

Valutazione ex-ante dei progetti di Alta Velocità ferroviaria: una rassegna della letteratura

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Ex-ante evaluation of high-speed railway projects: a structured literature review

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1. Introduction

Infrastructure plays a fundamental role in the development and growth of a territory. In particular, transport infrastructure (e.g., roads, railways, ports, and airports) is a real pillar of an area's economic competitiveness, facilitating access to markets, job opportunities, and essential services, as well as supporting tourism and culture. Furthermore, an integrated transport network contributes to greater territorial cohesion, reducing the gap between metropolitan areas and more remote areas.

In this context, however, the assessment of the so-called wider economic impacts of transport infrastructure has been the subject of ongoing controversy (Vickerman, 2018). At the heart of this controversy lies a problem of causality: there is no doubt that better transport and better economic performance are linked, but which of the two is the driving force remains ambiguous.

In 1998, the European Commission launched a program to define standards for the development of an integrated and interoperable high-speed rail network to achieve the strategic objectives of social inclusion, cohesion, and accessibility (Cascetta et al., 2013). The projects implemented in Europe cover the following countries, for a total of approximately 6,500 kilometres: (i) France (Paris-Lyon); (ii) Spain (AVE); (iii) Germany (ICE); (iv) Benelux (Thalalux); (v) Italy (TAV). New projects are under discussion or underway in Sweden, the United Kingdom, Portugal, Russia, and Turkey. Since 2011, China has been the country with the largest number of service lines, with more than 3,500 kilometers of railway lines in operation.

For several decades, economic literature has been studying the impact that infrastructure has on the territory, both with theoretical and, above all, empirical contributions. In particular, studies that have assessed the socio-economic impacts of high-speed rail (HSR) can be grouped into: (i) ex-ante assessments, mainly carried out using cost-benefit analyses; (ii) Computable General Equilibrium (CGE) models; (iii) ex-post assessments, using regression and/or counterfactual models (Di Matteo et al., 2022).

This chapter has two objectives. First, provide a theoretical overview of the effects of infrastructure on the territory (paragraph 2), with particular reference to HS, where specific studies exist. A second contribution is a systematic review of the literature on the ex-ante assessment of the socio-economic impacts of new HS lines in Europe (paragraph 3). Finally, section 4 outlines some conclusions.

2. The role of infrastructure in a territory: theoretical notes

Most contributions in the literature on the socio-economic impact of infrastructure, particularly transport infrastructure, are empirical cases. The creation of the so-called TEN-T (Trans-European Networks – Transport) in Europe – i.e. the set of integrated transport infrastructures designed to support the single market, ensure the free movement of goods and people, and strengthen the EU's growth, employment and

competitiveness – has renewed this interest in academia, with a proliferation of studies on various countries (Vickerman et al., 1999).

The theoretical literature on the socio-economic impacts of infrastructure is more fragmented. In this regard, in this section we will focus on the following: (i) the impact on economic geography, and therefore on the location choices of businesses and workers; (ii) the impact on urban rent, approximated by real estate market values; (iii) the impact on the urban hierarchy; and finally (iv) an excursus on direct, indirect and induced impacts. The following sub-sections explore each of these four aspects in depth.

2.1 The location of businesses

The impact of infrastructure on the so-called economic geography, and therefore on the location of businesses and workers in the territory, has been the subject of both theoretical and empirical studies. This section will present a summary of how and why infrastructure can contribute to the agglomeration or dispersion of economic activities from a theoretical point of view¹.

As Ottaviano (2008) points out, when identifying impacts, it is first of all important to distinguish between 'local infrastructure', which mainly affects interactions between economic actors at short distances, and 'global infrastructure', which mainly affects long-distance interactions. The transport of goods and people, including high-speed rail infrastructure, can be considered both local and global. The role of transport costs in the location of businesses is well known in economic theory and was first formalised in the studies of Alfred Weber (1909). Good transport infrastructure reduces transport costs, making it cheaper for businesses to transport raw materials and finished goods, which therefore tend to be located near infrastructure hubs. This is particularly true for industries that are heavily dependent on the movement of goods, such as manufacturing and logistics.

Furthermore, infrastructural changes can affect the geographical distribution of businesses and workers both between locations ('external geography') and within them ('internal geography') (Martin and Rogers, 1995). The nature of the impact of infrastructure on the distribution of economic activities certainly depends on the specific details of the project, but also on the specific sources underlying existing agglomeration economies.

Within the theoretical framework of New Economic Geography (Krugman, 1991), only infrastructure changes that improve the market potential of a given location can attract economic activities to that location. Market potential is understood as a combined measure of proximity to customers and competitors (Head and Mayer, 2004). Consequently, improving global transport infrastructure between a developed location that enjoys an advantage in terms of market size and a less developed location can diminish the attractiveness of the latter. This is the so-called 'straw effect': economic activities migrate to developed locations via new infrastructure, just as juice is sucked from a glass through a straw (Behrens et al., 2007). In this case, the agglomeration forces of the developed location prevail, to the detriment of the centrifugal forces generated by competition. This is because better transport infrastructure improves the market potential of the developed location more than it improves the market potential of the less developed site.

Another possible consequence of improving global infrastructure is the so-called 'shadow effect': the location considered a hub or gate casts a shadow over other places around it. A hub is a location with better accessibility than all others. A gate refers to a location through which goods mainly transit to and from a region (Behrens et al., 2006).

¹ For further information, see Ottaviano (2008), on which the discussion in this paragraph is based.

However, improving global infrastructure can also reduce geographical disparities. There are three situations in which this would occur. First, if the prices of so-called non-tradable goods and services² were much lower in less developed locations, then improved transport connections would cause businesses and workers to move to these locations (Puga 1999). The same would happen if improved infrastructure allowed for long-distance commuting (Borck et al. 2007). Finally, improved ICT infrastructure would allow for the dissemination of local knowledge across the territory, with a spillover of knowledge from developed to less developed locations, thus encouraging dispersion (Borck et al. 2007).

In conclusion, infrastructure improvements, such as the construction of a high-speed railway line, can influence economic geography in various ways. Suppose the infrastructure is interregional; in that case, the influence on the location choices of businesses and workers should also be considered from an interregional perspective.

2.2 Urban rent

At the heart of urban economics studies is the concept of urban rent, which is closely linked to the location decisions of businesses and households, thus determining the evolution of urban centres. Since Adam Smith (1776), there have been two recognised sources of land rent in general: the fertility (or productivity) of the land, and its location, i.e. its proximity to markets. The latter, in turn, consists of two elements: (i) hierarchy, i.e. belonging to a territorial system characterised by a given level of services offered, and (ii) accessibility, i.e. the possibility of easier access to urban centres of attraction. Transport infrastructure, including the construction of a high-speed railway station, has an impact on the latter component, improving it.

As identified by Camagni (2007), urban rent can change because of: the disposal of areas that are significant in terms of size and function, cumulative degradation, the urbanisation of peri-urban agricultural areas, the redevelopment of historic centres, and the provision of new public goods (e.g., underground railways, universities, etc.). Urban rent can be measured through property prices. In fact, 'rent is usually understood as the rent received for the possession of a property: the price of the property, however, is the rent capitalised over time, and for this reason it can be used as a proxy for rent' (Capello, 2001, pp.87).

The literature on the impact of the construction of a new high-speed railway station on land rent is rather divided: in some cases, there has been an increase in demand for space around the new high-speed station, resulting in an increase in property values. Conversely, where the construction of the station has been accompanied by an increase in degradation and crime, market values have fallen sharply. Gargiulo and de Ciutiis (2008) identified the following cases in which the construction of a new high-speed station caused significant changes in property values in the cities involved:

- when the opening of a new station or the upgrading of an existing station is part of a broader process of redevelopment of an urban area with high levels of physical and social degradation in high-ranking cities;
- when the station is located in a central area of the city, causing a drastic physical and functional change due to widespread industrial decline;
- when the opening of a new high-speed station involves investment in a small to medium-sized city with poor functional organisation.

² These are goods and services that can only be sold in the same place where they were produced. For example: public goods, accommodation and catering, the property market, etc.

2.3 Urban hierarchy

Many studies in both America and Europe have addressed the concept of hierarchy within a city system. Among the founding fathers of the so-called central place theory are Christaller (1933) and Lösch (1954). Their studies aim to identify an interpretative rule for urban hierarchy, both in terms of the size of urban centres of a given hierarchical level and their geographical distribution.

Since then, many studies have been conducted on the subject. For example, Friedmann (1986) created a hierarchy among world cities by considering the presence of the control and command functions of market-leading companies, thus identifying not only a hierarchy among cities, but also among economic systems. Sassen (2000), on the other hand, considered the location of centres of innovative service production, which is one of the strengths of the globalised economy, in identifying an urban hierarchy.

In summary, there are therefore many studies on the subject, and analysing some specific list of cities, proposing a hierarchical structure of the global/European/American urban system based on specific lists of indicators.

What role does infrastructure play in this context? The most important infrastructure (e.g., ports, airports and railway hubs) can change existing urban hierarchies, increasing the possibilities for interconnection and exchange between cities, and potentially creating new territorial disparities (Myrdal, 1957).

Specifically, regarding the construction of new high-speed rail lines in Europe, Mazzeo (2008) identified the following impacts on the European city system:

- a new high-speed line could reinforce the existing division between cities, particularly the most important ones;
- it could promote and improve the position of intermediate cities;
- it could lead to the integration of new centres into the European hierarchy, strengthening the urban network system.

The author also points out that there is a clear correlation between hierarchical order and high-speed infrastructure: the cities at the top of the hierarchy are all equipped with high-speed hubs, because a high-speed network makes cities more attractive for activities that require national and international interaction.

However, even activities located in an extensive area around an AV node can obtain significant location advantages, with a consequent impact on the urban hierarchy. Consequently, an AV node has the potential to create a polarising force on the regional economy, strengthening urban areas that already have a prominent position and favouring urban areas that have not been provided with one. This potential depends, however, on two other factors: (i) the distance between a centre and the nearest higher-level centre (the ability of a smaller center to act as a support hub for a larger centre); (ii) the policies that accompany the intervention on the high-speed rail node with various measures, such as the creation of local intermodal networks that reach the node and promote its use and sustainability, or the implementation of innovative and high-quality functions that make a center and a territory attractive (Mazzeo, 2008).

In conclusion, the impact of infrastructure improvements on the urban hierarchy has a positive effect on prominent urban locations. As for the other centres involved, the effect depends on how urban actors react to new opportunities, making the role played by policy makers central.

2.4 Direct, indirect and induced impacts

New infrastructure can generate economic, social and environmental impacts on the territory. These effects can vary considerably depending on the type of infrastructure, its location and its scale, and can be classified as direct, indirect and induced impacts.

-Direct impacts: immediate and tangible effects resulting from the construction and direct management of the infrastructure, such as increased employment and income (company level). In the case of a high-speed (HS) line, the on-site impact includes activities that provide services to people, for example, within railway stations, concession shops, car rentals, bars, restaurants, newsagents, etc. The off-site impact concerns the economic impact generated by economic activities located outside the HS station but connected to it in that they serve its users, i.e. travel agencies, hotels, restaurants, and commercial activities. The direct off-site impact also includes expenditure made in the region by passengers to reach the station, expenditure by non-resident passengers during their stay in the region, and expenditure by crews. The most studied and quantified impact (on and off-site) is the employment generated on the railway line, in railway stations and in their immediate vicinity.

-Indirect impacts: effects linked to intermediate activities (goods and services used as intermediate inputs in production for the final sector) with a chain process (Leontief multiplier effect, studied using the input-output model). The indirect effects most analysed concern the number of people employed in the production of intermediate goods and services.

The input-output or sectoral interdependence model, first developed by economist W. Leontief (1986), makes it possible to determine: (i) the degree of integration of each economic sector with other productive sectors; (ii) the capacity of an economic sector to generate income and employment; (iii) the reciprocal exchanges between the productive sectors of an economic system and between the latter and the final consumption sectors of households. The analysis of sectoral interdependencies in the economy yields the Leontief multiplier, which expresses the capacity to activate expenditure in relation to the chain of industrial supplies required by the sectors upstream of the activities directly and indirectly involved in the production process (Zucchetti, Bacelli, 2001). There are three types of multipliers: the production multiplier³, the value-added multiplier⁴ and the employment multiplier⁵.

-Induced impacts: these impacts arise from the fact that infrastructure, through direct and indirect impacts, distributes income to other sectors in its vicinity, generating an increase in overall demand.

³ For example, if the production multiplier value is equal to 0.42, this means that for each unit of direct production (on and off site), the production activated in the supplier sectors within the region is equal to 0.42 units, which are added to direct production (hence the concept of multiplier) (Zucchetti and Bacelli, 2001).

⁴ If the value added (v.a.) multiplier is equal to 0.37, this means that for each unit of v.a. connected to direct activities, the v.a. activated in the supplier sectors within the region is equal to 0.37 units, and therefore lower than production. This is due to the fact that activities directly related to rail transport have a higher VA per unit of product than those upstream in the industrial chain, so that the ratio between the VA activated directly and that activated indirectly is lower than the ratio between the values of the respective productions (Zucchetti and Bacelli, 2001).

⁵ If the employment multiplier is equal to 0.40, this means that activities directly related to the provision of rail services and services immediately related to rail transport are characterised by a higher labour intensity (units of labour per unit of production) than upstream industrial activities (Zucchetti and Bacelli, 2001).

Induced impacts are the long-term economic, social and environmental impacts that result from changes in economic activity generated by direct and indirect impacts. Induced impacts on employment concern the number of people employed in production activated by growth in consumption, following the increase in income derived from transport demand. For example, a large part of the salary of railway employees is spent locally; part of this expenditure becomes a source of income for individuals in the area who provide services to transport workers. Subsequently, part of this second cycle of spending is spent locally and thus becomes income for another group of individuals living in the area.

Changes in residence and migration patterns are among the induced impacts: for example, improved transport infrastructure can attract new residents to a region or induce people to move to more developed cities or areas. Finally, infrastructure can generate long-term social impacts, such as improved quality of life and access to better education and health services, which result indirectly from greater efficiency in transport infrastructure or communication networks.

3. The case of high-speed rail: ex-ante assessment of socio-economic impacts

The systematic review of the literature on the ex-ante assessment of the socio-economic impacts of high-speed rail was developed following the PRISMA system (Moher et al., 2009). Key information on the method used to select articles, books and book chapters is presented in Table 1.

Two databases, Scopus and Web of Science, were used to search for articles, book chapters and books. The first stage of the search process involved identifying two sets of keywords – in Italian and English – for the construction of Boolean operators to be used in both Scopus and Web of Science. The following two sets of keywords had to be present in the search:

First group of keywords:

'HSR' OR 'high speed rail' OR 'high-speed rail' OR 'high speed rail system' OR 'high-speed rail system' OR 'high-speed railway' OR 'high-speed railways' OR 'high speed railway' OR 'high speed railways' OR 'high speed train*' OR 'high-speed train*' OR "Alta velocità" OR "tren* veloc*" OR "hyperloop"

"AND"

Second group of keywords:

"Socio-economic effect*" OR "Socio-economic effect*" OR "Socio-economic impact*" OR "Socio-economic impact*" OR "Socio-economic impact*" OR "Socio-economic impact*" OR "Economic effect*" OR "Economic effect*" OR "Economic impact*" OR "Economic impact*" OR "Social impact*" OR "Social effect*" OR "Social impact*" OR "Territorial impact*" OR "Territorial effect*" OR "Territorial impact*" OR "Territorial effect*" OR "Assessment" OR "evaluation*" OR "evaluation" OR "Ex-ante assessment" OR "Ex ante assessment" OR "Ex-ante evaluation" OR "Ex ante evaluation" OR "Ex ante evaluation" OR "Ex ante evaluation" OR "Externalities" OR "externalities" OR "Land use" OR "Regeneration" OR "Tourism" OR "Localisation" OR "Labour market" OR "Commuting" OR "Polarisation" OR "Agglomeration" OR "Agglomeration".

No filters were applied to the searches, and all years and all types of manuscripts (articles, book contributions, books, etc.) were checked.

Scopus provided 382 records and Web of Science 130. Subtracting 43 articles present in both databases from the final list, we obtained a total of 469 records. Subsequently, other records were excluded because

they were outside the scope of the research, resulting in 158 records for the Scopus database and 130 for Web of Science.

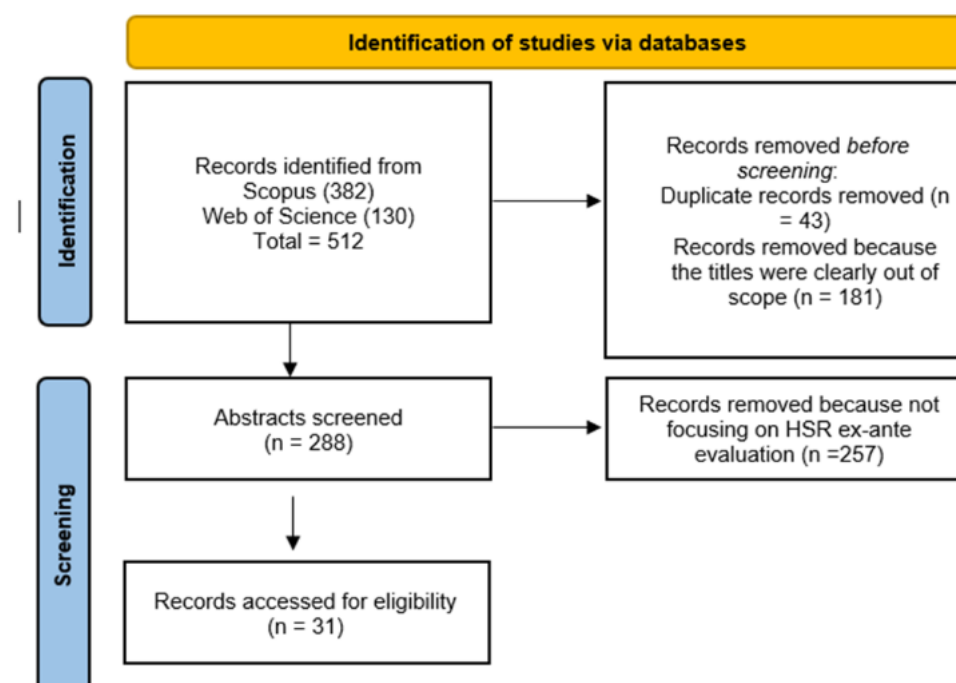
The second stage of the selection process was the screening stage, in which we checked the abstracts of the 288 records to see if they could be of potential interest, considering that the systematic review of the literature focused on the ex-ante assessment of the socio-economic impacts of high-speed rail. 255 records were excluded, leaving 33 papers published in international journals (Table 2), of which 16 were selected from the Scopus database and 17 from Web of Science. All stages of the process are illustrated in Figure 1.

Table 1: Key information on the systematic literature review.

Who carried out the review?	The authors of the chapter
When was the data collected?	September 2024-October 2024.
What sources were used to collect the articles?	Articles in peer-reviewed academic journals, books and peer-reviewed book chapters. Databases used: Scopus, Web of Science.
How many articles relevant to the research were found?	The final dataset consists of 35 documents (articles, books and book chapters).
What selection criteria were used?	Keyword search in the title, abstract, or keywords; the languages used in the search were Italian and English.

Source: adapted from Michelsson and Heikkurinen (2022).

Table 2: PRISMA flow chart



The results of the selection process are described in Table 3 (in Appendix), which presents (i) the authors of the articles and the year of publication; (ii) the name of the journal; (iii) the title of the article; (iv) the methodology used; (v) the country of analysis; (vi) the results relating to the impacts of high-speed rail.

Figure 2 shows the main topics addressed by the journals in which the articles were published, with 62.5% covering the topics of economics, transport and territory.

Figure 3 shows the year of publication of articles on the ex-ante assessment of high-speed rail, which shows a concentration after 2016 (81%). This concentration is explained by the fact that many high-speed rail projects from the early 1980s and 1990s were completed in the first decade of the 2000s, a period in which some European countries began to consider new HS projects and develop ex-ante evaluations.

Figure 4 summarises the methodologies of the selected works, which show a concentration of quantitative analyses (59%) and mixed methods, i.e. quantitative and qualitative (28%); these are followed by qualitative analyses, which mainly concern literature reviews.

Finally, Figure 5 highlights the concentration of studies in certain European countries, primarily the Czech Republic with eight studies, followed by the United Kingdom, Spain, Italy, France and the Netherlands. Two studies focused on several European countries.

An analysis of the European context was written by Vickerman (2015) and focused on intermediate stations on the high-speed rail routes connecting London, Paris, Brussels, Amsterdam and Cologne. The review of studies shows that access to new high-speed rail infrastructure does not automatically bring benefits. The impact on intermediate cities, which are far from large metropolitan areas, depends on local access to the high-speed rail network and how it integrates with local rail or public transport services. In the United Kingdom in particular, the main impact of high-speed rail has been an increase in commuting to London, reinforcing existing patterns of activity rather than creating new business activity in intermediate cities such as Ashford.

De Fabiis et al. (2023) study the territorial economic impacts of the extension of the TEN-T network in the Adriatic and Ionian regions, covering both EU countries (Italy, Slovenia, Croatia and Greece) and non-EU countries (Bosnia and Herzegovina, Montenegro, Albania, North Macedonia and Kosovo). The authors find an estimated percentage change in per capita Gross Domestic Product due to TEN-T road and rail extension projects of +0.9% on average at NUTS-3 level. Considering the entire Adriatic and Ionian region, the average increase in accessibility was +14%.

Studies on the Czech Republic concern the Prague-Brno route. Kowalski et al. (2023) focus on the competitiveness between high-speed rail and cars and find, through quantitative analysis, that the journey time of the high-speed train between Prague and Brno should be less than 60 minutes to make the journey faster and more attractive than travelling by car.

Pařil and Viturka (2020) extend the analysis to the various planned routes: Prague-Vienna, Prague-Berlin, Prague-Munich and Brno-Katowice, and use quantitative analysis to assess the likely impacts of a significant improvement in quality parameters and thus in the competitive position of rail transport, including the potential for shifting part of the demand from road and air transport to high-speed rail. Overall, they find that the potential positive impacts of high-speed rail on passenger transport growth in the Czech Republic will not be so significant and that the planned construction of high-speed rail stimulates the extraction of economic activity from 'rural' regions in favour of metropolitan regions. Subsequently, Pařil et al. (2023)

analyse the potential effects of high-speed rail construction in the Czech Republic on worker mobility (change of municipality of workplace). The results highlight the positive impacts on labour mobility, especially in favour of the capital Prague. Also in the case of the Czech Republic, Viturka et al. (2021; 2022 a,b) adopt a multi-criteria analysis to assess the environmental and economic impacts of the construction of high-speed rail lines. Viturka et al. (2021) pay particular attention to the potential conflicts of the proposed routes with protected areas of European importance and the degree of connection with the territorial systems of centres and development axes that influence the regional quality of the entrepreneurial ecosystem. Finally, Petříček et al. (2022) focus on analysing occasional commuter mobility within three large metropolitan areas in the Czech Republic in the context of future high-speed rail lines and find that passengers with higher income levels are more likely to use the future high-speed rail.

Studies in Great Britain analyse the impacts of the large-scale railway project, High Speed 2 (HSR2)⁶, which connects London, Birmingham, Manchester, the East Midlands and Leeds, and is expected to be completed by 2033. The main purpose of the HS2 construction is to shift freight transport from road to rail. McNaughton and Banks (2018) illustrate how the route for phase 1 of HSR2 (from London to Birmingham) was determined, analysing the process of generating and selecting options. Liu (2021) conducts a review of the grey literature on the project's impact on the creation of new jobs, the attraction of new investment and the regeneration of the cities it passes through. Furthermore, HSR2 has been designed to minimise environmental impact. Cornet et al. (2018) conduct a review of the literature on the long-term environmental consequences of HSR2. The authors discuss mitigation measures (rather than alternative routes) and the legacy value of the project for future generations.

Liu et al. (2021) focus on assessing the project's effects on changes in supply chains and conduct a sensitivity analysis of HSR2's development on the supply chain and logistics through air-rail-road freight transport. The analysis measures the capacity, performance and environmental changes that could follow the project's implementation. The research results show slight positive changes in freight transport and logistics with high development potential and reveal the project's weaknesses and opportunities for better integration of systems and commercial synergies. Although HSR2 has been presented to society as a project that could bring many benefits, the research results indicate that some of the benefits are debatable and cannot justify these high costs.

Fingleton and Szumilo (2019) simulate the impact of transport infrastructure investments in the HSR2 project on wages, using a dynamic spatial panel model. The results show that the project will increase wages on average, but that the impact will be spatially uneven. The areas that will benefit most are those where travel times are expected to be reduced the most, thanks to direct access to new stations or the indirect effect of improved travel times even in the absence of direct access. Furthermore, the analysis highlights that low-wage areas tend to benefit most from increased connectivity, supporting the hypothesis that transport investments reduce territorial disparities.

Another study analysing the impact of high-speed rail (HSR 1 and HSR2) on Great Britain was conducted by Vickerman (2018). The author highlights how transport infrastructure alone is not capable of having a transformative effect, but when combined with other policy interventions, it can contribute to such an effect.

The ex-ante impact of HSR development in Spain has been studied by several authors. Monzon et al. (2013) analyse the implications in terms of equity and efficiency of HSR projects with a focus on the extension of

⁶ HSR1 is the high-speed line connecting the Channel Tunnel to London.

HSR in Spain. The authors find that the highest accessibility values are concentrated around high-speed stations, which leads to the existence of 'islands' with higher levels of accessibility and shadow areas in isolated locations. Furthermore, both the accessibility of each city in the initial situation and its geographical location are two important factors that increase the likelihood of obtaining accessibility benefits.

Naranjo and Gómez (2016) analyse the impact on social cohesion of future motorway and high-speed rail networks in Spain. The results of the study show that the three existing centre-periphery models (Madrid, Barcelona and Valencia) will remain in place even after the construction of the high-speed rail line. Although there will be positive effects on the socio-economic development of about half of Spanish municipalities, the other half will be negatively impacted in terms of achieving greater social cohesion. Naranjo et al. (2020) analyse the impact of high-speed rail on municipalities in peninsular Spain in the 2018 and 2024 scenarios. The analysis shows that coverage distribution is very different in municipalities with lower AV coverage, smaller populations, and those located in peripheral areas (border areas) or between high-speed lines. In addition, a more pronounced tunnel effect will be visible by 2024. Finally, Soria-Lara et al. (2021) adopt an ex-ante participatory approach to assess the social and territorial impacts of HS at the urban and regional levels, focusing on the case of San Sebastian and its province, which is expected to be connected to the Spanish HS network by 2025. The research found that different economic sectors agree on some of the economic impacts triggered by HS, but disagree on many social and regional impacts. This approach has interesting potential for policy-making, as it complements traditional impact assessment methodologies.

Another study covering both Spain and France, and in particular the high-speed rail link between Perpignan (France) and Barcelona (Spain), was conducted by Masson and Petiot (2009). The authors analyse whether the AV can enhance the tourist appeal of the two areas. They find that increased spatial competition may reinforce the phenomenon of agglomeration of tourist activities around Barcelona at the expense of Perpignan. Differentiation of the tourist product is one solution for Perpignan to counteract the forces of agglomeration.

Oosterhaven and Rom (2003) study the indirect effects on the population and economic activity of a possible magnetic levitation railway system connecting the city of Schiphol, where the international airport is located, to the city of Groningen in the north of the Netherlands. Using quantitative and qualitative analyses, they assess two main indirect economic effects and two derived indirect economic effects of the six variants of the high-speed rail project. The first main effect is related to the behaviour of commuters: with a fast rail link, commuters can choose to move to larger homes at lower prices, in greener and less central areas, while keeping their current jobs (housing migration, Ustaoglu et al., 1999). This leads to a regional redistribution of purchasing power within the Netherlands. A new rail link will also reduce consumer prices and increase market reach, particularly for high-end services. As a result, there will be a reduction in consumption-induced employment in regions with a less varied range of services.

The second main indirect effect is linked to changes in economic activity brought about by lower transport costs. Both consumers and producers will therefore be able to choose from a wider range of products that are better suited to their production and consumption needs. Shifts in economic activities (employment induced by transport costs) will lead to labour migration. In addition to residential migration driven by reduced travel times, there may also be labour migration driven by changes in job opportunities.

Another study on the Netherlands was conducted by Hof et al. (2011), who compared five econometric models to assess the broader economic benefits of the transport infrastructure on the Amsterdam-Leeuwarden route. Several models were tested to calculate the broader economic effects. It

appears that all models predict positive direct effects, and three out of five models predict broader economic benefits.

The literature review identified only one article on the ex-ante evaluation of high-speed rail in Russia. Ponomarev and Radchenko (2023) find an increase in GDP per capita due to the increase in the length of the national high-speed rail network. The study presents three different models for estimating the impact of new infrastructure on labour supply and demand.

Only one study analysed the case of the new HS in Germany (Wenner and Thierstein, 2021). The results of the quantitative analysis show a slight trend towards greater balance in accessibility between regions and greater polycentrism within the rail network, demonstrating the importance of network integration and improvements beyond the HS network.

The AlpTransit high-speed rail project in Switzerland was analysed by Rossi and Maggi (2019). The authors find that the propensity to travel to Zurich more often thanks to AlpTransit is influenced by internal company characteristics, such as sector, frequency and destination of current business trips.

Ireland, and in particular the Dublin region, is the subject of analysis in the quantitative study by Ustaoglu et al. (2018). The authors find that HS investments have a positive impact on urban form and development, reducing the negative consequences of urban sprawl.

The case of HS in Poland is described by Pomykala and Engelhardt (2023), who outline the following main socio-economic effects: (i) stimulation of economic growth and employment; (ii) increased competitiveness of Polish regions in accordance with the principles of sustainable growth; (iii) increased social, economic and spatial (territorial) cohesion; (iv) development of transport infrastructure; (v) limitation of the negative effects of transport on the environment.

The review identified a non-European study in the province of Ontario in Canada. Llorca et al. (2018) use big data to develop a long-distance travel demand model. The main contributions of the paper are the integration of alternative data sources for destination alternatives and modal service level, as well as a sensitivity analysis of the impact of high-speed rail scenarios.

Figure 2: Main topics covered by journals

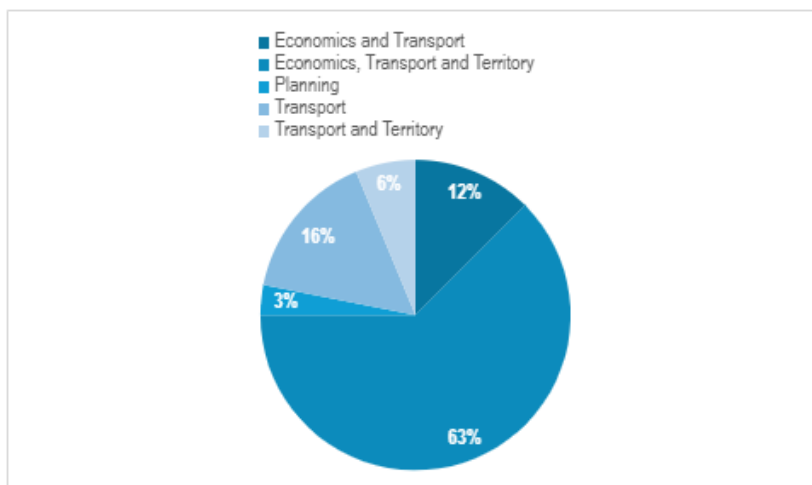


Figure 3: Year of publication of articles

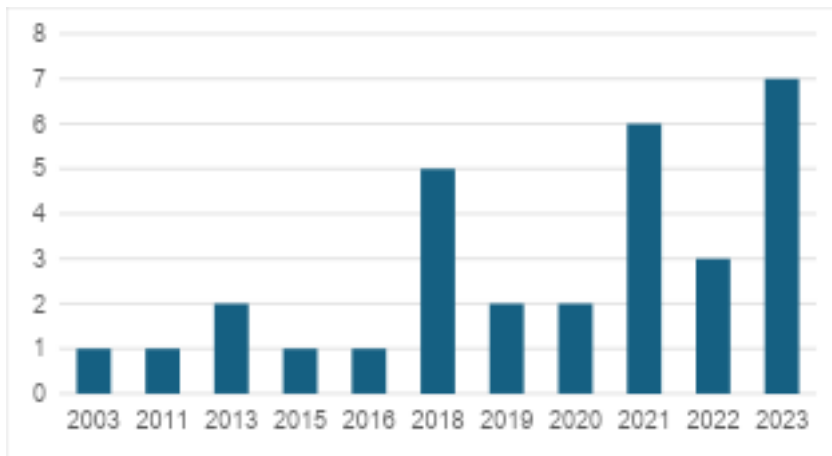


Figure 4: Methodologies used in the articles

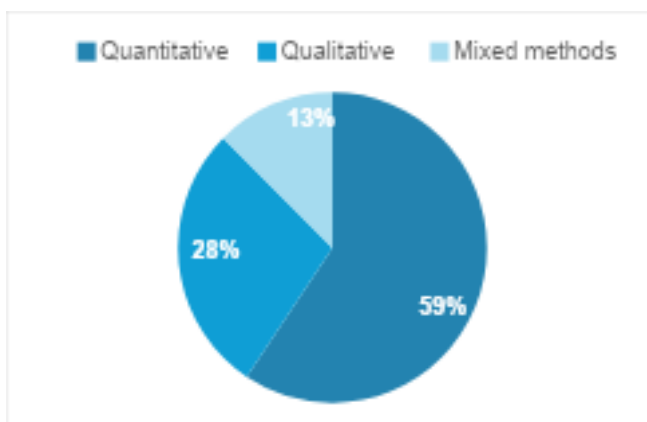
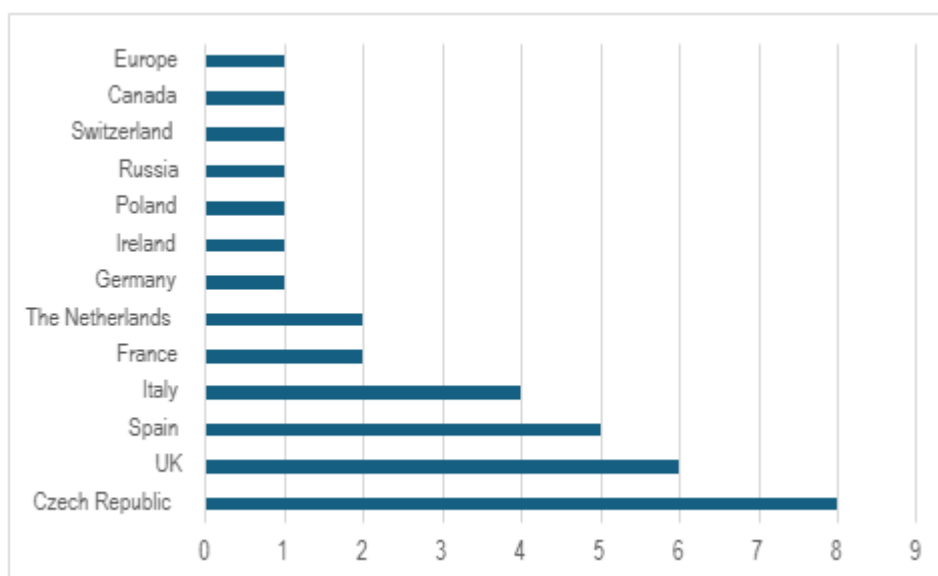


Figure 5: Countries covered by the studies



3.1 Empirical studies on high-speed rail in Italy

As highlighted by Cascetta et al. (2013), while most high-speed rail projects around the world connect pairs of cities 500-700 km apart (e.g. Tokyo-Osaka, Paris-Lyon, Madrid-Barcelona, etc.), creating a competing modal alternative to air transport, in Italy, due to the geographical structure of the country, high-speed rail connects a sequence of medium and large metropolitan areas at distances between 100 and 250 km. As a result, high-speed rail in Italy not only competes with air transport, as has been observed in many case studies (Roman et al. 2007), but also with the car.

In Italy, the first high-speed rail service was launched in 1992 between Florence and Rome with the so-called Direttissima, which allowed trains to travel at 230 km/h, covering the 254 km between Rome and Florence in about two hours. The Direttissima project, however, dated back to 1970. In fact, the new generation of high-speed rail (i.e., with trains travelling at a maximum speed of 300 km/h) began in December 2005 between Rome and Naples (205 km) and Milan and Bologna (182 km). The project took a second step in December 2009 when the Milan-Turin (125 km) and Bologna-Florence (79 km) lines were completed, as well as the Rome- Naples- and Naples-Salerno sections.

Two studies focused on the ex-ante evaluation of high-speed rail in Italy. Pagliara and Ruocco (2018) explored, through quantitative analysis, whether and how public participation could improve policy makers' decisions on railway investments. The case studied is the Turin-Lyon high-speed rail line (Italy-France), and the study shows that the benefits of public participation outweigh the costs. The authors highlight how public participation is an important tool for administration as it reduces monetary costs and time.

Venezia (2023) conducts a cost-benefit analysis of the Bari-Naples high-speed rail line, with a focus on assessing social equity. The results show a very significant impact on equity in terms of perception. Equity is measured in terms of increased access to mobility, reduced air pollution, reduced transport costs and improved economic opportunities. The CBA results therefore indicate that the project produces net benefits for the community and can therefore be considered cost-effective from both an economic and social point of view.

4. Conclusions

The theoretical excursus has highlighted that high-speed rail can have both positive and negative effects on the territory. The positive effects mainly concern the reduction of geographical disparities if: (i) the prices of so-called non-tradable goods and services (property market, public goods) are much lower in less developed areas; (ii) infrastructure improvements enable long-distance commuting; (iii) ICT infrastructure improvements enable the dissemination of local knowledge (human capital) throughout the territory (Borck et al., 2007). Negative effects include: (i) the straw effect, i.e. when the agglomeration forces of the locality affected by the high-speed rail line prevail at the expense of intermediate localities; (ii) the shadow effect, when the locality considered a hub (better accessibility) or gate (where goods pass through) casts a shadow over other localities around it.

The structured review of the literature on the ex-ante evaluation of high-speed rail has shown that the phenomenon is mainly dealt with in journals on economics, transport and territory, with a concentration of articles starting in 2016. Quantitative analyses are mainly used, followed by qualitative analyses and mixed

methods. The countries most studied are the Czech Republic, Great Britain, Spain, Italy, France and the Netherlands. Unlike the other countries, the Italian case is peculiar because in Italy, high-speed rail connects closer metropolitan areas (100-250 km), competing with the car (Cascetta et al., 2013). Studies focusing on competition between high-speed rail and cars find that the use of high-speed rail is preferable to cars (c et al., 2023). Some studies highlight that access to new high-speed rail infrastructure does not automatically bring benefits to intermediate cities (Vickerman, 2015; Pařil and Viturka, 2020; Pařil et al., 2023). Furthermore, the type of impact depends greatly on the degree of accessibility of intermediate cities to the AV network and the degree of integration with local rail or public transport services. Few studies have focused on how public participation in a high-speed rail project can improve policy decisions, reduce time and costs and bring benefits that outweigh the costs incurred. Finally, according to other studies, transport infrastructure must be combined with other policy interventions to contribute to positive effects on the territory.

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Appendix

Table 3

Appendix

Table 3: Literature Review

N.	Author	Journal	Title	Methodology	Country/Period of analysis	Results
1	Kowalski M.; Marada M.; Chmelák J. (2023)	Review of Economic Perspectives	The impact of city public transportation use on the competitiveness between high-speed rail and the car: The example of the Prague - Brno connection	Quantitativa	Czech Republic (Prague – Brno)/2021	The paper aims to determine how fast the HSR connection in conjunction with public transport between Brno and Prague should be to be time-competitive with car use . The analysis has shown that the journey time of the fast train between Prague and Brno should be shorter than 60 minutes to make travelling by public transport faster and more attractive than by car.
2	Liu R.; Stefanovich A.; Kaewunruen S. (2021)	Frontiers in Built Environment	Sensitivity of a High-Speed Rail Development on Supply Chain and Logistics via Air-Rail-Road Freight Transportation	Quantitativa	UK (High-speed 2)	The research findings demonstrate slight beneficial changes in freight transportation and logistics with a high potential for development and reveal the project's weaknesses and opportunities for better systems integration and business synergy.
3	Masson S., Petiot R. (2009)	Technovation	Can the high speed rail reinforce tourism attractiveness? The case of the high speed rail between Perpignan (France) and Barcelona (Spain)	Qualitativa	France and Spain (Perpignan-Barcelona)	It results that increased spatial competition may reinforce the phenomenon of the tourism activities agglomeration around Barcelona to the detriment of Perpignan . Tourism product differentiation is one solution for Perpignan to confront agglomeration forces.
4	McNaughton A.; Banks N. (2018)	Proceedings of the Institution of Civil Engineers – Transport	HS2 railway, UK: Route optioneering	Qualitativa	UK (High-speed 2)/ London and Birmingham	This paper explains how the phase 1 scheme for the UK's High Speed Two (HS2) north–south railway was determined.
5	Munro A. (2021)	Proceedings of the Institution of Civil Engineers – Transport	HS2 railway, UK - Why the country needs it	Qualitativa	UK (High-speed 2)/ London, Birmingham and Manchester	The review underlines that, by bringing new investment, employment and regeneration to cities, HS2 can support hundreds of thousands of jobs . The new National Colleges for High Speed Rail will deliver the skills for HS2 and a skills legacy. HS2 is being designed to minimise environmental impacts. It will set new standards for passenger experience and reliability in the UK. It will deliver value for money for taxpayers, with benefits more than double the costs.

6	Oosterhaven J.; Romp W.E.	Tijdschrift voor Economische en Sociale Geografie	Indirect economic effects of new infrastructure: A comparison of Dutch high speed rail variants	Mixed methods	NL (Schiphol-Groningen)	It results in markable differences in outcomes with the official Maglev proposal. Results focus on the indirect employment and population effects.
7	Pařil V., Viturka M., Rederer V. (2023)	Review of Economic Perspectives	The change of commuting behaviour with planned high speed railways in Czechia	Quantitativa	Czech Republic	The results document the strategic position of Prague as the main commuting centre. A positive impact on labour mobility is also on two other commuter centres (Brno and Pilsen).
8	Ponomarev Y.Y.; Radchenko D.M. (2023)	Studies on Russian Economic Development	Assessment of the Effects of High-Speed Rail Development: Global Experience and Russia's Outlook	Quantitativa	Russia	The results show an increase in GDP per capita due to an increase of the length of the national high-speed rail network
9	Rossi F.; Maggi R. (2019)	REGION	Business travel decisions and high-speed trains: An ordered logit approach	Quantitativa	Switzerland	Results show that internal firm characteristics, such as sector, frequency and destination of current business travels significantly influence the propensity to travel to Zurich more often due to AlpTransit.
10	Soria-Lara J.A., Tarriño-Ortiz J., Vassallo J.M. (2021)	Journal of Urban Planning Development	Participatory Approach to Assessing Social and Spatial Impacts of High-Speed Rail at the Urban and Regional Levels: Case of San Sebastian, Spain	Qualitativa	Spain (San Sebastian)	The research found that different economic sectors agree on some economic impacts triggered by HSR but disagree on many social and regional equity impacts . This approach has interesting potential for policymaking since it complements traditional impact assessment methodologies
11	Vickerman R. (2018)	Transport Policy	Can high-speed rail have a transformative effect on the economy?	Qualitativa	Europe and UK (North-west Europe and UK-HS1 and HS2)	It results that transport infrastructure by itself is not likely to be transformative, but coupled with other policy interventions it can contribute to such an effect.
12	Viturka M., Pařil V., Low J. (2021)	Folia Geographica	Territorial assessment of environmental and economic aspects of planned czech high-speed	Quantitativa	Czech Republic	It results the general importance of the planned HSR routes for regional development .
13	Viturka M., Pařil V., Chmelik J. (2022)	GEOGRAPHIA CASSOVIENSIS	Multicriteria analysis of the effectiveness of high-speed rails construction projects: case study of the Czech Republic	Quantitativa	Czech Republic	It results synthesized information on the factual focus and geographical and practical context of application of the criteria used, and further on the results of the comparative evaluation of the four main planned high-speed routes . The acquired knowledge is subsequently discussed from the point of view of the most important stakeholders, interpreted through relevant scenarios, i.e. investor, business, and civic scenarios .

14	Viturka M., Pařil V., Farbiak M. (2022)	GEOGRAFIE	Evaluation of the usefulness and relevance criteria for high-speed railway route construction projects: case study of Czechia	Quantitativa	Czech Republic	The article assessed the effectiveness of the high-speed railway routes construction programme in Czechia according to the criteria of usefulness (with primary links to potential revenues) and relevance (with primary links to potential costs).
15	Wenner F., Thierstein A. (2021)	disP - The Planning Review	Which Regions Benefit from New Rail Accessibility? Germany in 2030	Quantitativa	Germany	The results show a slight tendency towards greater balancing of accessibility across regions and greater poly-centralisation within the rail network, showing the importance of network integration and improvements beyond the HSR network.
16	Hof B., Heyma A., van der Hoorn T. (2011)	Transportation	Comparing the performance of models for wider economic benefits of transport infrastructure: results of a Dutch case study	Quantitativa	Fictitious: Amsterdam – Leeuwarden (The Netherlands)	Different models are tested to calculate wider economic effects. All the models predict positive direct effects; three out of five models predict wider economic benefits.
17	Monz3n A., Ortega E., L3pez E. (2013)	Cities	Efficiency and spatial equity impacts of high-speed rail extensions in urban areas	Quantitativa	Spain	Higher accessibility values are concentrated in the surroundings of HSR stations, which causes the existence of “islands” with enhanced levels of accessibility, and shadow areas in isolated locations –Moreover, both the accessibility of each city in the initial situation and its geographical position are two important drivers of their potential to gain relative accessibility benefits.
18	Vickerman R. (2015)	Journal of Transport Geography	High-speed rail and regional development: the case of intermediate stations	Qualitativa	North-west Europe HSR network, which links London, Paris, Brussels, Amsterdam, and K3ln.	The provision of access to new HSR infrastructure does not bring automatic benefits. The impact on intermediate cities, which are away from major metropolitan areas, depends on local access to the HSR network and how it integrates with local rail or other public transport services. Specifically, in UK, the main impact of HSR was an increase in commuting towards London, reinforcing existing patterns of activity rather than creating new business activity in intermediate towns such as Ashford.
19	Naranjo M., G3mez J. M. (2016)	Sustainability	Impacts on the Social Cohesion of Mainland Spain's Future Motorway and High-Speed Rail Networks	Quantitativa	Spain	The three (Madrid, Barcelona and Valencia) existing center-peripheral models are going to remain also after the construction of the HSR. Although approximately half of Spanish municipalities are going to receive positive effects on socioeconomic development, the other half are going to receive negative effects in achieving greater social cohesion.
20	Ustaoglu E. Williams B., Petrov L.O.,	Sustainability	Developing and Assessing Alternative Land-Use Scenarios from the MOLAND	Quantitativa	Greater Dublin Region (Ireland)	Positive impacts of rapid rail investments on urban form and development: they reduce the negative consequences of urban sprawl.

	Shahumyan H., van Delden H. (2018)		Model: A Scenario-Based Impact Analysis Approach for the Evaluation of Rapid Rail Provisions and Urban Development in the Greater Dublin Region			
21	Cornet Y., Dudley G., Banister D. (2018)	Case Studies on Transport Policy	High Speed Rail: Implications for carbon emissions and biodiversity	Qualitativa	UK	Review of the studies focusing on the complex long-term environmental impacts associated to the HSR2 (e.g., carbon emissions impacts on long-term climate change and trade-offs with local biodiversity systems).
22	Pagliara F., Di Ruocco I. (2018)	Regional Science Policy and Practice	How public participation could improve public decisions on rail investments?	Quantitativa	Turin-Lyon (Italy-France)	There is evidence that the benefits are higher than the costs. Public participation is an important and powerful tool for administrations in order to realize projects without problems, without wounded people, avoiding a lot of monetary costs, and spending less time.
23	Llorca C.; Ji J., Molloy J., Moeckel R. (2018)	Research in Transportation Economics	The usage of location based big data and trip planning services for the estimation of a long-distance travel demand model. Predicting the impacts of a new high speed rail corridor	Quantitativa	Province of Ontario (Canada)	This paper described the development of a long-distance travel demand model for the province of Ontario (Canada). The major contributions of the paper are the integration of alternative data sources for of the paper are the integration of alternative data sources for destination alternatives and modal level-of service, as well as a sensitivity analysis of the impact of high speed rail scenarios.
24	Fingleton B., Szumilo N. (2019)	Regional Science and Urban Economics	Simulating the impact of transport infrastructure investment on wages: A dynamic spatial panel model approach	Quantitativa	UK	The paper finds that HSR will, on average, positively increase wages but that the impact will be spatially uneven. The districts that will benefit most will be the ones projected to see the biggest reduction in commute times, due either to direct access to new stations or to the indirect effect of better commute times even where there is no direct access. Moreover, the paper highlights that linking an underperforming district with a successful one does not adversely affect wages in the low-wage district. This is because low-wage districts tend to be relatively remote and see the greatest benefit from enhanced connectivity. Locations that will benefit the most from the new infrastructure will be the ones that currently have the poorest links to the rest of the economy. This has important implications for transport investment as an instrument of policy aimed at reducing spatial disparities in economic performance.
25	Naranjo Gomez J.M., Alexandre Castanho	Infrastructures	Assessment of High-Speed Rail Service Coverage in	Quantitativa	Spain	The comparison of the distribution of the high-speed railway coverage in the 2018 and 2024 scenarios

	R., Cabezas Fernandez J., Carlos Loures L. (2020)		Municipalities of Peninsular Spain			highlighted that the distribution of coverage is much different in municipalities with less coverage of HSR, less population, and also where the territorial position is in peripheral areas (borderlands) or between the high-speed lines. Moreover, a more pronounced tunnel effect will be visible yet scarce by 2024.
26	Paril V., Viturka M. (2020)	Review of Economic Perspectives	Assessment of Priorities of Construction of High-Speed Rail in the Czech Republic in Terms of Impacts on Internal and External Integration	Quantitativa	Czech Republic	The paper investigated the issue of convergence in development (indicators: population density per km ² , GDP per capita, unemployment rate), which is the main objective of EU regional policy about HSR. Results did not confirm that the planned construction of the HSR stimulates convergence tendencies in regional development. Rather, it seems more likely that the HSR will stimulate the extraction of economic activity from "rural" regions in favor of metropolitan regions.
27	Petricek J.; Komarek M., Marada M., Randak J.(2022)	Review of Economic Perspectives	Planned construction of HSR in Czechia and occasional long-distance work commuting: impact of passenger income	Quantitativa	Czech Republic	The paper used results from a questionnaire, in which respondents answers to hypothetical situations about their willingness to travel between Prague and Brno, or Prague and Ostrava, for a specific price in relation to the travel time (the price increased as the travel time decreased). Results show that the level of income plays a significant role in the issue of using potential high-speed lines for occasional long-Main socio-distance commutes.
28	Pomykala A., Engelhardt J. (2023)	Socio-Economic Planning Sciences	Concepts of construction of high-speed rail in Poland in context to the European high-speed rail networks	Qualitativa	Poland	Main socioeconomic effects: 1. Stimulation of economic growth and employment, 2. Increase in the competitiveness of the Polish regions along with respect for the principles of sustainable growth, 3. Increase in social, economic and spatial (territorial) cohesion, 4. development of transport infrastructure, 5. Limitation of the negative effects of transport on the environment.
29	De Fabiis F., Mancuso A., Silvestri F., Coppola P. (2023)	Sustainability	Spatial Economic Impacts of the TEN-T Network Extension in the Adriatic and Ionian Region	Quantitativa	Adriatic–Ionian (AI) region	The estimated Gross Domestic Product per Capita percentage variation due to road and railway projects extending the TEN-T network in the Adriatic-Ionian region was found to be equal to +0.9% on average at the NUTS-3 level. Considering the whole AI region, the average accessibility increase was found to be equal to +14%.
30	Paril V., Viturka M., Rederer, V.(2023)	Review of Economic Perspectives	The change of commuting behaviour with planned high-speed railways in Czechia	Quantitativa	Czech Republic	The paper analyses the potential effects of HSR construction in Czechia on labour mobility (change in the location (municipality) of the workplace). Results highlight the positive impacts of HSR on labour mobility, especially in the favour of Prague.

31	Venezia E.(2023)	Sustainability	Cost-Benefit Analysis in High-Speed Railway Projects: Appraisal of Methodological Approaches and an Initial Social Equity Evaluation, A Case Study	Quantitativa	Bari-Napoli (Italy)	The results of the CBA indicate that the project produces net benefits for the community and, therefore, can be considered convenient from points of view both economic and social. Other expected effects: reduction in travel time, which contributes to the well-being of users; operating costs; externalities, such as atmospheric pollution, noise, pollution, contribution to the greenhouse effect, accidents, congestion; economic growth (regional, local, national) induced by the strengthening of the transport offer; changes in productivity; effects on international trade.
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