finally, we allow for direction-specific effects (TABLE 4). That is, we distinguish whether the country with the HSR network acts as an importer or as an exporter. For Germany, Italy, Spain and Turkey, the effect is similar in both directions. In Belgium and The Netherlands only exports are affected, and in France only imports (at 10% level), whereas no significant impact is detected for Korea and China. With respect to China, this result does not contradict our previous estimations because in this analysis we consider all the pairs of countries and not just those which an HSR network.

TABLE 4. Poisson estimates (PPML) with country-pair fixed effects. Sample period 1960-2012.

Variables	**Coefficient**	**Variables**	**Coefficient**
EXPORTS		**IMPORTS**	
lnHSRKM-BELG	0.031 (0.009)***	lnHSRKM-BELG	0.009 (0.018)
lnHSRKM-FRAN	0.006 (0.011)	lnHSRKM-FRAN	0.017 (0.009)*

Variables	Coefficient	Variables	Coefficient
EXPORTS		IMPORTS	
lnHSRKM-GERM	0.030 (0.010)***	lnHSRKM-GERM	0.027 (0.011)**
lnHSRKM-ITALY	0.047 (0.015)***	lnHSRKM-ITALY	0.044 (0.015)***
lnHSRKM-NETH	0.044 (0.010)***	lnHSRKM-NETH	0.013 (0.015)
lnHSRKM-SPAIN	0.082 (0.017)***	lnHSRKM-SPAIN	0.077 (0.019)***
lnHSRKM-CHINA	0.027 (0.019)	lnHSRKMCHINA	0.005 (0.031)
lnHSRKM-KOREA	-0.019 (0.022)	lnHSRKM-KOREA	-0.019 (0.016)
lnHSRKM-TURKEY	0.059 (0.011)***	lnHSRKM-TURKEY	0.066 (0.011)***

Notes: The regressand is the value of bilateral export flows (X_{ijt}). Robust standard errors (clustered by country-pairs) are in parentheses.* significant at 10%; ** significant at 5%; *** significant at 1%.

5. Case study: HSR and international trade in Spain

We take a more in-depth look at the relationship between HSR and trade by studying the Spanish case in more detail. With more than 3,000 km of constructed HSR lines, Spain is the country with the greatest number of HSR kilometres per inhabitant. Moreover, the results of our previous analysis show the greatest effect of HSR per kilometre in our sample. In absolute terms, only China has built more HSR kilometres than Spain. HSR in this country has prompted a number of researchers to study, among other things, the efficiency-equity dilemma (Albalate et al., 2012), the effect of infrastructure on national construction (Bel, 2011), and a cost-benefit analysis of HSR (De Rus, 2011). The discussion of HSR in Spain has gone beyond the bounds of academic debate and is now the focus of political and social arguments questioning Spanish HSR infrastructure policies. The Spanish government plans an investment of €108 billion by 2020, doubling the current HSR capacity and interconnecting 90% of the population with HSR.

The following figure depicts the Spanish current (depicted by the dark line) and planned HSR lines (shown in light grey). Much of the controversy is related to the star configuration, which interconnects Madrid (in the center) with the periphery. The HSR runs in parallel with low-speed and cargo lines. Therefore, Spain is a suitable example for further examining our hypothesis, since it has a duplicated capacity and the railways run towards freight ports.

FIGURE 3. Spanish HSR network. Source: ADIF.

Spain has three main shipping ports: Algeciras, Barcelona and Valencia. The last two cities are interconnected with Madrid via HSR. However, the distance from Valencia to Madrid (350 km) is about half the distance from Barcelona to Madrid. Valencia's port moves more containers than Barcelona's and is the third busiest port in the Mediterranean, after Marseille in France and Gioia Tauro in Italy. One likely reason for the success of Valencia's port is its relative proximity to Madrid, and this advantage has been further enhanced by the opening of the HSR line connecting the two cities.

FIGURE 4 shows the evolution of shipments (measured in intermodal transport units) in Madrid's dry port (an intermodal hub connecting Madrid with four Spanish ports). In 2001, all four ports had a similar weight in terms of Madrid's shipping trade. Valencia grew steadily until 2009, at which point it shot up exponentially. In 2009, the Madrid-Valencia HSR line launched its service, freeing conventional railroad for cargo traffic towards Valencia's port.

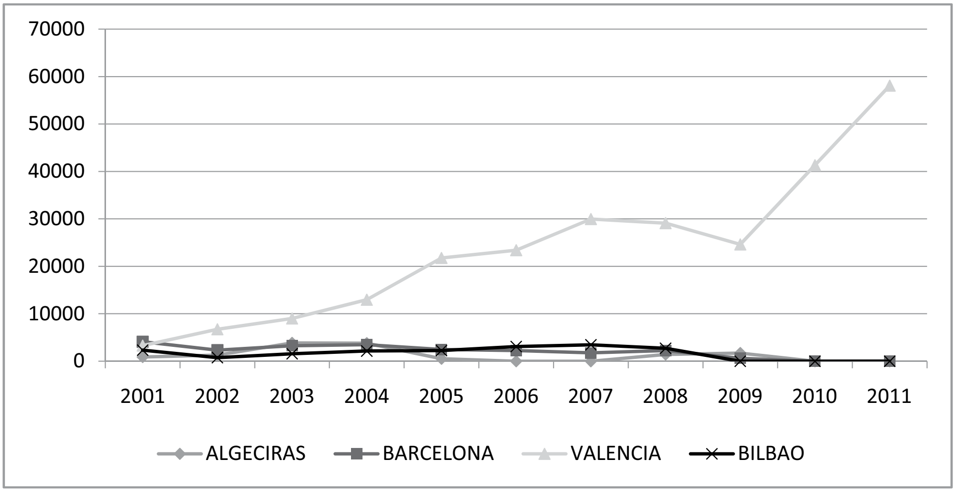

FIGURE 4: Madrid's dry port traffic towards the main shipping ports.

These stylized facts invite us to study the effect of the Madrid-Valencia HSR line on Spanish trade at the national and regional level. TABLE 5 reports gravity estimates of the HSR line with respect to Spain, Madrid and Valencia. The data come from the Ministry of Economy and Competitiveness (http://datacomex.comercio.es) which tracks international trade at the regional level. The dependent variable is the log of exports towards the 131 countries that appear in the Appendix (TABLE A). The period under study spans the years 1999 to 2011. The regressions include a set of country- and time-fixed effects.

TABLE 5. Case study: HSR line Madrid-Valencia (Spain). Years: 1999-2011.

	(1)	(2)	(3)
	Export_Spain	**Export_Madrid**	**Export_Valencia**
lnYj	0.369	0.312	0.508
	(0.13)***	(0.27)	(0.25)*
lnDist	-1.132***	-0.982***	-1.128***
	(0.08)***	(0.19)***	(0.10)***
Border	-0.954	-0.459	-1.139
	(0.35)***	(0.50)	(0.31)***
Colony	0.603	0.743	0.439
	(0.30)**	(0.82)	(0.55)
Lang	1.130	1.262	1.116
	(0.36)***	(0.93)	(0.70)
Religion	0.379	0.295	0.488
	(0.25)**	(0.58)	(0.55)

	(1)	(2)	(3)
	Export_Spain	**Export_Madrid**	**Export_Valencia**
Land	-0.139	0.131	-0.507
	(0.17)	(0.25)	(0.31)*
RTAs	0.371	0.369	0.382
	(0.08)***	(0.14)***	(0.11)***
HSR	0.313	0.263	-0.045
	(0.09)***	(0.16)*	(0.13)
No. Observ.	972	972	972
R^2	0.958	0.921	0.955

The regressand is the log of bilateral exports. Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Time and country dummies included

The gravity equation performs well in explaining more than 90% of the variation in Spanish exports. The usual gravity variables are significant and with the expected sign. However, the results at the national level in column 1 show more statistically significant results than the regional analysis in columns 2 and 3. We estimate an effect of approximately 35% of trade increase in Spain since the HSR line opened in 2009. Rather than the magnitude of this effect, we are interested in its regional distribution. As shown in columns 2 and 3, Madrid and its hinterland are driving this trade increase, with an estimated coefficient of 0.263, which indicates an increase of nearly 30%. The Valencian Region (officially Valencian Community – VC) shows no significant gain from the HSR line.

This case analysis sheds some light on the underlying mechanisms of the HSR effect studied in this paper. The effect of the Madrid-Valencia HSR line highlights two distinguishable traits. First, that the effect of HSR is notable on free railway capacity towards shipping ports. Second, that the HSR effect increases trade for landlocked regions.

6. Conclusions

In this paper, we have estimated the impact of HSR infrastructure on international trade using a sample of 119 countries over the years 1960-2012. Furthermore, we have analysed the particular case of an HSR line in Spain. The idea is that HSR networks, by generating a redundancy of tracks, have freed resources from the traditional train lines allowing higher efficiency in the management of cargo and thus reducing trade costs.

Using the gravity equation, our results show that countries with an HSR network trade around 17.5% more on average, and moreover, a stronger impact is detected when both partners have this transport infrastructure. When we calculate elasticities we obtain an economically moderate but statistically significant impact: doubling the HSR capacity would increase trade by around 2.8%.

The disaggregated analysis shows the greatest impact for Spain and Turkey, followed to a lesser extent by Belgium, Germany, Italy and The Netherlands. Finally, no impact is detected for France and Korea whereas China presents mixed result. Taking into account the direction of trade, these impacts can be further refined for the case of Belgium and The Netherlands since for these countries only exports are affected.

The specific regional analysis of the Spanish case reveals that the HSR effect on trade is mainly driven by trade of the landlocked Spanish capital, with maritime regions benefitting very little from HSR infrastructure. This result is in line with our previous findings, which revealed that countries with landlocked capitals (Madrid for Spain and Ankara for Turkey) show the highest impact. Further studies proposing an in-depth analysis of other countries and regions are certainly encouraged. Moreover, policy recommendations should analyse specific country characteristics. Enlarging the HSR network might not have a homogenous effect in trade for all countries and regions.

The global impact of HSR on trade as shown in this paper invites further studies in this area. Additional research is certainly welcome in order to comprehensively analyse the interplay of HSR and trade. Other studies could analyse the effect of HSR lines on the competitiveness of national products. For example, an analysis of the effect of HSR on the level and composition of trade between interconnected cities is a natural extension of this paper.

References

Albalate, D., & Bel, G. (2012). High-Speed Rail: Lessons for Policy Makers from Experiences Abroad. *Public Administration Review*, *72*(3), 336-349.

Albalate, D., Bel, G., & Fageda, X. (2012). Beyond the efficiency-equity dilemma: Centralization as a determinant of government investment in infrastructure. *Papers in Regional Science*, *91*(3), 599-615.

Anderson, J. E. (1979). A theoretical foundation for the gravity equation. *American Economic Review*, *69*(1), 106-116.

Anderson, J. E., & Van Wincoop, E. (2003). Gravity with gravitas: a solution to the border puzzle. *The American Economic Review*, *93*(1), 170-192.

Aschauer, D. A. (1989). Is public expenditure productive? *Journal of Monetary Economics*, *23*(2), 177-200.

Baldwin, R., & Taglioni, D. (2006). *Gravity for dummies and dummies for gravity equations*. NBER Working Paper No. 12516.

Banister, D. (2012). Transport and economic development: reviewing the evidence. *Transport Reviews*, *32*(1), 1-2.

Behrman, J. R., & Craig, S. G. (1987). The distribution of public services: An exploration of local governmental preferences. *The American Economic Review*, *77*(1), 37-49.

Bel, G. (2011). Infrastructure and nation building: The regulation and financing of network transportation infrastructures in Spain (1720-2010). *Business History*, *53*(5), 688-705.

Bougheas, S., Demetriades, P. O., & Mamuneas, T. P. (2000). Infrastructure, specialization, and economic growth. *Canadian Journal of Economics/Revue Canadienne D'économique*, *33*(2), 506-522.

Bougheas, S., Demetriades, P. O., & Morgenroth, E. L. W. (1999). Infrastructure, transport costs and trade. *Journal of International Economics*, *47*(1), 169-189.

Campos, J., & de Rus, G. (2009). Some stylized facts about high-speed rail: A review of HSR experiences around the world. *Transport Policy*, *16*(1), 19-28.

Cantos, P., Gumbau-Albert, M., & Maudos, J. (2005). Transport infrastructures, spillover effects and regional growth: evidence of the Spanish case. *Transport Reviews*, *25*(1), 25-50.

Castells, A., & Solé-Ollé, A. (2005). The regional allocation of infrastructure investment: The role of equity, efficiency and political factors. *European Economic Review*, *49*(5), 1165-1205.

Clark, D. J., Jørgensen, F., & Pedersen, P. A. (2009). Strategic interactions between transport operators with several goals. *Journal of Transport Economics and Policy (JTEP)*, *43*(3), 385-403.

Deardorff, A. (1998). Determinants of bilateral trade: does gravity work in a neoclassical world? In J. A. Frankel (Ed.), *The regionalization of the world economy* (pp. 7-32). Chicago: University of Chicago Press.

Deng, T. (2013). Impacts of Transport Infrastructure on Productivity and Economic Growth: Recent Advances and Research Challenges. *Transport Reviews*, *33*(6), 686-699.

De Rus, G. (2009). La medición de la rentabilidad social de las infraestructuras de transporte. *Investigaciones Regionales*, *14*, 187-210.

De Rus, G. (2011). The BCA of HSR: Should the government invest in high speed rail infrastructure? *Journal of Benefit-Cost Analysis*, *2*(1).

Duranton, G., Morrow, P. M., & Turner, M. A. (2014). Roads and Trade: Evidence from the US. *The Review of Economic Studies*, *81*(2), 681-724.

Eaton, J., & Kortum, S. (2002). Technology, geography, and trade. *Econometrica*, *70*(5), 1741-1779.

Egger, H., & Falkinger, J. (2006). The role of public infrastructure and subsidies for firm location and international outsourcing. *European Economic Review*, *50*(8), 1993-2015.

European Commission. (2001). White paper-European transport policy for 2010: time to decide. Office for Official Publications of the European Communities. Retrieved from http://ec.europa.eu/transport/white_paper/documents/doc/lb_texte_complet_en.pdf

Evenett, S. J., & Keller, W. (2002). On theories explaining the success of the gravity equation. *Journal of Political Economy*, *110*(2), 281-316.

Givoni, M. (2006). Development and Impact of the Modern High-speed Train: A Review. *Transport Reviews*, *26*(5), 593-611.

Givoni, M. (2007). Environmental Benefits from Mode Substitution: Comparison of the Environmental Impact from Aircraft and High-Speed Train Operations. *International Journal of Sustainable Transportation*, *1*(4), 209-230.

Glick, R., & Rose, A. K. (2002). Does a currency union affect trade? The time-series evidence. *European Economic Review*, *46*(6), 1125-1151.

Helpman, E., Melitz, M., & Rubinstein, Y. (2008). Estimating Trade Flows: Trading Partners and Trading Volumes. *Quarterly Journal of Economics*, *123*(2), 441-487.

Limão, N., & Venables, A. J. (2001). Infrastructure, Geographical Disadvantage, Transport Costs, and Trade. *The World Bank Economic Review*, *15*(3), 451-479.

Marincioni, F., & Appiotti, F. (2009). The Lyon-Turin High-Speed Rail: The Public Debate and Perception of Environmental Risk in Susa Valley, Italy. *Environmental Management*, *43*(5), 863-875.

Martínez-Zarzoso, I., García-Menéndez, L., & Suárez-Burguet, C. (2003). Impact of transport costs on international trade: the case of Spanish ceramic exports. *Maritime Economics & Logistics*, *5*(2), 179-198.

Offner, J.-M. (1993). Les « effets structurants » du transport : mythe politique, mystification scientifique. *Espace Géographique*, *22*(3), 233-242.

Roll, M., & Verbeke, A. (1998). Financing of the trans-European high-speed rail networks:: New forms of public-private partnerships. *European Management Journal*, *16*(6), 706-713.

Rose, A. K. (2000). One money, one market: the effect of common currencies on trade. *Economic Policy*, *15*(30), 7-46.

Rose, A. K. (2004). Do WTO members have more liberal trade policy? *Journal of International Economics*, *63*(2), 209-235.

Silva, J. M. C. S., & Tenreyro, S. (2006). The log of gravity. *The Review of Economics and Statistics*, *88*(4), 641-658.

Silva, J. M. C. S., & Tenreyro, S. (2010). On the Existence of the Maximum Likelihood Estimates in Poisson Regression. *Economics Letters*, *10*(2), 310-312.

Socorro, M. P., & Viecens, M. F. (2013). The effects of airline and high speed train integration. *Transportation Research Part A: Policy and Practice*, *49*, 160-177.

Tomz, M., Goldstein, J. L., & Rivers, D. (2007). Do we really know that the WTO increases trade? Comment. *The American Economic Review*, 2005-2018.

Tzanakakis, K. (2013a). High-Speed Railway. In *The Railway Track and Its Long Term Behaviour* (pp. 19-19). Springer Berlin Heidelberg.

Tzanakakis, K. (2013b). The "Stakeholders" of the Railway System. In *The Railway Track and Its Long Term Behaviour* (pp. 25-27). Springer Berlin Heidelberg.

UIC. (2014). International Union of Railways. Retrieved from http://www.uic.org/

Van den Berg, L., van Klink, H. A., & Pol, P. M. J. (1996). Airports as centres of economic growth. *Transport Reviews*, *16*(1), 55-65.

World Bank. (2013). World Bank Open Data. Retrieved from www.worldbank.org

Yang, H., & Zhang, A. (2012). Effects of high-speed rail and air transport competition on prices, profits and welfare. *Transportation Research Part B: Methodological*, *46*(10), 1322-1333.

Appendix

Table A1. Sample of countries for global regressions.

Albania	Croatia	Japan	Poland
Algeria	Czech Republic	Jordan	Portugal
Argentina	Côte d'Ivoire	Kazakhstan	Romania
Armenia	Denmark	Kenya	Russia
Australia	Djibouti	Korea	Senegal
Austria	Dominican Republic	Kuwait	Sierra Leone
Azerbaijan	Ecuador	Kyrgyz Republic	Slovak Republic
Bangladesh	Egypt	Latvia	Slovenia
Belarus	El Salvador	Lebanon	Spain
Belgium-Luxembourg	Equatorial Guinea	Lithuania	Sri Lanka
Benin	Eritrea	Macedonia	St. Tome and Principe
Bolivia	Estonia	Madagascar	Swaziland
Bosnia and Herzegovina	Finland	Malaysia	Sweden
Brazil	France	Mali	Switzerland
Bulgaria	Georgia	Mauritania	Tanzania
Burkina Faso	Germany	Mexico	Thailand
Burundi	Ghana	Mongolia	Togo
Cameroon	Greece	Morocco	Tunisia
Canada	Guinea	Mozambique	Turkey
Cape Verde	Guinea Bissau	Nepal	Uganda
Central African Republic	Guyana	Netherlands	Ukraine
Chad	Haiti	New Zealand	United Kingdom
Chile	Hungary	Nicaragua	United States of America
China - Mainland	Iceland	Niger	Uruguay
China – Hong Kong	India	Nigeria	Venezuela
China – Macao	Indonesia	Norway	Vietnam
Colombia	Ireland	Panama	Yemen
Congo, D.R.	Israel	Paraguay	Zambia
Congo, Republic of	Italy	Peru	Zimbabwe
Costa Rica	Jamaica	Philippines	

TABLE A2. Sample of countries for the Spanish case study.

Albania	Dominican Rep	Kenya	Russia
Algeria	Ecuador	Kuwait	Saudi Arabia
Angola	Egypt	Latvia	Senegal
Antigua and Barbuda	El Salvador	Lebanon	Seychelles
Argentina	Equatorial Guinea	Libya	Singapore
Australia	Estonia	Lithuania	Slovak Rep
Austria	Finland	Malaysia	Slovenia
Bahamas	France	Malta	South Africa
Bahrain	Gabon	Mauritania	Sri Lanka
Bangladesh	Gambia	Mauritius	St Kitts and Nevis
Barbados	Georgia	Mexico	Sudan
Belarus	Germany	Moldova	Sweden
Belgium	Ghana	Morocco	Switzerland
Bermuda	Greece	Mozambique	Syrian
Bolivia	Guatemala	Namibia	Thailand
Bosnia-Herzegovina	Guinea	Netherlands	Togo
Brazil	Guinea Bissau	New Zealand	Tunisia
Bulgaria	Honduras	Nicaragua	Turkey
Cameroon	Hungary	Niger	Ukraine
Canada	Iceland	Nigeria	United Arab Emirates
Cape Verde	India	Norway	United Kingdom
Chile	Indonesia	Oman	United States
China	Iran	Pakistan	Uruguay
Colombia	Ireland	Panama	Uzbekistan
Costa Rica	Israel	Paraguay	Venezuela
Cote d' Ivoire	Italy	Peru	
Croatia	Jamaica	Philippines	
Cyprus	Japan	Poland	
Czech Rep	Jordan	Portugal	
Denmark	Kazakhstan	Qatar	

SET IN DANTE MONOTYPE BY
FABRIZIO SERRA EDITORE, PISA · ROMA.
PRINTED AND BOUND BY
TIPOGRAFIA DI AGNANO, AGNANO PISANO (PISA).

★

October 2015

(CZ 2 · FG 13)

Direttore responsabile: Fabrizio Serra · Autorizzazione del Tribunale Civile di Pisa n. 12/1997