Chapter 2
Overview of Findings on HSR Accessibility

Abstract This chapter provides an introductory background to understand the relationship between accessibility and HSR. The impact of speed on accessibility is first presented along with determinant HSR characteristics and operating models. Previous studies on the accessibility of HSR systems are thus analyzed and categorized. Finally, few pertinent implications are highlighted to develop a conceptual framework for the present study.

Keywords HSR · Impact · Speed · Accessibility · Operation · Cities · Station · Stops · Mixed · Ridership · Freight · Economic · Measure · Intermediate · Conventional

Speed on Rails

Changes in relative speed through the introduction of HSR have reduced travel times. Transport effects of time savings have been represented as if speed shortened distances. The maps drawn by Spiekermann and Wegner (1994) represent graphically these changes in time–distance. The result is a 'shrinking' Europe (Fig. 2.1). This indicates that a reduction of travel time on some origin–destination (O–D) pairs may produce a new balance in terms of time–space relationships. As a consequence, cities' relative position to neighboring ones may change through HSR implementation.

Spatial imbalances thus derive from increases in relative speed on rails. Therefore, understanding their variations is essential before finding what could be appropriate to detect them.

High-Speed Rail Definition

Historically, the development of railways has been organized on the basis of national requirements producing a great level of diversity in the rail infrastructure, rolling stock and traffic management. Around the world, railway systems differ in

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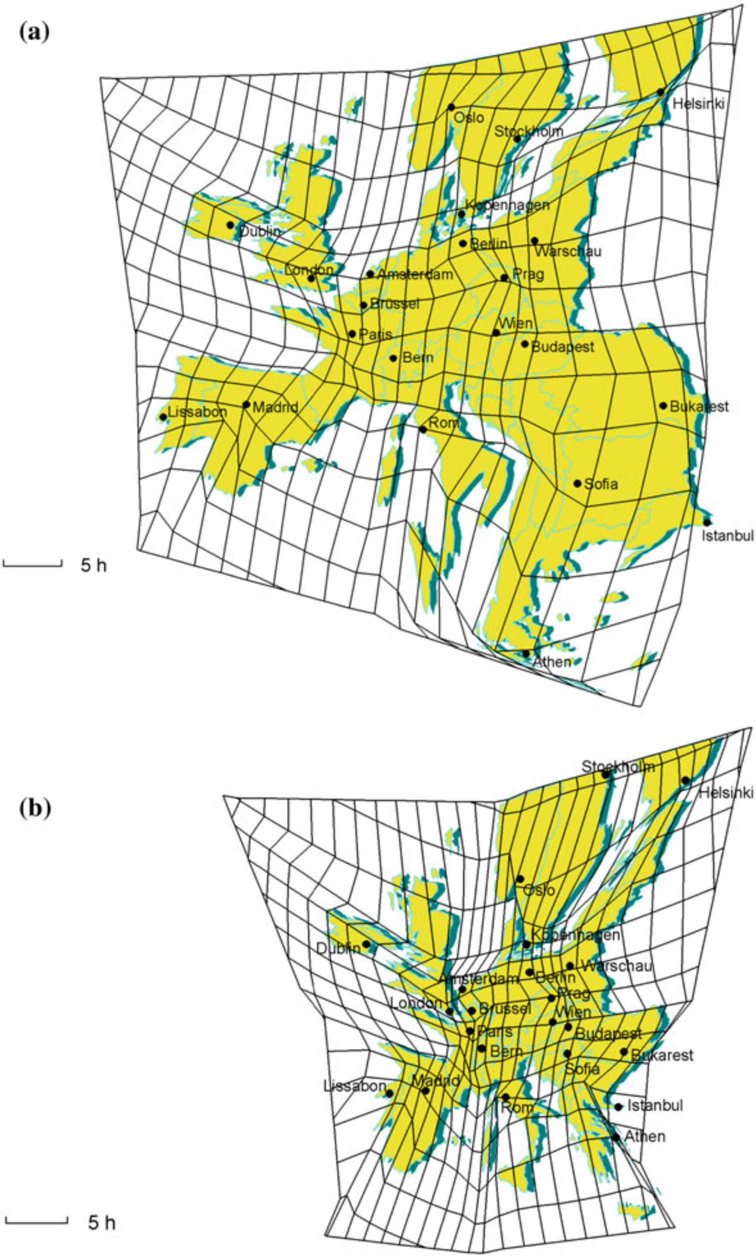

Fig. 2.1 1993 and 2020 (optimistic forecast) time–space maps of rail travel times compared to 60 km/h base scenario (Spiekermann and Wegener 2004)

travel directions, electric traction, signaling systems, safety requirements, allowed axle loads, gauge, pantograph sizes, etc. This great variety makes it difficult to precisely define a railway. One common definition is often simplified to *steel wheels on steel rails* to include all possible railway systems. So, what generally distinguishes HSR from other rail transport is the factor of speed and technology is what differentiates HSR from other high-speed ground transportation (e.g. MAGLEV floating over magnetic fields).

The European Council has given a fairly broad definition of HSR to categorize infrastructure, rolling stock and operation according to the maximum speed achievable on the lines. Infrastructure category I includes specially built high-speed lines equipped for speeds generally equal to or greater than 250 km/h; infrastructure category II includes specially upgraded high-speed lines for speeds in the order of 200 km/h; infrastructure category III includes specially upgraded high-speed lines which have special features as a result of topographical, relief or town-planning constraints, on which the speed must be adapted to each case (EU 1996). The purpose of this definition is to provide a threshold to achieve interoperability of railways within Europe (Fig. 2.2).

The very same concept of speed on rails could be further clarified as Campos et al. (2009) suggest: (1) *maximum track speed* depending on the radius of the curves and the gradient of the slopes of the rail infrastructure; (2) *maximum operating speed* depending on technology (train design and traffic management systems); (3) *average operating speed* depending on the optimal technical speed as recommended by manufacturers' maintenance plans and (4) *commercial speed* resulting from the whole line length divided by the total travel time, including intermediate stops.

Commercial speed is a critical concept for both users and operators in terms of travel time savings and quality of service. Passengers desire to arrive earlier to increase their value of time. Operators desire to be competitive by moving faster trains. So, whether commercial speed is commonly used as a parameter of performance for HSR systems (Taylor 2007, 2009), maximum operating speeds are usually reported for marketing reasons.

Furthermore, speeds tend to increase with every technological leap in the industry. In the coming years, maximum operating speeds are likely to progress in the range of 320–360 km/h as test speeds break new records (Fig. 2.3).

The Impact of Intermediate Stops

Track design for new high-speed lines requires rigorous parameters. For example, for speeds in the order of 300 km/h, it is recommended a minimum curve radius of 3500 m, a maximum cant of 150/170 mm, a track center distance of 4.5/5 m or a maximum slope gradient up to 12/15 mm/m (UIC 2015b). The same applies to rolling stock, e.g. with a limited axle load of 11 to maximum 17 t, and to the management of high-speed traffic, such as a full on-board signaling system.

Fig. 2.2 European HSR network classified by speed (UIC 2015a)

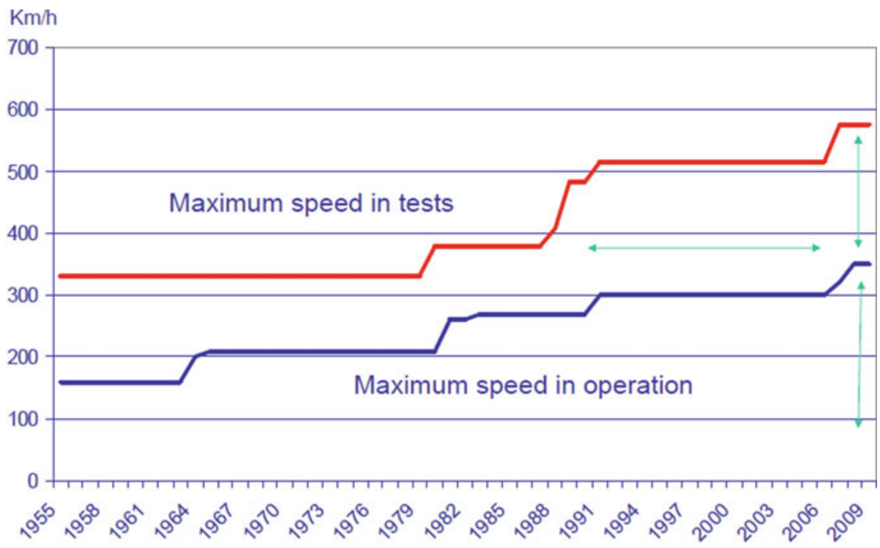

Fig. 2.3 Evolution of maximum speed on rails (UIC 2009a)

Whereas these are planning parameters intrinsic to HSR characteristics, some others are related to particular features of the local conditions where the line is located. For example, environmental or noise protection, traffic intensity and the number of stops along the line are factors limiting speed.

The recently completed Wuhan–Guangzhou HSR line is regarded as offering one of the highest commercial speeds in the world, averaging around 300 km/h (PRC Ministry of Railways 2010). This was possible by avoiding stops at the 13 intermediate stations along the 922-km distance separating the two cities and thanks to sustained top speeds, reaching up to 350 km/h. Most services with high values in commercial speed do not perform stops at all and some stopping services are represented by their best O–D connections (Table 2.1).

As an example, the international train *Thalys Soleil* from Belgium to the south of France connects Brussels to Marseille, being 1054 km apart. This HSR service does not perform stops until Valence. Thus, it is represented with a commercial speed of 244.6 km/h over the first 831.7 km. The remaining 222.3 km from Valence to Marseille require more than an hour to travel and one further stop in Avignon with a commercial speed of 208 km/h. The overall commercial speed is thus reduced to 236 km/h for the whole journey.

Other examples include north-eastern American rail services provided by Amtrak with Acela Express trains. While commercial speed is quite sustained when looking at journeys without intermediate stops (e.g. from Baltimore to Wilmington), the overall commercial speed is significantly reduced when considering longer journeys including intermediate stops (e.g. from New York to Washington DC).

Table 2.1 Selected HSR services by commercial speed (data sources: Taylor 2007, 2009; AMTRAK 2010; PRC Ministry of Railways 2010)

Country	Train (speed limit km/h)	From	To	Distance (km)	Time (min)	Speed (km/h)	Stops
China	G1001 (350)	Wuhan	Guangzhou	922.0	177	312.5	0
France	TGV5422 (320)	Lorraine	Champagne	167.6	36	279.3	0
Japan	Nozomi 1 (300)	Okayama	Hiroshima	144.9	34	255.7	0
Taiwan	7 train (300)	Taichung	Zuoying	179.5	44	244.7	0
Inter.	Thalys Soleil	Brussels Midi	Valence	831.7	204	244.6	0
Inter.	Thalys Soleil	Brussels Midi	Marseille	1054.0	268	236.0	2
Spain	7 AVE train (300)	Madrid	Zaragoza	307.2	78	236.3	0
Germany	ICE train (300)	Frankfurt	Bonn	144.0	37	233.5	0
France	TGV9864 (320)	Marseille	Lille Europe	996.1	271	220.5	4
France	TGV5444 (320)	St Pierre des Corps	Strasbourg	697.1	242	172.8	5
USA	7Acela Exp (240)	Baltimore	Wilmington	110.1	41	161.1	0
USA	15Acela Exp (240)	New York	Washington DC	362.0	167	130.0	5

Table 2.2 Braking distances for given initial speeds (UIC 2010b)

Braking distance (m)	Initial train speed (km/h)
1900	200
3100	250
4700	300
5800	330
6700	350

The reduction in commercial speed is technically due to time delays of train stopping at stations, including decelerating, accelerating and dwell times. Deceleration and acceleration time delays impact on average operating speed as do the travel regimes on the track section. Given that maximum acceleration for passenger comfort and safety in transit systems is recommended 1.0–1.8 m/s^2 (Vuchic 2007), high-speed trains (HSTs) take 10–20 km to accelerate from 0 to 300 km/h. With similar or slightly higher deceleration rates (2.0–3.0 m/s^2), braking distances to come to a standing stop vary mostly upon the initial train speed (being $V^2/2$ the braking retardation) (Table 2.2).

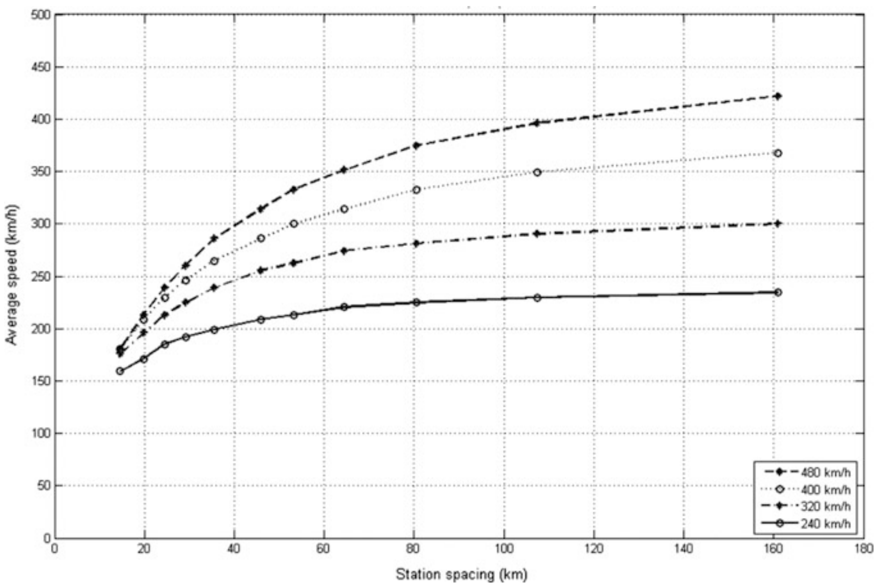

Fig. 2.4 Commercial speed as a function of interstation distance (adapted in metrics from US DOT, 1990 as cited in Schneider 1993, 1994)

Clearly, the effective commercial speed of the service is significantly affected by the number of stations along the line. Station-positioning impacts especially in terms of interstation distance. Schneider (1993) reports on the results of eight HSR scoping studies in the United States. He shows the impact of station spacing on commercial speed as trade-off curves between average operating speeds and average distance between the stations served (Fig. 2.4).

A 20% reduction in commercial speed is computed at a distance of 103 km, mean value of interstation spacing. The impact on commercial speed increases sharply as the distance between stops falls below the mean value (Schneider 1993). In particular, Vuchic and Casello (2002) demonstrate that increases in maximum speed have decreasing marginal gains in travel time savings and these reductions depend on the distance between stations with minimal values below 100 km (Fig. 2.5).

However, when locating a HSR station, it is recommended a value not much greater than 50 km between successive stops to avoid losing demand on a direct O–D option without intermediate stops, despite the journey time and performance advantages (Atkins Engineering Consultancy 2003, p. 5.2). This argument is further supported by recent studies on the successful experiences of cities connected by HSR within the range of 50–100 km from a major urban area (Romero and Garmendia 2009; Urena et al. 2010). Thus, HSR station location choices appear fundamental to determine the level of service offered in terms of commercial speed and population served.

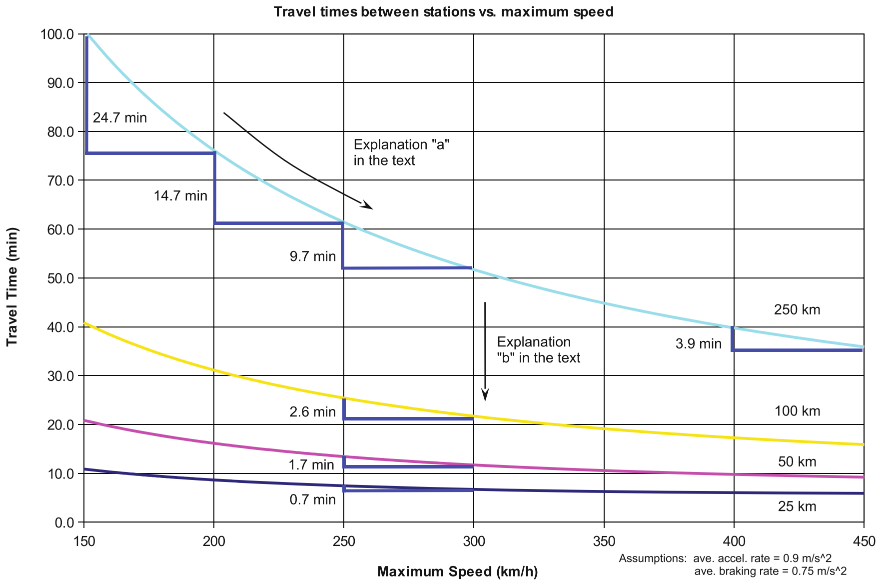

Fig. 2.5 Impact of increases in maximum speed on travel times for different station-to-station distances. Curve *a* represents time–speed relations for connections with interstation distances of 250 km showing smaller travel time savings for increasing operating speeds. Curve *b* exhibits even smaller gains for interstation distances below 100 km (Vuchic and Casello 2002)

Ridership is a trade-off factor between travel time savings and the presence of major destination centers along the line, guiding decisions on a number of skip-stop policies, access connections, station locations and operating models for the management of trains and infrastructure. Eventually, even the Wuhan-Guangzhou HSR direct service, serving the marketing purpose of showing off China's efficiency, was soon cancelled and substituted by more profitable stopping HSR services (China Daily 2010).

HSR-Operating Models

Operating models for the management of trains and infrastructure are of strategic importance impacting on the capacity of lines and determining speed constraints and accessibility options. These models provide greater understanding of HSR specificities based on the relationship with existing conventional services. The comparison between systems is based on the characteristics of infrastructure and rolling stock.

For technical, reliability and safety reasons, HSR requires specially designed trains; lines with special layout parameters, transverse sections, track quality, catenaries, power supply; and in-cab signaling. Thus, the level of compatibility between different systems provides a benchmark for a HSR more detailed

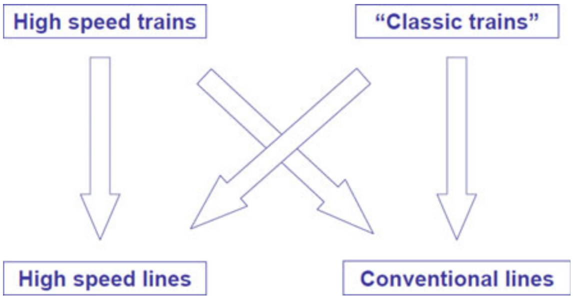

Fig. 2.6 Operating models impact on infrastructure exploitation and train interoperability (UIC 2009b)

definition, as it offers indications on performance levels, safety, quality of service and costs. Thus, Campos and de Rus (2009) have proposed an economic definition of HSR based on the adoption of different operating models. These give insight on the organization and use of rail infrastructure, providing a notion on their economic value and market prospects.

If operating models could be used to determine different cost ranges to build and manage HSR systems, they could also establish the grounds for the provision of services. With profoundly different management regimes, the models would greatly influence choices in relation to possible accessibility strategies. In fact, it seems that the accessibility provided by a HSR service could be a priori influenced by the operating model adopted for the management of trains and lines in the system.

Four operating models have been identified (UIC 2009b; Campos and de Rus 2009) and categorized (Fig. 2.6). Therefore, some well-known international experiences are reported to show how the choice of a model has impacted on service provision. These experiences suggest that the adoption of a specific operating model would shape the parameters on which to design the whole of the HSR architecture, either in terms of infrastructure, rolling stock or subsystems. Strategically speaking, speed regimes depend on the adoption of a specific operating model as it does the capacity of lines and number, location and size of stations impacting on choices over possible strategies to exploit accessibility opportunities.

Exclusive Exploitation

The exclusive exploitation model foresees high-speed and conventional services operating independently, each one on its own infrastructure. Japan has adopted this model since the very beginning of HSR services in 1964. The same word *shinkansen* literally means 'new main line' to distinguish the high-speed dedicated tracks from the old congested conventional narrow gauge network. With the separation of infrastructure, service provision is fully independent. On the HSR network, trains could be operated with short headways and homogeneous high speeds, thus with high performance levels in terms of efficiency. A further advantage is the released capacity on the conventional network allowing smoother freight and commuter services. However, compatibility is non-existent with consequences on possible integration strategies to enhance accessibility.

Mixed High Speed

The mixed high-speed model foresees HSTs running either on purposely built new lines or on upgraded segments of conventional lines. France adopted this model mainly to lower construction costs of new infrastructure, becoming a best practice example (Nash 2003). Even though the TGV does not perform stops between Paris and Lyon, 447 km apart, HSTs are allowed to run on upgraded conventional tracks, especially in rural areas (Torchin et al. 2008, 2009). This configuration has permitted a new regional high-speed service to be implemented in the northern regions around Calais and Lille, the *Train Express Régional à Grande Vitesse* (TERGV). Thanks to electrification and upgrading of conventional tracks, HSR rolling stock is capable of good performance in a regional context, increasing accessibility and reducing commuting times.

Mixed Conventional

The mixed conventional model foresees some conventional trains running on high-speed lines. Spain adopted this model to save acquisition and maintenance costs of rolling stock, having developed since 1942 a technology allowing special trains to run both on broad gauge and standard gauge infrastructure. In so doing, Spain takes advantage of providing regional services through a relatively empty countryside on certain high-speed routes.

Fully Mixed

The fully mixed model foresees both high-speed and conventional services running on both types of infrastructure. This model ideally endows the highest levels of compatibility, thus providing greater accessibility choices. Germany and Italy opted to pay higher interoperability and maintenance costs to have the flexibility of using spare capacity of high-speed lines for freight or conventional services as well as running HSTs on the whole network.

However, the fully mixed model requires to deal with higher constraints deriving from mixed traffic management of lines. Figure 2.7 provides a visual understanding of the impact of mixed traffic on effective speeds and schedule stability. The number of trains impacts on schedule stability (intended as the impact of 1 min

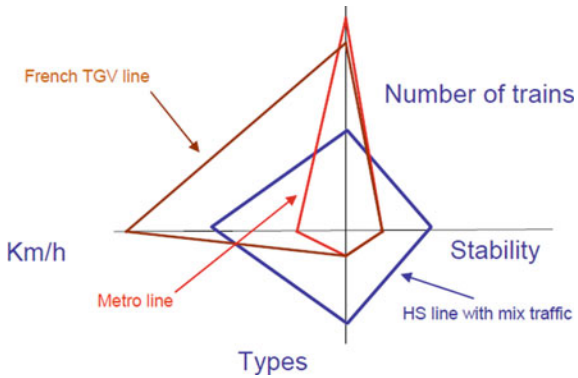

Fig. 2.7 Balancing capacity between quantity and variety of trains (UIC 2009b)

delay of one train on other trains) since the more the trains are shortly spaced and run at high frequencies, the more the probability that delays could propagate (red line). Thus, speed increases are possible with homogeneous train types (brown line), while the variety of trains impacts both on speed and capacity since slower trains take long slots of time so that faster trains need to wait and run less frequently (blue line).

HSR Ridership

Forecasting HSR ridership is a particularly complex task in that the risk of uncertainty should be reduced to a minimum, being HSR a long-term and high-cost investment. Thus, modeling HSR transport demand refines and evolves over time to restrain forecasting errors.

Models are algorithms that produce a simulation of a scenario resembling reality or a possible circumstance. More realistic models require increasing amount of data and a number of variables, often including functions of other models (e.g. catchment area; station access/egress times and modes; business, commute, recreation trip type; mode shift, induced demand, socioeconomic forecasts, etc.). In particular, HSR estimates on travel behavior differ from other transit forecasting for the mode choice function computed taking, especially into consideration competition with air travel.

Many other factors influence the forecasting model, such as the assumptions used to build the prospected scenario, data collection methodologies (e.g. stated or revealed preference) and changes in relative generalized costs or service levels. Furthermore, forecasting errors might not always be easily detectable or measurable, depending on a variety of aspects ranging from the inadequacy of the very same model, limitations in data collection, uncertainties in socioeconomic and land-use trends, ramp-up risks, political optimism bias and strategic misrepresentation (Flyvbjerg et al. 2003).

Therefore, apart from the need for greater accountability of promoters and better public involvement in decisions, risk analysis has gained increasing attention in recent years to account for what could not be kept under control. So, forecasting results are usually presented as a probabilistic distribution of ridership and revenue.

HSR Freight

A question would be whether HSR, traditionally voted to passenger travel and thus designed to serve major agglomerations with high population densities, could be more profitably implemented in a regional context with low population densities if it could be economically supported by freight handling. Such analysis would be very important for the evaluation of HSR to devise favorable conditions for freight movement and for wider benefits on regional development and competitiveness.

Conceptually, the use of HSR as a freight carrier is not new. It has been well investigated (Liang et al. 2016; Pazour et al. 2010; Troche 2005; van Ham and Muilerman 2002; Plotkin 1997) and some good practices have been developed. Above all, the French TGV postal has been an example of time sensitive parcels delivered on HSTs running at speeds up to 270 km/h. However, the operator reduced services in 2009 and altogether terminated them in 2015 after more than 30 years of service. With volumes steadily growing, capacity constraints were adduced as a reason for ending the service and moving it to swap bodies. To fill in the gap left by the TGV postal, a consortium formed in 2009, EuroCarex is studying the development of a HSR freight network connecting Amsterdam-Schiphol, Liege, Paris-Roissy-CDG, Lyon-Saint Exupery airports and the London basin (Fig. 2.8), eventually extending to Germany, Spain and Italy.

Rail freight volumes are increasing also along the Eurasian corridors as trains run faster than container vessels and cheaper than air cargos. A trip connecting China to Europe could be completed in 14/17 days by rail against the 30/40 days required by sea. Thus, operators are intensifying services and new shipment offers on the current trans-Siberian railway (Railway Gazette 2017).

In this context, the Russian Federation has expressed interest in developing a trans-continental HSR network to shorten travel times and improve capacity. This project, backed by the United Nations Economic and Social commission for Asia and the Pacific (UNESCAP 2015), might find support in close collaboration with China, already investing a considerable amount of money on its own HSR network.

Studies on the Accessibility of HSR Systems

HSR impacts might be strictly transport related, such as time savings, changes in demand, mode share or investment returns; however, several studies have been looking at the wider socioeconomic effect of HSR, such as economic growth,

Fig. 2.8 The European high-speed rail freight network (EuroCarex 2017)

regional development and city regeneration. These studies might use different approaches, such as macroeconomics, market studies or microeconomics, but they have the common feature of regarding accessibility as the essential link between transport and any possible benefit (Banister and Thurstain 2010; Vickerman 2008; Weisbrod 2008; Wegener 2004; Weisbrod and Treyz 1998; Haynes 1997).

The concept of accessibility is renowned within the regional transport debate and significant research has been conducted since the 1950s. First defined as the potential for opportunities of interaction (Hansen 1959), accessibility has undergone several interpretations, generally linking it to concepts of nearness or proximity. Often considered as the ease of spatial interaction (Weibull 1976), accessibility was later seen as the potentiality of using the opportunities offered (Domanski 1979), related to the concept of utility, and thus better interpreted as a potential or expected benefit (Ben-Akiva and Lerman 1979; Leonardi 1978).

In more recent years, the concept of accessibility has re-emerged as a fundamental element of transport sustainability (Nijkamp and Van Geenhuizen 1997; Reggiani 1998). As such, it provides a useful framework for the integration of transport and land-use planning. In this sense, accessibility allows to reflect both the geographical capillarity and the efficiency of a transit service. Thus, the concept not only deals with transport but also incorporates land-use elements, such as an attention to people and opportunities. This makes of accessibility a bridge to understand the interaction between transport and land use, and eventually a planning instrument for the improvement of their relations (Bertolini et al. 2005). Within approaches considering land-use and transport integration as a requirement for sustainable development (Meyer and Miller 2001; Priemus et al. 2001; Wegener and Fürst 1999), accessibility connects the quantities of the transport system, such as travel time improvements, and the qualities of the land-use system, such as a variety of destinations (Handy and Niemeier 1997). Thus, a shift in focus has occurred toward considering accessibility as a means to better understand the interdependences between transport and land use (Banister and Berechman 2001; Bertolini and le Clercq 2003; Straatemeier 2008).

In this way, accessibility could be linked to planning goals and assist in considering different effects on the economy (e.g. providing a firm with access to workers, customers, suppliers), on society (e.g. providing people with access to jobs, services, goods and contacts) and on the environment (e.g. using resources efficiently), leading to a broader, more holistic view in the evaluation of alternative transport options and policies (Geurs et al. 2006).

The studies reviewed below are classified by nation to reflect specific interests in relation to HSR. France (and Japan) obviously developed research on the topic showing firsthand concern over HSR impacts. British scholars appear interested in understanding prospective HSR effects onto their economy, while the Dutch tend to analyze relative positioning of cities connected by HSR and look for broader accessibility solutions to increase rail use. Spain has been particularly proficient in investigating HSR accessibility both quantitatively and qualitatively.

Pioneering French Studies

Earliest contributors to the topic on the impacts of HSR could be found in France, thanks to the deployment of TGV since 1981 (Table 2.3). French studies have opened investigations to identify the role of HSR in transforming space, obtaining the first important results on possible effects.

Bonnafous (1987) reports on a series of surveys conducted ex-ante and ex-posts (with a 5–7-year gap) to understand the reaction of enterprises, businessman and

Table 2.3 Review of main research in France on HSR impacts

Main author	Study description
Bonnafous (1987, 2002)	Survey analysis on HSR regional impacts involving enterprises, businesses and tourism
Menerault (1996, 1997, 1998, 2006, 2008), Menerault and Barré (2005)	Spatial analysis of local policies on HSR and rail transport
Plassard (1988, 1990, 1991, 1992a, b), Plassard and Cointet-Pinell (1986)	Social and spatial changes (‘structuring effects’) deriving from HSR (e.g. tunnel effect)
Troin (1995, 1997)	Effects of HSR on territorial organization

tourists to the introduction of TGV. Evidence is provided on the increase of business and leisure journeys and longer range return journeys (with a threshold of 4–6 h of travel). Results regarding changes in the location of enterprises appear less impacting with choices made largely on industry restructuring or government interventions, rather than HSR availability (regarded at most as a 'bonus').

Plassard (1988) brings forward the discussion and analyses more deeply the relationships developing between HSR networks and territories. He sees TGV as an efficient mode of transport, linking major cities with sufficient rail traffic, but he also recognizes its intrinsic compulsion to avoid intermediate stops not to lose time gains in stopovers. This characteristic causes a sort of 'tunnel effect' as if HSR infrastructure would be running underground. The rupture in the territorial continuity, through direct linking of distant cities without intermediate stops, inspired Plassard to identify a marginalization risk: places, in which it is not possible to transfer, do not have the possibility to interact, remaining in a quiescent status (Plassard 1991).

The notion of 'dual space' (Plassard 1991; Troin 1995) derives from the recognition of a dichotomy between 'network space' (nodes located on the HSR network, usually large cities) and 'ordinary space' (portions of territory not connected to the network). This dualism impacts on regional cohesion by means of polarization effects toward the nodes and might produce changes in the urban hierarchies of a region. For these reasons, Plassard (1992a) calls for a process termed 'rail irrigation' to improve integration between HSR and public transport systems, especially local train service.

Actually, among the earliest contributors, there is no mention of accessibility as such, but the first recognition of pertinent issues is addressed by means of 'irrigation' or 'congruence' (Offner 1985). This congruence is intended as the necessary adaptation of the project to the context made of local pre-existing dynamics and the strategies adopted by the actors to integrate the new supply in transportation.

Thus, from the perception of macroeffects, studies have progressed in the analysis of more nuanced effects, including development around station areas. However, evidence that the presence of a HSR station is not enough to entice development and spatial changes has been noticed by Troin (1997), in regard to the Creusot-Montchanin TGV station. This realization has led to a consensus among scientists that HSR would accelerate or amplify effects which are already trending. In line with this, Menerault has stressed the importance of local policies to support development trends. He reports on the efficacy of negotiation when the municipality of Lille was able to influence the alignment of TGV and derive new opportunities from this (Menerault 1996; Menerault and Barré 1997; Menerault and Barré 2005).

The early identification of HSR impacts has ignited a large body of literature to investigate the socioeconomic effects of HSR. Studies have multiplied to research specific accessibility issues and methods to measure them as more subtle effects on the economy.

British Studies: Issues and Doubts

During the 1990s, studies to investigate transport, economic or spatial impacts deriving from HSR have increased. While in continental Europe HSR development had taken off, the United Kingdom has been more cautious. The link with France through the Channel Tunnel (opened in 1994) was only completed in 2007 comprising 111 km between Folkstone Eurotunnel Terminal and St. Pancras international station in London. Thus, British scholars (Table 2.4) have started to carefully investigate issues, developing some reservations over the possible benefits of HSR.

One of the main British contributors to the investigation over spatial effects of HSR is Vickerman. He has researched the role of HSR in the development of regions with an interest on spatial microeconomic models. His reuse of convergence/divergence terminology to address regional implications deriving from HSR links back to French studies (Vickerman 1997). Convergence and accessibility are thus reconnected. Their antinomy indicates the imbalances between core and peripheral regions, while further divergences in accessibility are believed to develop within core regions between places on HSR corridors and places left in their shadow. Following this main HSR accessibility issue, Vickerman (1997) questions French claims over regional development benefits deriving from HSR.

Doubts over regional development promoted by HSR are shared by other authors (Harman 2006; Givoni 2006). Even though these studies are manly based on review of existing literature, it appears that most British research is conducted to build or critique a case for HSR in the United Kingdom (Atkins Engineering Consultancy 2010; Preston 2010; Greengauge21 2010; Hall 2009; Gourvish 2009; SDG 2009, 2004). If French research has shown concentration effects toward the access points of the HSR network, so there is consensus among British scholars that a city's accessibility depends on the connection to the HSR network. This generally favors large cities on the lines at the expense of smaller intermediate cities (Hall 1999, p. 14).

Table 2.4 Review of main research in the United Kingdom on HSR impacts

Main author	Study description
Banister (1993, 2008), Banister and Berechman (2001) Banister and Givoni (2013) Banister and Marshall (2000)	HSR connection as indicator of city's status and commitment to improved quality
Hall (1995, 1999, 2009), Hall and Pain (2006)	Analysis of HSR accessibility issues identifying need for strategic planning to link transport hubs to cities
Nash (1991, 2004, 2009)	Economic views on HSR investment and policies
Preston (2009, 2010, 2013), Preston and Wall (2008), Preston et al. (2006)	Socioeconomic investigation on the interaction between HSR and land use, accessibility issues and creation of HSR commuting suburbs
Vickerman (1987, 1995, 1997, 1998, 2006, 2008, 2010, 2012, 2013), Vickerman et al. (1999), Vickerman and Ulied (2009)	Critique on assumptions of improved regional development and cohesion due to difficult HSR network access

Thus, positive spatial and socioeconomic impacts are considered probable to occur at places connected to the HSR network, while negative impacts are more likely to occur in bypassed areas. For these reasons, Whitelegg and Holzapfel (1993) conclude that the overall socioeconomic impact of HSR is negative.

The general recognition that HSR effects could be of a mixed nature leads to the awareness that HSR alone is not sufficient for wider socioeconomic benefits to take place. Most authors agree that such impacts depend on several other factors, not least the vitality of the local economy to take advantage of the new opportunities offered by the HSR accessibility (Banister and Berechman 2001, p. 282). It is also recognized the need for ancillary planning policies to support HSR development for wider economic benefits to be perceived (Preston 2009). Wheat and Nash (2006) identify at least four areas on which to address these policies: (1) network access; (2) market competition; (3) national regulations and (4) technical interoperability.

The Dutch School: Refining the Concept of Accessibility

Stringent regulations on land use and the large availability of public data on infrastructure investments in the Netherlands have allowed a long-term perspective on their possible interaction.

Research has flourished investigating accessibility as the indissoluble link between transport and land use. This relationship is at the center of many Dutch studies concerned with sustainable transport and planning (Bertolini et al. 2005; Straatemeier 2008; Geurs et al. 2006). Hence, accessibility has become a key concept in mobility and spatial planning (Dutch Ministry of Transport, Public

Table 2.5 Review of main research in the Netherlands on HSR impacts

Main author	Study description
Bertolini (1998, 2008), Bertolini et al. (2005, 2012), Bertolini and le Clercq (2003)	Research on HSR station development and sustainable balancing of place and node functions
Bruinsma et al. (1992, 2008), Bruinsma and Rietveld (1993, 1997, 1998a, b)	Analysis of cities accessibility where HSR increases inequalities reinforcing the position of core regions
Geurs and Halden (2015), Geurs and van Wee (2013), Geurs et al. (2016, 2006)	Evaluation of the sustainability of transport and land-use policies from an accessibility viewpoint
Pol (2002, 2008)	Study on urban development and implications deriving from HSR
Rietveld (2000), Rietveld and Bruinsma (1998)	Comparison of studies on the accessibility of cities with interest in city regeneration and HSR commuting
Willigers et al. (2003, 2005, 2007), Willigers and van Wee (2010)	Investigation on city attractiveness and HSR economic impacts; attention to intraregional distributive effects

Works and Water Management 2006; Dutch Ministry of Housing, Spatial Planning and the Environment 2006). Thus, many urban regeneration plans have been launched around the refurbishment projects of railway stations on the HSR network to revitalize neglected areas and promote rail use (Table 2.5).

Accessibility of Cities

The relative position of a city in respect to others depends greatly on the choice of the transport network used to calculate the indices (Rietveld and Bruinsma 1998). The ranking of cities based on rail transport shows the lowest overall accessibility when compared to rankings by road and air transport. However, improvements in the rail network, such as accessibility changes deriving from HSR, produce the highest effects on city positioning with relatively large impacts on peripheral cities (e.g. Italy and Spain in regard to north-western Europe). Nevertheless, these effects are accompanied by the greatest inequalities among cities (Bruinsma and Rietveld 1993). Table 2.6 gives insight into the inequity in accessibility presenting some key summary indicators on accessibility for rail traffic, weighed by population size (Rietveld and Bruisma 1998, p. 136). The impact of HSR deployment on average accessibility is overall positive, increasing sharply the accessibility of agglomerations with a HSR station. However, not all agglomerations are connected by HSR and these have very low accessibility scores. Thus, the coefficient of variation indicates that there are large differences in the accessibility of agglomerations. Summing up, the already very accessible agglomerations increase their accessibility with HSR connections, while the accessibility of low scoring agglomerations hardly rises without a HSR station, so the equity in accessibility decreases (Rietveld and Bruinsma 1998, p. 136).

Switching geographical scale from national to regional, further Dutch studies have looked at city attractiveness in terms of location choices to evaluate commuting and business travel by HSR (Willigers et al. 2007; Elhorst and Oosternhave 2008). Results from these studies do not always show positive effects. First of all, accessibility impacts appear larger for business travel than for commuting, due to the value of time of travelers being a dominant factor; second, spatial effects among cities appear to be strongly influenced by differences in rail service levels; third, the issue of connectivity to the HSR network becomes most influential in determining effects at the urban level. Places along a HSR corridor may suffer lower accessibility levels by being bypassed, while neighborhoods around major urban centers served by HSR have the possibility to transfer to and from the conventional railway network and still enjoy accessibility benefits of HSR.

Table 2.6 Inequity in accessibility of 42 European cities with and without HSR (Rietveld and Bruinsma 1998, p. 136)

	Without HSR	With HSR
Averages score	211,304	205,695
Standard deviation	59,321	79,673
Coefficient of variation	0.281	0.318
Average accessibility	100	118.6

Accessibility of Stations

The issue of accessibility is further examined at the local level and station accessibility is presented as part of the effort (and option) to access the HSR network.

If HSR network accessibility has weighed in many studies concerned with HSR effects at higher geographical scales, at the urban scale, railway station accessibility plays an essential role in the propensity to use rail and HSR (Wardman and Tyler 2000). Givoni and Rietveld (2007, 2014) pay attention to rail services on offer, access modes and population characteristics to determine overall satisfaction on rail journeys and potential to increase rail use. They found that the quality of access facilities is significant in the use of rail, especially for infrequent users, indicating that improvements in station access might attract new passengers. While Debrezion et al. (2009) developed a measure of rail service quality as determinant of access mode and station choice, Brons et al. (2009) suggest that improvements in station access might substitute improvements in the levels of service provided at that station. This might imply that access time weights significantly on total travel time, and that improvements to reduce the first will impact positively on the overall experience.

Bertolini (2008) views the trade-off issue between access and service levels as an opportunity to balance the functions of stations as nodes in the rail network and as places in the urban area. Thus, by increasing the correlation between transport and land-use development around stations, it would be possible to detect which functions need improvement. This framework could also be applied for the sustainable positioning of new stations (Bertolini and Spit 1998; Reusser et al. 2008). According to Pol (2008), the link between HSR stations and the effects on urban systems depend on the specific regional context, not just based on its mono-centric or polycentric structure but also on the vitality of the service and knowledge economy. In his view, economic growth does not occur in a balanced way across the region and HSR reinforces the hierarchical position of cities. Those benefitting from HSR will constitute an enlivened horizontal urban network, some of which with a catalyzing role attracting new activities, while others with a facilitating role, when already prosperous cities further benefit from HSR (Pol 2002).

The Spanish School: New Trends and Perspectives

Spain is among the most active countries in HSR development with Japan, France, and more recently China. The Spanish government has revealed strong commitment to enhance rail services and it has enabled research by releasing a large amount of public capital data at the regional level covering the last 40 years (Pereira and Roca-Sagalés 2003). Thus, Spanish studies have been particularly proficient thanks to this availability. Here, studies on the economic effects of HSR are first presented, followed by studies on the quantification and evaluation of HSR accessibility benefits.

Economic Perspective

According to Campos (2008), the Spanish government has decided to develop HSR to win back rail customers, integrate the Country regions, reduce congestion and increase mobility. He warns that this expensive strategy needs to be carefully observed during implementation to avoid future reliance on subsidies. His economic definition of HSR based on its capital and operating costs presupposes a clear choice of the operating model to apply (Campos and de Rus 2009).

In this regard, sector competition appears as the key for wider services on offer, capable also of influencing market competition. For HSR, user benefits of time savings are regarded as one of the main products to influence competition with other transport modes. These benefits expressed in terms of travel time are highly dependent on the original mode used to access the HSR station (Tapiador et al. 2009; Burckhart and Blair 2009).

As total travel time includes access, egress, and waiting time in addition to in-vehicle time, it appears that benefits are higher than costs when travel distance is long enough (around 500 km) to allow HSR commercial speed to double that of the car, but not too long to reduce the competitive advantages of HSR with air transport (de Rus 2008). Thus, further increases in speed to lower in-vehicle travel time might not produce the expected outcomes if access, egress and waiting time impact on the total travel time savings (SDG 2004).

A further issue is that lowering transport costs (e.g. in terms of travel time) does not necessarily facilitate convergence or regional development. Puga (2002) argues that reductions in transport costs through the introduction of HSR might affect the balance between dispersion and agglomeration forces. These are strictly related to the spatial location of economic activities. For intermediate values of transport costs, firms and workers tend to cluster to overcome financial externalities. At this point, mobility becomes essential to reinforce agglomeration, notwithstanding increases in the price of local factors and the availability of goods. However, if mobility is impaired, firms might relocate in response to wage differentials (Puga 2002). Whereas a better connection between two regions with different development levels could provide opportunities to firms in a less developed region to access inputs and markets of more developed regions, it also facilitates firms in richer regions to supply poorer regions at a distance, potentially harming the industrialization prospects of less developed areas (Puga 2002). These considerations reflect the fears of Spain of maintaining a peripheral position in respect to the center of gravity of central Europe (Table 2.7).

How to Measure Accessibility

A group of Spanish scholars has directed research efforts toward the development of new methodologies to measure accessibility benefits deriving from HSR (Table 2.8).

Table 2.7 Review of main research in Spain on HSR economics

Main author	Study description
Campos (2008), Campos and de Rus (2009),Campos et al. (2009)	Study of the economic and operational characteristics of HSR with attention on cost and demand
de Rus (2008, 2011, 2012), de Rus and Ingalada (1997), de Rus and Nombela (2007)	Investigations on the economic effects of HSR investment and on the conditions for its profitability
Puga (1999, 2002, 2006)	Evaluation of HSR impacts on regional development: effects appear to depend most on wage rigidity and interregional migration

Among these, Gutiérrez et al. (1996) estimated the accessibility benefits of future HSR in Europe to determine the areas which would have benefitted most from HSR construction. They found increases in territorial polarization effects between major urban centers and their hinterlands. In their analysis, the distribution of accessibility is distorted by the presence of HSR corridors, which leave areas of rarefaction in between access points, also defined as 'islands' (Gutiérrez et al. 1996).

Gutiérrez (2001) further examined the accessibility impacts of HSR to estimate territorial inequalities. His results show greater impacts at the regional level, while disparities appear reduced at the national corridor level. He explains this incongruence as peripheral cities on the Iberian Peninsula gaining greater accessibility benefits from HSR than central large cities, already highly accessible even without HSR. Thus, core–periphery patterns are reduced at the national level, while they are exacerbated at the regional level. Gutiérrez (2001) concludes that statements could be true or false according to the geographical scale and the accessibility indicator selected.

Regarding the issue on the indicators, it is evident that if emphasis is placed on trips over long distances, as in the case of a location based indicator, effects will be significant at the interstate/international scale. On the contrary, indicators, which account for short distances, such as for the economic potential or the daily accessibility, will show minor effects (Gutiérrez 2001). Following this path, López et al. (2009) have developed a methodology to measure cross-border exchanges of benefits deriving from HSR infrastructure. To assess cross-border effects, they formulated spillovers as those effects extending outside the limits of the project area.

Table 2.8 Review of main research in Spain on HSR accessibility

Main author	Study description
Gutiérrez (2001, 2013), Gutiérrez et al. (1996, 1998, 2011, 2010)	Evaluation of HSR impacts on accessibility in modifying the relative position of places by means of polarization effects
López (2007), López et al. (2008a, b, 2009)	Assessment of cross-border integration/regional cohesion through estimation of HSR accessibility spillovers between different regions
Martín et al. (2004), Martín and Reggiani (2007), Martín (2008)	Synthetic accessibility indices to overcome the specificities and limitations of individual indicators

Thus, López et al. (2009) computed effects in neighboring regions as a percentage change between accessibility indicators of the construction and the do-nothing alternatives in terms of network efficiency, as suggested by Gutiérrez et al. (1998) to neutralize the influence of geographical location.

To avoid partial approaches, Martín et al. (2004) and Martín and Reggiani (2007) have felt the need for synthetic values of accessibility. To identify the global accessibility of different areas as an effect of new HSR infrastructure, they propose to compare the accessibility performance of cities and regions with two different methodologies: the data envelopment analysis (DEA) and the principal component analysis (PCA). The first method has been commonly used in several fields to evaluate data with multiple inputs and outputs, where there might be no clear distinction or functional relationship between variables; the second is used in multivariate analysis of random processes and has revealed useful for dimensionality reduction and for finding patterns in data of high dimensions (Martín et al. 2004; Martín and Reggiani 2007). Both methods have shown consistent results in the ranking of cities based on HSR accessibility gains.

Regarding the issue of scale, other studies have noticed differences in the effects of accessibility evaluations according to the level of analysis. Kwan and Weber (2008) point out the problem of modifiable aerial unit (MAUP) associated with multilevel modeling and dependent on the partitioning of zone-based data according to the geographical scale considered. They explain methods for evaluating accessibility at multiple scales and the hurdle of using coefficients of variation to make results converge. Their conclusion suggests evaluating accessibility with space–time measures, which are linked to individual characteristics and activity behavior, and unlikely to differ among geographic areas (Kwan and Weber 2008).

Accessibility of Intermediate Cities

A second group of Spanish scholars has been working on the evaluation of accessibility impacts on local development of intermediate cities along a HSR line (Table 2.9).

Some experiences of HSR intermediate stations, such as Le Creusot and Mâcon-Loché on the Paris–Lyon line, or Limburg and Montabaur on the Köln–Frankfurt line, or Ashford and Calais on the London–Brussels/Paris route, have shown disappointing results in terms of local growth (Gourvish 2009; Banister and Berechman 2001; Givoni 2006; Preston and Wall 2008; Hall 2009). In contrast to these experiences, several cities on the Madrid–Seville line have demonstrated very different urban and territorial effects.

In the region of Castilla-La Mancha, HSTs serve Ciudad Real and Puertollano. These two small intermediate cities have seen a significant increase in long-distance commuting toward Madrid since the introduction of HSR (Urena et al. 2005;

Table 2.9 Review of main research in Spain on the accessibility of intermediate cities by HSR

Main author	Study description
Garmendia (2008), Garmendia et al. (2008, 2009, 2011, 2012)	Study of HSR impacts on mobility patterns and local development in small intermediate cities
Guirao et al. (2005), Guirao and Soler (2009, 2010)	Analysis of local mobility in medium size cities integrated into metropolitan areas by HSR
Menéndez et al. (2001, 2002, 2006, 2011)	Investigation on the socioeconomic effects of HSR in minor cities
Urena (2008, 2012), Urena and Ribalaygua (2007), Urena et al. (2005, 2006, 2009a, b)	Multilevel investigation of HSR effects on large intermediate cities

Garmendia et al. 2008). In particular, Ciudad Real, within an hour of travel from Madrid, has strengthened its service-based economy with a significant share of business and discretionary trips (Garmendia et al. 2011). To a lesser extent, Puertollano attracts HSR users as far as 100 km into its hinterland (Menéndez et al. 2001). As a consequence, issues of integration and coordination with local transport arise to increase HSR share. Location advantages deriving from HSR are expected to be larger for isolated or sparsely populated territories, rather than for regional urban systems already well connected to the national metropolitan areas (MAs) by means of motorways (Garmendia et al. 2011).

Similarly, the city of Toledo, only 30 min from Madrid, presents a partial integration of mobility patterns into the larger MA (Guirao and Soler 2009). In this case, it is the inconvenience of the HSR station location at the edge of the city to call for greater coordination and integration of local transport modes.

Regarding big intermediate cities, such as Cordoba, always on the Madrid–Seville line, and Zaragoza on the Madrid–Barcelona line, territorial implications could include effects at all spatial aggregation levels. At the national level, location advantages might transform cities' roles and relationships and attract passengers and activities from near MAs; at the regional level, HSR operations and services might influence big intermediate cities' regional roles through improved connectivity; at the local level, HSR could create new city images and urban development (Urena et al. 2009b).

Trends point in the direction of an increasing role of HSR as a new intra-metropolitan transport with more intermediate stations and mixed services (Urena et al. 2010). The former role as an alternative to air transport increasingly appears substituted by HSR potential competitiveness with road transport (Garmendia et al. 2011). Thus, more options for HSR use are envisaged to facilitate integration of suburban areas and small cities. These cities endowed with a HSR stations and located within a range of 100 km from a major MA could have the opportunity to work as subcenters for long-distance HSR travel, attracting office relocation and development. However, HSR services are currently scarcely available in minor centers as confirmed in the comparative analysis conducted by Urena et al. (2010).

To conclude this review, Martinez and Givoni (2012) attempt a very rare research effort. They consider the accessibility changes on cities not directly connected to the HSR network. One of the first effects they noticed is an increase in travel time due to the need to transfer to an HSR station; a second effect is a substantial reduction of conventional rail services in nearby networks. Thus, the accessibility of many unconnected cities appears low or even worsened with the introduction of HSR. In their analysis, they present the case of Alcazar de San Juan always in the Castilla-La Mancha region. This city was traditionally a rail hub with passenger and freight flows from Madrid toward east (Valencia), south (Andalusia) and west (Portugal). Since the deployment of HSR and location of a station in Ciudad Real, the number of daily services at Alcazar has progressively declined with almost a reduction of more than 40% in the period 1989–2007 (Martínez 2008, 2012).

From a regional accessibility perspective, Martinez and Givoni (2012) question the efficacy of HSR, both because it might lower regional rail (RGR) use, even if overall national levels might increase, and because resources seem to be directed more toward HSR than redeveloping the conventional rail network.

China, USA and Australia: Great Expectations

Over just a few years since 2008, China has built the largest HSR network in the world with more than 20,000 km of lines, 1500 train sets and 800 million passengers per year (UIC 2015b). The United States has committed to build a twenty-first-century transportation network that includes a central role for HSR (FRA 2009). Many other large countries are looking favorably to the development of HSR. Among them, Australia launched initiatives to better understand possible impacts (e.g. Infrastructure Australia 2008).

Studies in countries without long HSR experiences have concentrated efforts in the evaluation of HSR in the attempt to build a case to justify or critique its deployment (Gertler 2009; ARUP-TMG 2001). Often, HSR plans have been revaluations of former proposals, which were turned down for the entity of capital investments required by governments (Thompson 1994; Anderson 2001). While previous evaluations were mainly based on demand forecasts (Lynch 2002; Hensher 1997), the newest investigations look for the HSR-presupposed socioeconomic and environmental benefits (Levinson 2010; CRC 2010). A study on the carbon footprint of HSR in France and China concluded that it could be up to 14 times less intensive than car travel and up to 15 times less than aviation, even when measured over the full life cycle of planning, construction and operation (UIC 2011). Murakami and Cervero (2010) confirm through empirical analysis that HSR might induce agglomeration effects for service and knowledge-based sectors around large and globally connected cities. Though this might come at the expense of smaller intermediate centers, they conclude that benefits could be shifted to edge cities when served by HSR and supported by proactive public policies. As such, HSR investment could produce spatial redistributive effects capable of real economic qualities, not just as a simple zero-sum game (Elhorst and Oosternhave 2008).

Table 2.10 HSR market positioning (adapted from FRA 2009)

Intercity distance (km)	Over 250 km/h	180–250 km/h	150–180 km/h
0–160	Commuter rail or road	Road or rail	Road
160–300		Regional HSR (some stops)	Emerging HSR (some stops)
300–800	Express HSR (few stops)		
800–1000		Road or air	Road or rail
1000–5000	Air		Road or air
Population density	High	Moderate	Light

However, in large countries, where development has occurred in sprawling forms, the issue of population density remains predominant in the debate over HSR. In the United States, the very same definition of HSR proposed by the FRA (2009) takes into account density and distance slots for competitive HSR service: a view which incorporates the lessons from Vuchic and Casello (2002), who suggest a HSR key role for trips between 100 km and 1000 km (Table 2.10), and from the GAO (2009), who reviewed world experiences expressly in light of HSR application in competition with US domestic flights (Fig. 2.9).

On his part, Cervero (2006) is aware that HSR is most suited to large metropolitan cities, especially appealing to the time-sensitive, high-salaried central business district (CBD) workers. He only warns over their high car ownership levels, which might lower rail use, and suggests instead addressing the commuting market with more transit options for the urban regions.

In Australia, Gordon (2010) more vigorously questions the logic of density, suggesting a transit design responsive to ridership needs to account for activity patterns which could generate trips. Similarly, Krugman (2009) considers density a relative concept, dangerous to rely on. Even though many regions in the Unites States might be dense enough, he believes that a potential market, larger than in any European country, would derive from the option value of having HSR as an alternative to road and air travel.

Implications

Having reviewed which factors influence HSR accessibility and under which circumstances HSR provides limited accessibility, it has been found that notwithstanding the claims of improved accessibility at the interstate/international level, HSR encounters difficulties to serve a regional level. The trade-off between regional accessibility and performance levels derives from the common assumption that views HSR as a competitor of air transport. This perspective is changing.

According to Garmendia et al. (2011), HSR is assuming a new role as high-end suburban transport with competition shifting to road transport. Moreover, the large majority of the reviewed studies concords that any positive regional effects can only

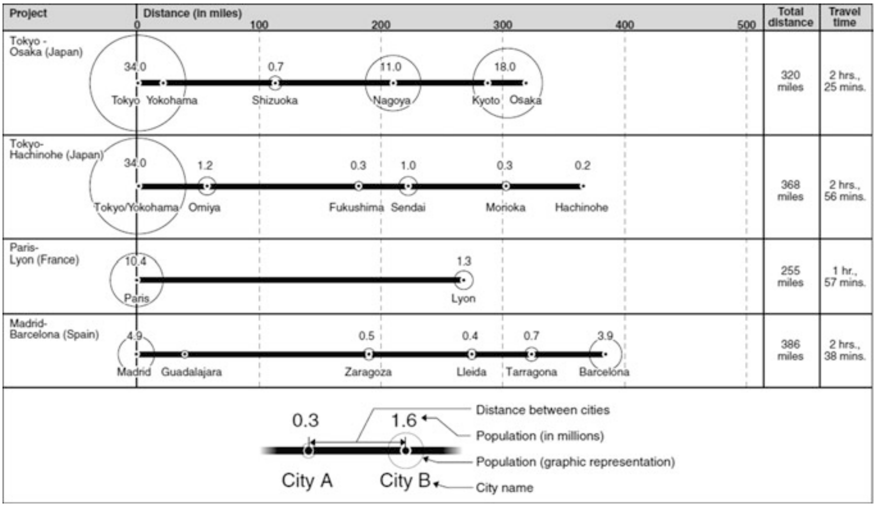

Fig. 2.9 Population of cities along selected HSR lines (GAO 2009)

be obtained by virtue of accessibility. Therefore, with the aims of increased territorial cohesion and competitiveness, more cities are requesting improved accessibility and connectivity through the HSR network. To achieve this, trends in HSR development indicate a direction toward the regionalization of services through the use of mixed operating models and an increase of intermediate stations.

Some positive effects have been identified on the mobility patterns of a relatively small number of cities, which fortuitously happened to be located on a HSR line (Garmendia et al. 2008). However, the presence of a HSR station at intermediate cities along the line does not necessarily mean that service levels are comparable to those at terminal stations. In fact, none of the cities compared in the analysis conducted by Urena et al. (2010) have the same number of HSR services as available at the central metropolitan HSR stations. It transpires that service levels are significant as much as their quality in the successfulness of intermediate cities to benefit from increased accessibility and function as regional subcenters.

However, research shows disappointing results in regard to cities located outside the HSR network, which are also the vast majority. Evidence from Spain, and in particular the case of Alcazar de San Juan, suggests that cities might experience a significant decline in service levels on the conventional network, once a HSR service is introduced in an unconnected network in close proximity (Martinez and Givoni 2012; Burmeister and Colletis-Wahl 1998). This means that depending on the location of the HSR stations and their integration and coordination with the local public transport, car travel might be the most attractive mode to access HSR. Thus, HSR services appear to reduce the accessibility of many regional locations or increase their car use. This is not tolerable within a framework where equity is inherent to accessibility as an essential aspect of sustainable mobility (Banister

2008; Marshall 2001) and where reduced levels of car use should be auspicated along with increased shares of public transport. However, in the literature, no solution was found for the accessibility of locations not directly connected to a HSR network. The only available suggestion was to adapt local public transport as a feeder system.

Following this line of thought, studies show the presence of subway or commuter lines at the HSR station as indicators of convenience from a user point of view, adding as a measure of accessibility quality the number of subway or commuter stations reached without need to transfer from the HSR station (UIC 2010). These indicators have been useful to explain the benefits of through-stations in respect to termini, but no particular reference is made to the quality or the level of service that such public transport should have to serve efficiently HSR.

There is evidently a knowledge gap in the synergies that could be established between HSR and local public transport. Certainly, not all sorts of public transport might be capable of exchanging significant accessibility benefits with HSR, as it might be limiting to consider feeders some transit options well capable to serve extended regional catchment areas. So, a need arises to demonstrate how and in which proportion alternative access transit options could distribute accessibility benefits deriving from HSR in areas not directly connected to a HSR network. The present investigation attempts to provide a contribution to this research area addressing the potential of alternative strategies to complement or interface HSR accessibility regionally. Improving HSR accessibility appears essential to distribute potential benefits, both in terms of territorial cohesion and competitiveness.

Thus, tackling HSR accessibility issues at the regional level by comparative analysis of alternative strategies is a noteworthy challenge in light of transit options that might not simply be feeders systems but complementary interfaces capable of integrating HSR functions and qualities. In so doing, transit options might be planned in close correlation with HSR to grow synergistically and develop as one integrated system. They might even pave the way to HSR deployment by instauration of greater territorial cohesion, facilitating circulation and benefit sharing, long before the opening of a region to higher levels of spatial competition brought by HSR.

To achieve the aim of demonstrating accessibility benefits at a regional level distributed by transit options working as integrated HSR strategies, this study is divided in three main parts. To begin with, the synergies establishing between HSR and potential strategies are explained and a method is developed to measure them in terms of NEs or resonance of HSR accessibility benefits (Chap. 3). Then, the suitability of transit options to perform the intended work on an extensive regional area, with urban penetrations, is investigated (Chap. 4). Finally, the comparative analysis is applied on a carefully selected case study and results are presented (Chap. 5). The book closes discussing the most appropriate strategy to complement HSR by contributing to greater accessibility at a regional level.

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