



The construction of a HSR network using a ranking methodology to prioritise corridors



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ARTICLE INFO

Article history:

Received 25 September 2013

Received in revised form

18 November 2013

Accepted 23 November 2013

Keywords:

High-speed rail line

Urban planning

Transport planning

Impacts assessment

ABSTRACT

The construction of new high-speed rail (HSR) lines, in a climate of financial instability since the onset of the global crisis of 2007–2008, has reopened the debate among the scientific community. Support for the new projects is facing serious concerns over the extremely elevated costs of high-speed and the ability of today's governments to fund or co-fund these systems. This is the main reason the assessment of methodologies to prioritise the construction of new high-speed rail (HSR) corridors has recently become an important issue for transport planners in countries like the U.S. where HSR does not exist.

The literature on ranking tools for prioritising HSR corridors is practically non-existent, even in Europe. In 2009, a new ranking methodology was developed and applied to 30,000 city pairs in the U.S. to determine their suitability for high-speed rail investment. As none of these lines has been constructed and none of them are in operation, this methodology has not been validated. The main objective of this paper is to analyse, validate and improve this ranking tool using data from a current HSR network: the Spanish one. Results show the consistency of the model as a preliminary approach to ranking pairs, mainly for the top first O–D relations; however the model fails to discriminate clearly between secondary groups of corridors. These deficiencies are chiefly due to the type of variables used by the model which ultimately, after improved, would provide policymakers with a useful tool when planning the construction of a new HSR network.

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Introduction

The search for validated methodologies to prioritise the construction of new high-speed rail (HSR) lines has recently emerged as a key issue for transport planners in countries with no previous HSR systems. The U.S. is a good example of this process. In February 2009, as part of the American Recovery and Reinvestment Act (ARRA), Congress allocated 8 billion dollars to the states for intercity rail projects, prioritising projects that support the development of a high-speed intercity service. Previously, high-speed rail (HSR) in the United States was limited to Amtrak's Acela Express Service, which runs along the Northeast Corridor (from Boston to Washington DC) at speeds averaging 110 km/h for the entire distance, although briefly reaching 240 km/h at times. This ARRA was accompanied in April 2009 by the publication of the first American High-Speed Rail Strategic Plan (Federal Railroad Administration FRA, 2009), an ambitious document directly proposing ten priority HSR corridors.

There is a wide divergence between U.S. and European scenarios for the implementation of HSR. Most authors (see Button, 2012) concur as to the “controversial” nature of the definition of HSR given in the American Strategic Plan, as it refers not to a new infrastructure but to the type of service (*Express, Regional and Emerging*). Emerging and Regional lines (with speeds under 250 km/h) cannot be considered “pure HSR” under European (The Council of the European Union, 1996) standards, and the vast majority of the HSR corridors in the American Strategic Plan barely fall into this last group (Emerging). In view of the fact that only new American HSR Express corridors will have comparable construction and operation costs to European and Asian HSR lines, the FRA takes an interesting approach in its Strategic Plan: not all the proposed HSR corridors will require the same type of passenger rail service. This approach reveals a genuine HSR planning process, involving an analysis of the particular features of each candidate corridor before funding. Even in European countries, the construction of the first HSR lines did not follow the results of a ranking assessment within a transportation and urban planning process. This is the reason that little research has been done in Europe on methodologies based on ranking HSR corridors, while there is much more literature on demand forecasting for new HSR lines.

The initial proposal of the FRA was to develop a mechanism to assess which corridors across the nation have the greatest potential

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demand for high-speed rail, and would thus provide the greatest transportation, economic, and social benefits; but finally no methodology was formally established. Only one subsequent document, published in 2009 (US Department of Transportation, 2009), offered an insight into how the FRA would make decisions on awarding the ARRA funding. In this document the FRA indicated that three categories of criteria would be used in the decision-making process. The first assesses the public return on investment. The second assesses project readiness and sustainability of benefits. In addition to these two categories of project-specific evaluation criteria, the FRA would employ cross-cutting selection criteria intended to balance projects against national priorities (geography, economic conditions, innovation and technology, and the existence of multi-state agreements).

This urgent need to devise a ranking methodology to prioritise future HSR corridors has coincided with a worldwide financial crisis. The construction of the first high-speed rail (HSR) lines in countries like United States and the U.K., immersed in a climate of financial instability since the onset of the 2007–2008 global crisis, has reopened the debate among the scientific community specialising in HSR. In 2012, vol. 22 of the *Journal of Transport Geography* included – at a very timely moment – a special section on rail transit systems and high-speed rail, featuring an in-depth discussion of the first American HSR Strategic Plan developed by the FRA. This special section contains an analysis that makes clear and constant references to the European HSR experience. Although some authors support the new projects (Johnson, 2012), opponents (Button, 2012) express grave concerns over the exorbitant cost of high-speed rail, and the ability of today's governments to fund these systems. Other authors (Givoni and Banister, 2012) focused their analysis on the integration of the transport system, arguing that experience proves that the success or failure of a new HSR line does not depend only on speed, but on door-to-door travel time, and this depends on the integration of the entire transport system. Against this economic backdrop, the prioritisation of future HSR corridors has become an indispensable tool for avoiding future financial failures.

The first attempt to develop a prioritisation tool was made by two American urban planners (Todorovich and Hagler, 2009). The model (described in detail in Section 'The ranking model approach') used twelve variables to create an index across five categories: population size, urban transit connections, origin-destination distance, economic vitality and congestion. These five categories were weighted and then added in an equation that allocated scores to 27,000 city pairs in the U.S., with New York–Washington coming top of the ranking. The top city pairs appeared to be consistent from a potential demand approach, although the model has not been validated with real data. For example, San Francisco–Los Angeles, in fifth position, is today the only express HSR route scheduled for construction in the U.S. as a new infrastructure that can realistically be termed "high-speed" according to European standards (CHSRA, 2012). There is therefore no real data available to check the results. The proposed methodology is based on the hypothesis that five main categories of variables determine the value of the Ranking Index (RI) to score corridors in order to evaluate their HSR potential demand.

Although demand forecast is not the only criterion for ranking corridors, it is a key factor for scoring projects. However traffic generated by a new transport infrastructure is always difficult to estimate by traditional modelling (Ortúzar and Willumsen, 2001) due to the percentage of "induced passengers": these are new passengers, new trips, that are not transferred from another previous mode of transportation in a corridor. As Ortúzar and Willumsen note, the sequential four-step model reveals a clear flaw in the generation stage in that it is viewed as virtually inflexible as regards any change in the offer of transport. This setback may be

important in the evaluation of certain structural projects, such as projects that may have a significant impact on the standards of service provided in different areas, and particularly for long-term estimations. These shortcomings also have a direct impact on the induction calculation. Attempts have been made to introduce a new concept in the generation stage, such as "demand feedback to any change in the transportation network" by means of an accessibility variable. However, the experience has so far proven ineffective, at least for aggregated models, partly due to the difficulty in establishing an adequate accessibility indicator (Ortúzar et al., 2000).

As a result, demand forecast for new HSR lines in Europe (Ni et al., 1994) has been based on an ad-hoc model in which the induced traffic generated by a new infrastructure can be interpreted as a joint gravity model (which uses the generalised cost of each mode in use together with a modal split model – Logit). Thus the induced traffic is proportional to the generalised cost and dependent on the services offered in terms of fares, frequency, comfort and access to the station. Modes other than high-speed lose the traffic that "emigrates" towards the new line. This loss can also be calculated using a modal split model to compare the competing generalised costs. The French experience estimating the induced traffic caused by a new HSR line was based on this approach, and research on induced traffic in Spain (Guirao, 2000, 2006) followed the same methodology.

In conclusion, if the ranking tool is based solely on the demand approach, the literature indicates that at least the current alternative modes to high-speed should be considered in each corridor. It would be also advisable – albeit difficult – to include some type of accessibility variable in this aggregated model in order to evaluate changes in accessibility caused by the new HSR line.

If the ranking tool is based on a financial approach using profitability criteria, the complexity of the methodology increases, depending on the concept of profitability used and the type of benefits considered for the profitability calculation. HSR profitability has recently emerged as an important issue for scientific literature, due to the restrictions in public expenditure caused by the financial crisis. In 2007, de Rus and Nombela (2007) were the first to calculate the required minimum level of demand from which investment in HSR could be considered profitable from a social perspective. They used the real costs of construction, maintenance and rolling stock for currently operating European HSR lines, in addition to potential time savings, standard values of time and expected growth in demand (which is not easy to predict, as argued above). Although this approach has been generally accepted by the scientific community, it is clear that the wider economic benefits of high speed are difficult to estimate, as they are swamped by many – not inconsiderable – external factors such as territorial impacts. Social benefits can be calculated not only according to potential time savings, standard values of time or expected growth of demand. Territorial impacts may lead directly to social and economic benefits, and although they are difficult to estimate and analyse, attempts to study them have been made by some Spanish authors. Gutierrez (2001) directly measured the accessibility impacts of the future Madrid–Barcelona–French border HSR line. This estimate revealed that while the new HSR line would increase territorial inequity at the national level, the same line would reduce the disparity in accessibility at the European and corridor level (as peripheral small and medium-sized cities would gain greater accessibility benefits than large central cities). HSR impacts at different territorial levels have also been analysed (Ureña et al., 2009) and it was concluded that HSR systems helped large intermediate cities attract mid-level business and technical consultancy firms, urban tourism, and interregional conferences, in addition to increasing the regional centrality of these cities in relation to smaller cities. Ortega et al. (2012) analysed the impact of high-speed rail on territorial cohesion at different planning levels. These territorial impacts are barely

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